

# Victorian Rock Lobster Fishery

## Stock Assessment Report

### 2018/19 Season

Victorian Fisheries Authority

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Published by the Victorian Fisheries Authority (VFA), 2020



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

Printed by VFA Melbourne, Victoria.

Preferred way to cite this publication:
VFA (2020) 2018/19 Victorian Rock Lobster Stock Assessment. Victorian Fisheries Authority Report Series No.10

**ISBN** 978-1-76090-288-9 **(Print)**
**ISBN** 978-1-76090-289-6 **(pdf/online/MS word)**

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# Contents

# Victorian Rock Lobster Fishery

## Stock Assessment Report for the 2018/19 Season

## 1. EXECUTIVE SUMMARY

### Overview

This report details the results of the 2018/19 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 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. This 2018/19 assessment will be used to support the TACC setting process for 2020/21.

### Western Zone Rock Lobster Fishery

The TACC for the Western Zone in 2018/19 was 245 tonne (t) as a result of the introduction of the harvest strategy. This represents a 15t increase from the previous TACC of 230t which was in place for four consecutive years.

Overall, the stock indicators in the Western Zone show a marginal improvement. The standardised catch per unit effort (CPUE) improved from 0.62kg/pot-lift in 2017/18 to 0.64kg/pot-lift in 2018/19. The numbers of undersize lobsters have increased from the recent historical low, but are still at very low levels. The pre-recruit index (PRI) was at 1.59 undersize/pot-lift. Whilst having increased, this remains below the PRI reference point of 1.81.

The stock assessment model indicates that egg production decreased from 24.8% to 23.5% of an estimated unfished stock, which is above the 20% limit reference point. Biomass decreased by 8% from the previous season to 728t, which is 10% below the recent peak in 2016/17. This resulted in an exploitation rate of 34.4%.

### Eastern Zone Rock Lobster Fishery

The 2018/19 TACC for the Eastern Zone was set at 47t following four years of 59t TACCs. In the subsequent 2019/20 season there was an additional substantial reduction to 40t. This reduction occurred because standardised CPUE reduced further from a recent high of 0.64kg/pot-lift in 2012/13 to 0.36kg/pot-lift in 2017/18. Direct application of the harvest strategy would have resulted in a TACC of 32t in 2019/20, however, as a result of industry consultation a lesser reduction to 40t was implemented.

The 2018/19 standardised CPUE increased to 0.41kg/potlift, supporting the rationale used for the previous 2019/20 TACC setting process. This is the first CPUE increase in six years. Nevertheless, the number of undersize lobsters has continued to fall and are at a historical low. The PRI declined to 0.08 undersize/pot-lift in 2018/19, 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 reduced over the last five years from 29.7% to 25.1% of an unfished stock, however this remains above the 20% limit reference point. The estimated available biomass in the Eastern Zone has declined for a fifth year in a row to 205t which is 29% below the recent 2013/14 peak. The decreased biomass and reduced catches combined to give an exploitation rate of 20.8%.

# 2. INTRODUCTION

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

The Victorian 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 has been 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 key indicators 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 unfished levels, with a 90% probability.
2. **Standardised CPUE** – to maintain the predetermined exploitation rates (32.5% and 20.5% 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 0.25kg/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 2018/19 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, effort and CPUE

The TACC in the Western Zone Rock Lobster Fishery was set at 245 tonne (t) for the 2018/19 season - a 15t increase from the previous TACC of 230t which was in place for four consecutive years (*Table 2*). This increase was obtained by the inaugural application of the harvest strategy to data from the 2016/17 season.

The 2019/20 TACC was retained in the same CPUE band from application of the harvest strategy to the 2017/18 season – despite increasing CPUE, low PRI prevented an increase in the CPUE band (see 2017/18 assessment for more details). However, the CPUE-TACC table in the harvest strategy was revised to include the latest information from the stock assessment model, this resulted in the TACC for that CPUE band increasing from 245t to 246t and the 2019/20 TACC was therefore set at 246t.

The effort required to take the catch was 299,629 pot-lifts, which is similar to the previous season, but a substantial reduction over the last five years due to increasing CPUE (*Table 1*, *Figure 1*).

