



Victorian Rock Lobster Fishery

Stock Assessment Report

2016/17 Season



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Published by the Victorian Fisheries Authority (VFA), February 2018

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Authorised by the Victorian Government, 1 Spring Street, Melbourne.

Printed by VFA Melbourne, Victoria.

Preferred way to cite this publication:

Victorian Rock Lobster Fishery Stock Assessment Report – 2016/17 Season

ISBN 978-1-925733-58-7 (Print)

ISBN 978-1-925733-59-4 (pdf/online)

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Contents

1. EXECUTIVE SUMMARY	1
2. INTRODUCTION	2
3. WESTERN ZONE ROCK LOBSTER FISHERY	3
3.1 Fishery Statistics.....	3
3.2 Model Outputs	4
3.3 Application of the Harvest Strategy	5
4. EASTERN ZONE ROCK LOBSTER FISHERY.....	6
4.1 Fishery Statistics	6
4.2 Model outputs.....	7
4.3 Application of the Harvest Strategy	8
5. METHODS.....	9
5.1 Catch Rate Standardisation	9
5.2 Stock Assessment Model	9
6. REFERENCES	10
7. WESTERN ZONE DATA	11
8. EASTERN ZONE DATA	23
APPENDIX 1: ROCK LOBSTER FISHERY HARVEST STRATEGY	35

Victorian Rock Lobster Fishery

Stock Assessment Report for the 2016/17 Season

1. EXECUTIVE SUMMARY

This report details the results of the 2016/17 stock assessment for the Victorian Rock Lobster Fishery. The assessment includes analysis of the fishery against the stock performance indicators and limit reference points set out in the new harvest strategy. The primary objective of the harvest strategy is to ensure that the stocks continue to rebuild. The strategy uses standardised catch rate, egg production levels, pre-recruit abundance and a set of decision rules to determine the total allowable commercial catch (TACC) for each zone in the fishery. The harvest strategy is attached at Appendix 1.

Western Zone Rock Lobster Fishery

The TACC for the Western Zone in 2016/17 was 230 tonne (t), which is the third year at this level. In response to oil and gas exploration activities, 20,783.10kg of the TACC was bought out by the oil and gas company and fishers were compensated for loss of access to the fishery whilst the seismic surveying was conducted.

Overall, the stock indicators in the Western Zone show a marginal improvement. The standardised catch per unit effort (CPUE) improved from 0.51kg/pot-lift in 2015/16 to 0.54kg/pot-lift in 2016/17. The numbers of undersize lobsters have increased from the historical low experienced three years ago, but are still at very low levels. The pre-recruit index (PRI) was at 1.25 undersize/pot-lift. Whilst higher than the previous year, it is the second lowest level since 2005/06 and below the PRI reference point of 1.81. The stock assessment model indicates that egg production remained steady at 41.6% of 1951 levels, which is well above the 20% limit reference point. Biomass increased slightly (by 0.4%), which combined with the unfished TACC, led to a reduction in exploitation rate to 29.5%.

Eastern Zone Rock Lobster Fishery

The 2016/17 TACC for the Eastern Zone was set at 59t for the third consecutive year. While the quota has been fully caught, increasing effort has been required over the last years to take the TACC. This has resulted in a standardised CPUE reduction from 0.56kg/pot-lift in 2014/15 to 0.45kg/pot-lift in 2016/17. The numbers of undersize lobsters continued to fall and are at a historical low. The PRI declined to 0.16 undersize/pot-lift in 2016/17, the lowest level since 2005/06 and below the PRI reference point of 0.32 undersize/pot-lift. The model estimated level of egg production has remained static at 26-27% of 1951 levels for the past six years and is therefore above the 20% limit reference point. The estimated available biomass in the Eastern Zone has declined for a third year in a row to a level that is 17% below the recent 2013/14 peak. As a result of the decreased biomass the exploitation rate has increased to 22%.

2. INTRODUCTION

The *Victorian Rock Lobster Fishery Management Plan* requires annual assessment of the southern rock lobster (*Jasus edwardsii*) stock in Victoria to enable review of the stock and setting of the annual TACC (Victorian Fisheries Authority 2017).

The Rock Lobster Fishery is divided into two separately managed zones; the Western Zone and the Eastern Zone. The two zones are assessed separately and a TACC for each zone is determined using the fishery's harvest strategy. Each licence holder is then assigned a proportion of the zonal TACC based on the quota units attached to their licence. The quota units are transferable, through permanent sale or temporary lease, throughout the zone.

The data collected to assist in the assessment of the fishery against the reference points includes data from commercial catch and effort logbooks, a fixed-site survey program, an on-board observer program, puerulus sampling, in-port sampling of legally-sized rock lobsters (discontinued in 2016/17), and a voluntary sampling program (which is being expanded from 2016/17 onwards).

The performance of the fishery is evaluated against the stock performance indicators and associated limit reference points specified in the fishery's harvest strategy (refer to Appendix 1 for more detail). The indicators and limit reference points are egg production, standardised CPUE and pre-recruit abundance. The annual TACC is determined using a set of decision rules:

1. **Egg production** - the model estimated egg production must be above the limit reference point of 20% of 1951 levels, with a 90% probability.
2. **Standardised CPUE** – to maintain the predetermined exploitation rates (32.5% and 15% of the available biomass in the western and eastern zones, respectively) the standardised CPUE must be above 0.40kg/pot-lift. If the standardised CPUE falls below this, exploitation rates are decreased. If the lower limit of 0.20kg/pot-lift is reached, the zone is closed to all fishing.
3. **Pre-recruit index** – to be eligible for a TACC increase, the PRI for that stock assessment period must be above the PRI threshold level for that zone. The PRI thresholds are:
 - a. 1.81 undersize per pot-lift in the Western Zone, and
 - b. 0.32 undersize per pot-lift in the Eastern Zone.

Available biomass is used as a secondary reference point. Whilst not used in the TACC determination it is monitored as part of the overall stock health. As the harvest strategy uses standardised CPUE, all references in this report (unless specified otherwise) are therefore standardised values.

The PRI is determined using data from fixed-site surveys and on-board observations and is averaged, weighting regions by their past commercial catch. The calculated PRI is then compared against the PRI threshold level, calculated from a reference period 2005-2014.

This report summarises the fishing activity and stock status of each zone for the 2016/17 season and provides the outputs from the southern rock lobster stock assessment model, including estimated egg production and available biomass.

3. WESTERN ZONE ROCK LOBSTER FISHERY

3.1 Fishery Statistics

Trends in catch and effort

The TACC in the Western Zone Rock Lobster Fishery was set at 230 tonne (t) for the 2016/17 season, which was the third year at this level. A number of seismic surveys were conducted during the season, which resulted in 20,783.10kg of quota being 'retired' (intentionally uncaught) for the remainder of the season as part of a compensation package provided to fishers by the oil and gas company for loss of access to the fishing grounds. This resulted in reduced exploitation of stocks; however the extent of the negative impact of the seismic survey on the lobster population remains unclear.

The remainder of the TACC, 209t, was fully caught during the 2016/17 fishing season (November to September) and the corresponding effort required to take the catch was 324,000 pot-lifts, which is a substantial reduction from the previous year and largely due to the uncaught quota (Table 1, Figure 1). The fishery also experienced a slight contraction in the number of active vessels (down by six to 42) and licences (down by four to 43) after four years of relative stability (Table 2).

Trends in nominal and standardised catch rates have been consistent since the 1980's. A record low of 0.34 kg/pot-lift (standardised) was reached in 2009/10. Since then, CPUE has been increasing and reached 0.54kg/pot-lift in 2016/17. Notably, the fishery has fluctuated around this level from 1986/87 through to the decline in the mid-2000s (Table 1, Figure 4).

When examined by region, the breakdown of catch is similar to previous years. The notable exception is Warrnambool where the catch declined by 32t, largely due to the unfished quota as a result of the seismic survey in that region. The highest catch in 2016/17 came from the Portland region at 126t, followed by Warrnambool at 42t, and Apollo Bay at 41t. The CPUE in the Portland and Apollo Bay regions showed increases and was steady in Warrnambool after four years of decreases (Figure 5).

Trends in fishing vessels

The number of active fishing vessels decreased from a high of 141 in 1988/89 to approximately 100 through the 1990s, to a record low of 42 vessels in 2016/17 (Figure 2). During the same period the average annual catch increased from a record low of 2.4t per vessel in 1988/89 to a record high of 5.9t per vessel in 2000/01 (Figure 3). The number of days fished was also at a record low in 1988/89 at 28 days per vessel, this increased rapidly to 48 days in 1993/94 as the fleet contracted and the catch per vessel increased (Figure 3). In the last three years the average annual catch has been consistent between 4.7t and 5.0t whilst the average number of days fished decreased from a record high of 60 days in 12/13 to 52 days in 16/17.

Trends in recruitment

Catch rates of undersized lobsters (animals between approximately 80mm carapace length (CL) up to the legal minimum lengths (LML)) are estimated from the fixed-site surveys (closed escape gaps) and the on-board observer program (open escape gaps). The fixed-site surveys have been conducted each year since 2001/02 and the on-board observer program has been in place since 2004/05.

The PRI indices calculated from both these indices show similar trends with a rapid decline from the recent peak in 2011/12 to record or near record low levels over the last three years. During this three year period, the fixed-site surveys, which have higher selectivity for small lobsters due to closed escape gaps, have increased 21% (from the record low). Nevertheless, in 2016/17, both the fixed-site survey and observer-based PRI were well below the reference point (Figure 6).

To calculate the annual PRI for use in the TACC determination, data from the fixed-site surveys and on-board observations is combined, averaged, and weighted by region based on their past commercial catch. The combined PRI for 2015/16 was 1.25 undersize/pot-lift, which is 31% below the reference point of 1.81 undersize/pot-lift (Figure 6).

Mean weight

The mean weight of legal sized lobsters has increased over the last six seasons (Figure 7), which may be an additional indicator of low recruitment to the fishery. However, it has been noted that mean weight may also be increasing as a result of lower yearly effort and therefore lower levels of exploitation on the stock, which may be allowing lobsters to survive longer prior to being harvested. Additionally there has been a disproportionate increase in the beach price of large lobsters. Anecdotal reports suggest this has influenced fishing behaviour and selectivity, thereby contributing to an increase in mean lobster weight.

Length-frequency distributions

In addition to numbers of undersize lobsters, the fixed-site surveys and observer program collect data on the length-frequency distribution of lobsters in the population. The trends in the length-frequency data are consistent with the trends in pre-recruits and legal size commercial catch rates. That is, between 2008/09 and 2010/11, the number of undersize lobsters was higher relative to other years. The frequency of lobsters in size classes below the LML has decreased since 2010/11 (Figures 8-10). The increase in commercial catch rates seen between 2010/11 and 2013/14 reflect the increase in numbers of legally sized lobsters entering the available biomass.

3.2 Model Outputs

Model estimated recruitment

Model estimated recruitment to 60mm CL has been highly variable over the past 30 years, with a distinct change in the relative abundance over the length of the time series. Between 1988/89 and 1999/00, recruitment was mostly above the long-term average. Conversely, from 2001/02 onwards, with the exception of 2007/08 and 2008/09, recruitment has been well below the average (Figure 11). It is therefore likely that the recent increases in catch rate are due to the animals from 2007-09 growing and becoming part of the available biomass, with comparatively little recruitment since that time.

Model estimated egg production

The harvest strategy sets a model estimated egg production limit reference point of 20% of E_{1951} (the year 1951 is used as a reference of unexploited stock). The Western Zone egg production has never fallen below the limit reference point and a declining trend observed between 2001/02 and 2007/08 has halted to maintain a level of stability. The stock assessment model estimated egg production in 2016/17 at 42% of 1951 levels, which is well above the 20% reference point (Figure 12).

Model estimated available biomass and exploitation rate

It should be noted that whilst trends in biomass and exploitation rate are consistent across stock assessments, the absolute values may all scale up or down as different parameter estimates are obtained.

Under the increasing exploitation rates experienced between 1980/81 and 2000/01, the modelled available biomass indicates a downward trend for the first decade before entering a phase of stability between 1987/88 to 2003/04 fluctuating around 820t. Exploitation rates dropped in 2001/02 with the introduction of quota, but steadily increased to a historical high of 66% in 2006/07. The corresponding available biomass decreased and reached a low of 442t in 2008/09. After 2006/07, the exploitation rate dropped significantly and the available biomass improved. In 2016/17, the available biomass was estimated to be 708t, with a corresponding fishing exploitation rate of 29% (Figure 13).

3.3 Application of the Harvest Strategy

The annual TACC is set on the basis of the response to the decision rules contained within the new harvest strategy (Appendix 1) as described below:

Decision Rule	2016/17 Stock Indicator Level	Outcome
1. <u>Egg Production</u>		
Is the model estimated egg production above the limit reference point of 20% of E_{1951} with a 90% probability?	The 2016/17 egg production level is estimated at 42% of E_{1951}	Decision rule has been met. Go to Rule 2
2. <u>TACC Determination</u>		
a. What is the standardised CPUE relative to the preceding season	Standardised CPUE is 0.54kg/pot-lift in 2016/17	Standardised CPUE has increased from 0.51 in 2015/16 to 0.54 in 2016/17
b. Is the 2016/17 PRI at or above the reference point of 1.81 undersize/pot-lift?	The PRI is 1.25 undersize/pot lift	Decision rule not met. No further decision rules considered
RESULT		NO INCREASE IN TACC

4. EASTERN ZONE ROCK LOBSTER FISHERY

4.1 Fishery Statistics

Trends in catch and effort

In 2016/17, the catch in Eastern Zone Rock Lobster Fishery was 52t during the fishing year (November – September) (Table 3) and 52.6t during the quota year (July – June). The TACC was set at 59t, which represented the third consecutive year at this level, but was only 89% caught (Table 4). The level of effort taken to catch the 52t was 121,000 pot-lifts, which is a substantial increase on past seasons (Table 3, Figure 17).

Standardised CPUE reached a 20 year peak of 0.63kg/pot-lift in 2012/13 but has since fallen rapidly to 0.45kg/pot lift in 2016/17 (Table 3, Figure 18).

The breakdown of catch within the Eastern Zone regions in 2016/17 was consistent with previous years. The majority of catch was taken in the Queenscliff region, followed by San Remo and a small, but consistent, amount taken in the Lakes Entrance region. The CPUE in the Queenscliff and San Remo regions have been in decline for several years, while there has been a steady increase in Lakes Entrance (Figure 19).

It should be noted that the reduction to the current fleet size of 24 vessels increases the potential for biased reporting as a result of operational changes from a small number of vessels that collectively hold a large proportion of the quota and which due to their large catches may have changed their fishing behaviour (e.g. fishing in deeper water).

Trends in fishing vessels

The number of active fishing vessels decreased from 90 in 1978/79 to approximately 50 through the 1990s to a record low of 21 vessels in 2014/15, and rising back to 24 in 2016/17 (Figure 16). The average annual catch increased from a record low of 1t per vessel in 1988/89 to a record high of 2.7t per vessel in 2014/15 (Figure 17). The number of days fished was also at a record low in 1988/89 at 18 days per vessel (Figure 17). This subsequently increased as the fleet contracted and the catch per vessel increased. In 2016/17 the average annual catch was 2.2t / vessel whilst in the last four years the average number of days fished per vessel has decreased from a record high of 38 days to 33 days.

Trends in recruitment

The PRI indices calculated from both fixed-site surveys and on-board observers show similar trends with a rapid decline from the recent peak in 2013/14 to record or near record low levels over the last three years. During the last two years, the fixed-site surveys were not conducted. In 2016/17, the observer-based PRI was at a record low of 0.16 undersize/pot-lift which is 50% of the reference point of 0.32 undersize/pot-lift (Figure 20).

From these trends, it is highly likely that the number of lobsters entering the fishable biomass in future years will continue to be at very low levels.

Mean weight

The mean weight of Eastern Zone lobsters has always been higher than those from the Western Zone, which is an artefact of the faster growth rate in the eastern area. However, since 2012/13 (when CPUE peaked), the mean lobster weight has increased from 1.12 kg/lobster to 1.42kg/lobster in 2016/17 (Figure 21). This is the highest mean lobster weight on record for the Eastern Zone and in combination with the CPUE decline during this period is indicative of a lack of a recent recruitment to the legal biomass combined with a pulse of larger lobsters that are growing through the size classes. Additionally it should be noted that there has been a disproportionate increase in the beach price of large lobsters. Anecdotal

reports suggest this has influenced fishing behaviour and selectivity, thereby contributing to an increase in mean lobster weight.

Length-frequency distributions

Despite the small sample sizes in the Eastern Zone fixed-site surveys and observer program, the trends in the undersize lobsters support those observed in other data sets. The observer program shows an increase in the abundance of legally sized lobsters from 2011/12 to 2016/17 comparative to the early years of the program which is consistent with the high level of pre-recruits recorded in 2007/08 – 2008/09 (Figures 22 and 23). The increase in lobster abundance from the fixed-site survey program during 2012/13 to 2014/15 in the 105-130mm CL size range is consistent with the increase in catch rates observed across the fishery during these years (Figures 24 and 25).

