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Recreational fishing for Western Rock Lobster: estimates of participation, effort and catch in 2022/23

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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.

Data for the recreational sector are obtained 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 from tour operators are used to convert the retained catch from numbers to weight.

This report provides estimates of recreational rock lobster fishing participation, effort and catch for 2022/23 (1 February 2022–31 January 2023). Participation in the RL recreational fishery (all species) by licensed fishers (RL licence holders aged five years and older) in 2022/23 was 67% or 35,236 fishers (95% CI 34,010–36,463) This was steady (*i.e.,* the 95% CI overlapped between survey years) when compared to phone-recall surveys conducted between 2018/19 and 2021/22 (67–68%).

The total fishing effort for RL fishing (all species) in 2022/23 by licensed fishers was 481,758 days fished (95% CI 447,711–515,804); of which 78% or 376,884 days (343,595–410,173) was by potting and 22% or 104,874 days (90,213–119,534) by diving. This was steady when compared to phone recall surveys conducted between 2018/19 and 2021/22. The majority of fishing effort in 2022/23 occurred in the Metro-West Coast region (69%).

The retained recreational catch of WRL by licensed fishers in 2022/23, based on an overall (*i.e.,* combined across potting and diving) average weight of 672.9 g, was 438 t (95% CI 401–476); of which 80% or 349 t (314–384) was harvested by potting and 20% or 89 t (72–107) 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 2022/23 was 17 t (based on an overall average weight of 523.2g) and has increased annually from 9 t in 2018/19. The majority of this catch in 2022/23 was taken by potting (95%).

The 5-year average recreational catch (for licensed and tour operators combined) was 498 t in 2022/23, which represents 4.7% 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. This was the first fishery in Western Australia to be managed under a resource allocation process (Newman *et al.*, 2023). 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 TACC limits. 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 for WRL (introduced in 2010/11). A recreational licence (introduced in the 1970s) is also required to target any RL species in Western Australia. When summarised by financial year, there were 56,397 RL licences issued in 2021/22 (DPIRD, 2023) which exceeds the previous peak in numbers that 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).

1.2 Need

Annual monitoring of rock lobster catches by the recreational sector are required to support a number of strategies for sustainable fisheries management, including harvest strategies and catch allocation for WRL.

1.3 Objectives

The objective of this report is to provide estimates of participation, fishing effort and retained catch (by numbers and weight) of RL (all species) from the recreational sector (licensed and charter fishers) during the 2022/23 fishing season (1 February 2022–31 January 2023). For WRL, 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

Data are collected from RL licence holders and charter fishers using phone-recall surveys, boat ramp surveys and Tour Operator Returns. These methods have been implemented consistently since 2018/19 and detailed descriptions are provided in previous reports (Smallwood *et al.*, 2021, 2022). Any changes to survey design and exploration of raw data specific to 2022/23 are described below.

2.1 Phone-recall survey

2.1.1 *Survey design*

The phone-recall survey is a single-phase design, with all sampling completed over a period of approximately four weeks. The population total for RL licence holders used to draw the survey sample in 2022/23 occurred 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 114 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.

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 was explored. In 2022/23 the median number of days fished per year was 10 for potting (Range = 1–165) and five for diving (Range = 1–82 (Appendix 2). The median retained WRL catch per year was 22 for potting (Range = 1–572) and 12 for diving (Range = 1–361) (Appendix 3).

2.1.2 *Response rate*

A random sample of 2,500 people were selected from those who purchased a RL licence in the 12-months prior to the survey (Table 1). In the 2022/23 fishing season there were 52,874 licences, and the sample represented ~5% of this total. The response rate was 77%, based on a maximum of 6 attempted calls to respondents. Eleven RL licence holders were out of scope (*i.e.,* international visitors).

Table 1 Sample size and response profile by stratum for the phone-recall survey conducted in February 2023. Note: total RL licence holder population valid for period 1 February 2022–31 January 2023.

	Total RL Holders	Initial sample	Sample loss	Net sample	Non-response		Full response	Response rate^
					Non Contacts	Refusals		
Metro	29,691	900	76	824	142	28	654	79%
Mid-West	7,734	400	43	357	64	15	278	78%
Peel	5,650	400	33	367	56	23	288	78%
South-West[#]	5,269	400	27	373	94	20	259	69%
Country *	4,519	400	37	363	83	11	269	74%
Out of scope	11							
TOTAL	52,874	2,500	216	2,284	439	97	1,748	77%

* Country combines Kimberley, Pilbara, 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 length and weight of WRL are measured from a representative sample of WRL retained by recreational fishers using a probability-based design within a restricted spatio-temporal sampling frame (Smallwood and Ryan, 2020; Desfosses *et al.*, 2022). 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.

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 sampling occurring at selected sites within the Metro-West Coast (Hillarys and Woodmans Point) and periods (December, January) which capture nearly 50% of RL fishing activity statewide (Appendix 4).

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).

2.2.2 *Response rate*

Interviews were conducted with 1,015 vessels at Hillarys and Woodman Point public boat ramps in December and January of 2022/23. The response rate was 97%.

2.3 Tour Operator Returns

2.3.1 *Data collection*

Daily trip sheets are a mandatory reporting requirement for all tour (charter) operators and provide an assumed census of fishing activity. The numbers of lobster retained and released by clients on each fishing trip are recorded and a random sample of lobster Carapace Lengths (CL) are measured from the retained catch. These CL are converted to an average weight, which are then multiplied by the catch (by numbers) to generate catch (by weight). Recreational catch and length data from tour operators for time periods which match the 2022/23 phone-recall survey were used in this analysis.

In 2022/23, catch (by weight) was also calculated for Southern Rock Lobster (SRL) (*Jasus edwardsii*) and Tropical Rock Lobster (TRL) (*Panulirus ornatus* and *P. versicolor*). In the absence of a dedicated boat ramp survey to collect weight data for these species, Tour Operator Returns were interrogated to determine if length data were available to provide an average weight to convert catch from numbers to weight.

Catches of the two species of TRL by tour operators between 2002–2023 provided length data from which an average weight could be calculated (n=176). Due to the differing growth rates for the two species, different length-weight equations were applied for *P. ornatus* ($0.0018*CL^{2.8466}$) (DPIRD unpublished data) and *P. versicolor* ($0.0038*CL^{2.6908}$) (Tirtadanu *et al.*, 2022). The weights for each species were combined to generate a combined average weight for TRL (1,270 g).

There were insufficient catches and length data for SRL from tour operators to calculate an average weight. Therefore, an average weight of 970 g was applied for this species based on commercial catches obtained in < 50 m water depth (DPIRD unpublished data).

