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**Recreational fishing for Western
Rock Lobster: estimates of
participation, effort and catch from
1986/87 – 2017/18**

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Executive Summary

The Western Rock Lobster (WRL) fishery is one of Australia's largest single-species recreational and commercial fisheries. The recreational sector has a long history of harvesting this resource, and there is an ongoing need to provide annual estimates of the recreational catch due to the formal resource sharing policy adopted in 2004. Mail-recall surveys, supplemented with occasional phone-recall surveys, provide cost-effective monitoring, since WRL is a single-species, licensed recreational fishery operating across large spatial and temporal scales.

This report presents estimates of participation, fishing effort and retained catch from annual mail-recall surveys of randomly selected licensed Rock Lobster (RL) recreational fishers from 1986/87 to 2017/18 and provides comparisons of estimates with phone-recall surveys conducted in 2001/02 and from 2015/16 to 2017/18. Participation rates were relatively stable from 1986/87–2004/05 with around 75% of licence holders fishing. Participation rates then began to decline to a low of 52% in 2011/12, before increasing to 64% by 2017/18.

The total fishing effort (potting and diving combined; all RL species) increased from 0.41 million fisher days (in 1986/87) to 0.94 million (in 2017/18); an increase of 127%, over the 32 years. Total effort was low and relatively steady, 0.34–0.43 million fisher days per year during 1986/87–1990/91, then increased to 0.59 million days in 1992/93, followed by several years of higher effort occurring in 1998/99 (0.85 million days) and 2002/03 (0.92 million days). Total effort then declined to 0.41 million days in 2011/12 but has since increased to peak at 0.94 million days in 2017/18. Effort by potting was 75–90% of the total effort, compared to 10–25% by diving across all years.

The estimated retained catch increased from 96 tonnes (CI 79–112) in 1986/87 to 480 tonnes (390–570) in 2017/18; an increase of 402% over the 32-years. Retained catch followed a similar trend to effort with significant peaks in 1999/00–2004/05 and in 2014/15–2017/18 but varied more from season to season, depending on factors such as lobster recruitment and management changes. Potting harvested 70–85% of the lobsters, compared to 15–30% by diving across all years.

The trends in participation, fishing effort and retained catch vary over the 32-time period and have been influenced by various societal, biological, and management factors, including changing abundance and recruitment of RL stocks and management regulations (i.e. season length, size and bag limits).

Phone-recall surveys were introduced as an alternative method of estimating recreational catch, due to declining survey responses for the mail-recall surveys. Phone-recall surveys were less biased from survey non-response and produced lower estimates of participation, fishing effort and retained catch than the mail survey. The lower estimates in the phone-recall survey were predominantly from pot fisher responses, whereas estimates for dive fishing were generally similar between survey methods.

1. Introduction

1.1. Background

The Western Rock Lobster (WRL) fishery is one of Australia's largest single species fisheries. In the 2017/18, the commercial catch for WRL was 6,400 tonnes, with a gross domestic product (GDP) value of \$424 million (de Lestang *et al.*, 2019). In comparison, the commercial catch of southern rock lobsters in Western Australia was much smaller (38 tonnes).

A formal resource sharing policy (Integrated Fisheries Management) for the WRL fishery was adopted in 2004 to i) set an allowable (sustainable) harvest level; ii) determine allocations between sectors; iii) manage each sector's catch within their allocation; and iv) develop mechanisms to enable the reallocation of catch share between sectors as required (Department of Fisheries, 2007; Crowe *et al.*, 2013). Consequently, there is a need to provide annual estimates of the recreational catch to inform this policy (Ryan *et al.*, 2016). The majority (95%) of the Total Allowable Catch (TAC) is allocated to the commercial sector with 5% allocated to the recreational sector. While it is mandatory for the commercial sector to record all catch and effort, there is no similar legislative requirement for the recreational sector. Therefore, the mail-recall survey (hereon referred to as mail survey) has been essential to determining the 5% allocation for the recreational sector since 2004 (Ryan *et al.*, 2016).

Recreational fishing for WRL occurs predominantly from Geraldton to Perth and is managed under fisheries regulations with a mixture of input and output controls. These controls have been adapted over time in response to fluctuations in the resource and sustainable management of the fishery (Appendix 1) (Ryan *et al.*, 2016). Input controls include the requirement of a recreational licence (without exemption), a closed season, and gear restrictions that include a maximum number of pots with specific size and escape gap and limiting equipment that can be used for diving (hand, loop, snare or crook). Output controls include a minimum carapace length and exclusion of females that are in breeding condition (tar spot or berried). In addition, there are daily bag and boat limits, as well as possession limits at the fisher's primary place of residence.

The Rock Lobster (RL) recreational fishing licence allows fishing for four species of rock lobsters: WRL (*Panulirus cygnus*), southern rock lobster (*Jasus edwardsii*), painted rock lobster (*Panulirus versicolor*) and ornate rock lobster (*Panulirus ornatus*). While all four rock lobster species are landed recreationally, the majority of licence holders target WRL. There were 55,368 RL recreational licences issued in 2017/18 (Department of Primary Industries and Regional Development, 2018). This is similar to the peak of 55,441 RL licences issued in 2016/17, but substantially higher than the 15,249 RL licences issued in 1986/87 (Melville-Smith and Anderton, 2000).

The licence database has provided a cost-efficient sampling frame for annual mail-recall surveys to determine estimates of fisher participation, fishing effort and retained catch

for this fishery since 1986. This has enabled an assessment of the annual variation and trends in these estimates (Melville-Smith et al. 2001 and 2004). However, to understand the biases within the mail survey, licensed fishers were also sampled periodically using phone-recall (Baharthah, 2007) and phone-diary surveys (Thomson, 2013), which were run concurrently with the mail survey. The resulting comparisons enabled an estimate of a bias correction factor for the catch in the mail survey by a factor of 0.44 (Baharthah, 2007) and 0.39 (Thomson, 2013). While all three survey methods are considered appropriate to estimate recreational catch, each survey method has associated costs and biases that require consideration before implementation. A 32-year time series has been collected using a consistent survey design in a cost-effective manner, which has provided adjusted estimates of recreational catch that can be compared against the TARC. Declining response rates for the mail survey in recent years has increased the potential for non-response bias and alternative data collection methods were considered to provide the robust data required for this fishery with similar cost efficiency. Annual phone-recall surveys, which have higher response rates, were re-introduced in 2015/16 to compare with the mail surveys.

1.1. Objectives

This report provides a synthesis of estimates of participation, fishing effort and retained catch from annual mail surveys and periodic phone-recall surveys of licensed recreational fishers in Western Australia from 1986/87 to 2017/18. The primary objective of the mail surveys was to estimate participation (number of fishers), effort (days fished), retained catch (number of WRL) from the recreational fishery overall and by fishing method (potting and diving), and harvest by converting retained catch to weight using an estimate of average weight. A secondary objective was to compare participation, fishing effort and retained catch from concurrent annual mail and phone-recall surveys in 2001/02, and from 2015/16 to 2017/18.

2. Methods

WRL is endemic to Western Australia, with a distribution extending from Exmouth (latitude 21°47'S) to Augusta (latitude 34°24'S). The majority of recreational fishing occurs in waters less than 20 metres of depth between Geraldton (28°46'S) and the Perth metropolitan area (31°57'S). In contrast, the tropical (painted and ornate RL) and southern rock lobsters are distributed throughout the northern and southern state of Western Australia, respectively. While fishing effort includes effort associated with catches of southern and tropical rock lobsters, catches of these species were excluded from analyses because reporting was infrequent, resulting in low sample sizes and low precision associated with catch estimates. Therefore, only the catch estimates for WRL are presented in this report.

The geographic scope of the mail and phone-recall surveys was fishing activity undertaken in Western Australia. Spatial data based on 23 marine regions was collected in mail surveys from 1999/00 to 2017/18 to assist respondents in recalling the regions where they undertook their rock lobster fishing (Appendix 3). These surveys were not designed to estimate catch on a regional basis, with effort and catch estimated at a statewide level.

All recreational fishing methods permitted by the rock lobster recreational fishing rules (i.e. potting and diving, from the shore and boats) were in scope. Fishers also reported effort and catch from 'other methods' with an explanation that allowed these data to be assigned to potting or diving as appropriate. The only 'other method' that could not be reassigned was 'beach collecting/beach combing', which occurred infrequently. Effort and catch data for this method were incorporated in total effort and catch estimates but have not been presented by method due to low sample size and low precision associated with estimates.

Fishers in the mail survey also reported effort and catch data from charter-boat recreational fishing which was incorporated into the total recreational effort and catch estimates until 2015/16. From 2016/17 onwards management arrangements allowed tour operators to supply charter fishers with lobsters without requiring a RL licence. Catches from charter fishing are reported through mandatory tour operator returns (charter logbooks) from 2016/17 and any catches from charter fishing reported in the mail survey were excluded from analyses. Catches from charter fishing are reported in Smallwood *et al.* (2021).

2.1 Mail survey

2.1.1 Survey Design

A mail survey was developed to collect effort and catch data from the RL recreational fishery and has proven to provide cost-effective data over large spatial scales (Melville-Smith and Anderton, 2000; Thomson, 2013; Ryan *et al.*, 2016). Key features of this methodology include the printed survey questionnaire, a cover letter and a postage-paid

return addressed envelope. A follow-up reminder letter was posted 2 weeks after the initial questionnaire to increase response rates.

The questionnaire was modified over time from 8-questions [Appendix 2 (1986/87–1997/98)], to 48 [Appendix 3 (1998/99)], to then 30 questions [Appendix 4 (1999/00–2017/18)]. However, the fundamental questions required to collect effort and catch data to consistently estimate effort and catch at a statewide level has remained the same.

Who was included in the survey?

Persons in scope included recreational fishers that held a RL licence or an Umbrella (UM) licence. The fishery-specific RL licence was introduced in 1986, the UM licence was in effect from 1992 to 2010, which collectively endorsed fishing for rock lobster, abalone, marron, netting, and freshwater angling (Melville-Smith and Anderton, 2000). Licensed fishers were considered to be valid for the survey if they purchased a licence for the 18-month period ending 30 June. For example, the 2017/18 season included all licensed fishers from 1 January 2017 to 30 June 2018. This accounts for the ability of fishers who purchased a licence in the previous season still being able to fish the current season. Commercial fishers were considered in scope if they held either the RL or UM licence, but any commercial catches by these fishers were not included. Indigenous fishing was not considered to be in the scope of this survey.

A database of licence holders was used as the sampling frame from which a sample was randomly selected without replacement. For the first three fishing seasons (1986/87–1988/89), most licence holders were sent a survey form enclosed with their licence expiry reminder letters: this usually occurred at the start of each new season. From 1989/90–1994/95 only 3–10% of licence holders were sent a survey; however, since the 1995/96 season, a set proportion of licence holders (10–20%) have been selected at the end of each season. For example, the mail survey was sent to a random sample of 8,000 people in July 2018 who represented 13% of licence holders for the preceding 18-month period for 2017/18.

A minimum age criterion of 5 years was applied to participants for all surveys. No substitution of respondents occurred if fishers did not choose to participate.

Survey Duration

Annual mail surveys were conducted each year in July to collect recreational fishing information for the previous fishing season. Although licences can be purchased at any time during the year, RL fishing is only permitted during the open season, which was from 15 November to 30 June (i.e. closed season from July to mid-November) from 1986/87 to 2013/14; and from 15 October to 30 June (i.e. closed season from July to mid-October) from 2014/15 to 2017/18. The follow-up reminder letter was posted in late July-early August and the majority of surveys were returned by the end of September; however, some surveys were received as late as December.

Survey Data Elements

The survey responses from returned mail surveys collected during 1986/87–2004/05 were entered manually into a survey database, and from 2005/06 onwards surveys were scanned electronically, and the survey responses imported into this survey database. The data was edited and validated before extracting the effort and catch data required for analysis. Ambiguous responses necessitated the use of decision rules during the analysis process i.e. if ticked 'did not fish' but proceeded to fill in the 'did fish' questions then response was changed to 'did fish'. Monthly effort recorded as greater than the true number of days possible i.e. 31 days in April was changed to 30 days. Respondent commented that catch was for more than one licence holder, i.e. 'catch is for 2 people' then respondents catch was halved. Respondents were excluded from the analysis entirely only if the survey was deliberately incomplete i.e. entering large number of days or catch but other information in survey form was missing, incomprehensive, or clearly inaccurate survey forms i.e. fished every day of the year. The effort (fisher days) by method was deemed to be more accurate than the total effort. The total is used as a memory jogger question whereas the question at the method level allows more emphasis to be placed on the recall.