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, standardised CPUE has been increasing and reached 0.64kg/pot-lift in 2018/19. Notably, the fishery has previously fluctuated around this level from the mid-1980s through to the decline in the mid-2000s (*Table 1*, *Figure 2*). Nominal and standardised CPUE have diverged in recent years – this is primarily due to a shift to a more efficient fleet that will have higher CPUE for the same biomass. The standardised CPUE removes this effect to provide the best index of stock abundance.

When examined by region, the breakdown of catch is similar to previous years. The highest catch in 2018/19 came from the Portland region at 139t, followed by Apollo Bay at 60t and Warrnambool at 51t. Compared to the previous 2017/18 season, Warrnambool experienced a substantial increase in CPUE while Portland CPUE has continued to increase and after eight years of increases Apollo Bay had a CPUE reduction (*Figure 3*).

### Trends in the commercial fleet

The number of active fishing vessels decreased from a high of 141 in 1988/89 to approximately 100 through the 1990s, and further to a record low of 41 vessels in 2017/18 (*Figure 4*). 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 5*). The number of days fished also increased from a record low in 1988/89 at 28 days per vessel to 48 days in 1993/94 as the fleet contracted and the catch per vessel increased (*Figure 5*).

In the last five years the average annual catch has been consistently between 4.7t and 5.7t whilst the average number of days fished decreased from a record high of 60 days in 2012/13 to 53 days in 2018/19. This trend in increased fishing activity among a smaller number of vessels is consistent with fleet consolidation and efficiency gains expected from an individual transferrable quota (ITQ) system, however, in this fishery this has also largely been driven by changes in catch and TACC.

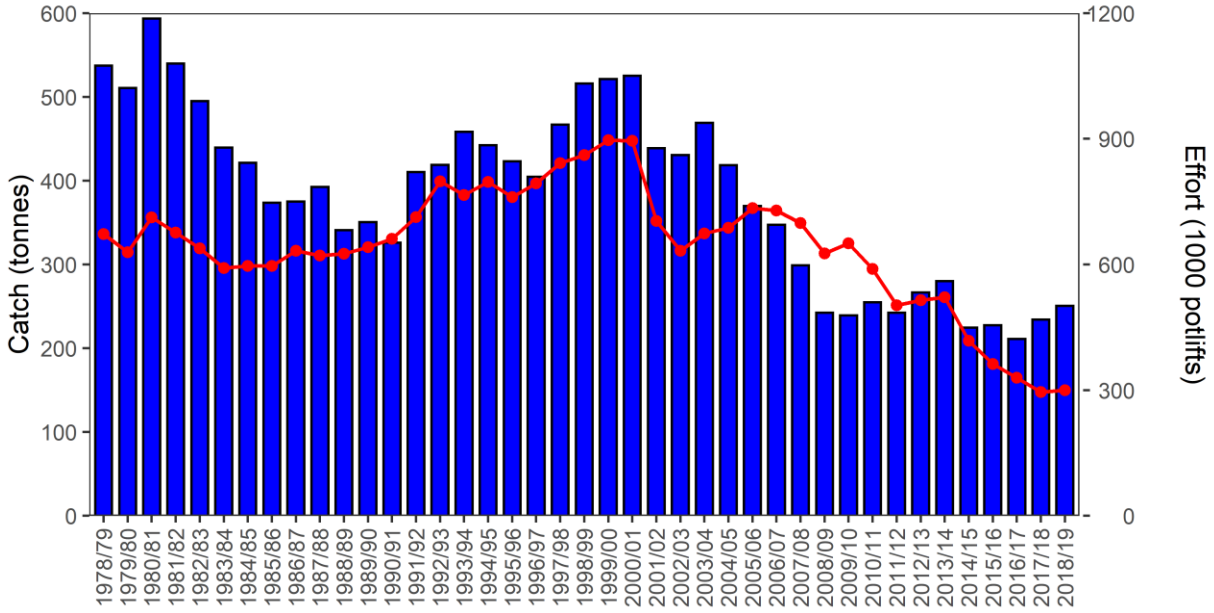



*Figure 1: Total catch (blue bars; tonnes) and nominal effort (red line; x1000 pot-lifts) in the Western Zone.*