2.3.2 *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 were extracted for this report on 9 May 2023 and >99% of Tour Operator Returns had been entered up until the end of January 2023. 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. The recreational sector's catch of WRL is monitored using the 5-year historic moving average of both the retained recreational catch (from licensed fishers and tour operators) and TARC.

3.0 Results

3.1 Participation

3.1.1 *Phone-recall survey*

The total number of RL licences issued statewide in 2022/23 (1 February 2022–31 January 2023) was 52,874. 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 2022/23 was 67% or 35,236 fishers (95% CI 34,010–36,463) (Figure 1a). 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) (82%), followed by access (i.e., sold equipment, location closed, relocation) (17%) and other (<1%).

Higher participation occurred in potting (67%) compared with diving (24%) in 2022/23, with the remaining 9% participating in both RL fishing methods (Figure 1b). Fishing for RL from boats had the highest participation (87%) compared with from the shore (6 %), with the remaining RL fishers using both platforms (Figure 1c).

Males accounted for the majority of RL licence holders who fished in 2022/23 (91%) compared with females (9%; Figure 1d). The highest number of RL licence holders that fished were in the 30–44 and 45–59-year age groups, with 28% and 29%, respectively (Figure 1g). The lowest numbers of RL licence holders that fished were in the 5–14-year age group (5%).

Most RL licence holders fished in the Metro-West Coast in 2022/23 (69%), followed by the Mid-West (23%) (Figure 1e). Lower proportions of RL licence holders fished in the North (3%), Gascoyne (4%) and South (2%) 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 (41%) in 2022/23, followed by 15 days or more (31%) and 1–5 days (28%; Figure 1f).

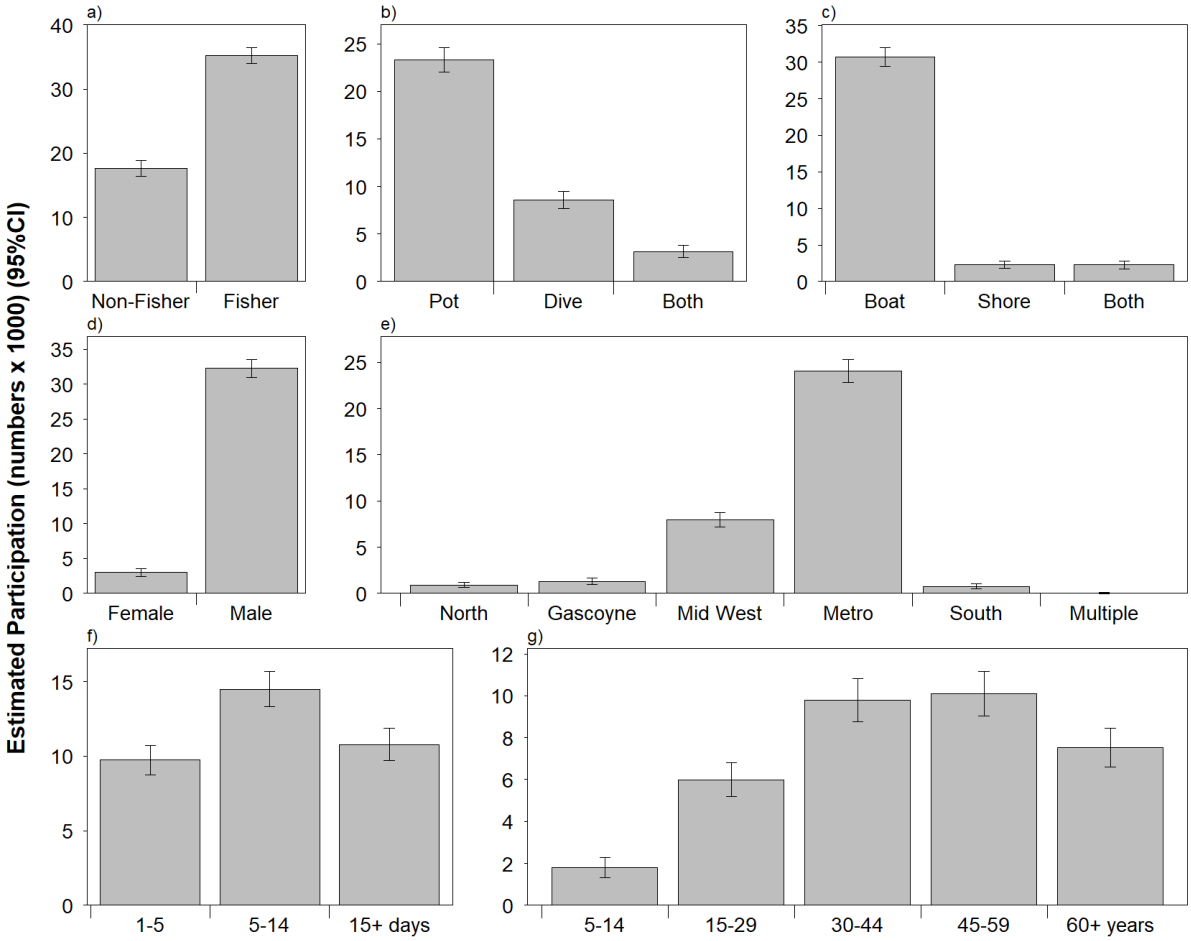

Figure 1 Number of RL licence holders (±95% CI) aged five years and older in 2022/23 summarised by (a) non-fishers and fishers. For those who fished, summaries are provided by (b) fishing method; (c) platform; (d) gender; (e) bioregion fished (f) avidity (days fished for RL per year); (g) age (years).

3.1.2 *Tour operators*

Fifty-seven tour operators undertook trips which involved catching RL species throughout Western Australia in 2022/23. Over 90% of these tour operators were in the West Coast Bioregion.

Participation in RL fishing in 2022/23 was 14,132 people (clients), of which 87% were on trips in which pots were used. Participation in diving for RL species was 13%.

Participation in RL fishing was highest in the West Coast Bioregion (>99%) (Table 2). Participation in all other bioregions was low (<1%) and could not be reported by fishing method due to confidentiality.

Table 2 Fishing participation (number of clients) for all rock lobster species by tour operators in 2022/23 in the West Coast Bioregion and all other bioregions combined, for trips with potting, diving and total.

Bioregion	Number of clients		
	Potting	Diving	Total
West Coast	12,334	1,753	14,087
Other	<3 operators		45

3.2 Gear type and loss

3.2.1 *Phone-recall surveys*

Of those RL licence holders who fished using pots, 85.0% used pots constructed predominately of wooden materials (i.e., jarrah batten pots or cane beehive pots). The remaining RL licence holders used plastic pots (8.6%), both wood and plastic pots (4.0%) or pots of unknown construction (2.4%).