2.1.2 Analysis

Response profiles

The mail survey design incorporated simple random sampling with samples randomly chosen from the licence frame during the 18-month period so effort and catch can be expanded to the population of RL licence holders. Exclusions from the sampling frame occurred before sample selection. For example, where currency of address information was invalid, fisher's full name was not provided, or fisher's birthdate was missing. All sampling was done without replacement.

Names, addresses, and telephone numbers were screened for inaccuracies, and excluded from sample selection. Despite this level of validation, mail surveys were still subject to incorrect addresses or participants moving address and phone-recall surveys to incorrect phone-numbers or changed numbers. The nature of the licence database also allowed for a fisher with a licence ID to obtain a new licence with a new licence ID if their licence has lapsed for a period or if an additional licence type had been purchased. Potential duplicate licence holders were checked (i.e. identical names, addresses, phone numbers, email, and date of birth) and any duplicates removed to determine the population of RL licence holders. Overseas licence holders were removed from all surveys due to the low number and difficulty to contact. Licence holders under the age of 5 were excluded for ethical reasons.

The number of surveys sent in 1986/87–1994/95 were not recorded and have been estimated from regression analysis based on known numbers from 1995/96–2010/11 (Thomson, 2013). For most years (1986/87–2011/12), non-valid returns (including sample loss for death, illness, away etc., incomplete surveys, and full refusals) were not systematically recorded and an accurate description cannot be provided. Accordingly, it

has not been possible to establish the survey return rate during these years. In the years that non-valid returns were recorded (2012/13–2017/18) the sample loss ranged from (8–12%) of surveys returned, with an average of 8.8%. The response rate from the mail survey is the effective response rate, or those that returned and fully completed the survey, and the effective response rate was used to calculate the sample weight (expansion factor to the population of RL licence holders).

The effective response rate (ERR) is determined by the equation, where SC is the completed sample (i.e. number of surveys fully completed) and SS is the gross sample.

$$ERR = \frac{SC}{SS} \times 100$$

Population estimates and uncertainty

Estimates for participation (number of fishers), fishing effort (number of days), and retained catch (number of WRL) over the mail survey was calculated by multiplying the number of fishers that did fish, the effort or catch for all respondents by the weighting factor. In the 1998/99 mail survey, the collection of effort and catch by method by month was introduced. From 1998/99 onwards, the effort and catch of all months by method was summed before applying the weighing factor to each respondent.

The sample weighting was determined by the inverse of the fraction it represented in the population, according to the following equation, where α_{hi} is the weighting factor for RL licence holder i in stratum h , N_h = total number of RL licence holders in stratum h , and n_h is the number of surveys completed correctly in stratum h .

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

Mail surveys are typically affected by recall and non-response bias (i.e. unequal representation of different 'groups' in returned surveys) (Pollock *et al.*, 1994; Fisher, 1996). In contrast, phone-diary surveys are considered to be less biased but are typically more expensive (Pollock *et al.*, 1994). Comparisons of retained catch estimates from seasons where both mail and phone-diary surveys have indicated that estimates of retained catch (overall from potting and diving combined) from the mail surveys need a correction factor to account for these biases (Thomson, 2013). Based on research carried out by Thomson (2013), a correction factor of 0.39 (\pm 0.032 SE) was applied to estimates of retained catch of RL each year. This constant correction factor has been developed and was applied to estimates of retained catch from the mail surveys for the entire time series since 1986/87.

Because these surveys only collect catch by numbers, estimates for catch by weight prior to 2015/16 were calculated using a constant average weight of 0.5 kg (Melville-Smith and Anderton, 2000). Since 2015/16, where there have been significant changes to management arrangements and corresponding changes in the stock structure, the average weight for WRL has been estimated from targeted boat ramp surveys (Smallwood *et al.*, 2021). This was calculated as the (arithmetic) average weight

combined across potting and diving (herein referred to as overall) for WRL in each survey year.

Bootstrapping was used to account for the error distributions for each season's retained catch (by numbers), correction factor, and average weight to determine the adjusted retained catch with confidence intervals. For each factor (retained catch, correction factor, average weight) 'Rnorm' in the stats package R was used to generate 100,000 independent bootstrap samples of size n, each drawn randomly with replacement from the n values of the original data set. Each of the bootstrap samples were then multiplied together. The mean and standard error of the bootstrap estimates were calculated and used to calculate the adjusted total catch (by weight) of lobsters per year.

The mail survey provides estimates in a cost-effective manner; however, they represent a sample from the population of RL licence holders. As such, the level of uncertainty in estimates is indicated using either the standard error (SE) or the 95% confidence interval (95% CI).

The upper and lower limits for the 95% confidence intervals were calculated as:

$$\text{Lower 95\% CI} = \theta - 1.96\sqrt{SE}$$

$$\text{Upper 95\% CI} = \theta + 1.96\sqrt{SE}$$

Where θ is the estimate catch, SE is the standard error. Any level of significance differences between estimates are based on overlapping 95% confidence intervals.

Expansion of survey data to population estimates was undertaken using the survey package (Lumley, 2017) version 3.33-2 in the statistical package R (R Core Team, 2020). Detailed descriptions of the survey package are given in (Lumley, 2004, 2010).

2.1.3 Response rates

Although strategies were employed to increase survey return rates and full response, such as modifying gross sample (surveys sent), questionnaire and design, and providing incentives, the effective return rates (ERR) declined over the 32-year period (Table 1). In the first three mail surveys (1986/87–1988/89), a large proportion (56%–100%) of the licence population were sampled, and the ERR was relatively high (44–51%). From 1989/90–1994/95, when the sample design changed to sample a smaller proportion (approx. 3–10%) of the licence population, the ERR remained relatively high and similar to earlier years (41–44%). However, the total number of returned forms (fully responding) was considerably lower and as such, concerns were raised over their representativeness to the licence population. From 1995/96–2002/03, the gross sample was increased to sample a higher average proportion of the licence population (8–13%) and incentives to return survey forms were also offered in an attempt to improve return rates and fully responding, and by 1998/99, the ERR increased to a high of 63% and the numbers fully responding had more than doubled from previous years. Effective return rates remained high (around 50%) for several years but then declined as the incentives were reduced then removed.

Table 1. Licence population, gross sample, effective return rate, and fisher participation from annual mail surveys of the rock lobster licensed recreational fishery from 1986/87–2017/18.

Season	Licence Population	Gross Sample	Full Response	ERR	Weighting Factor	Fishers n (%)	Potting n (%)	Diving n (%)
86/87	16,484	9,269	4,049	44%	4.07	3,524 (87)	2,512 (62)	1,232 (30)
87/88	15,249	15,249	7,808	51%	1.95	5,921 (76)	4,617 (59)	1,679 (22)
88/89	22,529	14,944	6,507	44%	3.46	4,605 (71)	3,614 (56)	1,295 (20)
89/90	23,374	1,623	658	41%	35.52	467 (71)	368 (56)	130 (20)
90/91	22,777	894	381	43%	59.78	267 (70)	169 (44)	111 (29)
91/92	25,907	793	325	41%	79.71	248 (76)	178 (55)	92 (28)
92/93	26,580	1,504	662	44%	40.15	490 (74)	370 (56)	165 (25)
93/94	25,079	2,474	1,109	45%	22.61	771 (70)	577 (52)	251 (23)
94/95	25,258	1,156	527	46%	47.93	369 (70)	277 (53)	118 (22)
95/96	22,592	2,929	929	32%	24.32	698 (75)	502 (54)	262 (28)
96/97	24,047	2,929	1,132	39%	21.24	857 (76)	577 (51)	354 (31)
97/98	28,776	2,929	1,505	51%	19.12	1,255 (83)	850 (56)	525 (35)
98/99	32,768	3,888	2,444	63%	13.41	1,951 (80)	1,279 (52)	878 (36)
99/00	36,906	2,920	1,478	51%	24.97	1,178 (80)	803 (54)	511 (35)
00/01	40,807	3,943	1,985	50%	20.56	1,516 (76)	1,072 (54)	619 (31)
01/02	40,714	3,941	1,789	45%	22.76	1,224 (68)	826 (46)	522 (29)
02/03	43,992	5,900	1,783	30%	24.67	1,350 (76)	922 (52)	597 (33)

Season	Licence Population	Gross Sample	Full Response	ERR	Weighting Factor	Fishers n (%)	Potting n (%)	Diving n (%)
03/04	46,805	3,896	1,669	43%	28.04	1,186 (71)	809 (48)	547 (33)
04/05	44,643	3,909	1,568	40%	28.47	1,063 (68)	774 (49)	400 (26)
05/06	41,563	5,793	2,431	42%	17.10	1,493 (61)	1,041 (43)	630 (26)
06/07	41,178	3,963	1,902	48%	21.65	1,113 (59)	727 (38)	496 (26)
07/08	40,452	3,936	1,651	42%	24.50	974 (59)	634 (38)	462 (28)
08/09	41,917	2,993	1,218	41%	34.41	678 (56)	427 (35)	340 (28)
09/10	44,250	3,990	1,408	35%	31.43	835 (59)	529 (38)	397 (28)
10/11	37,882	3,970	1,439	36%	26.33	817 (57)	509 (35)	393 (27)
11/12	37,335	8,000	2,597	32%	14.38	1,397 (54)	899 (35)	636 (24)
12/13	39,702	8,000	2,852	36%	13.92	1,472 (52)	1,019 (36)	593 (21)
13/14	45,146	8,000	2,523	32%	17.89	1,408 (56)	942 (37)	581 (23)
14/15	50,734	8,000	2,315	29%	21.92	1,493 (64)	1,111 (48)	517 (22)
15/16	56,449	8,000	2,355	29%	23.97	1,542 (65)	1,172 (50)	533 (23)
16/17	62,138	8,000	2,315	29%	26.84	1,461 (63)	1,135 (49)	485 (21)
17/18	61,245	8,000	2,063	26%	29.69	1,326 (64)	1,075 (52)	392 (19)

During 2003/04–2010/11, a similar proportion of the licence population were sampled (8–14%) and the ERR had initially been relatively high (>40%), but then started to decline as the numbers fully responding declined. In 2011/12, the gross sample was doubled to 8,000 to counteract a declining return rate, sampling approx. 20% of the licence population, while this did improve the number of fully responding surveys received, near doubling, the return rates remained below 40% and continued to decline. As the licence population increased during 2013/14–2017/18, the gross sample remained constant which resulted in the numbers sampled declining to 12–13% of licence holders. In addition, the ERR continued to decline, and in 2017/18 was 29%.

The weighting factor varied over time according to changes in the number of surveys sent, completed returned surveys, and total licences. From 1986/87 to 1988/89, the weighting factor was low, with each respondent representing approximately 2–4 people. When sample numbers were relatively low during 1989/90–1994/95, the weighting factor ranged from 23–80. From 1995/96, the weighting factor ranged from 13–34 (Table 1).

2.2 Phone-recall survey

2.2.1 Survey Design

A phone-recall survey was developed to collect effort and catch information from the RL recreational fishery in 2001/02 and from 2015/16–2017/18. The phone-recall survey was designed to replicate questions found on the mail survey questionnaire. Auxiliary questions were introduced in the phone-recall survey, while a number of auxiliary questions were excluded from the mail survey; however, the fundamental questions required to estimate the total effort and catch at a statewide level are identical.

Who was included in the survey?

Persons in scope included recreational fishers that held a RL licence. Licensed fishers were considered to be valid for the survey if they purchased a licence for the 12-month period ending 30 June. For example, the 2017/18 season included all licensed fishers from 1 July 2017 to 30 June 2018. Commercial fishers were considered in scope if they held a RL licence, but any commercial catches by these fishers were not included. Indigenous fishing was not considered to be in the scope of this survey. A database of RL licence holders was used as the sampling frame. A probability-based design was implemented where the sample was randomly selected without replacement from the database. A minimum age criterion of 5 years was applied to all surveys. International Licence holders were removed from the sample. No substitution of respondents occurred during the mail surveys.