4.2 Model outputs

Model estimated recruitment

The long-term time series for the model estimated recruitment to the 60mm CL size class shows that recent recruitment has been below the long-term average more than it has been above it. Levels have been low since 2009/10, and reached a historical low of 54% of the long-term average in 2012/13. Since then, recruitment has been increasing, reaching 89% of the long-term average in 2014/15 (the most recent reliable estimate) (Figure 26).

Model estimated egg production

Unlike the Western Zone, the egg production in the Eastern Zone has been at levels below the long-term average. A historical low was reached in 1995/96 after which time there was a steady increase. Eastern Zone egg production levels are now considered to be well above the long-term average. The current stock assessment model estimated egg production in 2016/17 at 26.1% of the 1951 level which is well above the 20% limit reference point (Figure 27).

Model estimated available biomass and exploitation rate

In 2016/17, the available biomass was estimated to be 232t, with a corresponding fishing exploitation rate of 22.3%. After a period of steady increase in the available biomass between 2008/09 and 2013/14, the biomass has since been in decline (Figure 28).

4.3 Application of the Harvest Strategy

The annual TACC is determined using the decision rules contained in the new harvest strategy (Appendix 1). The results are described below:

Decision Rule	2016/17 Stock Indicator Level	Outcome
1. <u>Egg Production</u>		
Is the model estimated egg production above the limit reference point of 20% of E_{1951} with a 90% probability.	The 2016/17 egg production level is estimated at 26.1% of E_{1951}	Decision rule has been met. Go to Rule 2
2. <u>TACC Determination</u>		
a. What is the standardised CPUE relative to the preceding season	Standardised CPUE is 0.45kg/pot-lift in 2016/17	Standardised CPUE has decreased from 0.47 in 2015/16 to 0.45 in 2016/17 but remains within the same CPUE band
b. Is the 2016/17 PRI at or above the reference point of 0.32 undersize/pot-lift?	The PRI is 0.16 undersize/pot lift	Decision rule not met. No further decision rules considered
RESULT		SET TACC AT CPUE RANGE 0.45 - <0.5

5. METHODS

5.1 Catch Rate Standardisation

The stock assessment model uses standardised CPUE (Walker *et al.* 2012). All catch and effort data are obtained from mandatory logbook returns and are firstly checked for any errors before being entered into the Victorian Fisheries Authority rock lobster database. Prior to standardisation, the data are filtered to ensure that only data from fishers contributing returns in more than two separate fishing years and contributing 200 or more records are included in the CPUE standardisation. The CPUE is then standardised for each zone separately by adjusting for average long-term differences among the regions, depth ranges, fishing seasons, months, fishers and vessels. For standardisation, the regions are Portland, Warrnambool and Apollo Bay in the Western Zone, and Queenscliff, San Remo and Lakes Entrance in the Eastern Zone. The fishing depth ranges are <40 m and ≥40 m. Only interactions between region and year are now included, which permits yearly estimates of standardised CPUE by region.

5.2 Stock Assessment Model

The stock assessment uses a model that has been designed for rock lobster fisheries in Victoria, South Australia, and Tasmania. It was developed through CSIRO and a series of FRDC projects (Hobday and Punt 2001; Hobday and Punt 2009; Hobday *et al.* 2005). The model is length-structured and currently set up in Victoria to account for numbers of rock lobsters in 5-mm-carapace length-classes.

The model infers change and absolute levels of stock abundance from three principal data sources: (i) standardised CPUE, to which biomass is assumed to vary in direct proportion, (ii) catches in both weight and number, which provide a highly precise measure of mean weight of lobsters in the catch, and (iii) length-frequency data interpreted in combination with the length-transition matrices to yield estimates of mortality rate and absolute biomass.

Recruitment in the model is dependent on changes in mean size and size distribution of the catch from length-frequency data, and on changes in CPUE, where, for example, a rise in CPUE and a decrease in mean size signals an increase in recruitment and visa-versa. For males and females separately, the model tracks, for each month, the number of rock lobsters in the population of size equal to or larger than 60 mm carapace length. The model also accounts for both natural mortality and fishing mortality.

Growth is modelled using length-transition matrices that specify the proportion of lobsters in each length category that grow into larger length classes during each summer and autumn moulting period. Growth in the model is sex specific, as is length-selectivity. Catchability by month is non-sex specific. The length-transition matrices were estimated using extensive tag-recovery data.

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7. WESTERN ZONE DATA

Table 1: Western Zone catch, fishing effort and CPUE (Fishing Year: November-September; CPUE: Catch per unit effort).

Fishing Year	Catch (tonne)	Catch ('000)	Nominal Effort ('000 potlifts)	Nominal CPUE (kg/potlift)	Standardised CPUE (kg/potlift)	Mean Mass (kg/lobster)
1978/79	485	485	621	0.78	0.80	1.00
1979/80	451	442	576	0.78	0.81	1.02
1980/81	546	546	679	0.80	0.81	1.00
1981/82	498	498	637	0.78	0.78	1.00
1982/83	460	455	608	0.76	0.78	1.01
1983/84	421	414	571	0.74	0.74	1.02
1984/85	406	394	578	0.70	0.70	1.03
1985/86	345	346	569	0.61	0.62	1.00
1986/87	351	353	595	0.59	0.60	0.99
1987/88	345	349	557	0.62	0.61	0.99
1988/89	303	321	577	0.52	0.53	0.94
1989/90	332	355	613	0.54	0.54	0.94
1990/91	317	337	650	0.49	0.50	0.94
1991/92	409	439	712	0.57	0.59	0.93
1992/93	408	433	779	0.52	0.55	0.94
1993/94	449	456	754	0.59	0.57	0.98
1994/95	435	444	789	0.55	0.51	0.98
1995/96	423	442	761	0.56	0.50	0.96
1996/97	402	414	787	0.51	0.45	0.97
1997/98	467	493	842	0.55	0.49	0.95
1998/99	517	569	864	0.60	0.54	0.91
1999/00	523	596	901	0.58	0.52	0.88
2000/01	526	599	898	0.59	0.50	0.88
2001/02	438	510	703	0.62	0.55	0.86
2002/03	431	495	631	0.68	0.58	0.87
2003/04	460	514	658	0.70	0.56	0.90
2004/05	410	452	667	0.61	0.51	0.91
2005/06	358	405	705	0.51	0.43	0.88
2006/07	336	392	698	0.48	0.42	0.86
2007/08	289	338	668	0.43	0.37	0.86
2008/09	235	267	605	0.39	0.35	0.88
2009/10	240	277	651	0.37	0.34	0.87
2010/11	255	307	590	0.43	0.40	0.83
2011/12	233	279	475	0.49	0.44	0.83
2012/13	259	296	485	0.53	0.46	0.87
2013/14	269	299	486	0.55	0.47	0.90
2014/15	225	242	418	0.54	0.46	0.93
2015/16	227	235	362	0.63	0.51	0.97
2016/17	209*	206	324	0.64	0.54	1.01

* The 2016/17 catch was reduced from 230t to 209t as a result of a compensation packaged offered to fishers by Origin Energy in recognition of the loss of access to fishing grounds during survey activity. A condition of accepting compensation was to retire an agreed amount of quota for the remainder of the 2016/17 season.

Table 2: Western Zone history of TACCs for each quota period from 2001-02 to 2015-16 (TACC: Total Allowable Commercial Catch).

Year	Season	TACC Set (t)	Catch (t)	% TACC Caught	Months Fished	Active Licenses	Vessels
2001-02*	1 Nov - 31 Mar	320					
2002-03	1 Apr - 31 Mar	450	440	98	12	79	83
2003-04	1 Apr - 31 Mar	450	436	97	12	80	79
2004-05	1 Apr - 31 Mar	450	421	94	12	79	86
2005-06	1 Apr - 31 Mar	450	405	90	12	75	77
2006-07	1 Apr - 31 Mar	450	329	73	12	71	68
2007-08	1 Apr - 31 Mar	380	319	84	12	68	64
2008-09	1 Apr - 31 Mar	320	244	76	12	61	60
2009	1 Apr– 30 Jun	55.2	36	64	3	54	53
2009-10	1 Jul – 30 Jun	240	230	96	12	54	53
2010-11	1 Jul – 30 Jun	240	237	99	12	54	58
2011-12	1 Jul – 30 Jun	240	237	99	12	50	53
2012-13	1 Jul – 30 Jun	260	258	99	12	47	45
2013-14	1 Jul – 30 Jun	260	260	100	12	47	47
2014-15	1 Jul – 30 Jun	230	230	100	12	48	47
2015-16	1 Jul - 30 Jun	230	230	100	12	47	48
2016-17	1 Jul - 30 Jun	230*	209*	100*	12	43	42

* The 2016/17 catch was reduced from 230t to 209t as a result of a compensation packaged offered to fishers by Origin Energy in recognition of the loss of access to fishing grounds during survey activity. A condition of accepting compensation was to retire an agreed amount of quota for the remainder of the 2016/17 season.

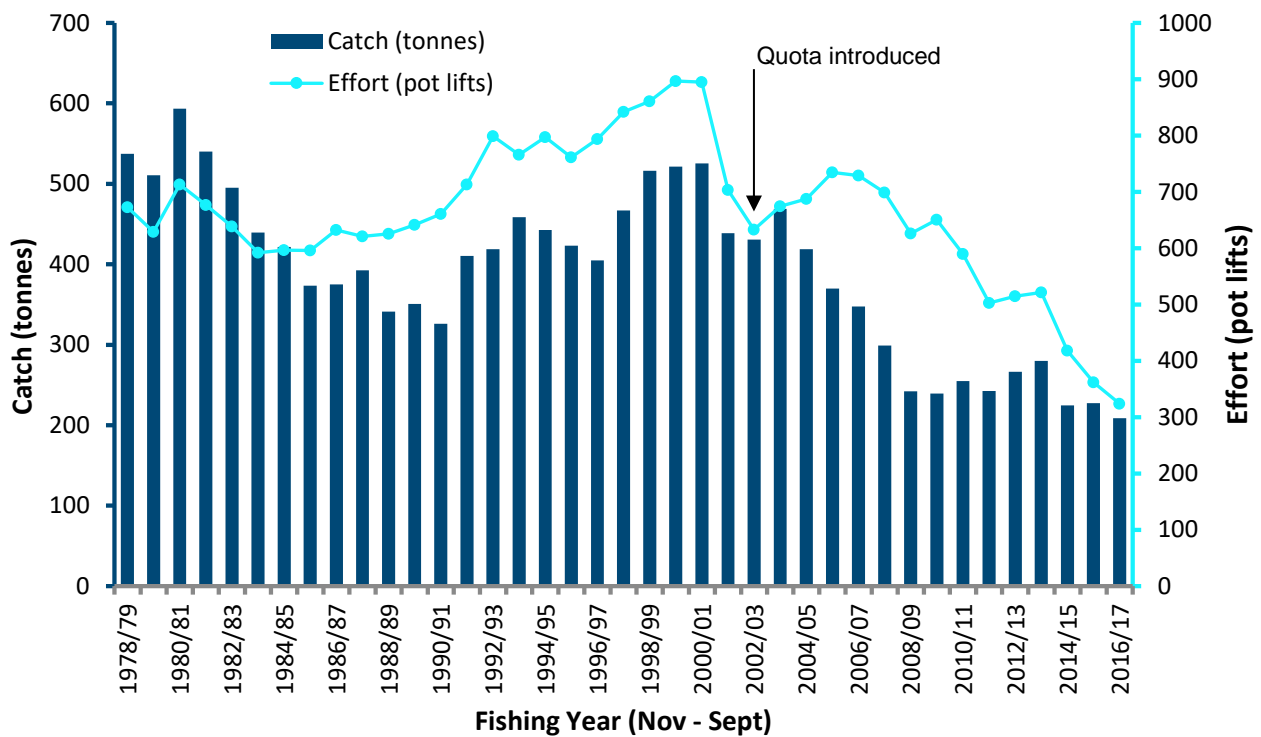


Figure 1: Total catch (tonnes) and nominal effort (x1000 pot-lifts) in the Western Zone from 1978/79–2016/17.

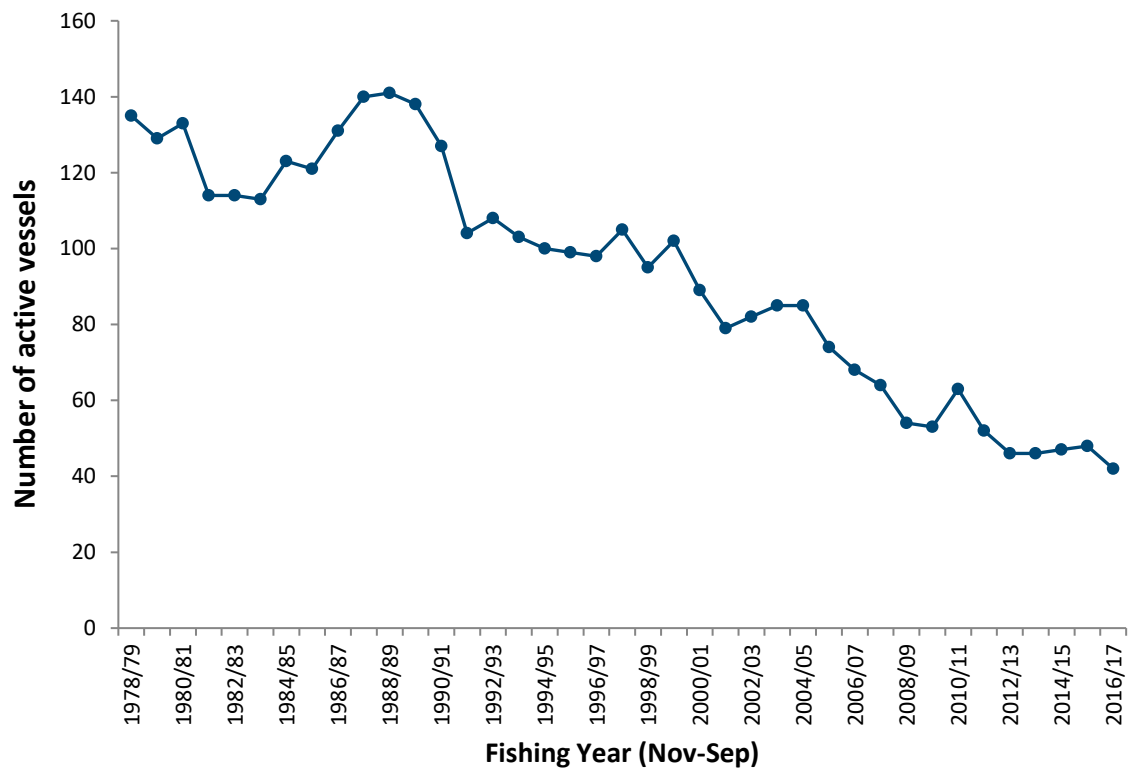


Figure 2: The number of active vessels in the Western Zone in each fishing year.