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 68% or 18,083 of pot fishers (95% CI 16,834–19,332) while 30% or 7,839 (6,870–8,808) reported loss of pots and floats, and 1% or 331 (115–547) reported the loss of floats only. The remaining pot fishers (1%) 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 had 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 58.1% or 20,485 RL licence holders (95% CI 19,203–21,768) while 25.0% or 8,814 (7,814–9,814) observed the loss of pots and floats, and 6.7% or 2,345 (1,806–2,884) observed the loss of floats only. Of the remaining RL licence holders who fished, 8.4% reported hearing about lost potting equipment from other fishers while 1.8% could not remember or were unsure.

Of those RL licence holders who dived, 57% were snorkelling or free diving, with the remainder either using compressed air (i.e., SCUBA or hookah) (33%) or a combination of methods (10%).

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 2022/23 was 481,758 days fished (95% CI 447,711–515,804); of which 78% or 376,884 days (343,595–410,173) was by potting and 22% or 104,874 days (90,213–119,534) by diving.

The majority (69%) of the fishing effort was in the Metro-West Coast (Table 3). Of this total, 82% or 271,556 days (242,511–300,600) was by potting and 18% or 59,748 days (47,937–71,560) by diving.

Table 3 Fishing effort (days) for all rock lobster species by licensed fishers obtained using phone-recall surveys in 2022/23 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	***91***	***0***	***267***	9,731	6,104	13,358	9,822	6,192	13,451
Gascoyne	***398***	***0***	***1,002***	11,514	7,731	15,296	11,912	8,068	15,756
Mid-West	102,112	83,827	120,397	19,209	13,616	24,802	121,321	102,404	140,238
Metro-West	271,556	242,511	300,600	59,748	47,937	71,560	331,304	301,131	361,478
South	***2,727***	***222***	***5,232***	4,672	1,884	7,460	7,399	3,656	11,142

3.3.2 *Tour operators*

Fishing effort (in days fished) based on trips where any RL species were caught by tour operators was 1,564 days in 2022/23. The majority of this effort was obtained by tour operators using potting (86%) whereas effort by diving was 14%.

The majority (99%) of the fishing effort by tour operators occurred in the West Coast Bioregion, of which 86% was by potting (Table 4). Fishing effort by tour operators in all other bioregions was low (<1%) and could not be reported by fishing method due to confidentiality.

Table 4 Fishing effort (days) for all rock lobster species by tour operators in 2022/23 in the West Coast Bioregion and all other bioregions combined, by potting, diving and total.

Bioregion	Fishing effort (days)		
	Potting	Diving	Total
West Coast	1,350	205	1,555
Other	<3 operators		9

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 2022/23 was 672.9 g (95% CI 649.0–699.8), calculated from 1,295 weight samples.

3.4.2 *Tour operators*

The number of WRL length samples recorded in Tour Operator Returns in 2022/23 was 16,087 or 50% of the total retained catch. The overall average weight (in grams) of WRL was 523.2 g (95% CI 520.1–526.4) in 2022/23.

3.5 Retained catch

3.5.1 *Phone-recall survey*

The average weight of WRL obtained from boat ramp surveys (Section 3.4.1) and a correction factor (0.62) (Trinnie *et al.*, 2021; Smallwood *et al.*, 2022) were used to convert statewide (Appendix 7) and regional (Appendix 8) estimates of the retained catch of this species by number to weight.

The retained catch of WRL by licensed fishers in 2022/23 was 438 t (95% CI 401–476); of which 80% or 349 t (314–384) was harvested by potting and 20% or 89 t (72–107) by diving.

The majority (66%) of the retained catch of WRL in 2022/23 was from the Metro-West Coast with 291 t (95% CI 261–320); of which 79% or 229 t (203–255) was by potting and 21% or 61 t (46–77) by diving (Table 5). The remainder of the statewide retained catch of WRL came from the Mid-West Coast (31%), South Coast (2%) and Gascoyne Coast (1%).

Table 5 Retained recreational catch (in tonnes) of WRL by licensed fishers obtained using phone-recall surveys in 2022/23 for each species and 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 and methods 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***	***1***	***0***	***0***	***1***
Gascoyne	***0***	***0***	***0***	6	2	10	6	2	10
Mid-West	117	92	142	18	11	24	135	109	160
Metro-West	229	203	255	61	46	77	291	261	320
South	***3***	***0***	***7***	*4*	*1*	*6*	7	2	11

The average weight of SRL and TRL were obtained from secondary data sources (Section 2.3.1). These values were used to convert statewide (Appendix 7) estimates of the retained catch by of these species by number to weight.

Retained catch of SRL by licensed fishers in 2022/23 was 9 t (95% CI 5–12); of which 66% was taken by diving. The majority of SRL was taken from the Metro-West Coast (85%), with the remainder from the South Coast (15%).

Retained catch of TRL by licensed fishers in 2022/23 was 20 t (95% CI 13–27); of which all was taken by potting. The majority of TRL was taken from the North Coast bioregion (76%).

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.

The retained catch (in tonnes) of WRL from charter fishers in 2022/23 was 17 t. The majority of the catch was taken by potting (16 t or 95%), with the remaining 1 t taken by diving. The majority (>99%) of the retained catch of WRL by tour operators occurred in the West Coast Bioregion. Retained catch of WRL by tour operators in all other bioregions could not be reported by fishing method due to confidentiality.

Retained catch of SRL and TRL species were reported in small numbers by tour operators in 2022/23 (Appendix 9). These cannot be reported by fishing method or bioregion, or converted to retained catch (by weight), due to confidentiality.

3.6 Recreational Harvest

3.6.1 *Total Allowable Recreational Catch (TARC)*

The TARC for 2022/23 was 585 t (Table 6). Assessment of the recreational WRL catch is based on 5-year historic moving averages of the retained catch and the TARC (see Section 2.4). Thus, in 2022/23, the 5-year moving average of retained catch was 498 t and the 5-year moving average of the TARC was 535 t.

3.6.2 *Allowable Harvest Level (AHL)*

In 2022/23, the recreational catch equated to 4.7% of the AHL, which is within the recreational sector's allocation of 5% of the AHL (Table 6).

Table 6 Total Allowable Recreational Catch (TARC), retained catch (licensed fishers + charter) and proportion of Allowable Harvest Level (AHL) attained since 2014/15.