Survey Duration

Annual phone-recall surveys were conducted each year in July to collect recreational fishing information for the previous fishing season. Although licences can be purchased at any time during the year, RL fishing is only permitted during the open season, from

15 October to 30 June (i.e. closed season from July to mid-October) from 2015/16 to 2017/18.

Survey Data Elements

A key feature of this methodology includes a Computer Assisted Telephone Interview (CATI). Interviews were conducted by CATI which provides a cost-effective and flexible means of recording questionnaire data that is entered directly into survey databases during interviews. It also provides an effective system for ensuring data quality as workstations are networked with a supervisor. Electronic survey data is contained within secure computer networks with appropriate management systems. Interviewers were allocated fishers from each stratum (metropolitan or regional) to reduce the potential for interviewer bias between stratum. Where possible and practical, the same interviewer maintained repeat contacts with the same respondent. When required, interviewer notes were made available for alternative interviewers on subsequent follow-up calls. Each respondent was attempted to be contacted at least 12 times.

2.2.2 Analysis

The phone-recall survey incorporated stratified random sampling by residence of licence holders, i.e. or 'metropolitan' for all residences within the Perth metropolitan area, or 'regional' for all residences within nine Regional Development Commissions. Exclusions from the sampling frame occurred before sample selection where currency of telephone (mobile, home or business) was invalid, fisher's full name or fisher's birthdate was missing. The sample consisted of a quota of 200 licence holders from metropolitan and regional stratum that had fished for RL in the previous 12-months with all sampling done without replacement.

Methods used to determine response profiles and expansion of survey data to population estimates were similar to those for the mail survey. Estimates for participation (number of fishers), fishing effort (number of days), and retained catch (number of WRL) over the phone-recall survey was calculated by multiplying the number of fishers that did fish, the effort or catch for all respondents by the weighting factor within each residential stratum.

The relationship between the mail survey estimated adjusted catch (by numbers) and the phone-recall survey estimated catch (by numbers) was determined by the linear regression without an intercept. Phone-recall survey statistics (participation, effort and catch) from 2001/02 (Baharthah, 2007) were included in all comparisons between the mail survey and phone-recall surveys but the time difference between the years of surveys, and different survey methods requires further considerations, therefore the linear regression has been provided with (all data) and without (subset) 2001/02.

2.2.3 Response rates

The licence population was 51,654 when the phone-recall survey commenced in 2015/16. This remained relatively steady during the phone-recall survey 3-year period, with 54,806 fishers in 2016/17 and 54,979 fishers in 2017/18 licensed to fish

recreationally for lobsters (Table 2). To achieve the quota sample of 200 fishers in each stratum, a net sample of 614 fishers was required in 2015/16, 668 fishers in 2016/17 and 710 fishing in 2017/18. This represented 1.19%, 1.22%, and 1.3% of licence holders in each of the 12-month periods respectively. The phone-recall surveys produced high effective response rates (99%). Over the 3 years, the weighting factor ranged from 99–107 for the metropolitan and 60–70 for the regional stratum.

Table 2. Licence population, gross sample, effective return rates and fisher participation from phone-recall surveys in 2001/02, 2015/16, 2016/17 and 2017/18.

Season	Stratum	Licence population	Gross Sample	Sample Loss	Eligible Sample	Refusals	Full Response	ERR (%)	Weighting Factor	Fisher n (%)	Potting n (%)	Diving n (%)
2001/02*	Total	36,500	499	97	402	1	401	99	91.02	245 (62)	156 (39)	108 (27)
2015/16	Regional	22,364	420	97	323	3	320	99	69.89	201 (64)	140 (44)	70 (22)
	Metropolitan	29,290	348	51	297	0	297	100	98.62	206 (69)	159 (54)	58 (20)
	Total	51,654	768	148	620	3	617	100	n.a.	407 (67)	299 (48)	128 (21)
2016/17	Regional	23,246	428	59	369	7	362	99	64.22	200 (55)	139 (38)	73 (20)
	Metropolitan	31,560	344	45	299	4	295	100	106.98	199 (68)	154 (52)	63 (21)
	Total	54,806	774	106	668	11	657	99	n.a.	399 (61)	293 (45)	136 (21)
2017/18	Regional	23,089	450	61	389	3	386	99	59.82	211 (55)	144 (37)	73 (19)
	Metropolitan	31,890	364	43	321	3	318	99	100.28	205 (64)	153 (48)	66 (21)
	Total	54,979	814	104	710	6	704	99	n.a.	416 (59)	297 (42)	139 (20)

*2001/02 are results summarised from (Baharthah, 2007) which were not stratified into Regional and Metropolitan

3 Results

3.1 Mail survey

3.1.1 Participation

In the 32-year period of the mail survey, there was an increase in licensed fisher participation in the RL recreational fishery by 175% (Table 3). The number of fishers was 14,347 at the start of the mail survey and remained relatively stable until 1996/97, ranging 11,564–19,769. The number of fishers then increased over several years to peak in 2002/03–2003/04, then slowly declined until 2011/12. From the beginning of the mail survey in 1986/87 to 2002/03, an average of 75% of licence holders had participated in RL fishing in the past 12 months. Licensed fisher participation then declined to 52% by 2012/13. This resulted in a decline in the number of fishers from the peak in 2003/04. From 2012/13 to 2017/18 the number of fishers also increased to a record high number, almost double the number of fishers (up 92%). This increase in number of fishers was driven by an increase in licensed fisher participation and by 2017/18, 39,418 fishers (64% of licence holders) fished in the RL recreational fishery.

There was a slight shift in licensed fisher participation by method over time with fishers tending to go fishing more with pots (13% increase) than diving (14% decrease).

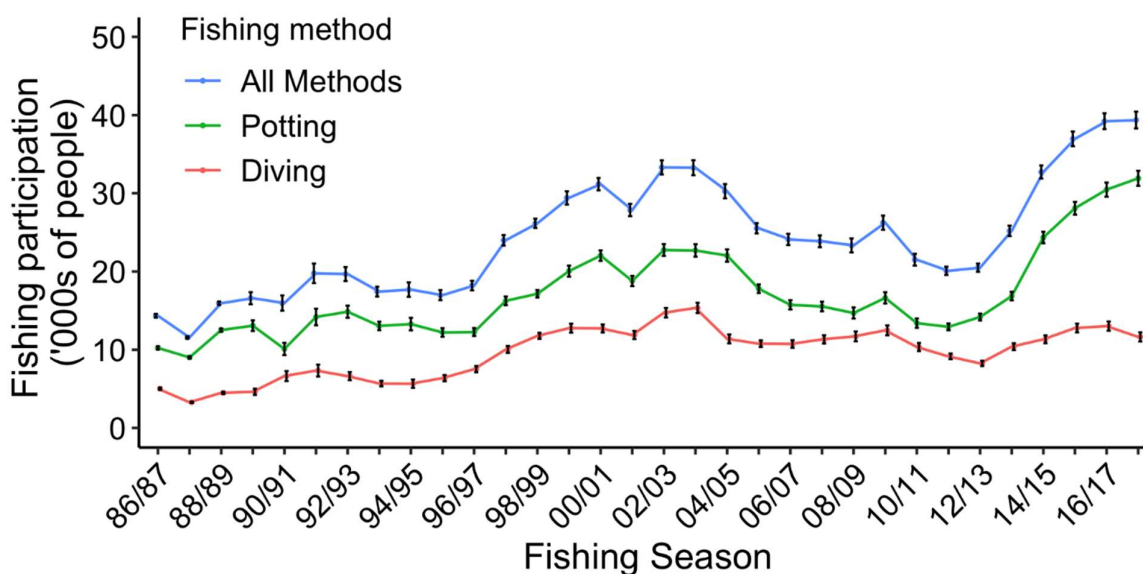


Figure 1. Estimated participation (number of fishers, with SE) from annual mail surveys of the rock lobster licensed recreational fishery from 1986/87–2017/18.

Table 3. Estimated participation (fishers) and recreational effort (days) from annual mail surveys of the rock lobster licensed recreational fishery from 1986/87–2017/18.

Season	Participation (fishers)			Effort (days)		
	Total (SE)	Potting (SE)	Diving (SE)	Total (SE)	Potting (SE)	Diving (SE)
86/87	14,347 (235)	10,227 (202)	5,016 (142)	413,114 (10,810)	349,954 (10,492)	62,687 (2,464)
87/88	11,564 (143)	9,017 (130)	3,279 (80)	340,823 (6,606)	300,879 (6,458)	38,660 (1,258)
88/89	15,944 (227)	12,513 (205)	4,484 (124)	427,805 (9,516)	377,980 (9,276)	48,686 (1,898)
89/90	16,589 (765)	13,072 (681)	4,618 (405)	383,717 (26,147)	325,424 (24,980)	56,943 (6,965)
90/91	15,962 (975)	10,103 (777)	6,636 (630)	390,915 (37,343)	315,949 (35,923)	74,967 (9,623)
91/92	19,769 (1,253)	14,189 (1,063)	7,334 (764)	519,973 (51,295)	413,316 (47,523)	106,657 (15,337)
92/93	19,674 (885)	14,856 (771)	6,625 (515)	592,670 (39,645)	506,867 (37,727)	85,000 (9,990)
93/94	17,435 (624)	13,048 (542)	5,676 (358)	525,845 (28,609)	451,874 (27,686)	73,925 (6,408)
94/95	17,685 (918)	13,276 (797)	5,655 (520)	488,769 (40,585)	425,743 (39,396)	62,881 (8,503)
95/96	16,974 (639)	12,208 (544)	6,371 (393)	522,899 (29,927)	449,311 (28,955)	73,345 (6,209)
96/97	18,205 (618)	12,257 (509)	7,520 (399)	485,805 (25,625)	400,047 (24,440)	84,271 (6,560)
97/98	23,996 (671)	16,252 (556)	10,038 (437)	695,710 (30,166)	562,117 (28,227)	132,370 (8,372)
98/99	26,158 (583)	17,148 (477)	11,772 (396)	851,968 (28,991)	665,845 (27,034)	184,648 (8,836)
99/00	29,415 (849)	20,051 (705)	12,760 (563)	824,117 (36,615)	677,268 (34,386)	146,750 (10,467)
00/01	31,165 (791)	22,038 (670)	12,725 (510)	842,680 (33,966)	712,200 (32,684)	130,295 (7,617)
01/02	27,856 (789)	18,798 (652)	11,880 (519)	751,969 (33,506)	624,752 (32,143)	126,898 (7,932)

Season	Participation (fishers)			Effort (days)		
	Total (SE)	Potting (SE)	Diving (SE)	Total (SE)	Potting (SE)	Diving (SE)
02/03	33,309 (897)	22,749 (747)	14,730 (602)	920,427 (36,823)	737,156 (34,534)	182,728 (10,525)
03/04	33,260 (957)	22,687 (795)	15,340 (655)	913,861 (39,392)	745,403 (37,215)	168,234 (10,177)
04/05	30,265 (921)	22,037 (790)	11,389 (569)	865,385 (38,532)	728,609 (36,709)	135,780 (9,527)
05/06	25,526 (653)	17,798 (549)	10,771 (428)	637,636 (25,108)	524,265 (23,397)	112,465 (7,475)
06/07	24,096 (716)	15,739 (582)	10,738 (481)	553,024 (25,241)	442,025 (23,708)	110,263 (7,170)
07/08	23,864 (759)	15,534 (615)	11,320 (526)	569,636 (33,436)	424,685 (24,901)	136,473 (20,736)
08/09	23,333 (891)	14,695 (710)	11,701 (634)	507,065 (27,985)	375,498 (25,250)	128,160 (10,146)
09/10	26,242 (902)	16,625 (721)	12,477 (625)	587,035 (31,492)	454,945 (28,912)	131,556 (10,029)
10/11	21,508 (748)	13,400 (593)	10,346 (521)	457,164 (24,033)	351,916 (22,428)	105,196 (7,584)
11/12	20,084 (532)	12,924 (430)	9,143 (362)	413,359 (16,807)	327,849 (15,619)	84,820 (4,904)
12/13	20,491 (528)	14,185 (443)	8,255 (338)	460,958 (18,481)	381,721 (17,511)	78,931 (4,708)
13/14	25,194 (664)	16,856 (547)	10,396 (430)	546,691 (22,565)	442,442 (21,447)	101,672 (5,771)
14/15	32,720 (837)	24,348 (727)	11,330 (497)	763,859 (30,369)	648,190 (29,141)	114,902 (7,462)
15/16	36,962 (930)	28,093 (817)	12,776 (552)	842,492 (33,247)	708,045 (31,391)	134,303 (8,798)
16/17	39,215 (1,014)	30,465 (900)	13,018 (590)	916,207 (35,025)	791,528 (33,378)	124,625 (8,606)
17/18	39,365 (1,070)	31,914 (969)	11,637 (587)	938,536 (38,594)	818,599 (37,119)	119,670 (8,421)

The highest proportion of fishing activity was from potting, with the trend in participation overall influenced by potting. The number of potting fishers was 10,227 (71% of total fishers) in 1986/87, peaked in 1992/93 and 2002/03, before declining until 2011/12. This was followed by an increase in potting fishers to record high numbers. In 2017/18, 31,837 fishers (80% of licensed fishers) went potting. The number of diving fishers was 5,016 (35% of licensed fishers) in 1986/87 and shows a similar trend to the potting fishers with a peak in 2003/04, followed by a decline until 2012/13. The number of diving fishers then showed an increase in the subsequent years; however, unlike the potting fishers, this increase did not exceed the 2003/04 peak. In 2017/18, the number of diving fishers was 11,787 (30% of total fishers) (Figure 1, Table 3).