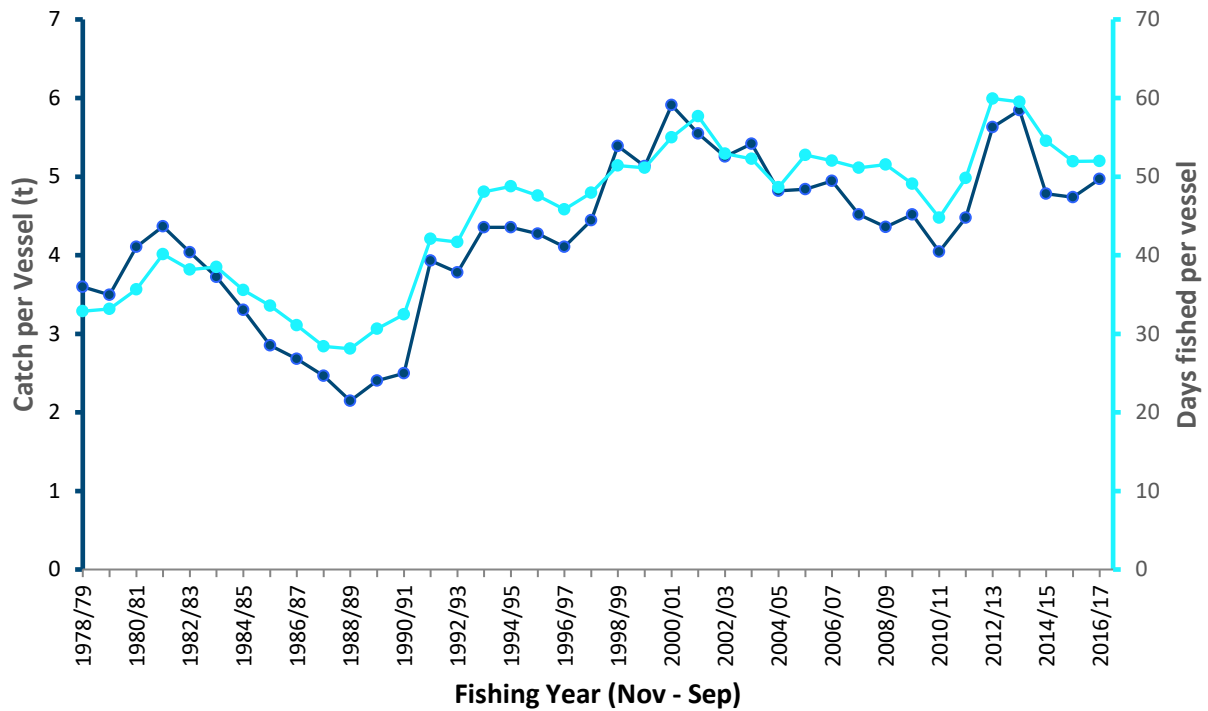


Figure 3: The annual mean catch and mean number of days fished per active fishing vessel in the Western Zone

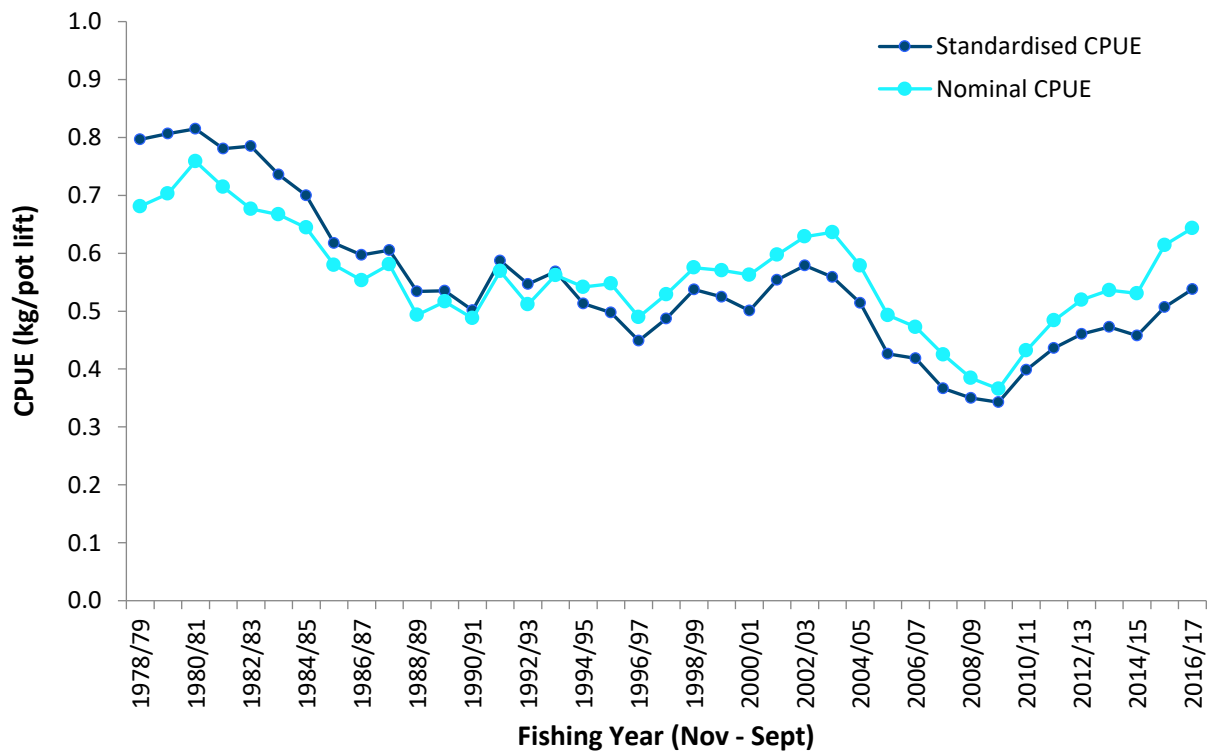
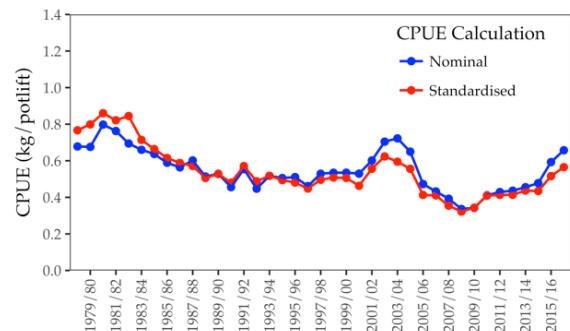
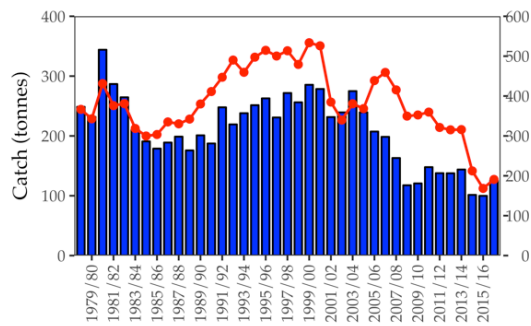
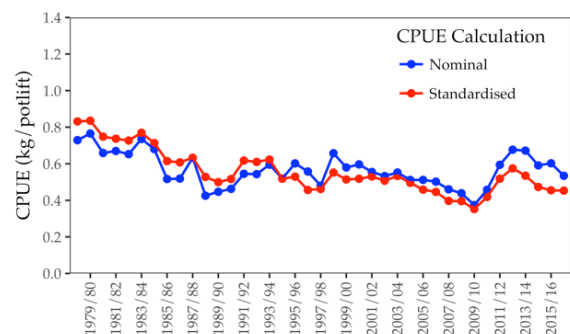
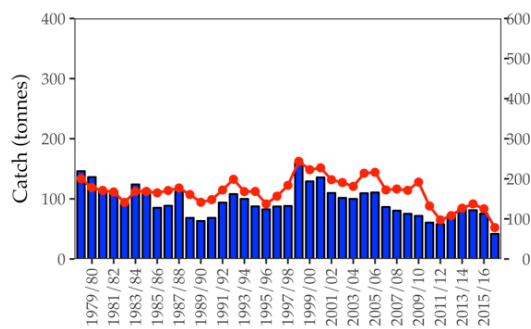
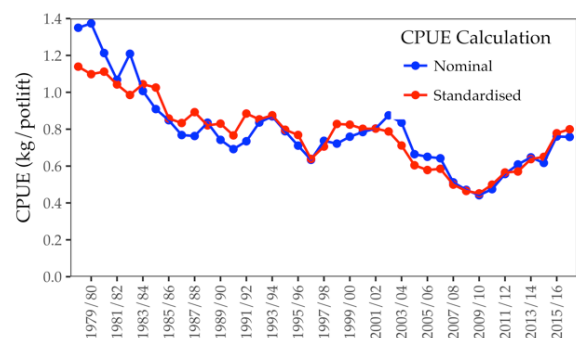
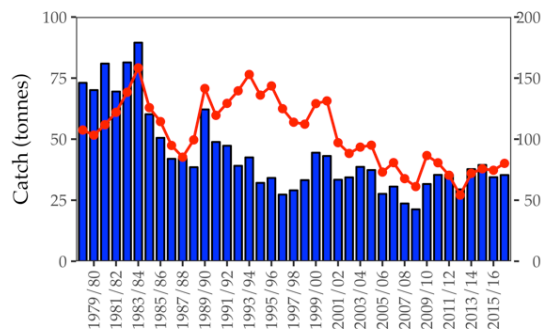


Figure 4: Standardised versus nominal CPUE (kg/potlift) in the Western Zone from 1978/79–2016/17. Note that standardised CPUE values differ slightly from one assessment to the next as the depth, seasonal and fisher coefficients are shared across years and are re-estimated including the new data.

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Fishing Year (Nov – Sept)

Figure 5: Regional catch (blue bars), effort (red line), and standardised CPUE (kg/potlift) in the Western Zone from 1978/79-2016/17.

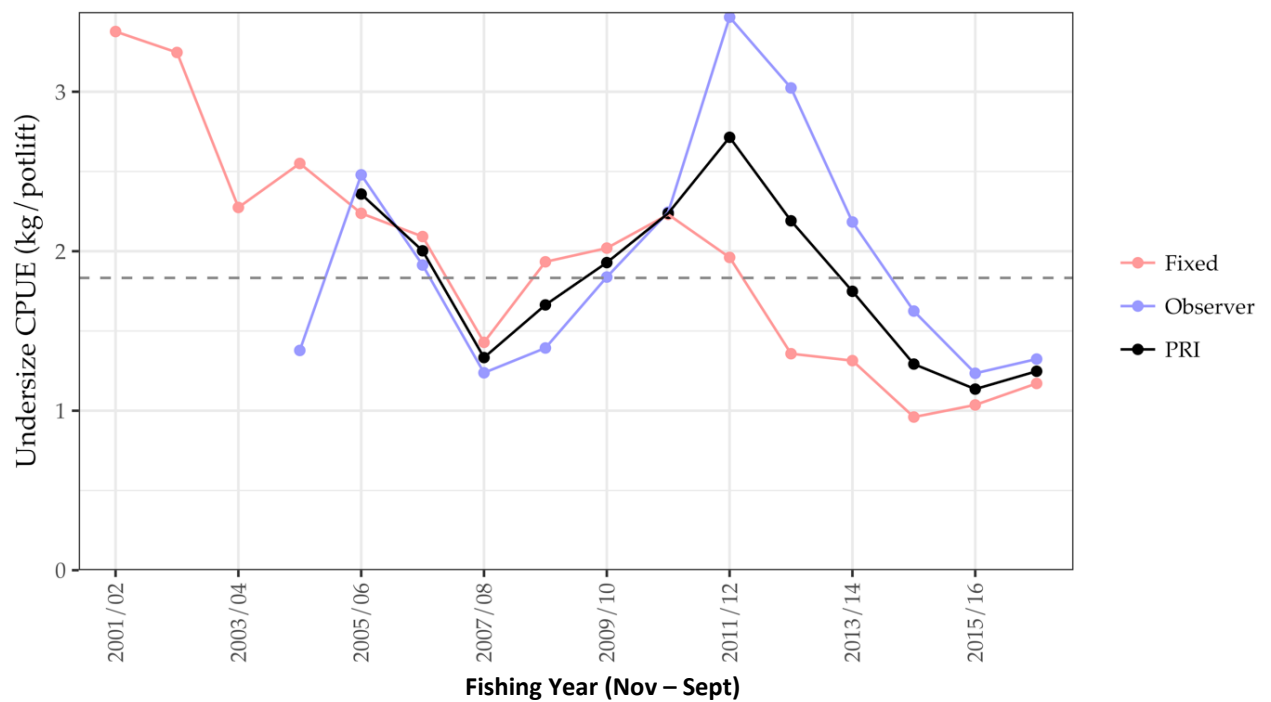


Figure 6: The undersize catch rate (kg/potlift) for the Western Zone as calculated from fixed sites, observer coverage and the final combined PRI. The dashed lines shows the trigger point (1.81 undersize/potlift).

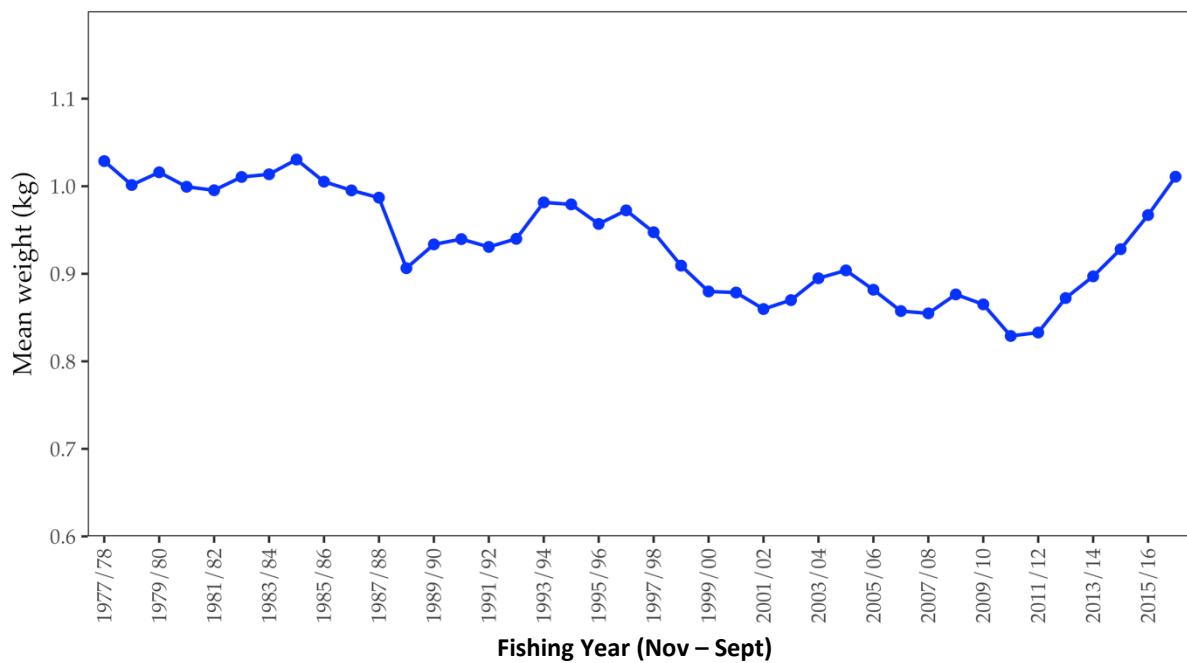


Figure 7: Mean weight of legal sized lobster in the Western Zone fishery from 1978/79 to 2016/17.

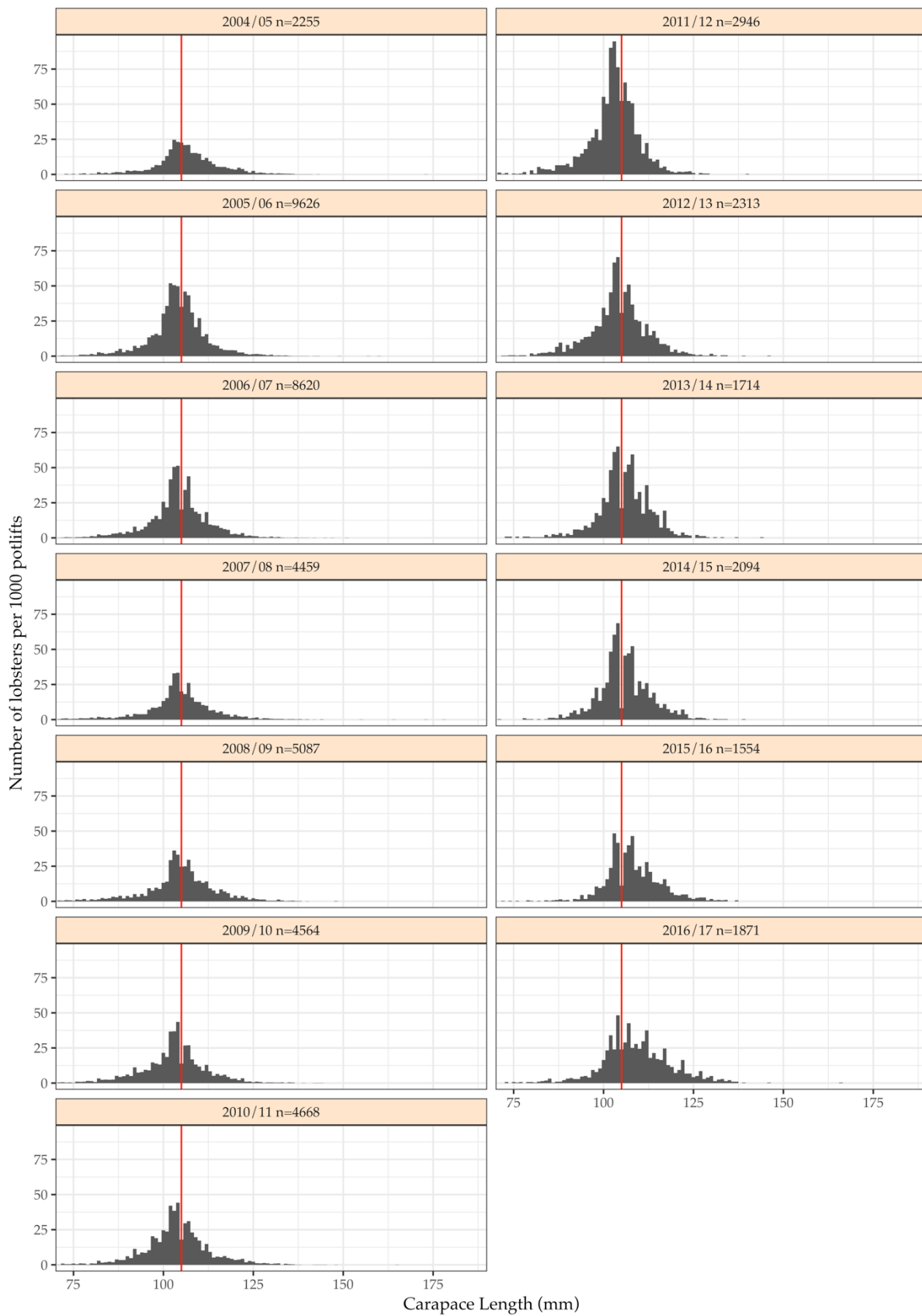


Figure 8: Length-frequency distribution of the number of female rock lobsters per 1,000 pot-lifts caught in the Western Zone on-board observer program from 2004–05 to 2016–17 fishing years (Nov–Sept). n, total number of lobsters measured.