Note:

1. Percentage of 5-year TARC formula: 100*(Catch 5-year average/TARC 5-year average);
2. Proportion of AHL formula: 5*(5–year moving average retained catch/5–year moving average TARC);

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 (%)
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%
2022/23	11,690	585	455^	535	498	93%	4.7%

^ 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

Participation in the RL recreational fishery (all species) by licensed fishers (RL licence holders aged five years and older) in 2022/23 (1 February 2022–31 January 2023) was 67% or 35,236 fishers (95% CI 34,010–36,463) This was steady when compared to phone-recall surveys conducted between 2018/19–2021/22 (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 in various fishery (i.e., bioregion fished) and demographic (i.e., gender, age) variables was largely consistent when comparing 2022/23 with previous survey years, and also different licence types. For example, males have been the dominant gender type participating in recreational fishing across all RL surveys (89–91%) (Smallwood *et al.*, 2022), which is also similar to Recreational Boat Fishing (RBF) (87%) licence holders (Ryan *et al.*, 2022).

A summary of the potting gear type (i.e., wooden or plastic) used by licensed fishers revealed >85% of those who fished with pots used those constructed predominately of wooden materials (*i.e.,* jarrah batten pots). Of all RL licence holders who fished using pots in 2022/23, 30% reported loss of pots and floats, and 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). These values were similar with those reported for the 2021/22 fishing season. Although general in nature, these questions 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 quantification about the amount and type of material being lost (*i.e.,* 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 (He and Suuronen, 2018; Richardson *et al.*, 2019; Gilman *et al.*, 2021).

4.2 Fishing effort and retained catch

In 2022/23 the total fishing effort for RL fishing (all species) was 481,758 days fished (95% CI 447,711–515,804); of which 78% or 376,884 days (343,595–410,173) was by potting and 22% or 104,874 days (90,213–119,534) by diving. This was steady when compared to phone recall surveys conducted between 2018/19–2021/22 (Smallwood *et al.*, 2021, 2022). The greatest effort occurred in the Metro-West Coast which was also consistent with previous phone-recall survey years.

The retained catch (by weight) of WRL by licensed fishers was obtained by integrating phone-recall surveys and boat ramp surveys. In 2022/23 the retained catch of WRL by licensed fishers was 438 t (95% CI 401–476); of which 80% or 349 t (314–384) was harvested by potting and 20% or 89 t (72–107) by diving. This was steady when compared to phone recall surveys conducted between 2018/19–

2021/22 (Smallwood *et al.*, 2021, 2022). The greatest proportion of retained catch of WRL occurred in the Metro-West Coast (66%), which was relatively consistent with previous phone-recall survey years (68–78%). Retained catch of WRL from other regions was also relatively consistent across all survey years; Mid-West Coast (20–31%), South Coast (0.4–2%) and Gascoyne Coast (0.5–1%).

Retained catches from licensed fishers since 2015/16 have been the highest since data collection commenced (Figure 2a). 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 2013/14–2022/23 (17–27%) when compared with 2005/06–2012/13 (26 – 37%) (Figure 2b).

Exploration of the distribution of raw data for effort and retained catch in 2022/23 also provided greater insight into the behaviour of licensed fishers. The median annual values for effort (10 days per year for potting and five per year for diving) and catch (22 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 of WRL 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). 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 (Reid *et al.*, 2013; Stoklosa, 2013; Caputi *et al.*, 2015). 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. Although variable between survey years, these values have been consistently higher than the previously applied constant (500g), with the average weight in 2022/23 (672.9 g) being the highest of all previous years (Appendix 10).

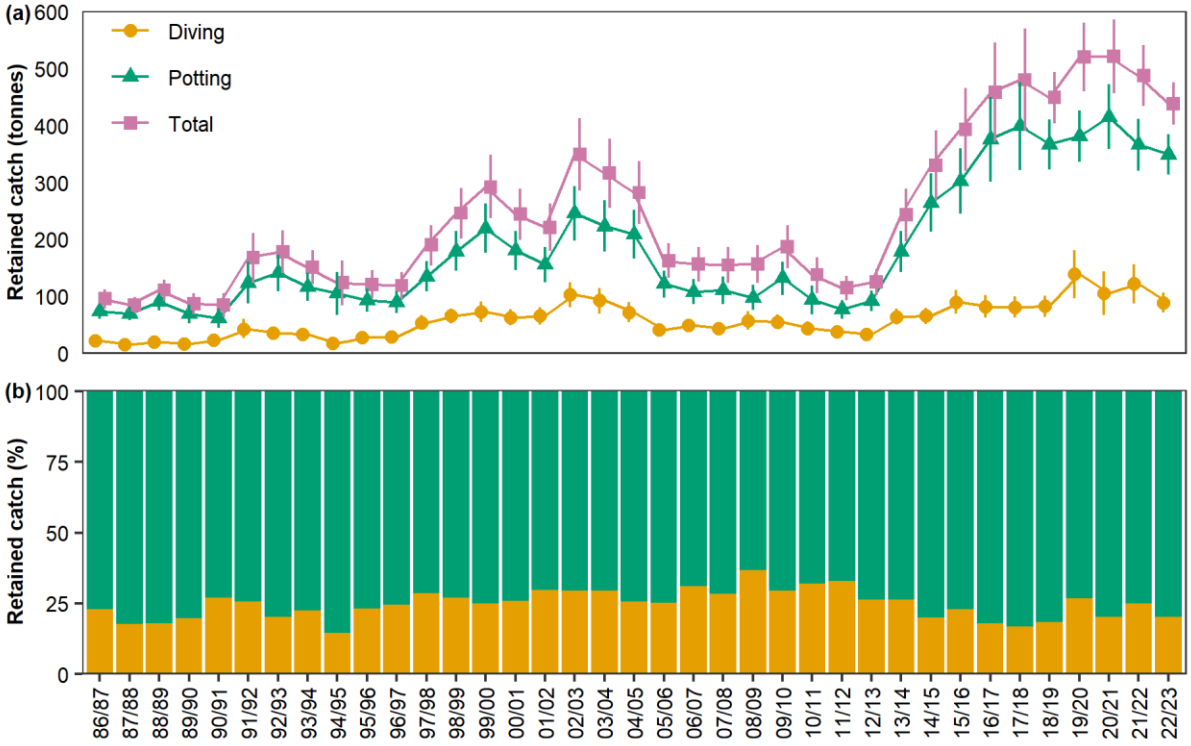

Figure 2 Time series of (a) retained catch (95% CI) and (b) proportion (%) of retained catch of Western Rock Lobster by licensed recreational fishers by potting (green), diving (orange) and total (purple) from 1986/87–2022/23, expanded from Trinnie et al. (2021). Note: A RL licence was required to fish 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 2022/23 (57) when compared to 2018/19–2021/22 (55–64), there was a decrease in participation in 2022/23 (14,132 people), when compared to most previous years (15,045–17,955 people), with the exception of 2020/21 (13,999 people) (Smallwood *et al.*, 2021, 2022). 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). This variation was not reflected in the retained catch which increased annually from 9 t in 2018/19 to 17 t in 2021/22 and remained at this level in 2022/23 (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 TARC. 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 5-year trial of the most recent changes to RL fishing on tour operator vessels began in November 2019 and included 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 80 for vessels licensed for more than 10 passengers). New catch reporting requirements have been implemented to evaluate the success of this trial and will monitor the effect of these new regulations.