3.1.2 Fishing effort

The total number of days showed a 127% increase in effort with three periods where higher fishing effort occurred (Figure 2). The number of days fished at the start of the mail survey was at 0.41 million days in 1986/87 and remained relatively stable until 1990/91 (ranging from 0.34–0.43 million days). The number of days then increased in 1991/92 and remained within the range of 0.49–0.59 million days until 1996/97. The number of days then increased substantially over two years, then stabilised within the range of 0.85–0.92 million days between 1998/99 and 2004/05. The number of days fished then declined for several years until 2011/12 (0.38 million days), a decline of 64% from the peak of 0.92 million days. This was followed by a substantial increase in effort to the highest number of total days fished recorded in 2017/18. Approximately 0.94 million days were fished by rock lobster recreational fishers, an increase of 147% since 2011/12 and 2% higher than the 2002/03 peak.

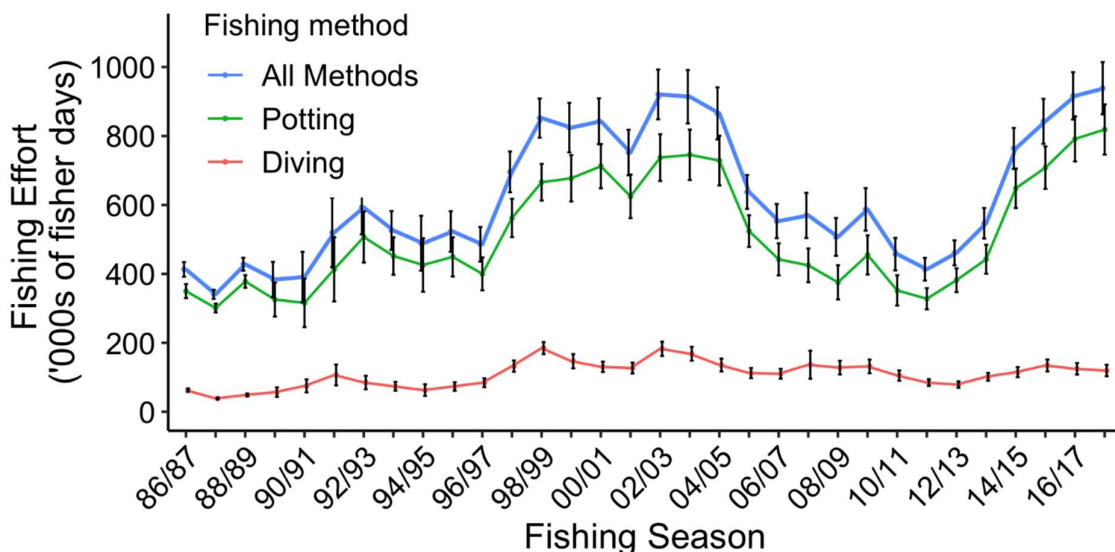


Figure 2. Estimated fishing effort (days, with SE) from annual mail surveys of the rock lobster licensed recreational fishery from 1986/87–2017/18.

3.1.3 Retained catch

The adjusted recreational retained harvest of WRL for 2017/18 was 480 t (95% CI 390–570): of which 83% or 399 t (321–476) was retained by potting and 17% or 81 t (63–100) was retained by diving (Figure 3; Table 4). The adjusted total recreational retained catch (tonnes) increased by 402% over the 32-year period.

From 1986/87–2014/15, the trend in WRL catch by weight is highly consistent with the trend in catch by numbers as the conversion is based on the multiplication of constant values (Appendix 6, Figure 3). However, from 2015/16 onwards the average weight was calculated using designated boat-ramp surveys, which has amplified the increase in catch by weight. The estimated average weight, based on boat ramp surveys carried out in each year was 583.8 g (± 8.54 SE) in 2015/16, 578.8 g (± 5.68 SE) in 2016/17, and 573.8 g (± 4.81 SE) in 2017/18 (Table 4). These values are all greater than the constant 500 g used prior to 2015/16.

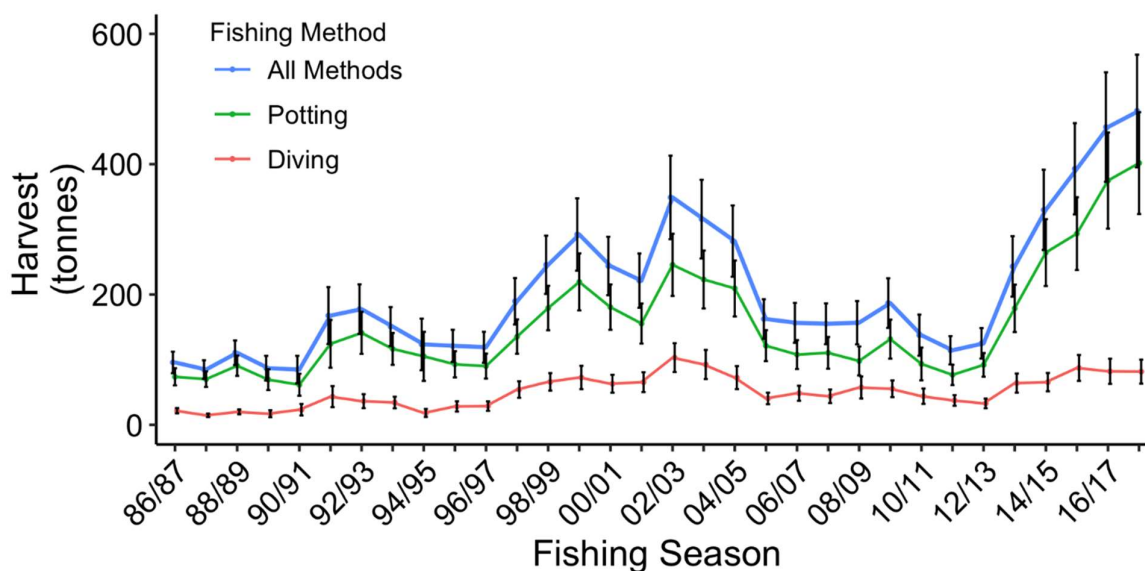


Figure 3. Estimated retained catch by weight (tonnes, with 95% CI) from annual mail surveys of the rock lobster licensed recreational fishery from 1986/87–2017/18.

Table 4. Estimated retained catch (in tonnes) of WRL from licensed fishers by potting, diving and total from 1986/87–2017/18, with harvest ranges (CI).

Season	Average weight (g)	Harvest (tonnes)		
		Total (CI)	Potting (CI)	Diving (CI)
86/87	500	96 (79-112)	74 (61-87)	22 (18-26)
87/88	500	85 (71-99)	70 (58-82)	15 (12-17)
88/89	500	111 (92-129)	91 (75-106)	20 (16-24)
89/90	500	87 (68-106)	69 (53-85)	17 (12-23)
90/91	500	85 (64-106)	62 (45-78)	23 (15-32)
91/92	500	168 (124-211)	124 (88-161)	43 (27-60)
92/93	500	178 (140-216)	141 (109-173)	36 (26-47)
93/94	500	151 (121-181)	117 (92-141)	34 (26-43)
94/95	500	124 (84-163)	105 (67-143)	18 (12-24)
95/96	500	121 (97-146)	93 (73-113)	28 (20-36)
96/97	500	119 (95-143)	90 (71-109)	29 (22-36)
97/98	500	190 (154-225)	135 (109-162)	54 (42-67)
98/99	500	246 (201-290)	179 (145-214)	66 (53-79)
99/00	500	292 (237-348)	219 (176-263)	73 (55-91)
00/01	500	244 (199-289)	181 (146-215)	63 (49-77)
01/02	500	221 (180-263)	156 (125-186)	66 (50-81)
02/03	500	349 (285-413)	246 (198-293)	103 (81-125)
03/04	500	316 (255-376)	223 (179-268)	93 (70-115)
04/05	500	282 (227-337)	209 (166-252)	72 (55-90)
05/06	500	162 (132-193)	122 (98-145)	41 (32-50)
06/07	500	157 (126-187)	108 (86-130)	49 (37-60)
07/08	500	155 (124-187)	111 (86-135)	44 (34-54)
08/09	500	157 (124-190)	98 (76-120)	57 (41-74)
09/10	500	187 (149-225)	132 (102-161)	55 (43-68)
10/11	500	138 (106-169)	94 (68-119)	44 (32-56)

Season	Average weight (g)	Harvest (tonnes)		
		Total (CI)	Potting (CI)	Diving (CI)
11/12	500	115 (93-136)	77 (61-92)	38 (29-46)
12/13	500	125 (102-148)	92 (74-110)	33 (26-40)
13/14	500	243 (197-289)	179 (143-215)	64 (50-79)
14/15	500	330 (269-391)	264 (213-316)	66 (51-80)
15/16	583.8	393 (320-465)	302 (245-360)	90 (70-111)
16/17	578.8	458 (371-545)	376 (301-450)	82 (63-102)
17/18	573.8	480 (390-570)	399 (321-476)	81 (63-100)

Note: due to the number of decimal places in the input values and rounding, the values by method within a year may not sum to the total.

Potting generally accounted for the vast majority of WRL retained catch, however the proportion varied from 63–85% across the survey years. The retained catch by each method shows similar trends to the total catch, with peaks in 1992/93, 1999/00, and in 2002/03, followed by a general decline until the 2011/12 season. However, while catches from potting increase markedly to record levels in 2017/18, the catches from diving increase only slightly before stabilising at levels lower than the 2002/03 peak. In 2017/18, 83% of total catch was caught by potting, 42% higher than the previous peak in 2002/03 and a 370% increase from the catch in 1986/87. In contrast, the catch for diving in 2017/18, was a 31% decrease from the 2002/03 peak and a 224% increase from the catch in 1986/87.

3.2 Phone-recall survey

3.2.1 Participation

The number of fishers at the start of the phone-recall survey was 34,363 (SE \pm 1,476) in 2015/16. The number of fishers was not significantly different over the 3-years with 34,133 (SE \pm 1,517) in 2016/17 and 33,179 (SE \pm 1,438) in 2017/18 (Table 2). In all surveys, a higher proportion of licensed fisher participation occurred in the metropolitan area (64–69%) compared with the regional area (55–64%). The proportion of licensed fisher participation declined over the 3-years from 67% in 2015/16, to 59% in 2017/18.

Throughout the phone-recall survey, the highest proportion of licensed fisher participation was from potting, and the number of fishers was largely influenced this method. The number by potting fishers was 25,465 (SE \pm 1,280) in 2015/16. Participation was not significantly different over the three years with 25,401 (SE \pm 1,310) in 2016/17 and 23,956 (SE \pm 1,234) in 2017/18. The proportion by potting fishers ranged from 72–74% of licensed fishers in any year. The number by diving fishers was also not

significantly different over the three years with 10,612 (SE ± 892) in 2015/16, 11,428 (SE ± 944) in 2016/17, and 10,985 (SE ± 898) in 2017/18. The proportion of licensed fisher participation from diving ranged from 31–33% of licensed fishers in any year (Figure 4, Table 5).