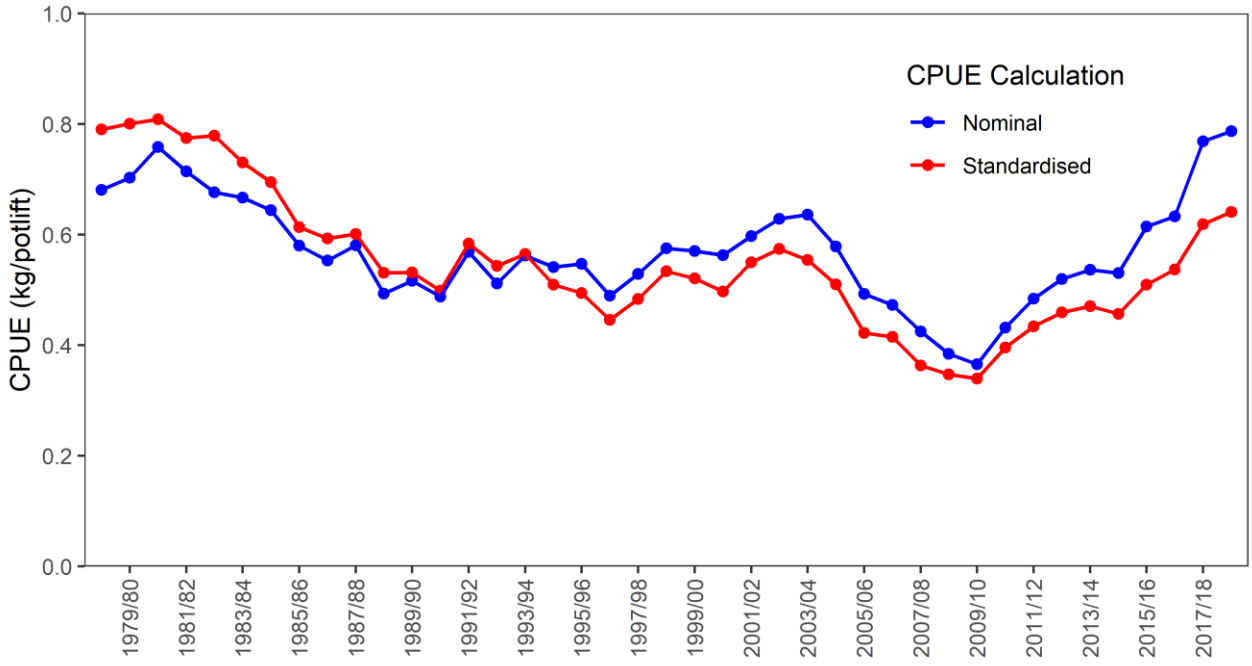
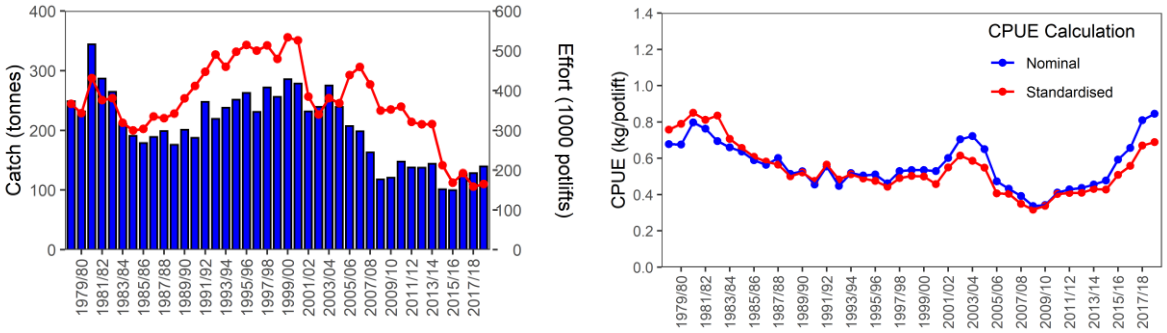
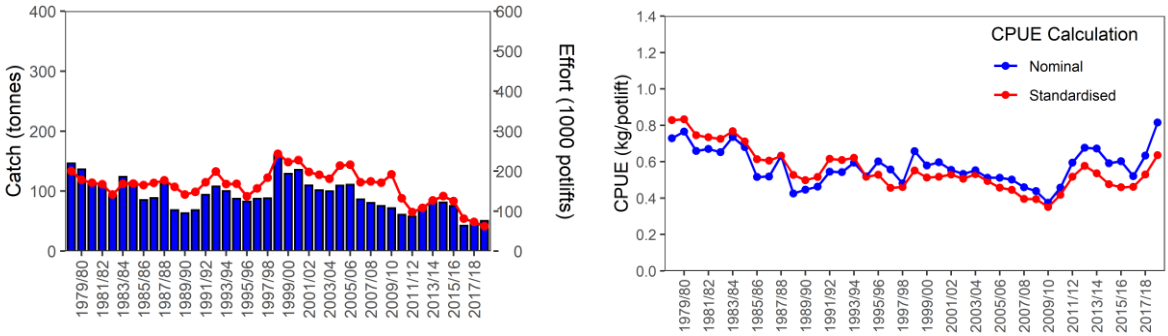