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 2022/23 was 585 t, the highest of all previous years. The 5-year average recreational catch (from licensed and charter fishing) in 2022/23 represents 4.7% of the AHL. This proportion has been steadily increasing from 2.8% in 2014/15 towards the 5% allocated to the recreational sector (IFAAC, 2010; DoF, 2014). 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.

This report also continues to provide support for management tools, including a review of harvest strategies for RL resources in the West Coast and South Coast bioregions.

4.4 Future research

As part of a review of the current survey methodologies, four research areas are being used to develop a revised best-practice approach for estimating the recreational catch of WRL. These areas include survey mode, recall period, correction factors and average weight (Smallwood *et al.*, 2021). This research is ongoing, and findings will be reported in additional publications as they are completed. For example, Desfosses et al. (2022) explored the differences between fishing method-based average weight versus overall average weight for WRL. 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

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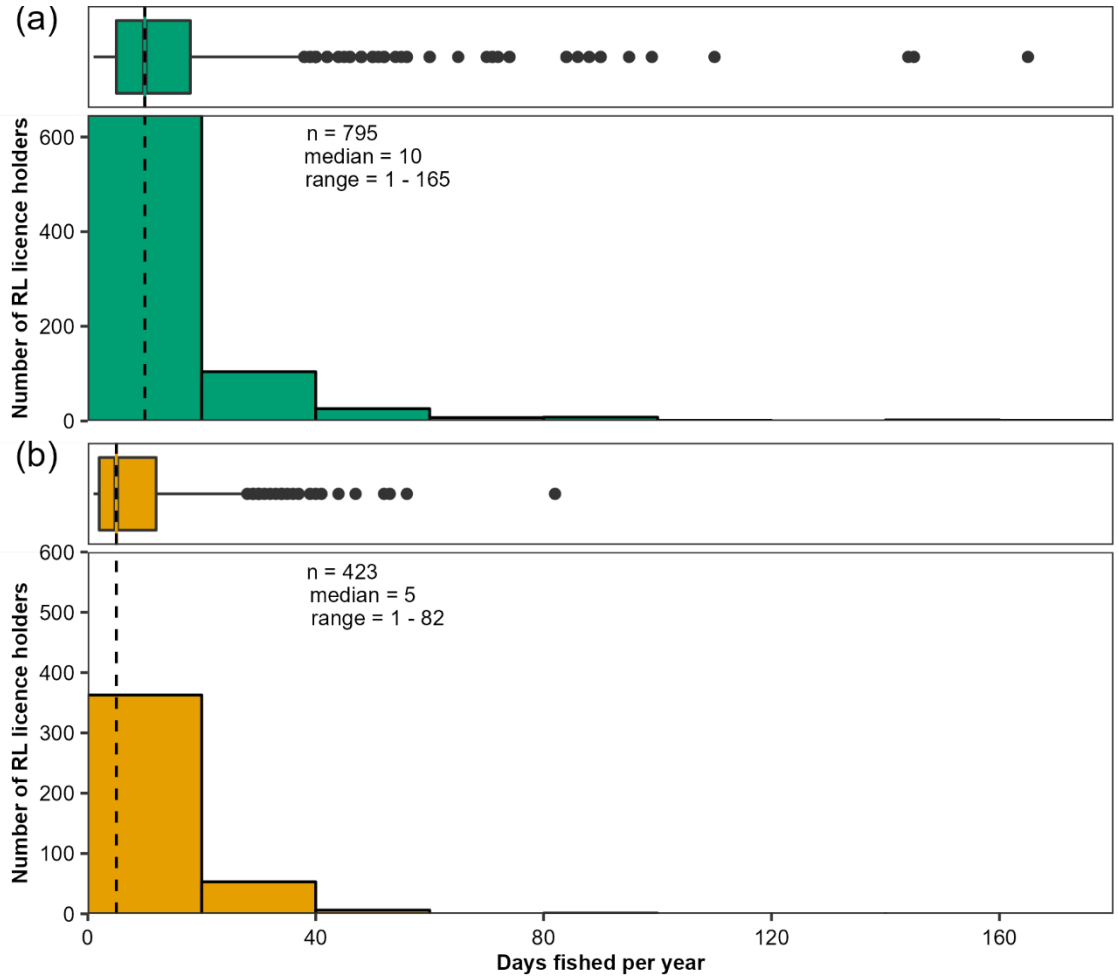
7.0 Appendices