3.2.2 Fishing effort

The number of days fished at the start of the phone-recall survey was 482,794 (SE $\pm 32,769$) in 2015/16 and was not significant different over the 3-years with 517,563 (SE $\pm 38,609$) in 2016/17 and 531,268 (SE $\pm 37,934$) in 2017/18. Potting was more popular than diving in this fishery and the number of days was largely driven by potting activity. The total effort by potting was not significant over the three years with 374,395 (SE $\pm 29,737$) in 2015/16, 407,136 (SE $\pm 33,879$) in 2016/17, and 422,375 (SE $\pm 36,453$) in 2017/18. The proportion of effort by potting ranged from 78–80% of the total effort in any one year. The total effort by diving was not significant over the three years with 104,341 (SE $\pm 13,615$) in 2015/16, 110,362 (SE $\pm 17,249$) in 2016/17, and 108,151 (SE $\pm 12,349$) in 2017/18. The proportion by diving ranged from 20–22% of the total effort in any one year (Figure 4, Table 5).

3.2.3 Retained catch

The total number of lobsters caught at the start of the phone-recall survey was 1,166,701 (SE $\pm 88,673$) in 2015/16 and was not significant different over the 3-years with 1,121,094 (SE $\pm 87,054$) in 2016/17 and 1,398,400 (SE $\pm 103,642$) in 2017/18. Potting accounted for the vast majority of WRL retained catch. Retained catch by potting was not significant over the three years with 840,538 (SE $\pm 78,054$) in 2015/16, 867,943 (SE $\pm 79,015$) in 2016/17, and 1,064,344 (SE $\pm 97,513$) in 2017/18. The proportion of catch by potting ranged from 72–76% of the retained catch in any one year. The retained catch by diving was not significant over the three years with 325,324 (SE $\pm 50,581$) in 2015/16, 253,150 (SE $\pm 36,587$) in 2016/17, and 334,057 (SE $\pm 55,302$) in 2017/18. The proportion by diving ranged from 23–28% of the total catch in any one year (Figure 4, Table 5).

3.2.4 Comparison of mail and phone-recall surveys

The phone-recall survey was designed to estimate participation, fishing effort and retained catch for direct comparison to the mail survey. Phone-recall surveys were undertaken in 2001/02 (Baharthah, 2007) as well as in 2015/16, 2016/17 and 2017/18. The results of the 2001/02 survey have been included (all data) and excluded (subset) in the comparison with the mail survey.

In all 4 survey year comparisons, the number of fishers was lower in the phone-recall than the mail survey (Figure 4). The number of fishers was not significantly different between the two survey methods in 2015/16 but was significantly different, albeit marginally, in 2001/02, 2016/17 and 2017/18. Participation by potting fishers was lower in the phone-recall survey than the mail survey, but was not significantly different.

Table 5. Estimated participation (number of fishers), fishing effort (days) and retained catch (number of WRL) for all methods combined, potting and diving from phone-recall surveys of the rock lobster licensed recreational fishery in 2001/02, 2015/16, 2016/17 and 2017/18.

Season	Participation (fishers)		
	Total (SE)	Potting (SE)	Diving (SE)
2001/02*	22,734 (901)	14,129 (933)	9,871 (849)
2015/16	34,363 (1,476)	25,465 (1,280)	10,612 (892)
2016/17	34,133 (1,517)	25,401 (1,310)	11,428 (944)
2017/18	33,179 (1,438)	23,957 (1,234)	10,985 (898)

Season	Effort (days)		
	Total (SE)	Potting (SE)	Diving (SE)
2001/02*	473,980 (47,034)	383,088 (47,535)	94,748 (11,933)
2015/16	482,794 (32,769)	374,395 (29,737)	104,341 (13,615)
2016/17	517,563 (38,609)	407,136 (33,879)	110,362 (17,249)
2017/18	531,268 (37,934)	422,375 (36,453)	108,151 (12,349)

Season	Catch (numbers)		
	Total (SE)	Potting (SE)	Diving (SE)
2001/02*	854,882 (107,494)	623,938 (90,124)	215,570 (31,735)
2015/16	1,166,701 (88,673)	840,538 (78,054)	325,324 (50,581)
2016/17	1,121,094 (87,054)	867,943 (79,015)	253,150 (36,587)
2017/18	1,398,400 (103,642)	1,064,344 (97,513)	334,057 (55,302)

*2001/02 are results summarised from (Baharthah, 2007)

In all 4 survey year comparisons, the total effort was lower in the phone-recall than the mail survey. Total effort was significantly different between the two survey methods for all 4 years. Effort from potting showed a similar trend to total effort and was significantly different in all 4 years, with potting effort lower in the phone-recall surveys than the mail surveys. Effort from diving, however, was not significantly different in any of the 4 years but were lower in the phone-recall surveys.

In all 4 survey year comparisons, the total catch was lower in the phone-recall than the mail survey. Total catch was not significantly different in 2001/02 but was significantly different between the two survey methods for 2015/16, 2016/17, 2017/18. Catch from potting showed a similar trend to total effort with no significant difference in 2001/02 and significantly different catches for 2015/16, 2016/17, 2017/18, with catches from potting lower in the phone-recall surveys than the mail surveys. Catch from diving, however, was significantly different in 2001/02 but not significantly different for 2015/16, 2016/17, 2017/18, with diving catches lower in the phone-recall surveys.

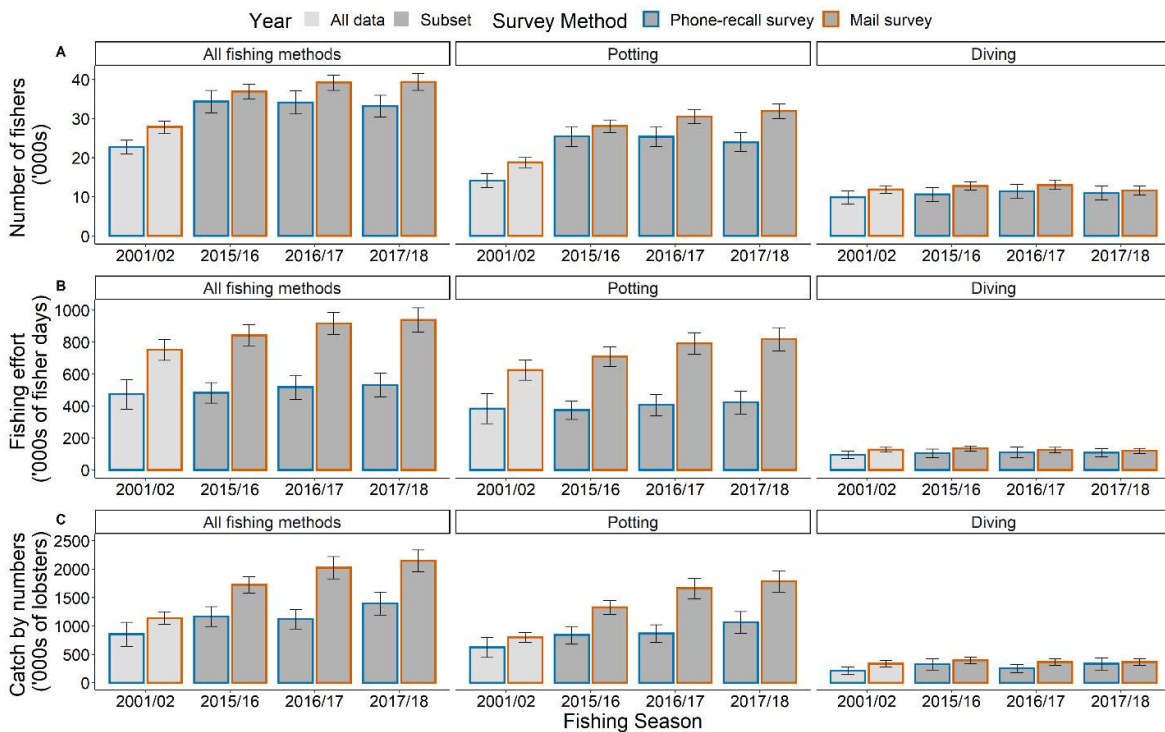


Figure 4. Estimated participation (number of fishers), fishing effort (days) and retained catch (number of WRL) for all methods combined, potting and diving from concurrent mail and phone-recall surveys of the rock lobster licensed recreational fishery in 2001/02, 2015/16, 2016/17 and 2017/18 (error bars represent one standard error).

The linear relationship between total catch (by numbers multiplied by the 0.39 correction factor) from the mail surveys and total catch (by numbers) from the phone-recall surveys, provided a slope of 0.61 (df=3, p<0.001) when all 4 survey years were included, and a slope of 0.62 (df=2, p=0.003) when the 2000/01 survey was not included (Figure 5; Table 6).

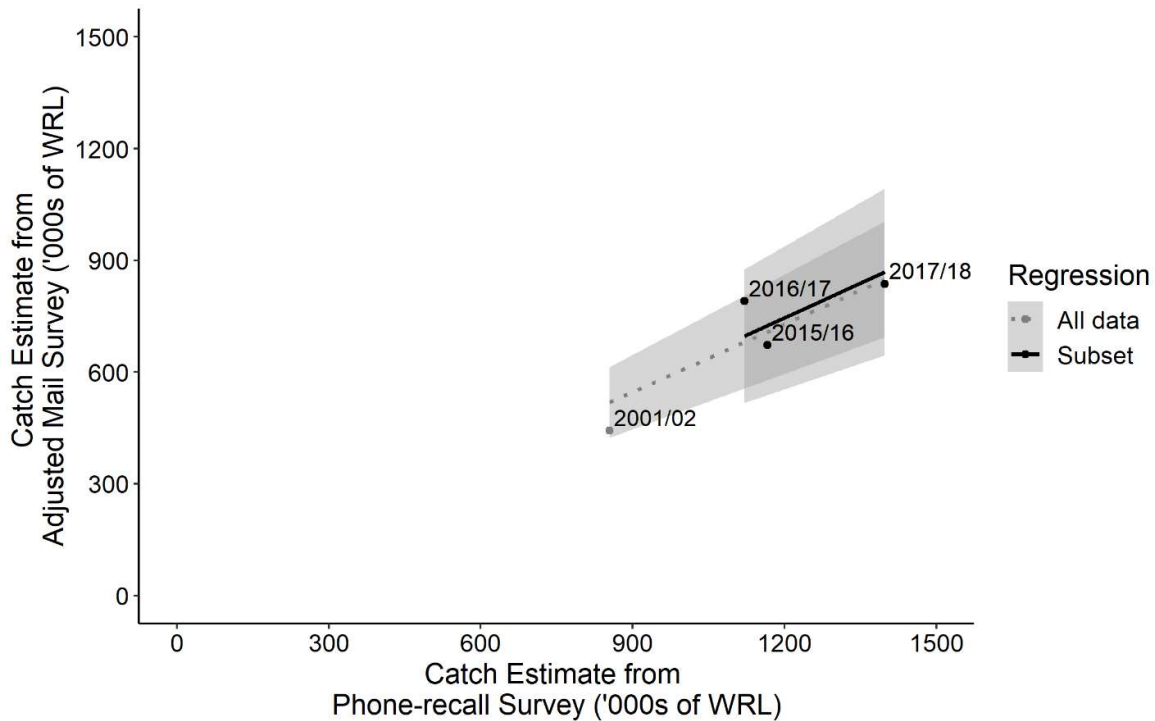


Figure 5. Linear regression of estimated retained catch (number of WRL) for all methods combined from concurrent mail and phone-recall surveys of the rock lobster licensed recreational fishery in 2001/02, 2015/16, 2016/17 and 2017/18 (shading represent 95% confidence intervals).

Table 6. Comparison of number of fishers, effort (days) and catch from mail and phone-recall surveys by total, potting and diving in 2001/02, 2015/16, 2016/17 and 2017/18.

	df	b	b(SE)	t value	p-value
All data	3	0.61	0.04	17.38	<0.001
Subset	2	0.62	0.04	16.71	0.003

4 Discussion

4.1 Changes in catch and effort

Recreational fishing effort and catch for WRL have been variable throughout the history of the mail and phone surveys, primarily due to three factors: management changes in the fishery; associated changes in the abundance of rock lobsters; and social factors affecting how people fish recreationally for RL.