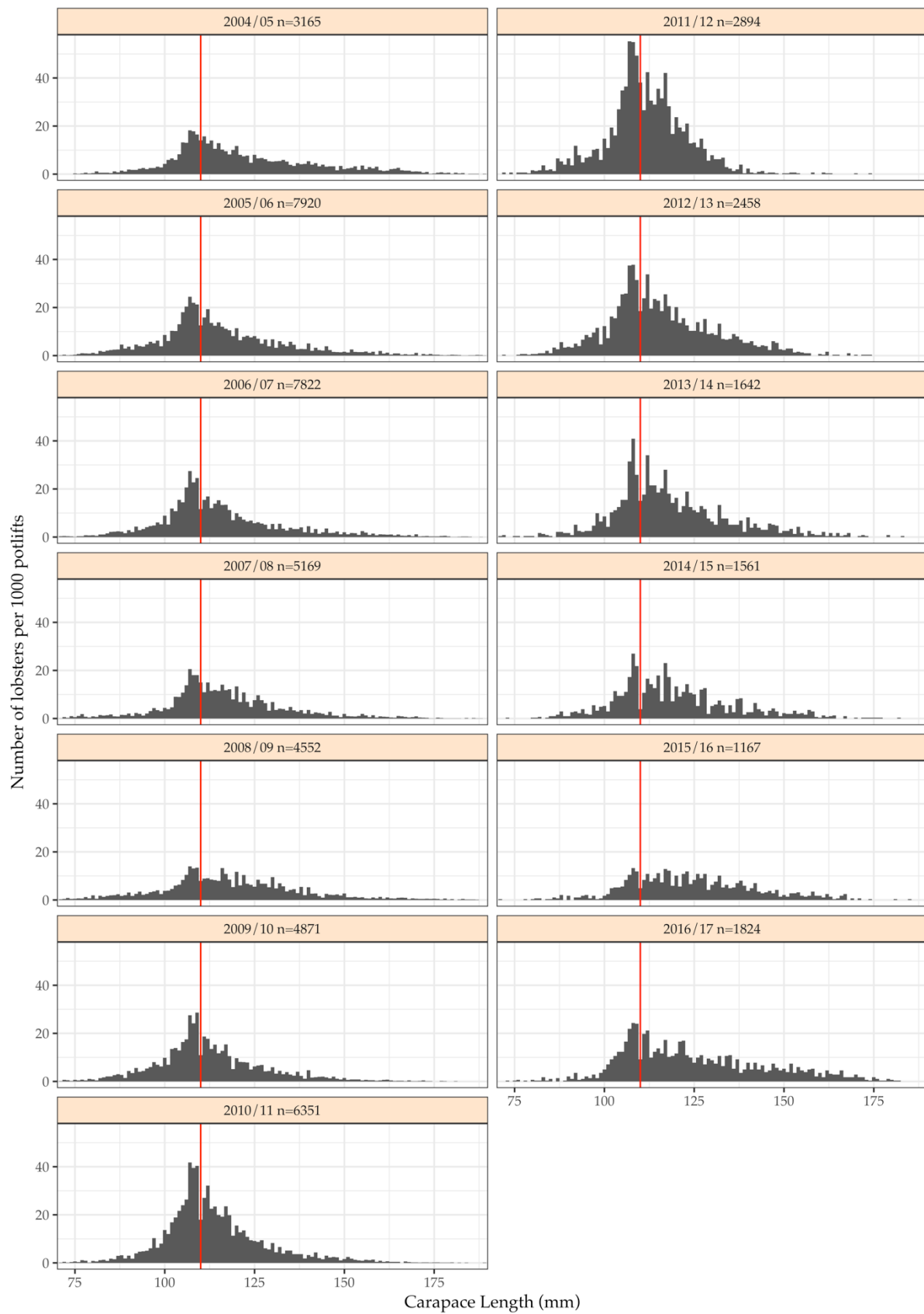


Figure 9: Length-frequency distribution of the number of male rock lobsters per 1,000 pot-lifts caught in the Western Zone on-board observer program from 2004–05 to 2016–17 fishing years (Nov–Sept). n, total number of lobsters measured.

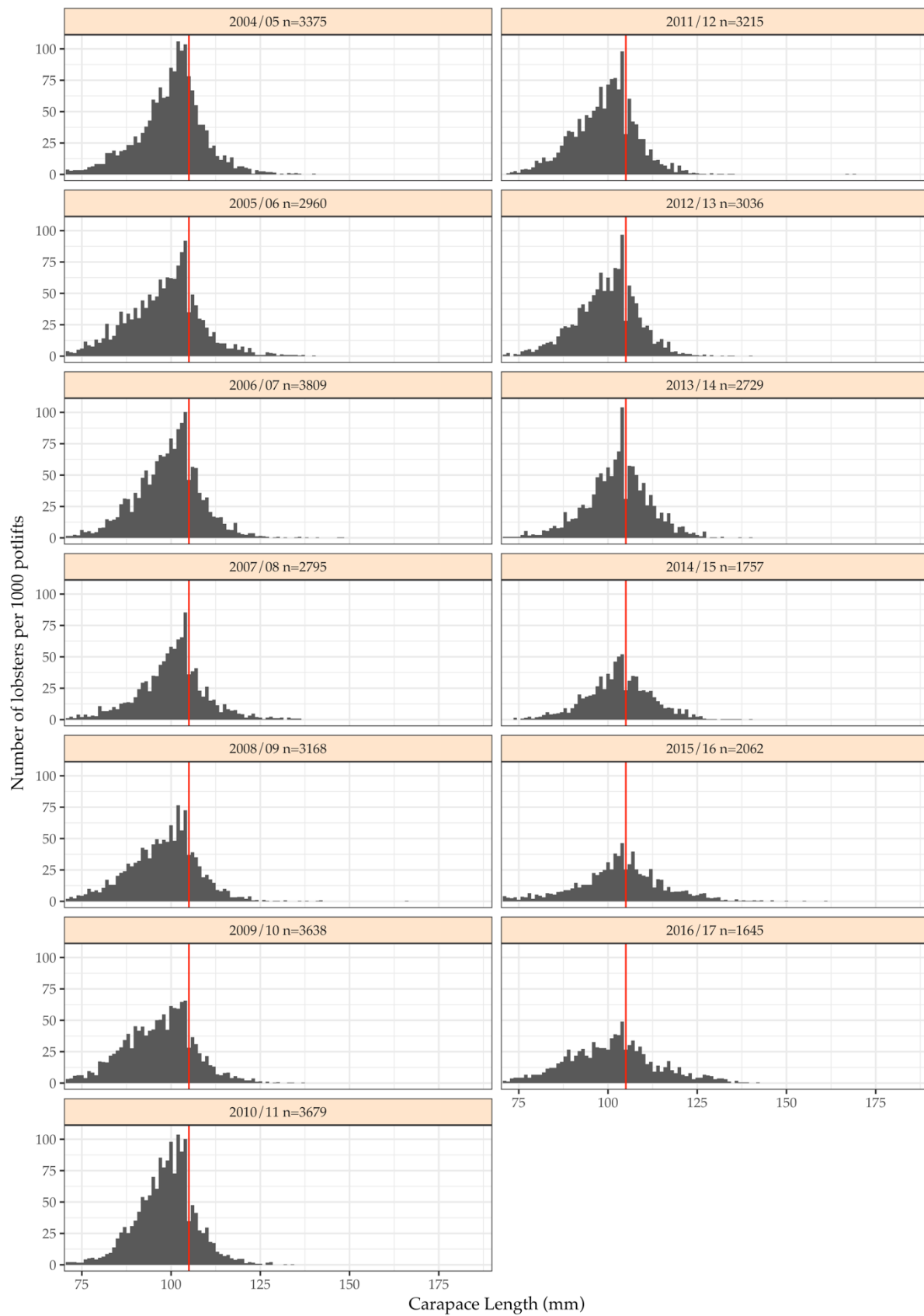


Figure 10: Length-frequency distribution of the number of female rock lobsters per 1,000 pot-lifts caught in the Western Zone fixed-site survey program from 1995–96 to 2016–17 fishing years (Nov–Sept). n, total number of lobsters measured.

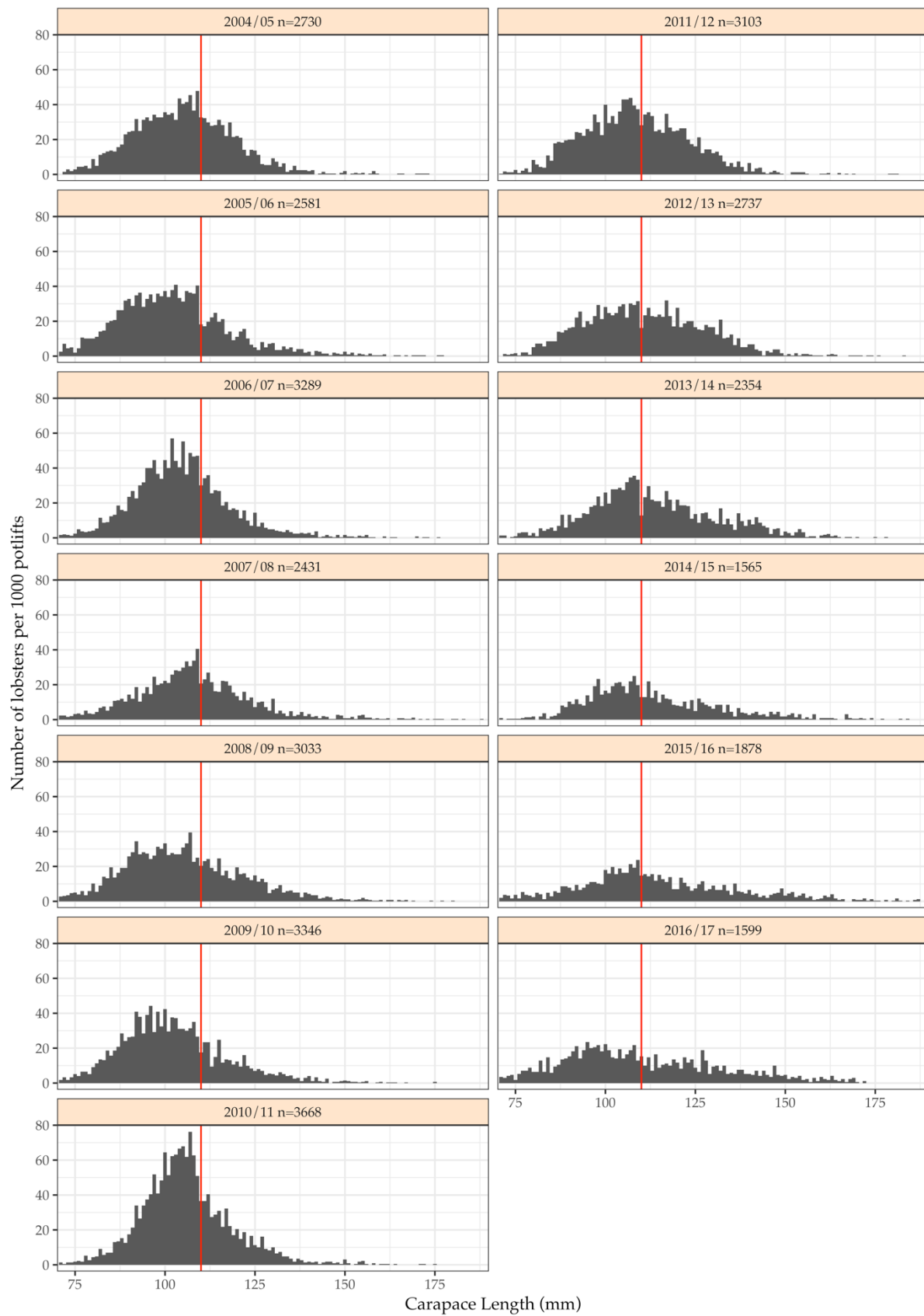


Figure 11: Length-frequency distribution of the number of male rock lobsters per 1,000 pot-lifts caught in the Western Zone fixed-site survey program from 1995–96 to 2016–17 fishing years (Nov–Sept). n, total number of lobsters measured.

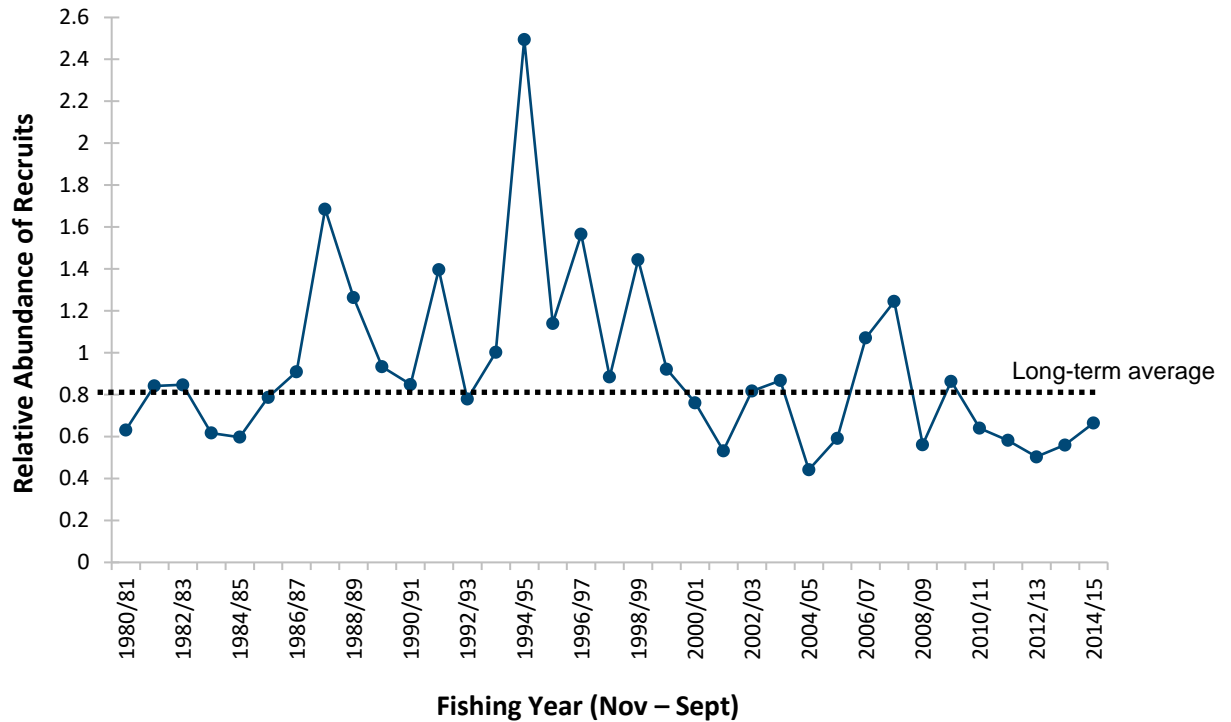


Figure 12: Relative number of recruits (to 60 mm in CL) in the Western Zone Fishery. These data are generated by the length-frequency model. The long-term average is indicated by the dotted black line. The most recent year plotted is 2014/15 as this is the most recent year for which reliable estimates are available.

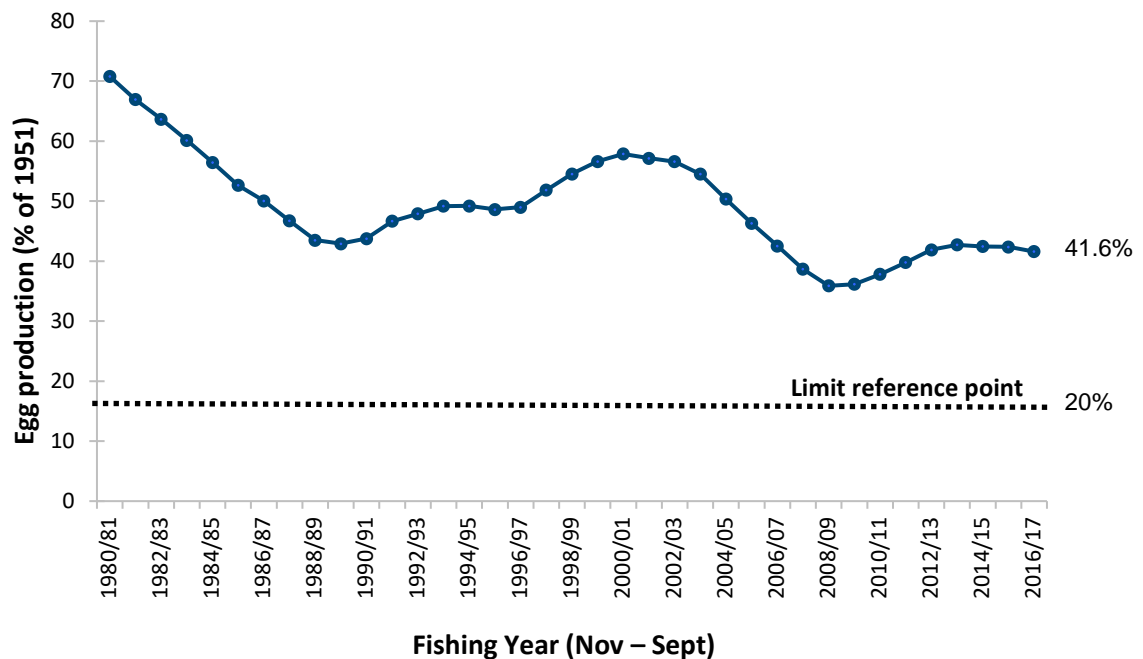


Figure 13: Model estimated level of egg production through time in the Western Zone fishery. The limit reference point (dotted line) is 20% of egg production estimated in 1951 (E_{1951}) as defined under the harvest strategy.