*Figure 2: Standardised versus nominal CPUE (kg/potlift) in the Western Zone. Note that standardised CPUE values differ slightly from one assessment to the next as the depth, seasonal and fisher coefficients are shared across years and are re-estimated including the new data.*

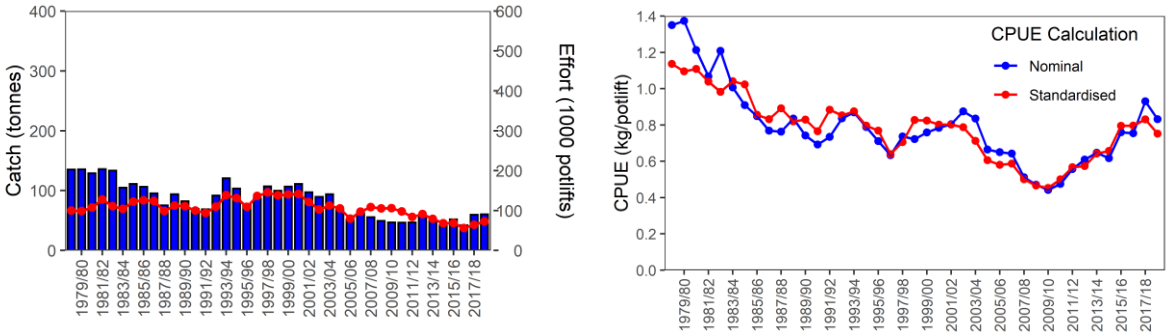
***PORTLAND***




***WARRNAMBOOL***




***APOLLO BAY***




**Fishing Year (Nov – Sept)**

*Figure 3: Regional catch (blue bars), effort (red line), and standardised CPUE (kg/potlift) in the Western Zone.*