4.1.1 Management changes

Following a decline in the puerulus settlement index in 2008 (discussed in section 4.1.2), the commercial fishery moved from an effort-controlled (maximum sustainable yield: MSY) to a quota-controlled (maximum economic yield: MEY) system in 2010. A new Harvest Strategy and Control Rules for both the commercial and recreational fishing sectors was also implemented (Department of Fisheries, 2014; de Lestang *et al.*, 2019; Gaughan and Santoro, 2019). The upper limit on the MEY was used to set the TAC (Caputi *et al.*, 2018) and the new harvest strategy had a primary objective to maintain egg production at sustainable levels whilst targeting maximum profitability. Subsequently, puerulus settlement returned to the long-term average over the next decade (de Lestang *et al.*, 2019). The rock lobster recreational fishery has benefitted greatly from the combination of fewer WRL being caught commercially and the return of puerulus settlement to the long-term average. Consequently, the popularity of recreational rock lobster fishing has increased, with record-high licence purchases and total fishers, with flow on effects to recreational effort and catch estimates.

Management changes relating to the recreational sector have included an increase in the daily bag limit, a decrease in the minimum legal length, and the ability to share pots with other fishers. These changes have contributed to the changes in estimated catch in recent years. Seasonal closures of demersal fishing during peak periods of lobster abundance (during the “white’s” migration) may also shift the boating effort towards WRL fishing during these months.

4.1.2 WRL abundance and recreational catch

Melville-Smith *et al.* (2001) demonstrated that the WRL recreational catch was correlated with time (survey year), licence usage (discussed in section 4.1.3) and the strength of the puerulus settlement at Alkimos 3 and 4 years earlier. This relationship was then used to predict future recreational catches as a management tool to assist in the resolution of commercial-recreational resource sharing. The basis for this relationship was that total fishers (i.e. licences bought and used) increased as the abundance of legal-sized lobsters increased, while the puerulus settlement was an accurate predictor of recruitment to the fishery (Melville-Smith *et al.*, 2004; Caputi *et al.*, 2014).

The improved WRL abundance, as a result of management changes introduced post-2008, has had a positive impact on the recreational catch overall, but the impacts have differed when looking at potting and diving individually. In the early stages of the mail survey, the proportion of the total catch taken from divers (<20%) was initially much lower than from pot fishers (>80%) (Melville-Smith and Anderton, 2000). As the popularity of RL recreational fishing increased during the late 1990's to early 2000s (peaking for total fishers, effort and catch around 2002/03), the diving catch increased more than the potting catch, peaking at 36% of the total in 2008/09. Likewise, diving effort and the total number of diving fishers also peaked at 25% and 50%, respectively, in 2008/09 of the total effort and total fishers.

When comparing lobster abundance and recreational catch by method, Thomson (2013) found a greater correlation in potting than diving, suggesting that fishers are more likely to go potting when lobster are abundant and easier to catch, whereas divers are more likely to fish year-round, even when lobsters are less abundant. As the fisheries productivity declined from 2008/09 and into the early 2010s, both methods of fishing were impacted at similar rates, with similar declines in participation, effort and catch. Yet since 2012/13, as the new harvest strategy has come into effect and lobster abundance has increased, the observation by Thomson (2013) has held true and pot fishers have benefitted far more than divers. Consequently, the proportion of divers has declined to 30% of all fishers, diving catch to 17% of the total WRL catch, and diving effort to 13% of the total fishing effort. Melville-Smith and Anderton (2000) inferred that increasing diving participation was likely caused from younger people participating in the fishery, thus it could be also inferred that the decline in diving participation is because there is a decline in younger persons participating. However, demographic changes in the fishery over time (e.g. changes in fishing method with age) warrants further investigation. Shark incidents in Western Australia have had a profound impact on the diving community, with the state government having to instigate several methods to mitigate shark interactions, such as tagging of white sharks, drum lining, shark enclosures, and subsidised shark shields. While the impact of sharks on diving is not quantifiable, over the past few decades, there has had an impact of the local dive stores in Perth with many stores closing over this period, suggesting that diving has become less popular.

4.1.3 Social factors and licence use

The mail survey benefited from a fishery-specific licence for rock lobsters throughout its entirety. This provided the survey with a sampling frame from which representative samples could be obtained, that has allowed researchers to implement a cost-effective off-site survey method. Over the 32-year period, the number of licences has increased in accordance with increases in the Estimated Residential Population in the state (73%) and Perth metropolitan area (80%) (ABS 2020). The relatively larger increase in licence numbers in the Perth metropolitan area demonstrates increased popularity in WRL fishing. However, licence numbers did not match population increases in a linear fashion, and peaked over several seasons that can generally be associated with high

lobster abundance and good recruitment into the fishery (Melville-Smith and Anderton, 2000).

Participation in the mail survey reflects the 18-month licence population. By sampling any person that was capable of fishing during the open season, there are fishers who purchased a licence in the previous season but would be valid to fish in the current season and could be sampled. However, they may not have wished to participate in the current season, thus there is likely to be a proportion of licence holders that do not fish. The rationale to buying a licence is highly variable and influenced by catch-related factors (e.g. perceived fish abundance and anticipated catch rates) and non-catch-related factors (e.g. fishing for food or recreation, catch and release, fishing with family or friends, cost of licence) (Hunt *et al.*, 2002; Hunt, 2005; Dabrowska *et al.*, 2014). Also, it cannot be assumed that all licence holders actually used their licence in any one year, as a proportion of licence holders would not fish due to psychological, physiological or social constraints, regardless of their intentions. Melville-Smith *et al.* (2004) reported that the fishing participation rate had remained relatively constant (70–80%) early in the mail survey, and annual licence numbers could be correlated with total fishers. However, during the mid-2000s, the fishing participation rate began to decline and resulted in a deviation between annual estimates of the number of fishers and licence numbers, reaching a low of 52% by 2012/13. This decline in fishing participation of a licensed fishery may be representative of declining participation in recreational fishing in general (Arlinghaus *et al.*, 2021), and has been observed in other Australian recreational fisheries, with Tasmanian rock lobster declining from over 86% to 72%, and abalone from 63% to 36% during a comparable time period (Lyle *et al.*, 2005). It is currently unknown as to why participation has declined since the mid-2000s and the mail survey did not incorporate social questions required to address this, but a number of factors could be contributing to this decline such as survey response bias, and fishers having less recreational time.

4.2 Survey issues and evolution

4.2.1 Survey participation rates

Sample sizes and response rates are crucial to the success of any mail survey: they are highly interdependent, as adequate sampling of the licence population will also be dictated by the effective response rates. Low effective sample size can decrease confidence in the probability-based mechanisms (Stedman *et al.*, 2019) and a low response rate can increase the likelihood of nonresponse bias (Rookey *et al.*, 2012). To help achieve high response rates for mail surveys, a well-designed survey questionnaire is integral to inducing a response and must be relevant to the targeted audience. However, it should also consider the response burden, as increased response burden can result in declining response rates (Dillman, 1991). Over the 32-year period, the mail survey has encountered and dealt with changes to sample size, response rates, and questionnaire design.

High effective response rates were achieved when the mail survey was first implemented, with an average of 46% from 1986/87–1988/89. In the first three years, when the number of licence holders was relatively small, between 56% and 100% of the licence holders were surveyed. As the licence population increased, the mail survey shifted from targeting a majority of licence holders to targeting a smaller sub-sample, creating a greater need to obtain high response rates. At this time, the survey was a relatively simple, 8-question questionnaire, designed to be folded and returned as a free business reply post. Follow up surveys of non-respondents found similar proportions of fishers to non-fishers, providing confidence in the mail survey program regarding possible non-response bias (Melville-Smith and Anderton, 2000). However, there was growing concern over the possible representativeness to the licence population due to the low sample size and decreasing effective response rates (Melville-Smith and Caputi, 1996; Melville-Smith and Anderton, 2000).

From 1995/96–2002/03 the gross sample was increased to sample a higher proportion of the licence population. An incentive program was also introduced, with prizes including tickets in a lottery to win up to \$500 and 20 free licences (Thomson and Melville-Smith, 2005). This succeeded in increasing the response rates from 32% in 1995/96 to 63% in 1998/99. Although the survey questionnaire in 1998/99 increased to 48 questions, the incentives being offered counteracted the increased respondent burden. Inducements were offered for a further 3 survey years but had been reduced to \$100 by 2001/02. This resulted in a small decline in responses rates. In 2002/03, research was conducted to determine whether inducements had biased the results. Inducements were found to be unlikely to bias the total catch or licence usage in the mail survey (Thomson and Melville-Smith, 2005), however, inducements were subsequently discontinued.

From 2003/04 to 2006/07, response rates continued to remain reasonably high without the inducements, the survey questionnaire had settled on 30 questions since 2001/02, and the gross sample was around 10% of the licence population. However, in 2007/08 response rates started to decline and in 2009/10 and 2010/11, response rates remained concurrently below 40% for the second time during the mail survey history. To counteract the decline, the gross sample was doubled in 2011/12, and while this improved the overall numbers of fully responding returned surveys, it did not improve the response rate. Both the response rate and proportion of licence holders sampled continued to decline until the 2017/18 season.

The decline in the mail survey response rate is not unique, and is consistent with trends in long-term mail surveys elsewhere (Stedman *et al.*, 2019). Although the survey questionnaire has remained relatively unchanged since 2001/02, the decline in response rates since 2007/08 is likely to be due to an underlying societal shift away from contributing to mail surveys

The response rates for the phone-recall survey were substantially higher than the mail survey as phone interviewers typically minimise respondent burden, whereas mail surveys rely solely on the respondent to complete and return the survey on their own

accord. The increased response rate does come at a higher cost per survey where the cost of sampling 800 people in the phone-recall was approximately half the cost of sending out 8000 mail surveys. This equates to a fivefold increase if a comparable 8000 sample was undertaken by the phone-recall survey.

4.2.2 Biases

Each survey has known biases that are associated with the survey design and implementation (Pollock *et al.*, 1994). The mail survey has inherent bias in the non-response, where non-avid fishers and non-fishers tend not to return the survey (Thomson, 2013); conversely, the high response rates in phone-recall surveys minimises non-response bias. Both the mail and phone-recall surveys have recall bias, having to recall events up to 12 months ago, and both survey methods have been found to overestimate events (Baharthah, 2007; Thomson, 2013). Furthermore, resource allocation requires the catch in numbers recorded in the mail survey to be converted to weight for comparison with the commercial fishery. Collecting biological data (e.g. length, weight) is extremely difficult to capture through off-site surveys; therefore, a survey to calculate the average weight of recreationally-caught lobsters is essential to facilitate this conversion.

Non-response bias

During the course of the mail survey, our understanding of the uncertainties and biases related to the survey evolved, and the WRL survey was corrected to account for these biases. Non-response bias typically occurs in mail surveys due to the tendency for licence holders who have not fished, or who have fished but have zero catch to report, to refrain from participating in the survey. This can have serious implications on how representative respondents are compared to the population of RL licence holders, and also for the estimates derived from the survey without the use of a correction factor to account for the nonresponse (Pollock *et al.*, 1994). The higher estimates of total fishers in the mail survey compared to the phone-recall surveys is indicative of the non-response bias, where survey respondents are more likely to have fished, than not, and are overrepresented in the sample of RL licence holders.

Recall bias

Recall bias occurs when respondents have trouble remembering events that happened a long time before the survey (Pollock *et al.*, 1994). With fishers required to recall events that happened more than six months prior to the survey, both survey methods are subject to recall bias. However, the high estimates of effort and catch in the mail survey are evidence of compounded bias, as the recall bias further exacerbates catch and effort of already avidity-biased respondents.

When differentiated by gear type, the effect of these biases on estimates of effort and catch from each of the surveys is starkly different. Pot fishers in the mail survey provided significantly higher number of days fished and catch than in the phone-recall survey, whereas diving effort and catch were relatively similar (albeit consistently lower)

between the survey types. These findings are consistent with recall surveys in general, where overestimation is more likely to occur as the number of events required to recall increases (Pollock *et al.*, 1994). Potting is the main method of capturing lobsters in the recreational fishery, and the average pot fisher would tend to fish more and catch more than the average diver; therefore, pot fishers are required to recall more in general. As the mail survey is also biased towards avid fishers, it would be expected that the recall burden for the avid pot fisher would be even higher than it would be for the average diver, resulting in the substantially higher over-estimations of effort and catch by potting.