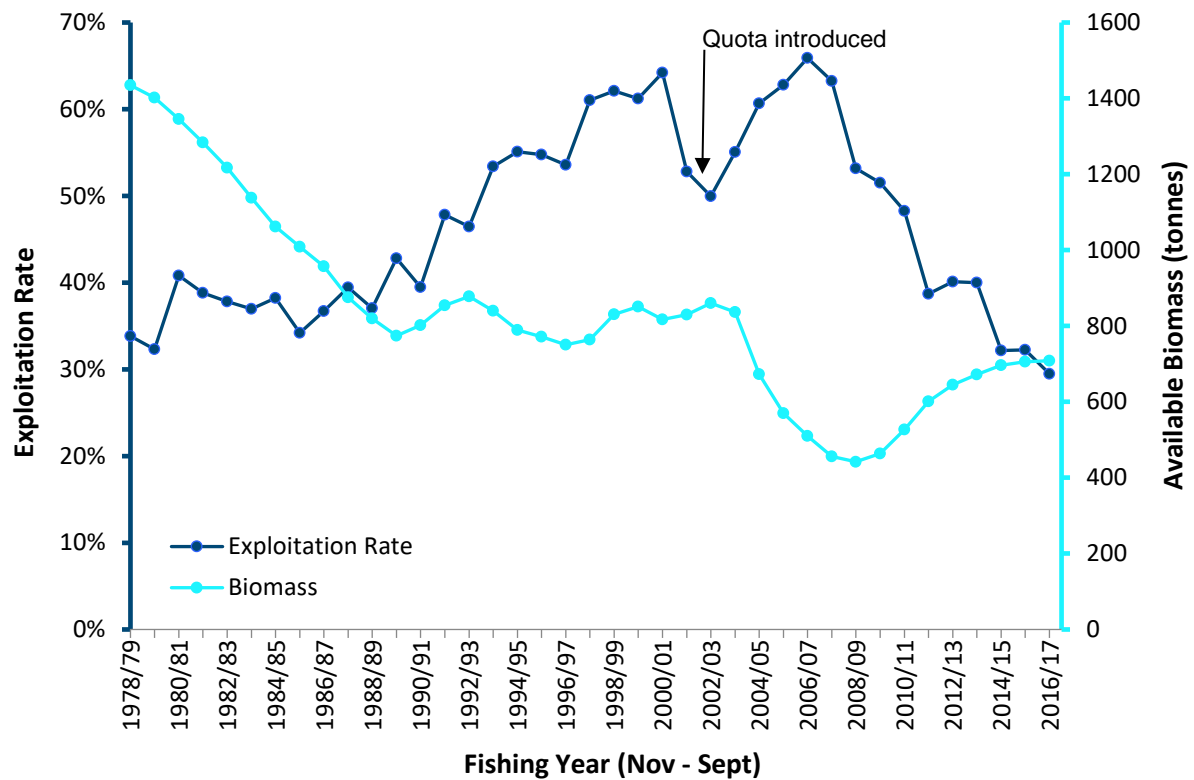


Figure 14: Model estimated levels of available biomass and associated fishing exploitation rates in the Western Zone fishery between 1978/79 and 2016/17.

8. EASTERN ZONE DATA

Table 3: Eastern Zone catch, fishing effort and CPUE (Fishing Year: November-September; SRL: Southern rock lobster; CPUE: Catch per unit effort).

Fishing Year	Catch (tonne)	Catch ('000)	Nominal Effort ('000 potlifts)	Nominal CPUE (kg/potlift)	Standardised CPUE (kg/potlift)	Mean Mass (kg/lob.)
1978/79	139	123	192	0.72	0.65	1.13
1979/80	115	108	171	0.67	0.66	1.07
1980/81	133	123	180	0.74	0.66	1.09
1981/82	131	120	193	0.68	0.62	1.09
1982/83	143	132	212	0.68	0.65	1.09
1983/84	136	128	230	0.59	0.56	1.06
1984/85	113	96	201	0.56	0.52	1.18
1985/86	95	81	175	0.54	0.46	1.17
1986/87	78	66	145	0.54	0.45	1.18
1987/88	70	62	130	0.54	0.40	1.13
1988/89	65	61	145	0.45	0.40	1.06
1989/90	84	85	198	0.42	0.38	0.99
1990/91	72	72	172	0.42	0.39	1.00
1991/92	65	64	175	0.37	0.35	1.02
1992/93	70	63	224	0.31	0.30	1.10
1993/94	79	68	260	0.30	0.29	1.17
1994/95	72	58	253	0.29	0.28	1.24
1995/96	57	48	220	0.26	0.28	1.19
1996/97	60	48	222	0.27	0.28	1.25
1997/98	66	54	220	0.30	0.28	1.23
1998/99	66	57	217	0.30	0.31	1.16
1999/00	73	68	228	0.32	0.31	1.07
2000/01	72	66	217	0.33	0.31	1.09
2001/02	54	50	151	0.36	0.34	1.08
2002/03	52	47	133	0.39	0.38	1.10
2003/04	56	52	133	0.42	0.41	1.09
2004/05	54	47	136	0.40	0.41	1.14
2005/06	52	46	122	0.43	0.41	1.14
2006/07	54	48	136	0.40	0.40	1.13
2007/08	46	39	123	0.38	0.39	1.19
2008/09	40	32	108	0.37	0.37	1.25
2009/10	55	49	145	0.38	0.41	1.11
2010/11	66	62	150	0.44	0.47	1.05
2011/12	62	55	114	0.54	0.54	1.13
2012/13	48	43	94	0.51	0.63	1.12
2013/14	59	48	114	0.52	0.60	1.22
2014/15	58	45	110	0.52	0.56	1.28
2015/16	50	39	114	0.44	0.47	1.30
2016/17	52	36	121	0.43	0.45	1.42

Table 4: Eastern Zone history of TACCs for each quota period from 2001-02 to 2015-16 (TACC: Total Allowable Commercial Catch).

Year	Season	TACC (t)	Catch (t)	% TACC Caught	Months Fished	Active Licenses	Vessels
2001-02	1 Nov - 31 Mar	42					
2002-03	1 Apr - 31 Mar	60	49.9	83	12	39	34
2003-04	1 Apr - 31 Mar	60	54.4	91	12	41	36
2004-05	1 Apr - 31 Mar	60	53.2	89	12	41	39
2005-06	1 Apr - 31 Mar	60	55.7	93	12	30	29
2006-07	1 Apr - 31 Mar	60	53.5	89	12	30	30
2007-08	1 Apr - 31 Mar	66	50.1	76	12	31	31
2008-09	1 Apr - 31 Mar	66	41.3	63	12	26	24
2009-09	1 Apr - 30 Jun	6.9	5.8	84	3	19	20
2009-10	1 Jul - 30 Jun	66	43.9	67	12	22	21
2010-11	1 Jul - 30 Jun	66	64.8	98	12	29	28
2011-12	1 Jul - 30 Jun	66	65.3	99	12	26	27
2012-13	1 Jul - 30 Jun	48	47.3	99	12	26	25
2013-14	1 Jul - 30 Jun	51	50.8	100	12	27	26
2014-15	1 Jul - 30 Jun	59	59	100	12	24	22
2015-16	1 Jul - 30 Jun	59	58	98	12	21	21
2016-17	1 Jul - 30 Jun	59	52.6	89	12	24	21

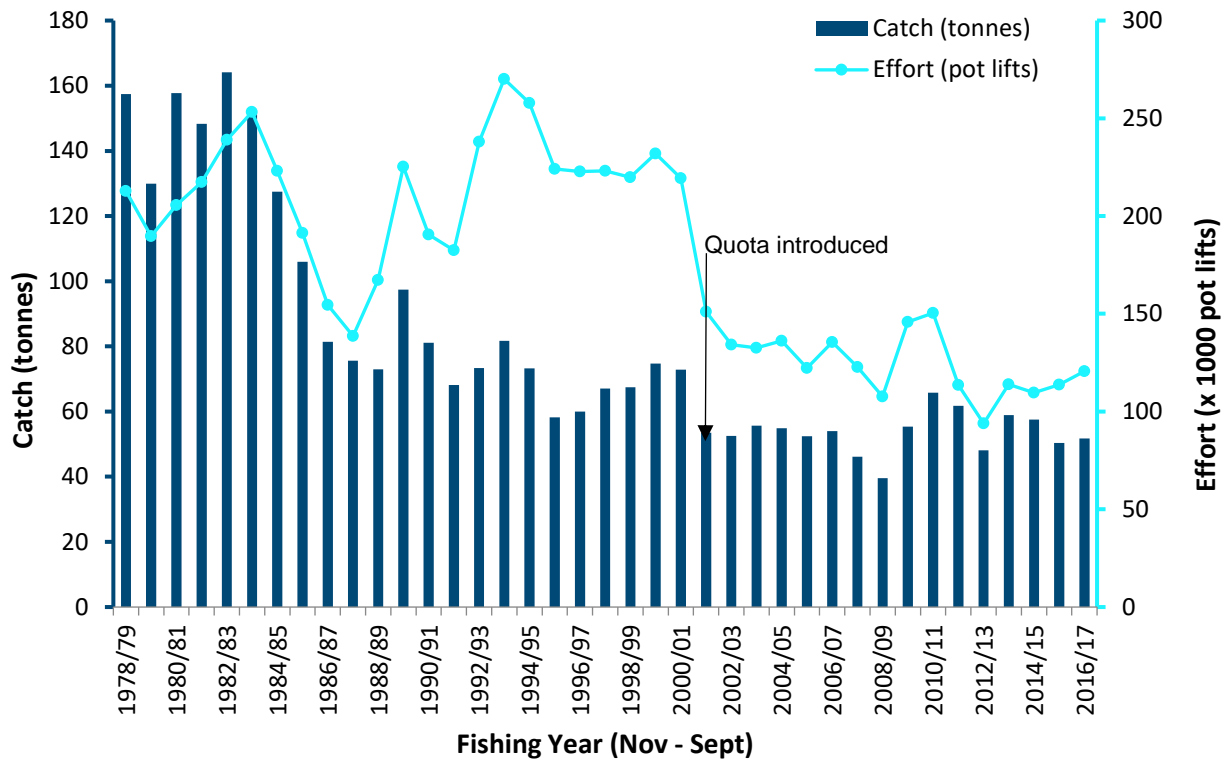


Figure 15: Total catch (tonnes) and nominal effort (x1000 pot-lifts) in the Eastern Zone from 1978/79–2016/17.

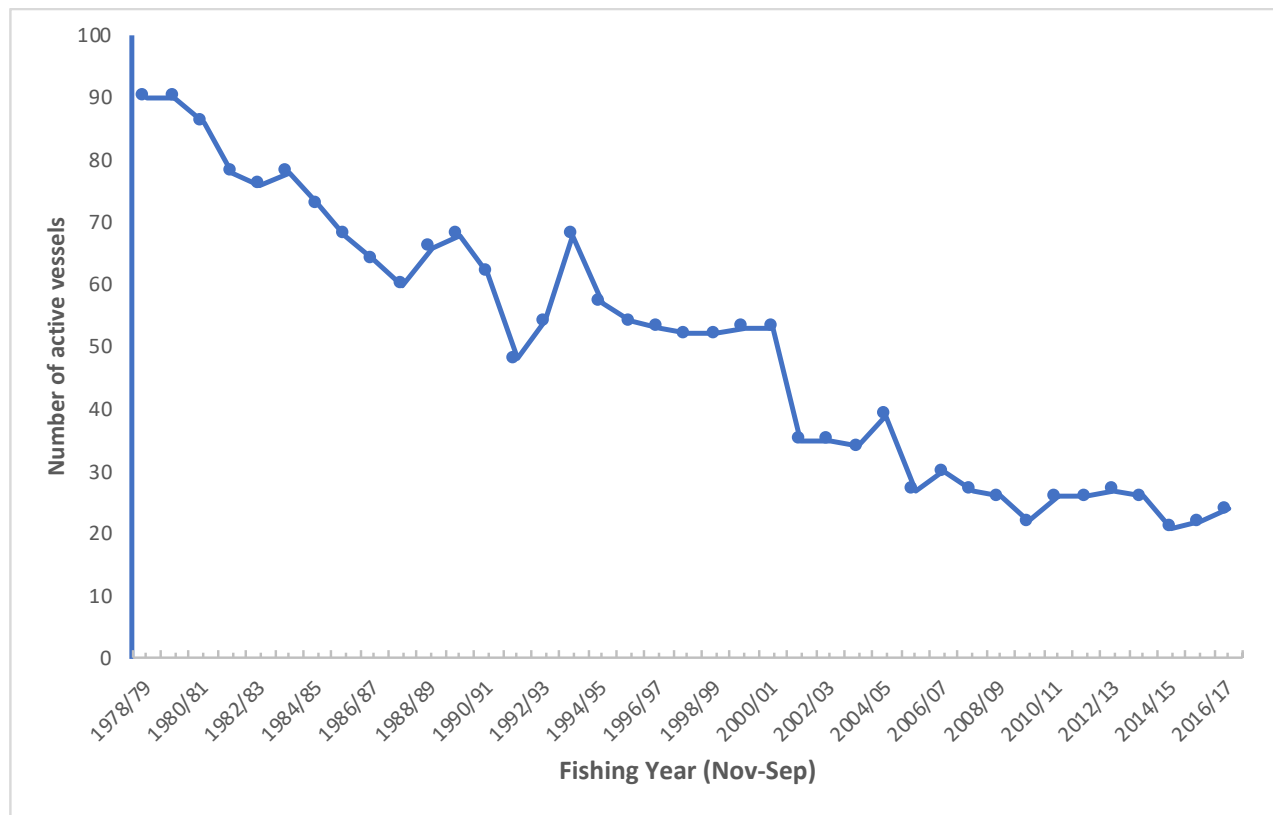


Figure 16: The number of active vessels in the Eastern Zone in each fishing year.