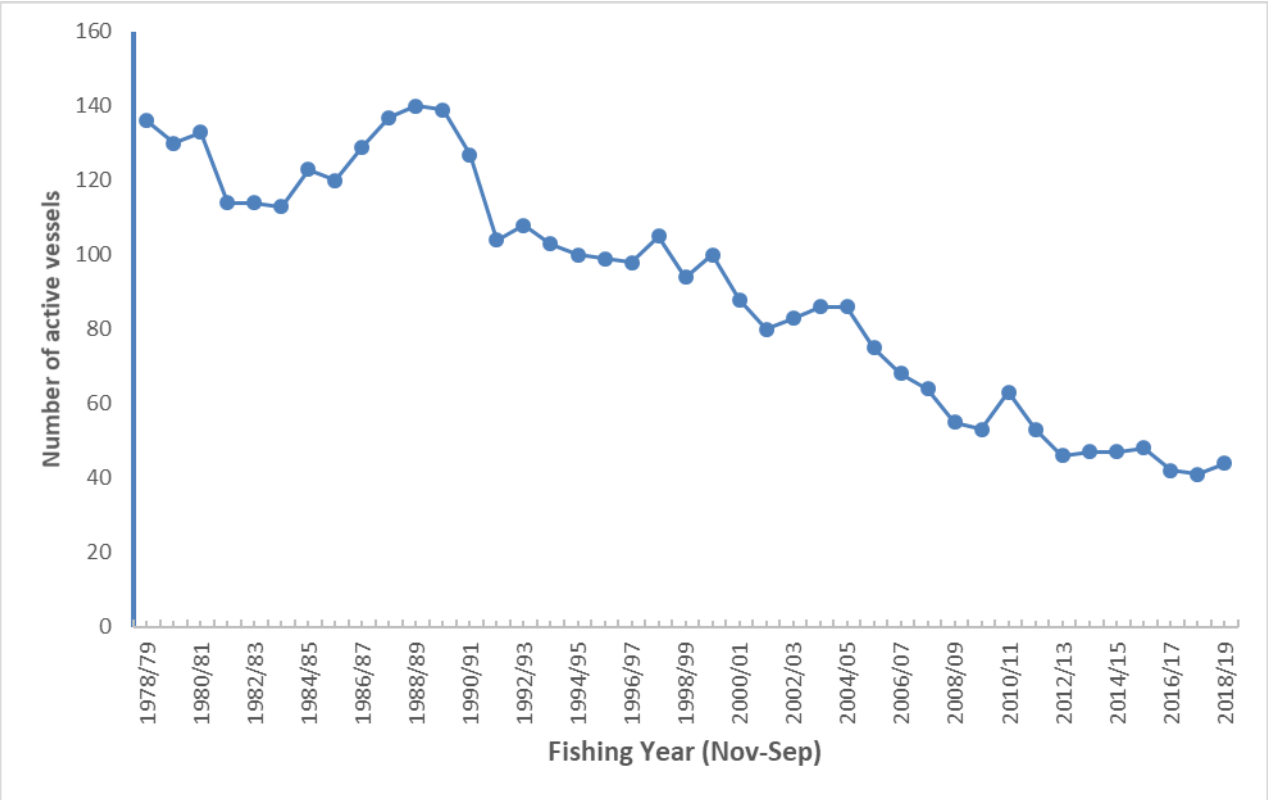



*Figure 4: The number of active vessels in the Western Zone in each fishing year.*

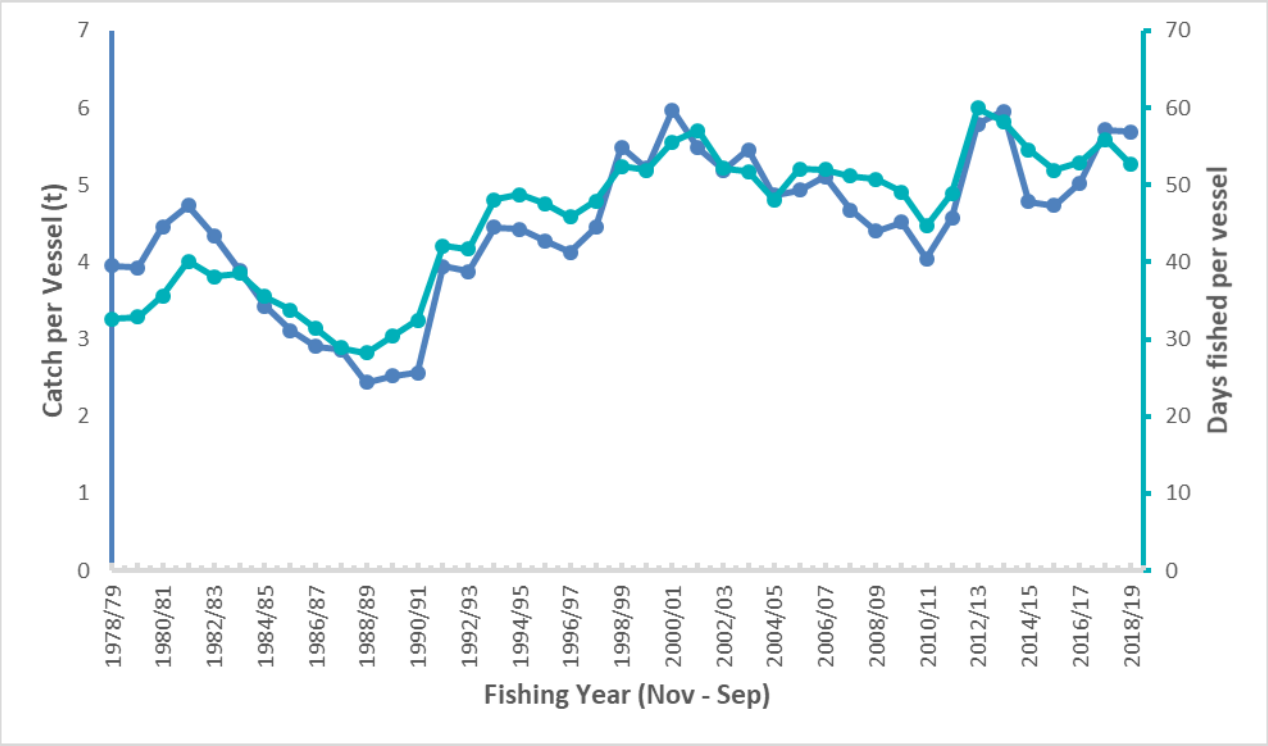



*Figure 5: The annual mean catch and mean number of days fished per active fishing vessel in the Western Zone*