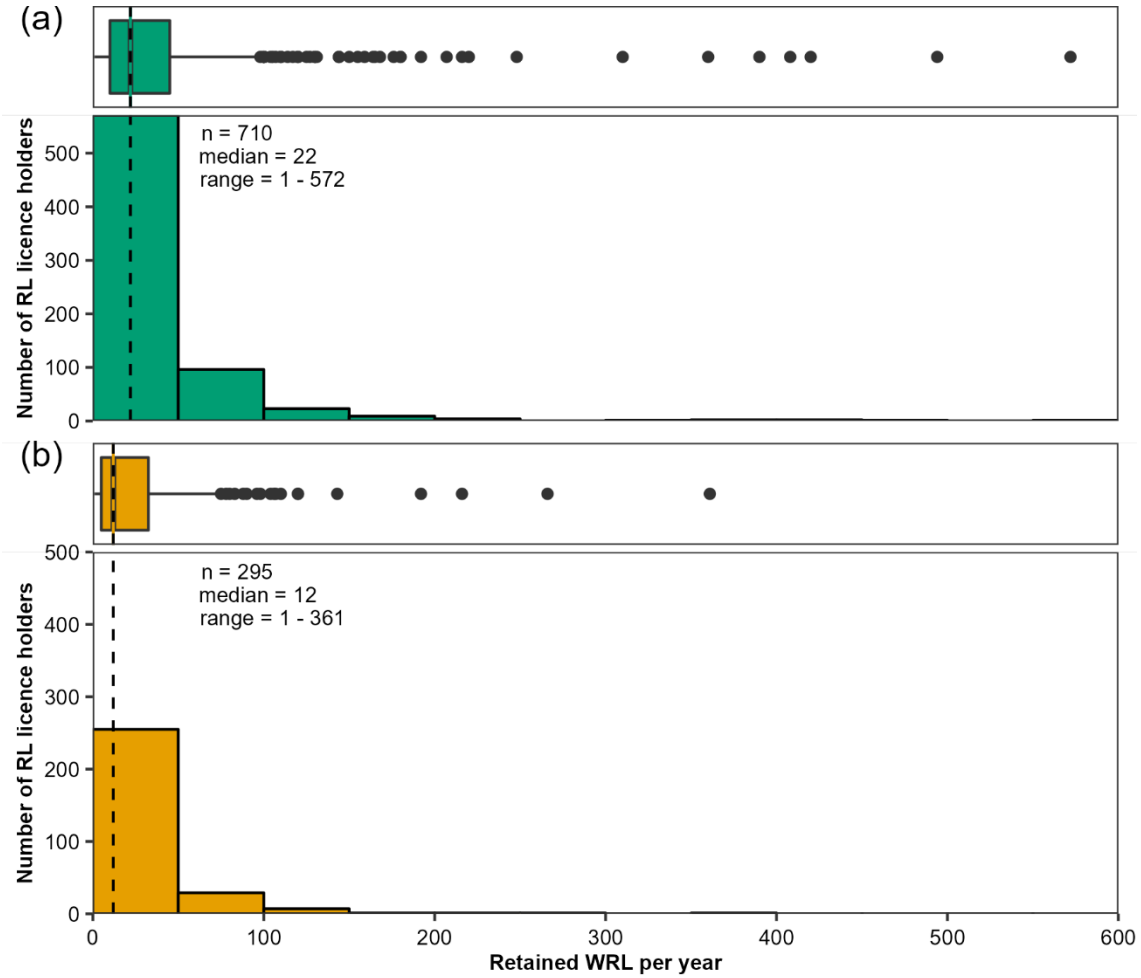
Appendix 1 Management history of the Western Rock Lobster recreational fishery [adapted from Ryan et al. (2016) and Trinnie et al. (2021)].

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 2022/23 by (a) potting and (b) diving using boxplots (top panel) and histograms with summary statistics (bottom panel)