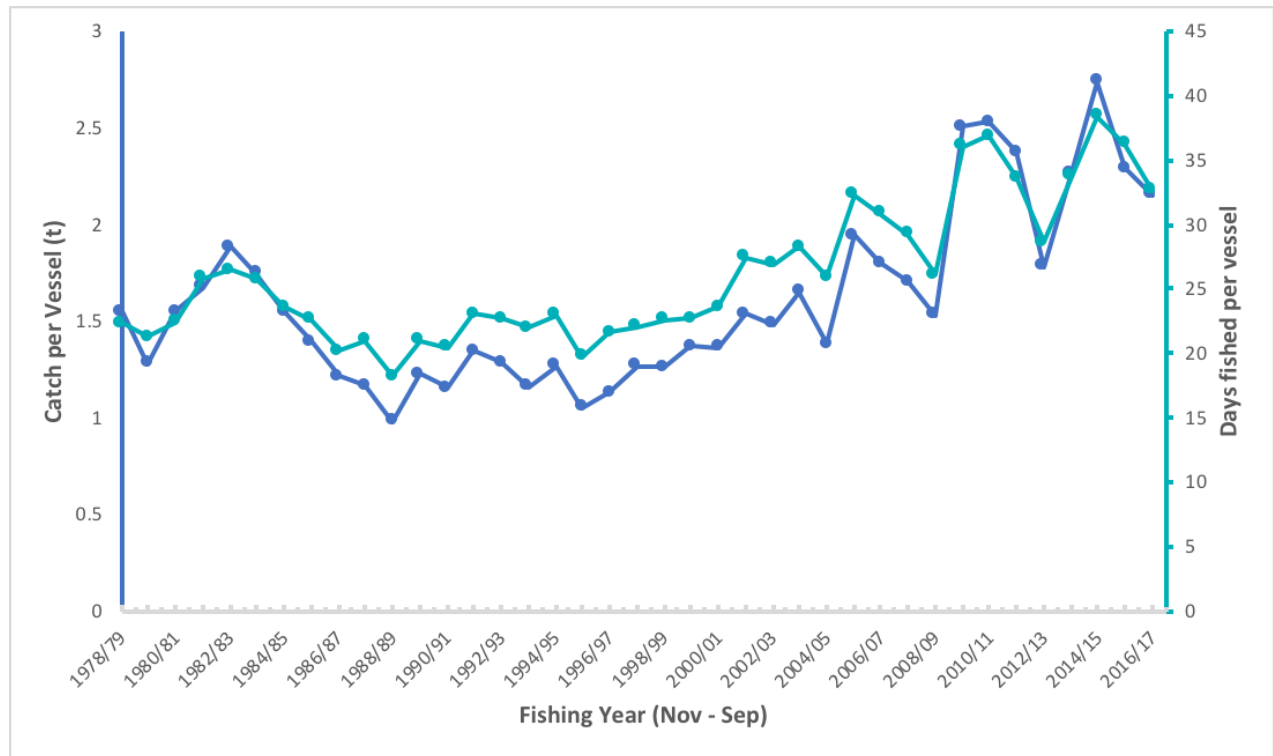


Figure 17: The annual mean catch and mean number of days fished per active fishing vessel in the Eastern Zone

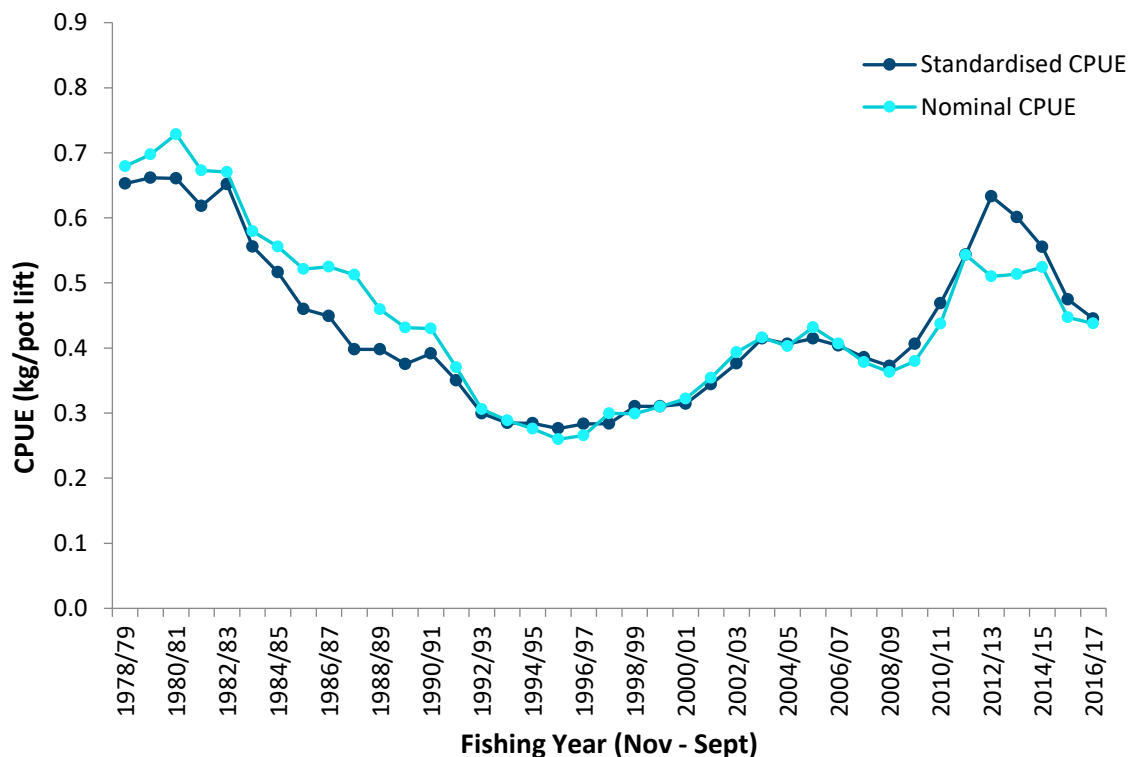
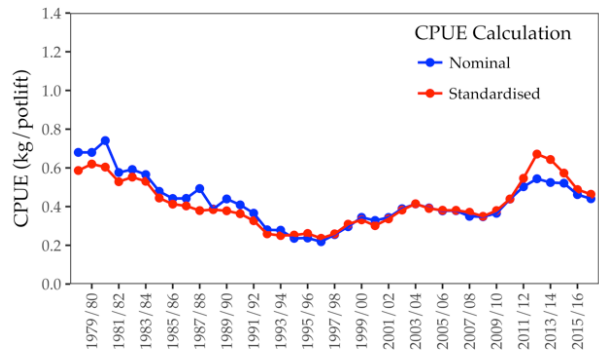
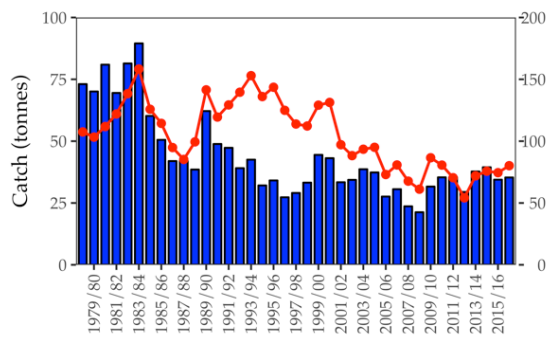
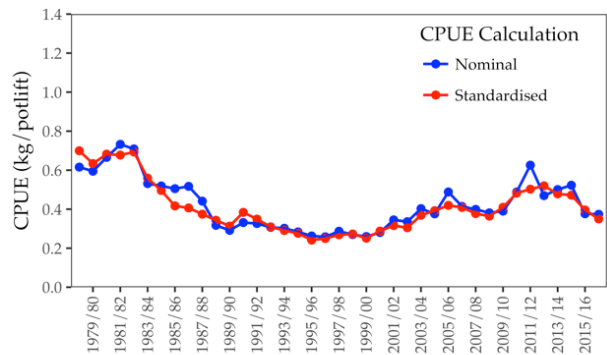
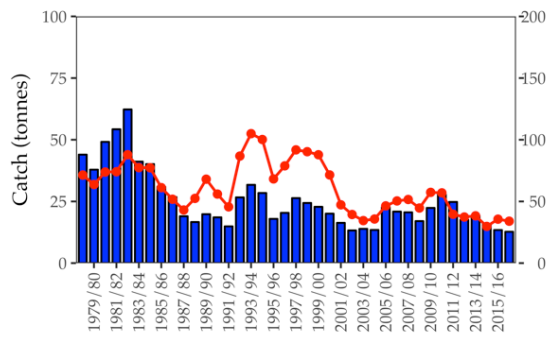
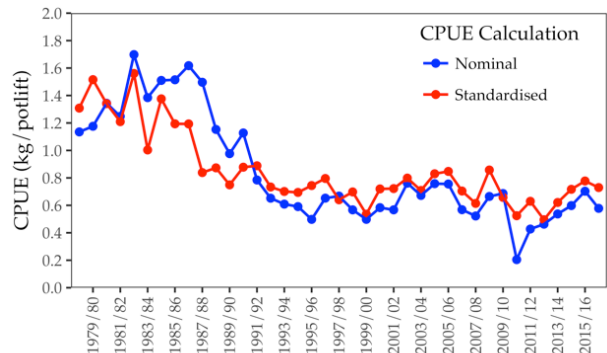
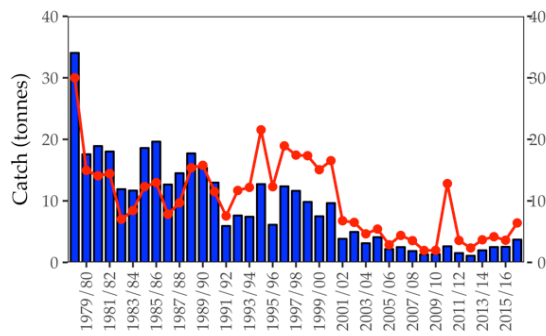


Figure 18: Standardised versus nominal CPUE (kg/pot-lift) in the Eastern Zone from 1978/79–2016/17. Note that standardised CPUE values differ slightly from one assessment to the next as the depth, seasonal and fisher coefficients are shared across years and are re-estimated including the new data.

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Fishing Year (Nov – Sept)

Figure 19: Regional catch (blue bars), effort (red line), and standardised CPUE (kg/potlift) in the Eastern Zone from 1978/79-2016/17.

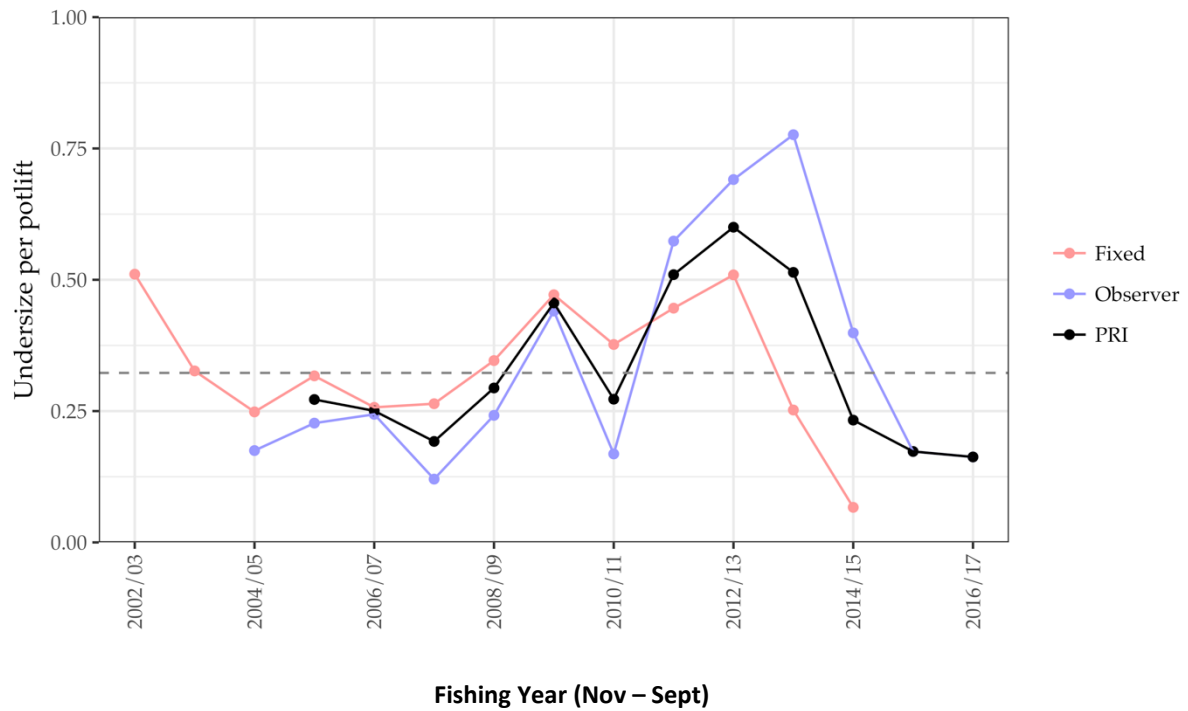


Figure 20: The undersize catch rate (kg/potlift) for the Eastern Zone as calculated from fixed sites, observer coverage and the final combined PRI. The dashed lines shows the trigger point (0.32 undersize/potlift).

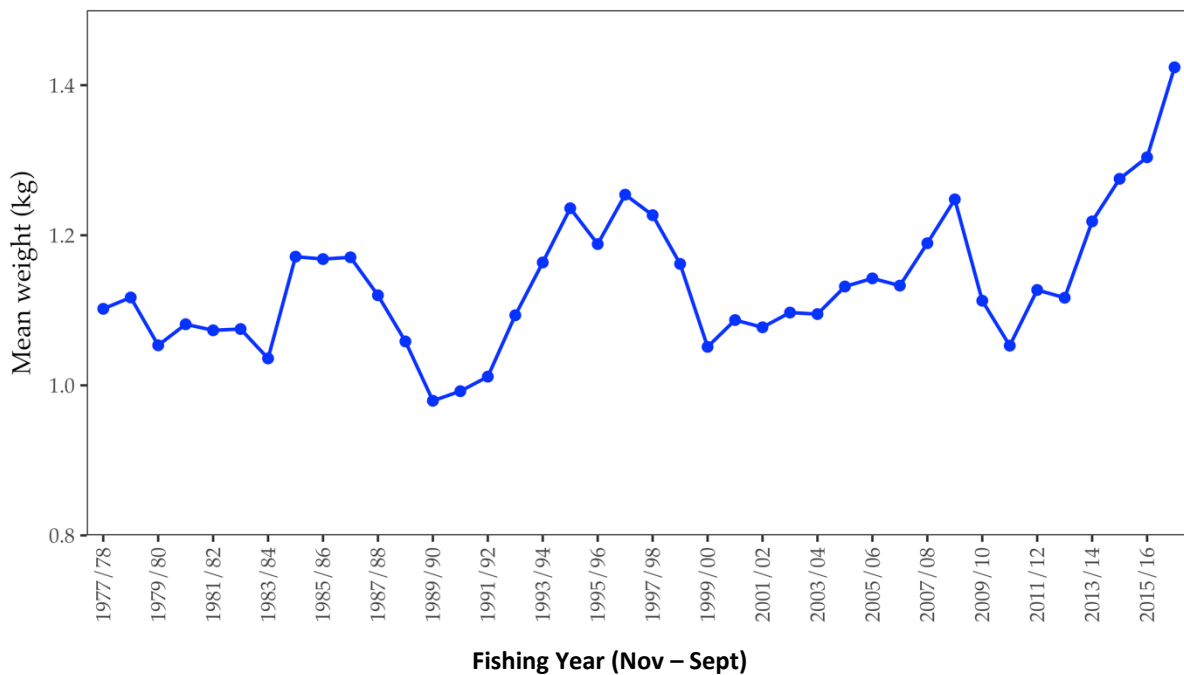


Figure 21: Mean weight of legal sized lobster in the Eastern Zone fishery from 1978/79 to 2016/17.

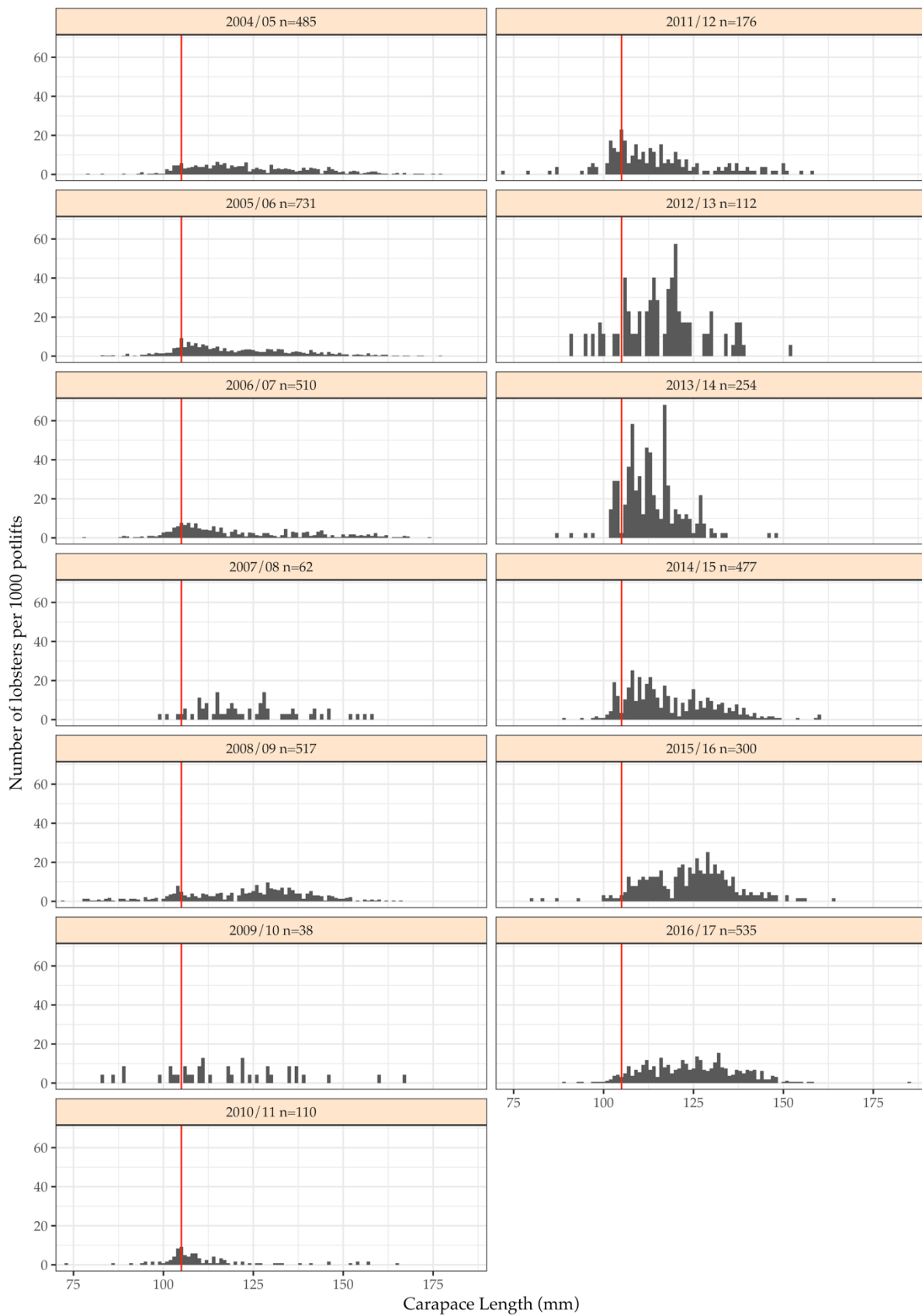


Figure 22: Length-frequency distribution of the number of female rock lobsters per 1,000 potlifts caught in the Eastern Zone onboard observer program from 2004–05 to 2016–17 fishing years (Nov–Sept). n, total number of lobsters measured.