4.2.2.3 Correcting for bias

The initial 1988/89 survey was compared to surveys from beach landings and boat ramps surveys (Melville-Smith and Anderton, 2000) with the daily lobster catches from beach/boat ramps found to be 65% higher than the average daily catches from the mail survey. The estimated total recreational catch of lobsters from the mail survey was then applied a multiplication (correction) factor of 1.65 times (Melville-Smith and Anderton, 2000) to correct a perceived underestimate.

In 2004/05, a comparison between two concurrent phone diary surveys (2000/01, 2001/02) and the mail survey found that the mail survey actually overestimated the catch and effort by 1.9 times, resulting in a correction factor of (0.53) (de Lestang *et al.*, 2019). In 2006, a comparison of three concurrent WRL surveys (mail, phone-recall, and phone-diary) concluded the mail survey overestimated the catch and effort by 2.3 times, resulting in a correction factor of 0.44 (Baharthah, 2007). In 2013, a comparison between several concurrent phone diary surveys (2000/01, 2001/02, 2004/05–2008/09) and the mail survey found the mail survey overestimated the catch by 2.55 times (correction factor of 0.39).

With each iteration of the correction factor, the estimated recreational catch was adjusted; however, the final correction factor of 0.39 (Thomson, 2013) was applied retrospectively to all years in this report and has been used until the 2017/18 season. The mail survey bias of 0.39 is not uncommon and mail surveys have been known to require correction factors in the range of 0.2–0.8 (Lyle, 1999). By applying the 0.39 correction factor retrospectively to all years, the mail survey takes account of the non-response bias and can reliably estimate the catch for the recreational sector. Any bias would not be expected to affect the annual trends in the data (Melville-Smith *et al.*, 2001).

4.2.3 Estimating average weight of recreationally-caught WRL

From 1986/87 to 2014/15, the estimated average weight of a recreationally caught lobster was based on the average weight of an animal of 81 mm carapace length, measured from a boat ramp survey of recreational fishers in 1997/98 (Melville-Smith and Anderton, 2000): this equated to 0.5 kg. The average weight over this period was thought to be relatively unchanged as WRL was consistently fished at harvest rates of 60–80% (Caputi *et al.*, 2018). But after the change in the harvest strategy, which resulted in a significant increase in lobster abundance (discussed in section 4.1.1), it

was suspected that the average size of lobsters caught by the recreational fishers was increasing, and a new boat ramp survey was conducted in 2015/16 (Smallwood *et al.*, 2021). The average weight was 13% higher in the first year of the boat ramp survey and continued to remain higher than the long-term index in the next two boat ramp surveys (up 16% and 13% from the 0.5 kg). The consequence of the higher average weight since 2015/16, has increased the total recreational catch during this period.

5 Summary

The WRL mail surveys have provided estimates of participation, fishing effort and retained catch at a statewide level. Although changes were made to the mail survey questionnaire over the 32-year period to meet other management objectives (e.g. fisher demographics and attributes), the fundamental objectives were maintained. Therefore, the questions relating to catch and effort can provide a comprehensive, long-term trend of catch and effort for the recreational WRL fishery.

Even though it is well understood that mail surveys can be prone to non-response and recall bias that may affect the accuracy and precision of estimates, these surveys have been adjusted (such as the mail survey) are essential for the estimation of recreational catch and effort. Moving forward, the survey method used to collect information on this recreational fishery not only needs to account for non-response and recall bias, but also changes in management (i.e. a change from 8 month to 12-month fishing season which occurred in 2018/19) and reporting (i.e. a change from reporting period from September–June to February–January, which occurred in 2019 to better align with the commercial sector).

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8 Appendices


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

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.

Appendix 2. Mail survey questionnaire used from 1986/87 to 1997/98.

https://www.fish.wa.gov.au/Documents/research_reports/frr122.pdf



FISHERIES
WESTERN AUSTRALIA

Recreational rock lobster fishing survey

1997/98 season

Please complete and return to:
W.A. Marine Research Laboratories
PO Box 20, North Beach, 6020
Enquiries (08) 9246 8482 / (08) 9246 8444

Assist us by filling in this survey form and put yourself in line for a prize

1. Contact phone no. (to verify any entries below)

Name

Address

Post Code

2. Did you fish for rock lobsters between 15 November 1997 and 30 June 1998 (please tick Yes or No below)

Yes If you answered yes, please complete this survey and return it to us.

No If you answered no, you can stop here, but **please still return** the survey form to us.

All these questions refer to you as a single licence holder - please fill out one form for one licence.

3. What **METHODS** did you use to fish for rock lobsters last season? (please tick)

Pots	Diving	Other	If other, please describe.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input style="width: 100%; height: 20px;" type="text"/>

4. How many lobster **POTS** did you pull each day you went fishing?

5. During which **MONTHS** did you fish for rock lobsters? (tick more than one if appropriate)

Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. **WHEN** did you do most of your fishing for rock lobster? (tick more than one if appropriate)

Week-ends	Week-days	School Holidays	Annual Holidays
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. On how many **DAYS** during the season did you go fishing for rock lobsters? (your best estimate of the total number for each method)

By using pots?	By diving?	By other methods?
<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>

8. What was the total number of **LEGAL SIZE WESTERN** rock lobsters you caught during the season? (your best estimate)


By using pots?	By diving?	By other methods?
<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>

9. **WHERE** did you do most of your fishing? (list locality or town with [1] being the most often fished. Indicate which fishing methods you used in each area)

[1] Town/locality	postcode	Pots	Diving	Other
<input style="width: 100%; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
[2] Town/locality	postcode	Pots	Diving	Other
<input style="width: 100%; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
[3] Town/locality	postcode	Pots	Diving	Other
<input style="width: 100%; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

10. Total number of **TROPICAL** (green or painted) or **SOUTHERN** rock lobsters caught this season?

By using pots?	By diving?	By other methods?
<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>
Tropical?	Southern?	
<input type="checkbox"/>	<input type="checkbox"/>	



Space for any further comments you'd like to make is provided overleaf

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Comments (optional)

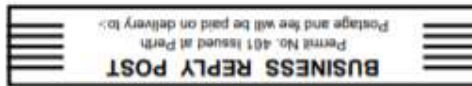
Fold 1

Postage is Paid.

Fold the form to show the return address - staple or tape the page and mail it.
Thank you for your input into the survey.

Fold 2


Rock Lobster Research
Western Australian Marine Research Laboratories
PO Box 20
NORTH BEACH WA 6020



No postage stamp required if
posted in Australia

O.H.M.S.

Appendix 3. Mail survey questionnaire used in 1998/99.



Recreational Rock Lobster Fishing Survey: 1998/99 Season

FISHERIES
WESTERN AUSTRALIA

Participating in this survey will put you in the running to win one of three cash prizes.
1st prize \$500, 2nd prize \$200, 3rd prize \$100

Please complete and return (free postage) to:
W.A. Marine Research Laboratories
PO Box 20, North Beach, 6020
Enquires: (08) 9246 8482 or (08) 9246 8444

Please note that all information supplied will be treated as strictly confidential

1. Contact details in case we need to verify any information you provide. We will also contact you if you win a prize.

2. How are you licensed to fish for rock lobster? (tick one)
 Rock lobster licence only
 Umbrella licence (all recreational fisheries)

3. What is your age? -----

4. What is your gender? Male
Female

5. What is the main language spoken at home?

Name: _____ Ph: _____

Home address: _____

Postcode: _____

6. What is your highest level of education? (circle one)
a) Below Year 12
b) Year 12
c) Apprenticeship or TAFE certificate
d) Tertiary

7. Did you fish for rock lobster between 15 November 1998 and 30 June 1999? (tick Yes or No).

YES If you answered Yes, please go to question 8, complete this survey, and return it to us.

NO If you answered No, please skip ahead to Q21, complete the survey, and return the form to us.

All the questions refer to you as a single licence holder - please fill out one form for one licence.

8. What methods did you use to fish for rock lobsters last season? (please tick)
Pots
Diving
Other
If Other, please describe:

9. Please indicate the approximate number of days you fished for rock lobster in each month using the following methods:

	Pots	Diving	Other
Nov '98	---	---	---
Dec '98	---	---	---
Jan '99	---	---	---
Feb '99	---	---	---
Mar '99	---	---	---
Apr '99	---	---	---
May '99	---	---	---
Jun '99	---	---	---

10. Where did you do most of your fishing? (list locality or town with [1] being the most often fished). Please note the number of days fished using each method.

[1]	Town/Locality	Postcode
	-----	-----
	(if known)	
	Number of days fished at locality:	
	Pots	Diving Other
	---	---

[2]	Town/Locality	Postcode
	-----	-----
	(if known)	
	Number of days fished at locality:	
	Pots	Diving Other
	---	---

[3]	Town/Locality	Postcode
	-----	-----
	(if known)	
	Number of days fished at locality:	
	Pots	Diving Other
	---	---

11. If you used pots, how many lobster pots did you typically pull each day you went fishing? -----

12. When did you do most of your fishing for rock lobster? (tick more than one if appropriate)
Weekends
Weekdays
School Holidays
Annual Holidays

13. What was the total number of legal size western rock lobster you caught during the season? (your best estimate)

By using pots -----
By diving -----
By other methods -----

14. Please indicate the number of legal size tropical (green/painted) or southern rock lobster caught during the season.

	Lobster	Pots	Diving	Other
Tropical	---	---	---	---
Southern	---	---	---	---

15. Do you own (or have regular access to) a boat? (tick one)
 Yes No
 Go to Q16 Skip to Q18

16. What is the length of the boat in metres? _____ m

17. Please tick the equipment you used: (tick more than one if appropriate)

B/W Echo Sounder
 Colour Echo Sounder
 View Bucket
 Radar
 Pot Winch
 GPS
 None of the above

18. In what depth range did you dive for rock lobster last season?

Depth	Percentage of Time Diving
0-10 m	-----
11-20 m	-----
21-30 m	-----
Below 30 m	-----
Didn't dive	<input type="checkbox"/>

19. In what depth range did you fish for rock lobster using pots last season?

Depth	Percentage of Time Potting
0-10 m	-----
11-20 m	-----
21-30 m	-----
Below 30 m	-----
Didn't pot fish	<input type="checkbox"/>

20. Please tick the type(s) of pots you used when fishing for lobster last season: (tick more than one if appropriate)

Stick/cane beehive
 Batten pots
 Plastic pots
 Don't use pots
 Other _____ (please specify)

21. For how many years have you participated in the recreational rock lobster fishery? _____

22. Consider the following statement: "Fisheries management is effective in conserving rock lobster stocks". Do you: (circle one answer only)

a) Strongly agree
 b) Agree
 c) Not sure
 d) Disagree
 e) Strongly disagree

23. In your experience, how fair do you think fisheries officers are in dealing with infringements that they find. As far as you know, do they treat people: (circle one)

a) Always fairly
 b) Sometimes fairly
 c) Never fairly
 d) Don't know, no contact with fisheries officers.

24. Consider the following statement: "Recreational rock lobster fishers generally abide by fisheries regulations". Do you: (circle one answer only)

a) Strongly agree
 b) Agree
 c) Not sure
 d) Disagree
 e) Strongly disagree

25. Please indicate the number of contacts you had with fisheries personnel while fishing for rock lobster in the last season: (circle one, but if greater than 1 contact, please write number)

i) Fisheries officers:
 a) None
 b) Seen only
 c) 1 contact
 d) More than 1 contact _____
 e) Did not fish last season

ii) Volunteer fisheries liaison officers (VFLO's):
 a) None
 b) Seen only
 c) 1 contact
 d) More than 1 contact _____
 e) Did not fish last season

[Note: VFLO's are recreational fishers who donate their time to educate other fishers about conservation and fish management. They usually wear distinctive yellow shirts and hats].