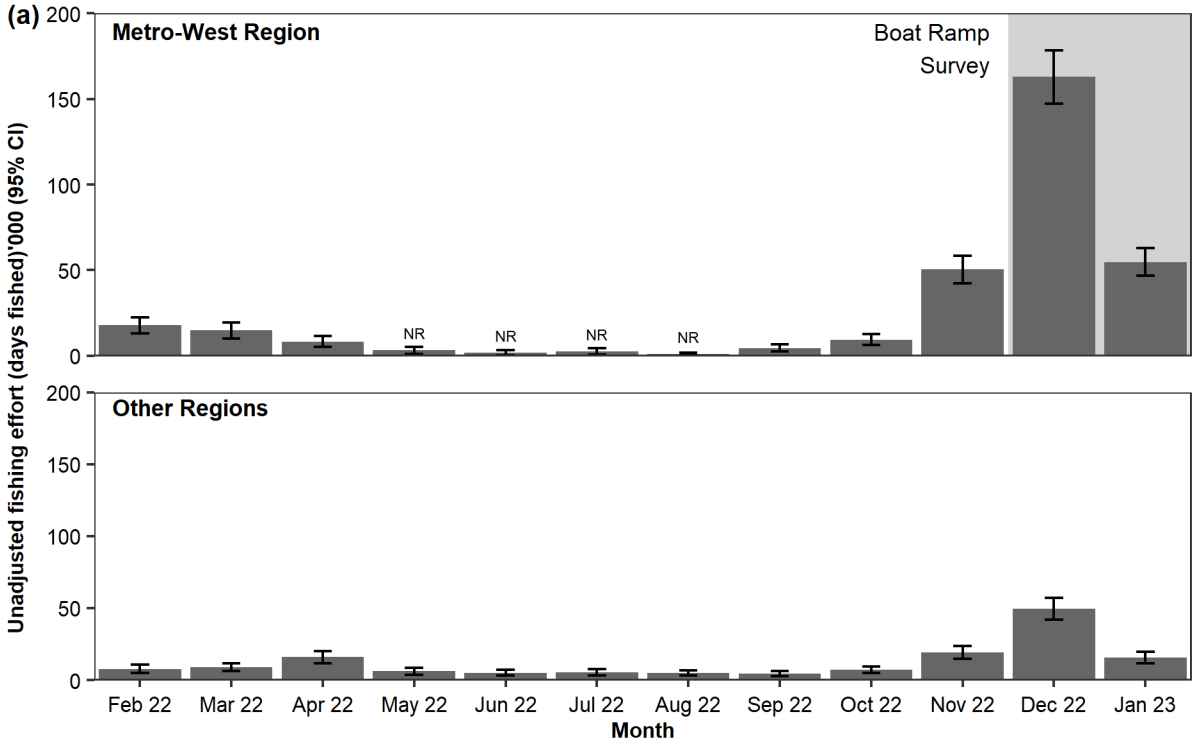


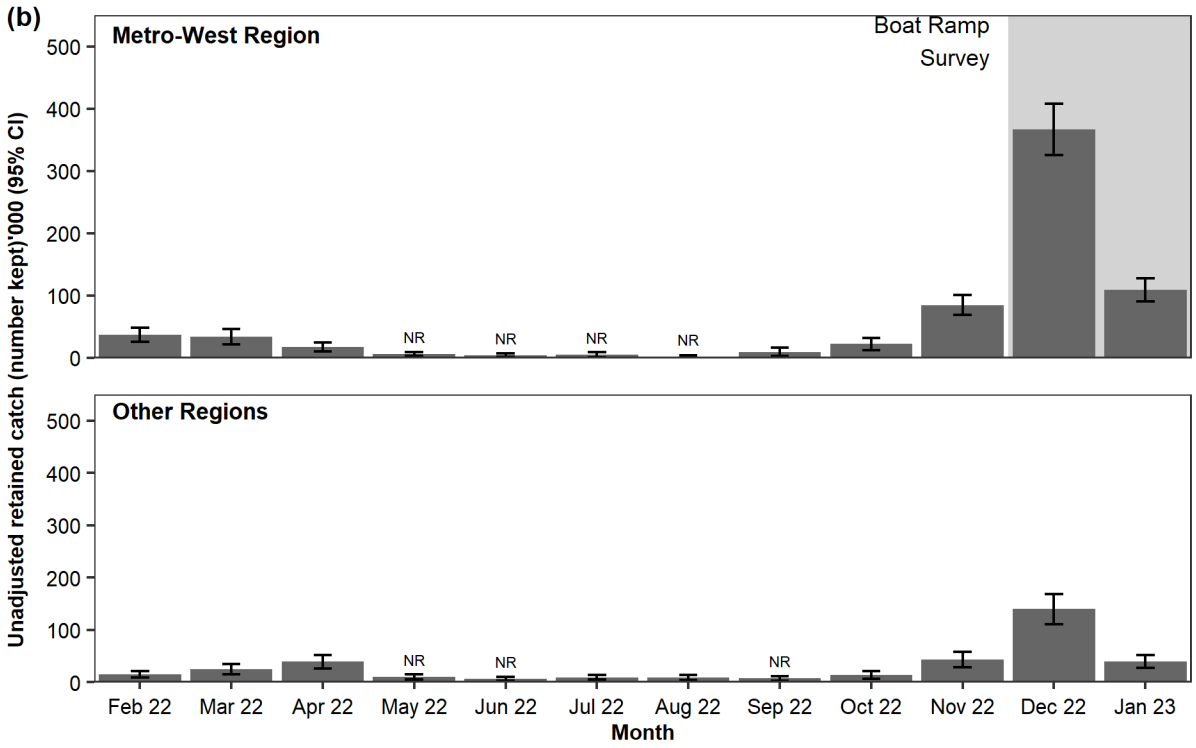
Appendix 3 Distribution of raw data for annual retained catch of WRL (by number) for each RL licence holder surveyed, and who fished, for RL in 2022/23 by (a) potting and (b) diving using boxplots (top panel) and histograms with summary statistics (bottom panel)



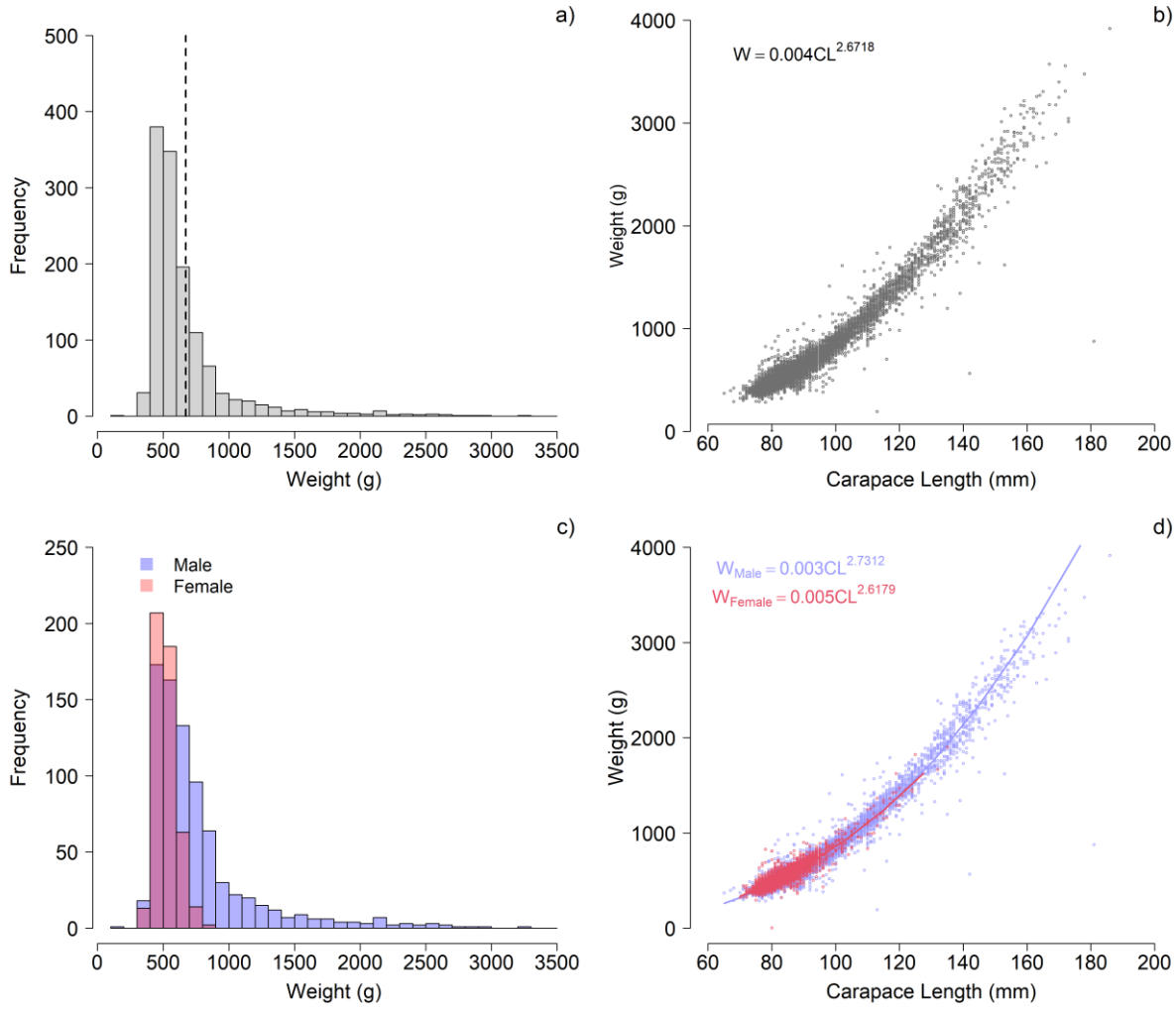
Appendix 4 *Unadjusted* (a) fishing effort (all species) and (b) *unadjusted* retained catch (in numbers) (Western Rock Lobster, *Panulirus cygnus*) by month and region from the 2022/23 phone-recall survey, with grey shading indicating spatio-temporal extent of the Boat Ramp Survey.