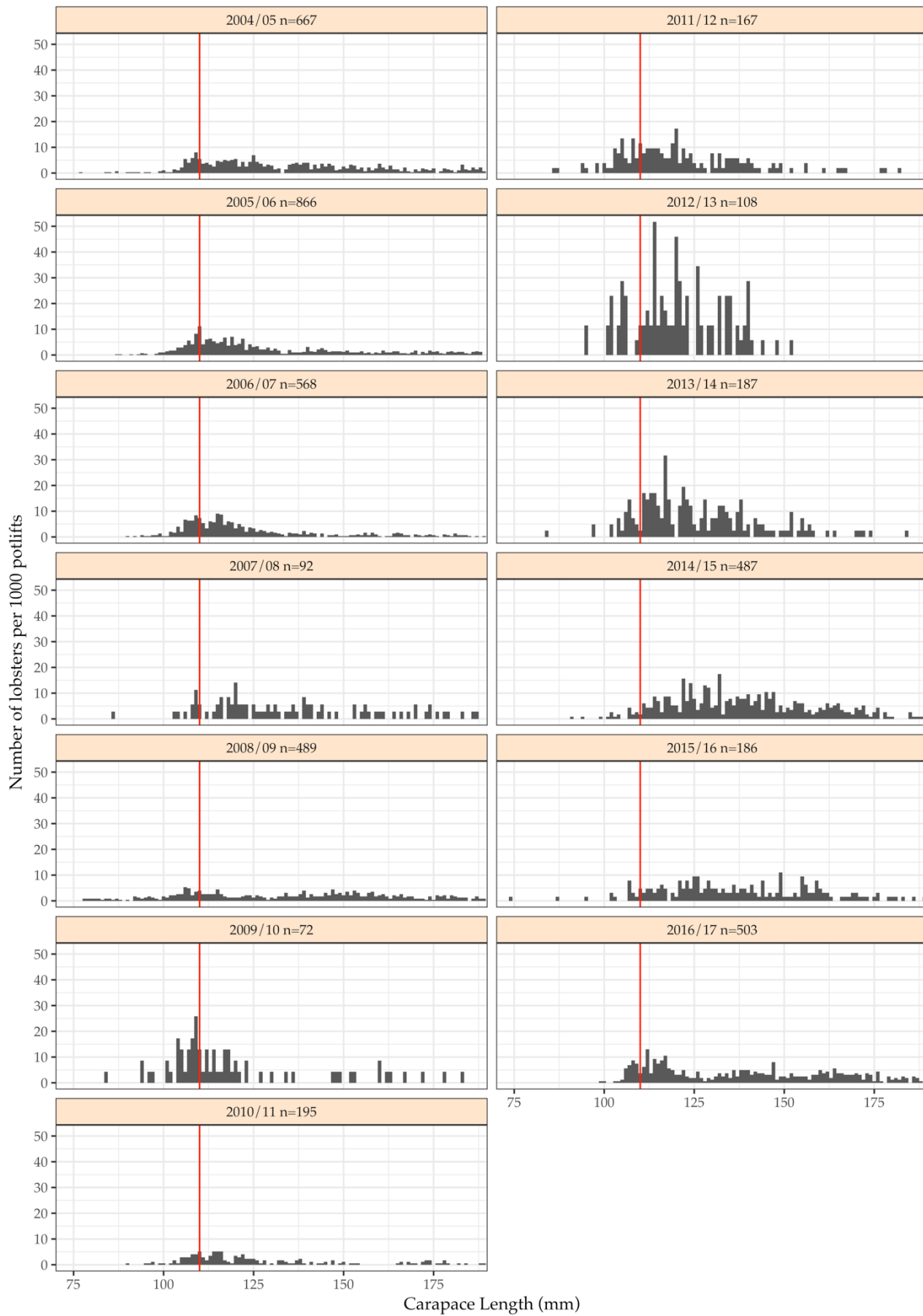


Figure 23: Length-frequency distribution of the number of male rock lobsters per 1,000 pot-lifts caught in the Eastern Zone on-board observer program from 2004–05 to 2016–17 fishing years (Nov–Sept). n, total number of lobsters measured.

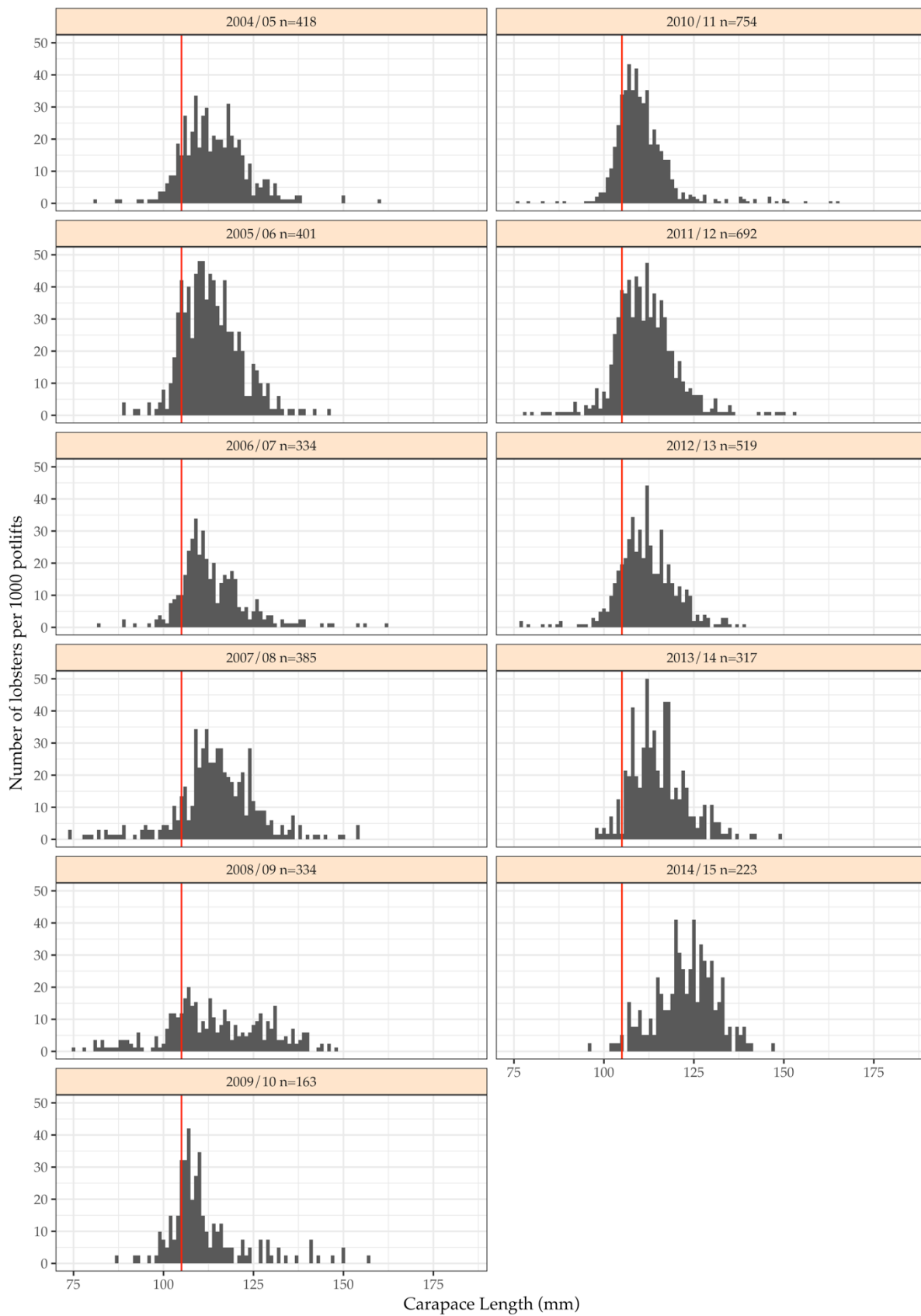


Figure 24: Length-frequency distribution of the number of female rock lobsters per 1,000 potlifts caught in the Eastern Zone fixed-site survey program from 1995–96 to 2014–15 fishing years (Nov–Sept), no new measurements were available from 2015–16.. n, total number of lobsters measured.

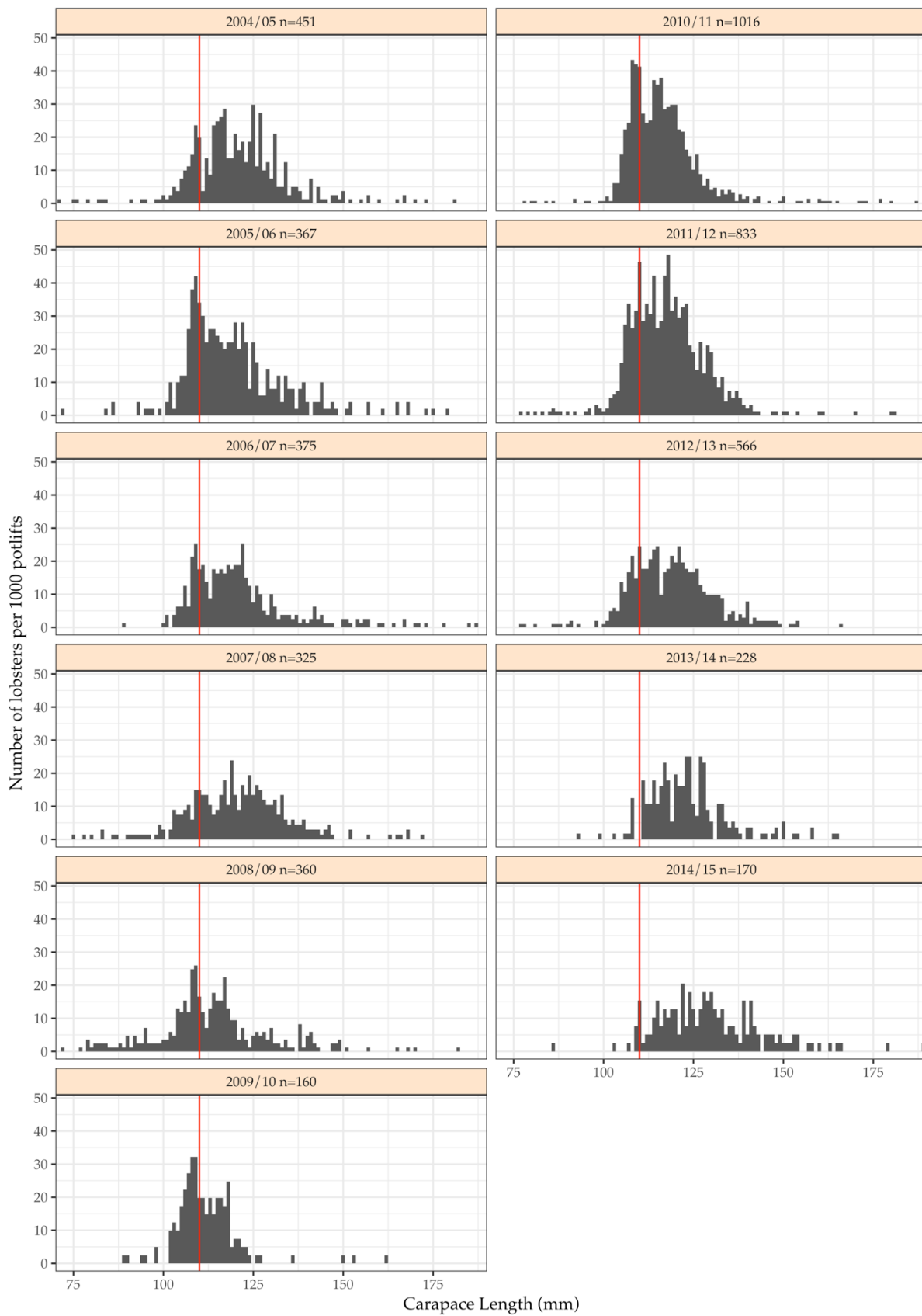


Figure 25: Length-frequency distribution of the number of male rock lobsters per 1,000 potlifts caught in the Eastern Zone fixed-site survey program from 1995–96 to 2014–15 fishing years (Nov–Sept), no new measurements were available from 2015–16.. n, total number of lobsters measured.

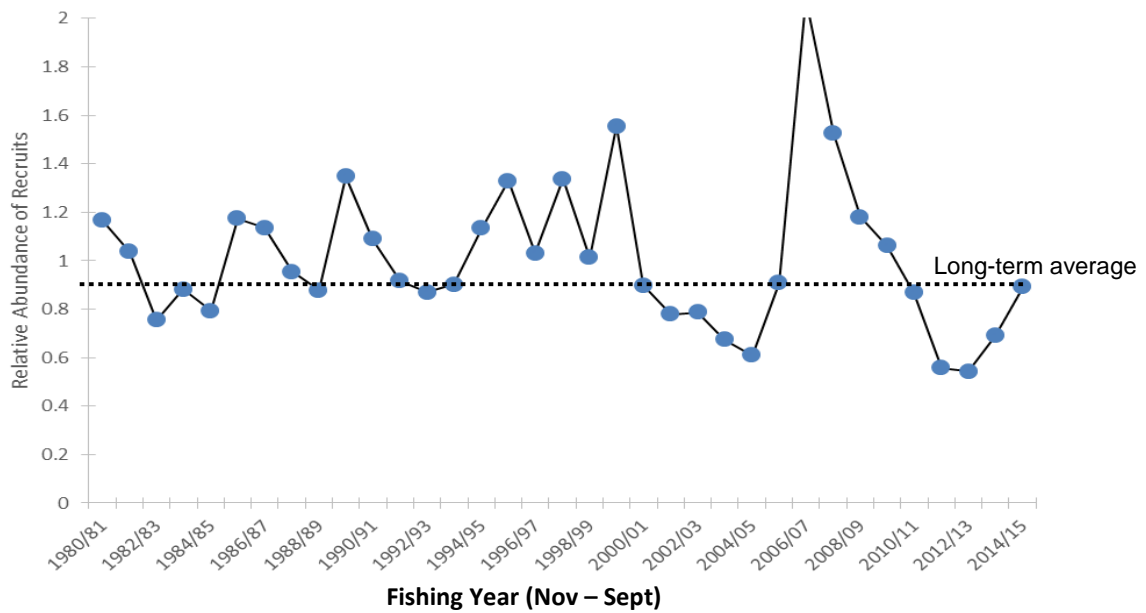


Figure 26: Relative number of recruits (to 60 mm in CL) in the Eastern Zone Fishery. These data are generated by the length-frequency model. The long-term average is indicated by the dotted black line.