26. How many times in total (over all your fishing years) have you come into contact with a fisheries officer (not a VFLO) while fishing for rock lobster? _____

27. Consider the following statement: "Commercial rock lobster fishers generally abide by fisheries regulations". Do you: (circle one answer only)

a) Strongly agree
 b) Agree
 c) Not sure
 d) Disagree
 e) Strongly disagree

28. The current pot limit is 2 for recreational fishers. Do you think this number is: (circle one)

a) Too low
 b) About right
 c) Too high
 d) Don't know

29. The current bag limit is 8 lobsters per day for recreational fishers. Do you think this number is: (circle one)

a) Too low
 b) About right
 c) Too high
 d) Don't know

30. In your experience, what percentage of recreational fishers do you think regularly sell some or all of their catch? (circle one)

a) 0%
 b) 1-2%
 c) 3-5%
 d) 6-10%
 e) More than 10%
 f) Don't know

31. In your experience, what percentage of recreational fishers do you think illegally pull other recreational fishers' pots? (circle one)

a) 0%
 b) 1-2%
 c) 3-5%
 d) 6-10%
 e) More than 10%
 f) Don't know


32. In your experience, what percentage of recreational fishers do you think illegally pull commercial fishers' pots? (circle one)

a) 0%
 b) 1-2%
 c) 3-5%
 d) 6-10%
 e) More than 10%
 f) Don't know

33. In your experience, what percentage of commercial fishers do you think illegally pull recreational fishers' pots? (circle one)


a) 0%
 b) 1-2%
 c) 3-5%
 d) 6-10%
 e) More than 10%
 f) Don't know

Appendix 4. Mail survey questionnaire used from 1999/00 to 2017/18.




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Government of **Western Australia**
Department of Fisheries



Recreational Rock Lobster Fishing Survey 2017/2018 Season

COMPLETION INSTRUCTIONS

Please shade the circle completely ● Please write clearly in boxes 1 2 A B PLEASE WRITE CLEARLY

If you make a mistake or want to change any of your shaded responses, please place a cross through the incorrect response ✕ and shade the correct response ●

For written responses, please cross it out and write your new response just above or below the one you have crossed out

I N C O R R E C T


CORRECT

When you have completed your questionnaire, please return it in the reply paid envelope (free postage)


SECTION A: START OF QUESTIONNAIRE

PLEASE NOTE: All of the questions refer to last season (15/10/2017 to 30/06/2018) for a single licence only.

1. What is your age? years
2. What is your gender? Male Female
3. What is your residential post code?
4. For how many years have you participated in the recreational rock lobster fishery? years
5. In addition to a rock lobster licence, please indicate which of the following licences you had last season.
 Net Fishing Marron Abalone Freshwater Angling Recreational Fishing from Boat
6. Of the previously listed licences, which did you actually use last season?
 Net Fishing Marron Abalone Freshwater Angling Recreational Fishing from Boat
7. Did you fish for rock lobster last season?
 Yes — If you answered **Yes**, please go to Question 8 and complete the rest of the questionnaire.
 No — If you answered **No**, please go to Question 27 on the back page.
8. What methods did you use to fish for rock lobsters last season?
 Pots Diving (SCUBA, hookah or snorkeling) Other (please specify)
9. Approximately, how many days did you fish for (western, tropical or southern) lobsters, last season? days
10. In total, how many days did you spend fishing for lobster, (western, tropical or southern) during last season for each of the following methods?
 By using pots days By diving days By other methods days



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SECTION B: WESTERN ROCK LOBSTERS

11. What was the **total number of legal size western rock lobsters** you caught and kept over the course of last season?

By using pots By diving By other methods

12. Please indicate the approximate number of legal size western rock lobster you caught and kept and the approximate number of days you fished for any species of rock lobster in each month using the following methods:

	POTS		DIVING		OTHER	
	Days	Catch	Days	Catch	Days	Catch
October 2017	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
November 2017	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
December 2017	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
January 2018	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
February 2018	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
March 2018	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
April 2018	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
May 2018	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
June 2018	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>

13. On how many days over the course of last season did you catch your bag limit? days

14. If you used pots, on average, how many did you use each day you went fishing?

SECTION C: FOR TROPICAL/SOUTHERN ROCK LOBSTERS ONLY

15. Please indicate the approximate **number** of legal size tropical (green/painted) or southern rock lobster you caught and kept during last season (i.e. different species from western rock lobster) using the following methods.

	POTS	DIVING	OTHER
Tropical	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
Southern	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>

SECTION D: ALL SPECIES OF LOBSTERS

16. Do you own (or have regular access to) a boat (excluding charter boats)?

- Yes — If you answered **Yes**, please go to Question 17
- No — If you answered **No**, please go to Question 19

17. What is the length of the boat in metres **OR** feet? metres **OR** feet

18. Please indicate the equipment you used: (Choose **more than one** if appropriate)

- B/W Echo Sounder
- View Bucket/Glass bottom bucket
- Pot Winch
- None of these
- Colour Echo Sounder
- Radar
- GPS

19. If you **dived** for rock lobster last season, choose the depth (in metres) in which you did **most** of your fishing?

- 0 to 10
- 11 to 20
- 21 to 30
- Deeper than 30





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20. If you potted for rock lobster last season, choose the depth (in metres) in which you did most of your fishing?
 0 to 10 11 to 20 21 to 30 Deeper than 30

21. Please indicate the type of pots you used when fishing for lobster last season: (Choose more than one if appropriate)
 Stick/cane beehive Plastic pots Other (please specify)
 Batten pots Don't use pots

22. If you dived for rock lobster last season, please indicate the equipment you used (Choose more than one if appropriate)
 SCUBA Snorkeling Loop Dive computer
 Hookah Underwater torch Shepherd's crook

23. If you dived for rock lobster last season did you dive from a charter boat? Yes No

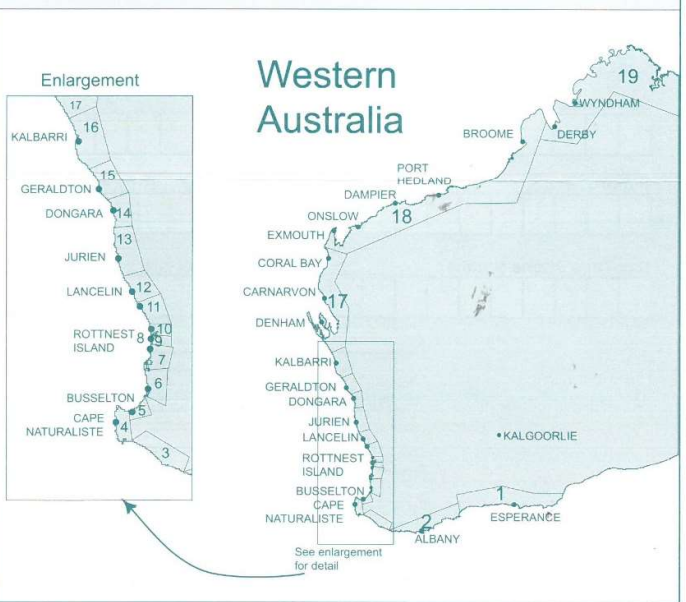
24. If you answered yes to question 23, approximately how many days did you dive for lobsters from charter boats last season and how many did you catch?
 Days dived Number caught

25. Where did you do most of your fishing? (Please refer to the map and list of map code numbers below for each locality or town with [1] being the most often fished). Please also provide the number of days fished using each method.

	MAP CODE # (1-22)	DAYS USING POTS	DAYS DIVING	DAYS USING OTHER METHOD
[1]	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
[2]	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
[3]	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>

26. Where do you live? (Please shade the circle to the left of the map code number corresponding with your locality/town of residence - not the place where you do most of your fishing.

- Code # Locality / Town
- 1. Esperance to just east of Bremer Bay
 - 2. Bremer Bay to just east of Walpole
 - 3. Walpole to just south of Cape Leeuwin
 - 4. Cape Leeuwin to Cape Naturaliste
 - 5. Busselton Area
 - 6. Bunbury to just south of Mandurah
 - 7. Mandurah
 - 8. Rottnest
 - 9. Rockingham
 - 10. Metropolitan
 - 11. Wanneroo to Two Rocks
 - 12. Just north of Two Rocks to Lancelin
 - 13. Jurien Bay
 - 14. Dongara
 - 15. Geraldton (incl. Abrolhos Islands)
 - 16. Kalbarri
 - 17. Shark Bay
 - 18. Exmouth to Broome
 - 19. Coastal Kimberley
 - 20. Northern Inland Area
 - 21. Southern Inland Area
 - 22. Interstate



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SECTION E: ILLEGAL FISHING

27. Have you been offered the opportunity to purchase or trade in recreationally caught rock lobster within the past 12 months?
- Yes
 - No
 - Not Sure

28. If you have observed illegal fishing activity, please provide specific details.

Empty text box for providing details of illegal fishing activity.

SECTION F: GENERAL COMMENTS

29. Please provide any other comments that you might have relating to the recreational rock lobster fishery.

Empty text box for general comments.

SECTION G: CONTACT DETAILS (OPTIONAL)

Please provide your contact details in case we need to verify any information you provided.

NB: ALL information supplied will be treated as strictly confidential and will be used only for research purposes.

First Name Surname

Street Address

Suburb Post code

Day Time Phone Number Email Address

THANK YOU FOR COMPLETING THE QUESTIONNAIRE.
WE ARE VERY GRATEFUL FOR YOUR VALUABLE INFORMATION

OFFICE USE ONLY



This questionnaire was constructed by
SAVANT Surveys and Strategies
www.savant.net.au
(08) 9325 1300



Appendix 5. Statewide *unadjusted* estimated retained recreational catch (in numbers, SE) of Western Rock Lobster (*Panulirus cygnus*) obtained during mail surveys from 1986/87–2017/18 for potting, diving and total (combined methods).

Note: these estimates have not been adjusted to account for biases in survey methods.

Season	Retained catch (numbers)		
	Total (SE)	Potting (SE)	Diving (SE)
86/87	491,369 (14,221)	378,688 (13,205)	112,062 (5,048)
87/88	435,257 (9,484)	359,764 (8,997)	74,964 (2,890)
88/89	567,459 (13,359)	465,094 (12,450)	102,120 (4,796)
89/90	446,770 (32,244)	356,116 (29,493)	87,883 (12,262)
90/91	435,393 (41,338)	315,949 (35,395)	119,445 (20,636)
91/92	860,112 (88,973)	637,950 (79,054)	222,162 (37,903)
92/93	910,666 (64,166)	724,084 (59,007)	186,582 (23,033)
93/94	774,080 (44,505)	597,803 (40,266)	176,277 (17,838)
94/95	633,080 (89,033)	539,237 (87,663)	93,843 (13,981)
95/96	622,216 (38,463)	476,912 (34,233)	145,182 (16,604)
96/97	611,074 (35,968)	462,267 (32,418)	148,063 (14,099)
97/98	972,896 (46,108)	694,161 (37,761)	278,200 (23,280)
98/99	1,259,825 (51,736)	919,569 (46,238)	338,755 (20,872)
99/00	1,498,089 (75,597)	1,125,034 (65,850)	372,656 (35,152)
00/01	1,250,914 (54,272)	926,329 (47,903)	323,927 (23,696)
01/02	1,134,826 (54,142)	797,348 (45,195)	336,408 (28,478)
02/03	1,789,707 (77,744)	1,259,731 (66,213)	529,088 (37,049)
03/04	1,619,133 (82,499)	1,144,044 (67,019)	475,089 (43,447)
04/05	1,445,089 (77,000)	1,073,382 (68,327)	371,422 (34,221)
05/06	832,679 (38,736)	623,411 (34,565)	208,260 (15,507)
06/07	803,058 (43,936)	552,894 (35,338)	249,385 (21,731)
07/08	796,397 (48,299)	566,941 (43,092)	225,414 (19,451)
08/09	804,510 (55,135)	503,004 (39,760)	294,383 (36,592)
09/10	958,666 (60,498)	674,278 (54,400)	284,262 (23,922)
10/11	705,727 (58,120)	479,935 (52,392)	225,712 (24,386)
11/12	587,210 (29,038)	393,850 (24,474)	192,656 (14,072)
12/13	641,329 (30,379)	471,802 (27,024)	169,221 (13,136)
13/14	1,246,230 (63,204)	917,324 (56,082)	328,744 (26,421)
14/15	1,693,398 (77,727)	1,356,581 (72,444)	336,269 (24,026)
15/16	1,723,816 (72,731)	1,327,930 (63,572)	395,598 (31,477)
16/17	2,027,685 (99,004)	1,663,205 (92,962)	364,480 (31,299)
17/18	2,146,841 (99,229)	1,782,547 (93,964)	362,868 (28,737)

Appendix 6. Statewide *unadjusted* estimated retained recreational catch (in numbers, SE) of Western Rock Lobster (*Panulirus cygnus*) obtained during mail surveys from 1986/87–2017/18 for potting, diving and total (combined methods).

Note: these estimates have not been adjusted to account for biases in survey methods