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





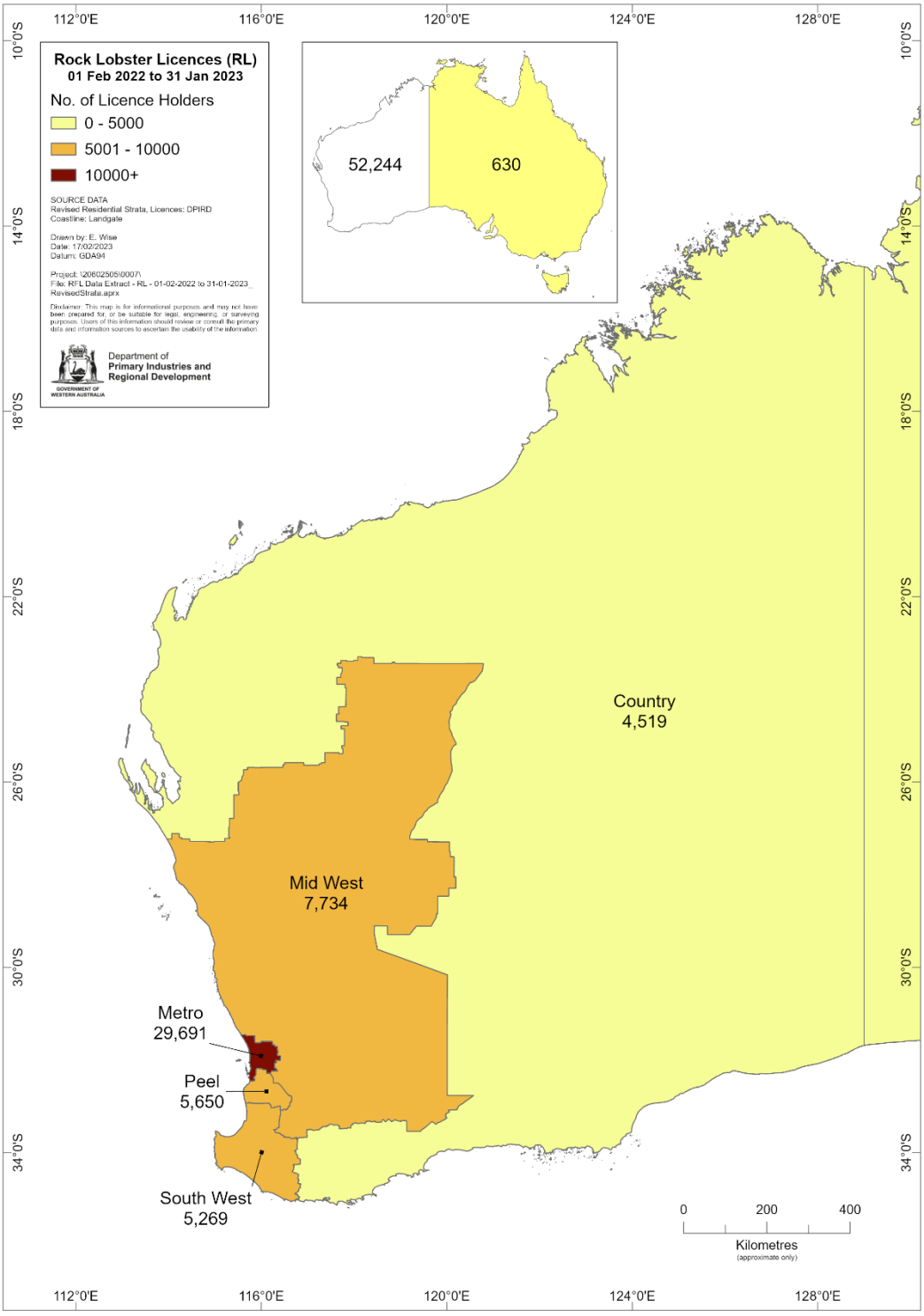
Appendix 5 Distribution of weight measurements for WRL shown as (a) histogram of weight combined across sexes for 2022/23 with arithmetic mean (dotted line), (b) length-weight relationship combined across sex for 2015/16–2022/23, (c) histogram of weight for each sex in 2022/23 and (d) length-weight relationship for each sex for 2015/16–2022/23.



Appendix 6 Number of RL holders within the modified Regional Development Commissions from 1 February 2022 to 31 January 2023.

Note:

1. country total includes interstate RL holders
2. out-of-scope fishers (n=11 excluded)



Appendix 7 Statewide *unadjusted* retained catch (in numbers) of Western Rock Lobster (*Panulirus cygnus*), Tropical Rock Lobster (*Panulirus ornatus* and *P. versicolor*) and Southern Rock Lobster (*Jasus edwardsii)* obtained during the phone-recall survey for 2022/23 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 (*Panulirus cygnus*)									
2022/23	836,821	752,225	921,417	213,828	171,818	255,838	1,050,649	960,632	1,140,667
Tropical Rock Lobster (*Panulirus ornatus* and *P. versicolor*)									
2022/23	0	0	0	15,570	10,055	21,085	15,570	10,057	21,084
Southern Rock Lobster (*Jasus edwardsii*)									
2022/23	*3,110*	*1,141*	*5,078*	6,106	3,120	9,091	9,216	5,661	12,770

Appendix 8 Regional *unadjusted* retained catch (in numbers) of Western Rock Lobster (*Panulirus cygnus*) obtained during phone-recall surveys for 2022/23 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
Western Rock Lobster (*Panulirus cygnus*)									
North				***898***	***0***	***2,044***	***898***	***0***	***2,044***
Gascoyne	***295***	***0***	***834***	14,341	5,609	23,073	14,636	5,871	23,401
Mid-West	280,347	221,234	339,459	42,632	27,513	57,751	322,979	262,404	383,554
Metro-West	549,138	486,312	611,964	147,406	110,400	184,413	696,544	626,749	766,339
South	***7,042***	***0***	***16,182***	*8,551*	*2,199*	*14,903*	15,593	4,474	26,711

Appendix 9 Statewide retained catch (in numbers) of Western Rock Lobster (*Panulirus cygnus*), Tropical Rock Lobster species (*Panulirus ornatus* and *P. versicolor*) and Southern Rock Lobster (*Jasus edwardsii)* in 2022/23 for potting, diving and total (combined methods) from Tour Operator Returns.

Season	Retained catch (numbers)		
	Potting	Diving	Total
Western Rock Lobster (*Panulirus cygnus*)			
2022/23	30,688	1,725	32,413
Tropical Rock Lobster (*Panulirus ornatus* and *P. versicolor*)			
2022/23	<3 operators		14
Southern Rock Lobster (*Jasus edwardsii*)			
2022/23	<3 operators		

Appendix 10 Timeline of retained catch (in tonnes) from licensed fishers by potting, diving and total (combined methods) from 1986/87–2022/23 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
2022/23	672.9	349	314	384	89	72	107	438	401	476

^ 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 2016/17–2022/23.

Note:

1. Data extracted from tour operator database on 9 May 2023;
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	506.5	16	1	17
2022/23	523.2	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.