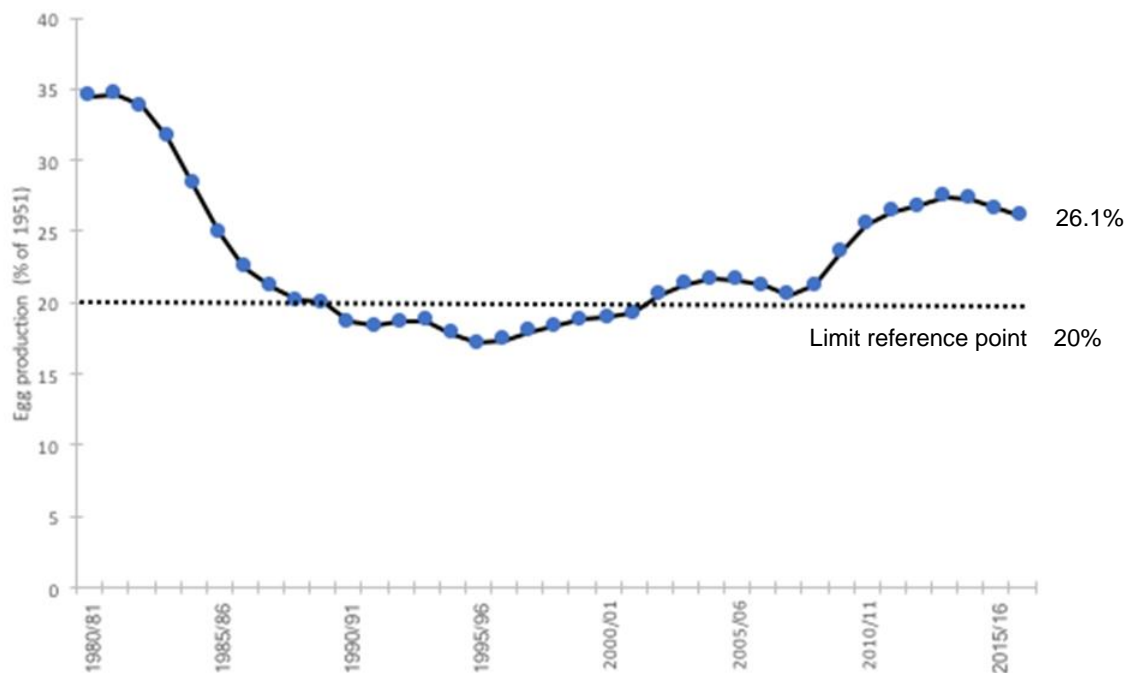


Figure 27: Model estimated level of egg production through time in the Eastern Zone fishery. The limit reference point(dotted line) is 20% of egg production estimated in 1951 (E_{1951}) as defined under the harvest strategy.

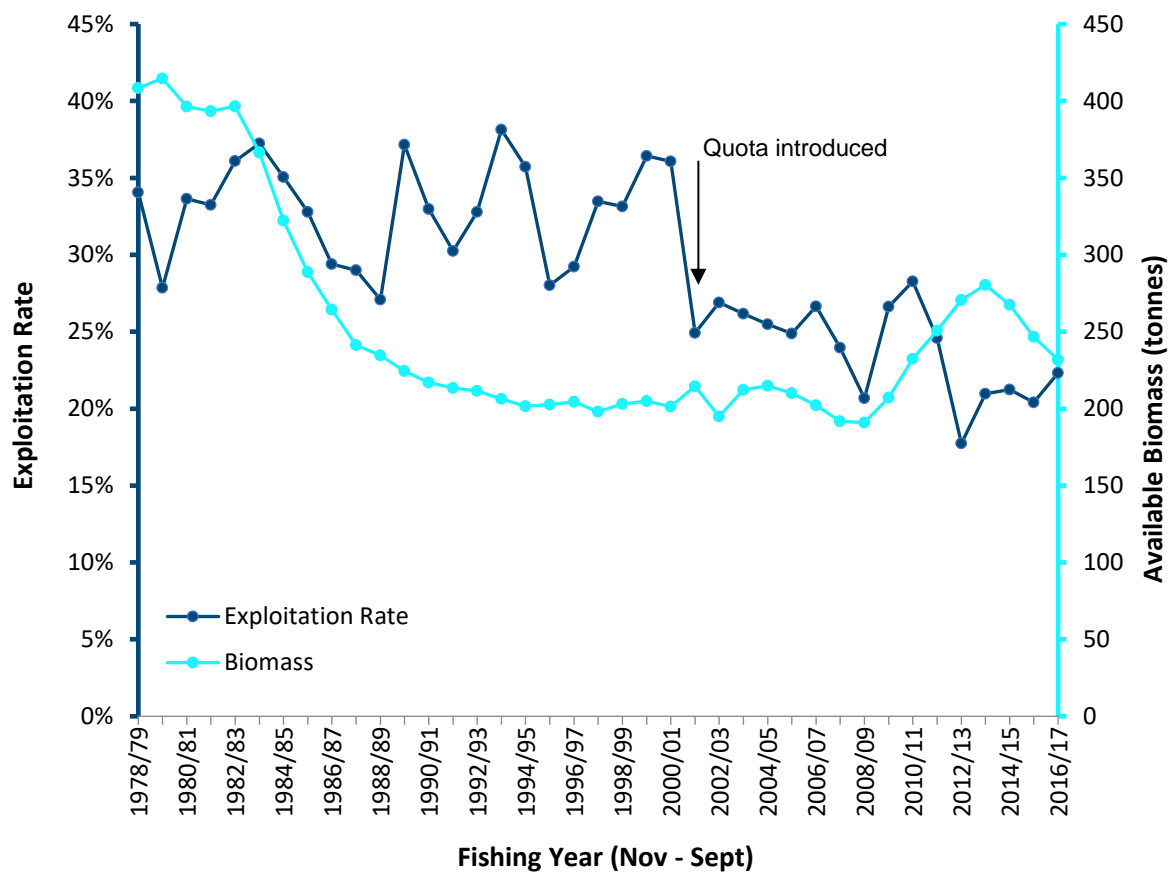


Figure 28: Model estimated levels of available biomass and associated fishing exploitation rates in the Eastern Zone fishery between 1978/79 and 2016/17.

Appendix 1: Rock Lobster Fishery Harvest Strategy (excerpt from the Victorian Rock Lobster Fishery Management Plan 2017)

Harvest strategies provide a structured framework for assessing the status of a fishery and a set of rules to determine what the annual catch limits will be. Decisions regarding catch limits are therefore set out in advance, ensuring that fishers, fishery managers and other relevant stakeholders know what action will be taken in response to the conditions in the fishery (Sloane et al 2014).

The foundation of this harvest strategy is the exploitation rate, which is the proportion of the available stock that can be caught. Unlike the previous harvest strategy used for the fishery, it does not include a rebuilding target so conservative exploitation rates that ensure that stocks rebuild, catch rates improve, profits are maximised and the objectives of this harvest strategy and management plan are met are used.

1. OPERATIONAL OBJECTIVES

This harvest strategy aims to achieve two main operational objectives, both of which link to the overarching objectives for the management of the fishery. These operational objectives are:

1. Continue to rebuild the rock lobster population by setting appropriately conservative TACCs on an annual basis.
2. Maintain catch rates above 0.40 kg/pot lift (standardised).

2. PRINCIPLES OF THE HARVEST STRATEGY

- The harvest strategy is based on standardised CPUE from commercial catch and effort logbook information and is derived from the 'fishing year data series' (i.e. November to September). All estimates of standardised CPUE are rounded to two decimal places.
- TACCs are predetermined and have been calculated using agreed rates of exploitation.
- TACCs are set by assessing the fishing zone's performance against stock performance indicators, biological reference points and applying decision rules. These factors include the standardised CPUE from that year's stock assessment, a pre-recruit index (PRI) and predefined TACC tables that determine whether the annual TACC is increased, maintained or decreased in the following season.
- The rate of exploitation is constant unless the annual standardised CPUE falls below 0.40kg/pot lift (the upper limit reference point), when it is incrementally reduced (Figure 9).
- The annual standardised CPUE will be rounded to two decimal points when it is at and above the upper limit reference point and the exploitation rate is constant (refer to the green zone in Figure 9). It will be increased to three decimal points when the annual standardised CPUE falls between the upper and lower limit reference points (refer to the orange zone in Figure 9).
- The fishery will be closed if the catch rate falls to 0.25kg/pot lift (the lower limit reference point) or less (Figure 9).
- To receive an increase in TACC, the annual PRI must be above the PRI threshold set for each zone.
- The TACC can only be increased by one level at any time ('one-jump rule').
- An upper limit, or cap, on TACC levels has been included in this harvest strategy. The cap for the Western Zone is 300 tonnes and 70 tonnes for the Eastern Zone.

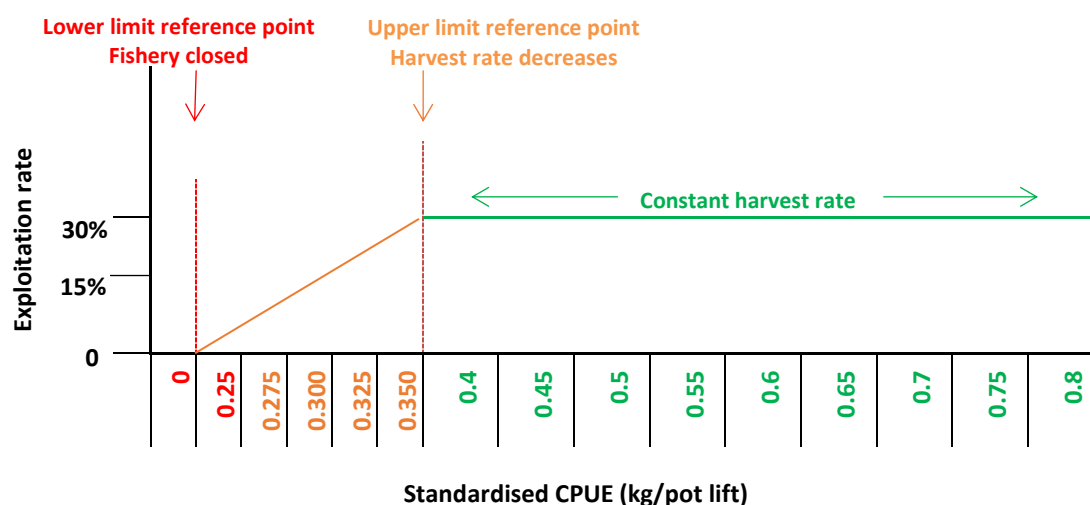


Figure 9. Theoretical construction of the proposed harvest strategy framework.

2.1 Exploitation rates

- The exploitation rates when the catch rate is at and above the upper reference point are:
 - 32.5% in the Western Zone; and
 - 15.0 % in the Eastern Zone.

2.2 Stock performance indicators

Performance indicators measure and track the performance of the stock against the operational objectives in this harvest strategy and are integral in determining the level at which the TACC will be set.

Three biological performance indicators are used in setting the TACC:

1. **Egg production** – an estimate of the spawning size of the population. It is a crucial determinant of the health of the stock and is used in this strategy as a primary indicator in the decision rules.
2. **Standardised CPUE** – CPUE data comes from the catch and effort logbooks submitted by commercial fishers. In lobster fisheries, CPUE is accepted as being proxy representing the abundance of rock lobsters in the fishery above the legal minimum length. It is expressed as the effort required to harvest a defined amount of catch. Standardised CPUE has had irregularities in the data removed and it has been standardised for a range of factors that affect catchability, such as month, year, depth, region and fisher (i.e. the ability and practices of fishers)
3. **Pre-recruit index** – is the number of undersize lobsters per pot lift and is derived from the data collected through the fixed-site survey and on-board observer programs. The annual PRI will be rounded to two decimal places.

A further performance indicator, available biomass, will be used in the assessment of the fishery. This indicator however does not result in explicit TACC adjustments in the fishery in the way egg production, standardised CPUE and pre-recruit index do. Available biomass, as well as historic exploitation rates, is used to provide a more comprehensive picture of the status of the fishery and trends over time.

2.3 Reference points for the performance indicators

Reference points are the benchmarks of performance that define acceptable levels of impact on a stock (Sloane et al. 2014). Reference points are usually linked to the performance indicators and three types have been used; these are limit, threshold and target reference points.

Limit reference points

Limit reference points (LRP) act like a safety measure as they establish the point at which there is significant risk to the sustainability of the stock. The LRPs used in this harvest strategy are:

1. Egg production LRP

Model estimated egg production must be above the LRP of 20% of E_{1951} with a 90% probability.

2. Standardised CPUE LRP

An upper and a lower LRP have been established, both of which are CPUE-based.

- a. Upper LRP: 0.40kg/pot lift
- b. Lower LRP: 0.25kg/pot lift

If the standardised CPUE starts to fall and then breaches the upper LRP, the harvest rates are decreased sequentially until the lower LRP is reached. If the LRP point is breached, the fishery will be closed to all fishing.

Threshold reference point

Threshold reference points can represent a threshold value which triggers a certain management action or a pre-determined management response.

Pre-recruit index threshold

In this harvest strategy, threshold reference points have been established for the PRI. The PRI threshold is determined using data from the fixed-site surveys and on-board observer program and is averaged, weighted by region based on past commercial catch during a reference period of 2005 to 2014.

To be eligible for an increase in the TACC in an upcoming season, the PRI for that stock assessment period must be above the threshold level for that zone.

The PRI thresholds are:

- 1.81 undersize per pot lift in the Western Zone; and
- 0.32 undersize per pot lift in the Eastern Zone.

Target reference point

The target reference point defines the level or value of an indicator that is considered ideal or desirable and at which management should aim.

Maximum economic yield

A target reference point is not explicit in this harvest strategy; however, it is an objective of the management plan to develop a long-term maximum economic yield (MEY) target reference point for the stock. MEY is the theoretical catch or effort level that maximises the profit of the commercial fishery. MEY occurs when the total fishing revenue minus total fishing costs is maximised. Economic efficiency in a fishery suggests that the stock is protected and the net returns (i.e. the profits) for fishers are maximised (Australian Government 2007).

3. DECISION RULES TO SET THE TACC

The annual TACC will be set using the following decision rules:

Decision Rule 1: Egg production

Model estimated egg production must be above the limit reference point of 20% of E_{1951} with a 90% probability. This decision rule must be satisfied before the CPUE-based harvest strategy can be used to set the TACC.

If this decision rule is not met, the TACC will be determined using the rock lobster fishery model to ensure that the TACC returns the egg production to above the limit reference point within two years with a 90% probability.

Decision Rule 2: TACC Determination

When Decision Rule #1 has been met, the TACC is set using the standardised CPUE tables. Refer to Tables 7 and 8, for the Western and Eastern Zones, respectively.

Step 1: Use the standardised CPUE from the preceding season to identify the CPUE band.

Step 2: Determine the TACC level according to the following conditions:

1. The TACC will be **increased** to the next level when:
 - i. the standardised CPUE is in a band higher than in the previous season;
AND
 - ii. the PRI (rounded to two decimal places) is at or above the threshold level of 1.80 undersize per pot lift for the Western Zone or 0.32 undersize per pot lift for the Eastern Zone.

One-jump rule: the TACC can only be increased one level per year.

2. The TACC will **remain at the same level** when:
 - i. the standardised CPUE remains in the current band;
OR
 - ii. the standardised CPUE has increased to a higher band but the PRI is below the trigger point.

3. The TACC will be **decreased** when:
 - i. the standardised CPUE has decreased into any lower band.

The TACC will be set at the level that corresponds to the standardised CPUE.

Decision Rule 3: TACC Cap

A TACC cap of 300 tonnes in the Western Zone and 70 tonnes in the Eastern Zone will be used over the life of the harvest strategy.

4. TACC TABLES

The levels of TACC are pre-set and based on the chosen harvest rate. The values of the TACCs and the corresponding CPUE are in the Tables 8 and 9. These tables, in association with the decision rules will be used to set the TACCs for the fishery over the life of the Management Plan.

- The TACC tables consist of CPUE bands and corresponding TACC levels. The tables comprise three levels, which correspond to the upper and lower limit reference points:
 - The CPUE are set at bands of 0.05kg/pot lift when the standardised CPUE is above the upper limit reference point of 0.40kg/pot lift.
 - The band-widths of the TACC levels reduce to 0.025kg/pot lift when the standardised CPUE is between 0.25kg/pot lift and 0.40kg/pot lift.
- If the standardised CPUE drops below 0.25kg/pot lift, the fishery in that zone will be closed to all fishing (commercial and recreational). To determine the status of the fishery in that zone after the closure:
 - Fishing is to be undertaken through the fixed-site survey program, using the survey protocols used in previous seasons;
 - A fixed-site survey measure of CPUE will be computed; and,
 - A re-scaling method will be applied to convert the fixed-site survey CPUE to standardised CPUE.

Table 8. CPUE thresholds and corresponding TACC levels for the Western Zone.

WESTERN ZONE	
CPUE band	TACC Levels - with 300t cap
<0.25	0
0.250 - <0.275	19
0.275 - <0.300	42
0.300 - <0.325	69
0.325 - <0.350	100
0.350 - <0.375	134
0.375 - <0.40	171
0.40 - <0.45	219
0.45 - <0.50	245
0.50 - <0.55	271
0.55 - <0.60	297
0.60 - <0.65	300
0.65 - <0.70	300
0.70 - <0.75	300
0.75 - <0.80	300

Table 9. CPUE thresholds and corresponding TACC levels for the Eastern Zone.

EASTERN ZONE	
CPUE band	TACC Levels - with 70t cap
<0.25	0
0.250 - <0.275	4
0.275 - <0.300	8
0.300 - <0.325	14
0.325 - <0.350	20
0.350 - <0.375	26
0.375 - <0.400	33
0.40 - <0.45	42
0.45 - <0.50	47
0.50 - <0.55	51
0.55 - <0.60	56
0.60 - <0.65	60
0.65 - <0.70	65
0.70 - <0.75	69
0.75 - <0.80	70

- Blue TACC values refer to the TACC cap
- Green TACC values refer to standardised CPUE values that are above the upper LRP and have a constant exploitation rate (32.5% in the Western Zone and 15% in the Eastern Zone).
- Orange TACC values refer to standardised CPUE values below the upper LRP and have incrementally decreasing exploitation rate