## 3.2 Stock structure data

### 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 data sources show similar trends with a rapid decline from the recent peak in 2011/12 to record or near record low levels over the last four years. During the last two years there has been a gradual increase in PRI. The current level of 1.59 undersize / potlift is 40% higher than the record low in 2015/16, however, it remains 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 eight seasons (*Figure 7*), although this rate of increase has slowed in the last two seasons. The overall increase is 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. From the late 2000s to present there has been a substantial decrease in the abundance of small lobsters including both animals below the LML and animals within approximately 10mm of the LML. The CPUE has been maintained at a high level through an increase in abundance of larger animals. The one exception is females from the observer program which showed an increase across most size classes. This dramatic change is highlighted in *Figure 8* with full length-frequency details provided in *Figure 25* to *Figure 28*.

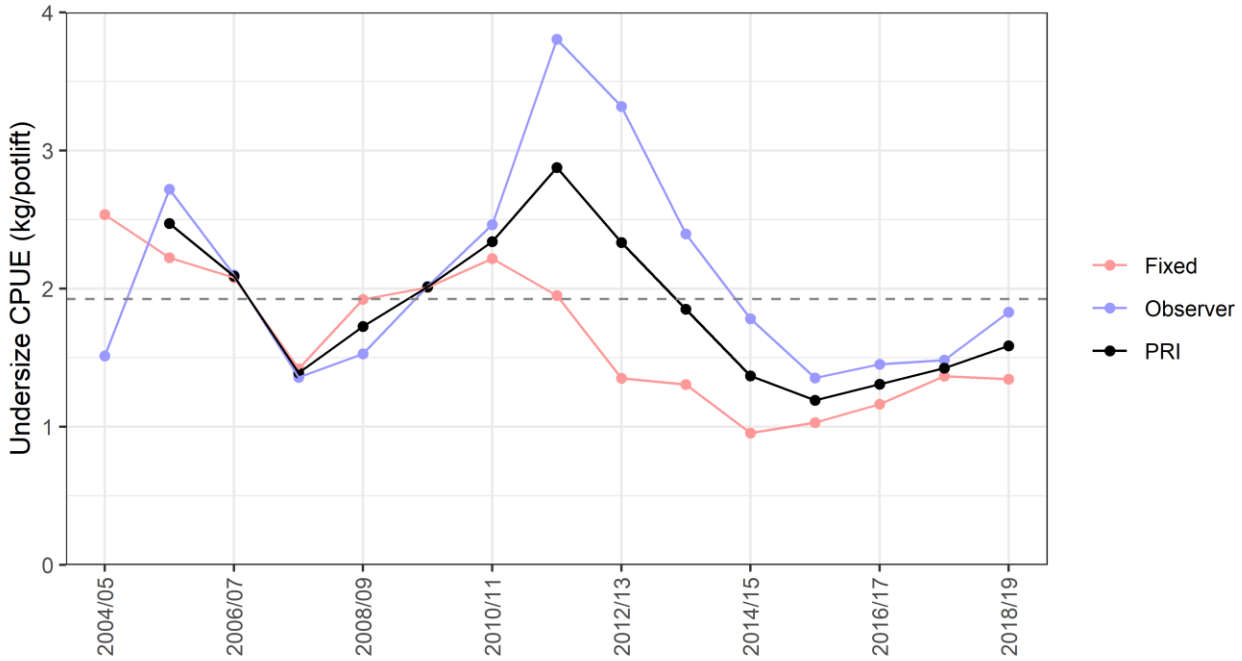



*Figure 6: The undersize catch rate (number undersize/potlift) for the Western Zone as calculated from fixed sites, observer coverage and the final combined PRI. The dashed line shows the trigger point (1.81 undersize/potlift).*

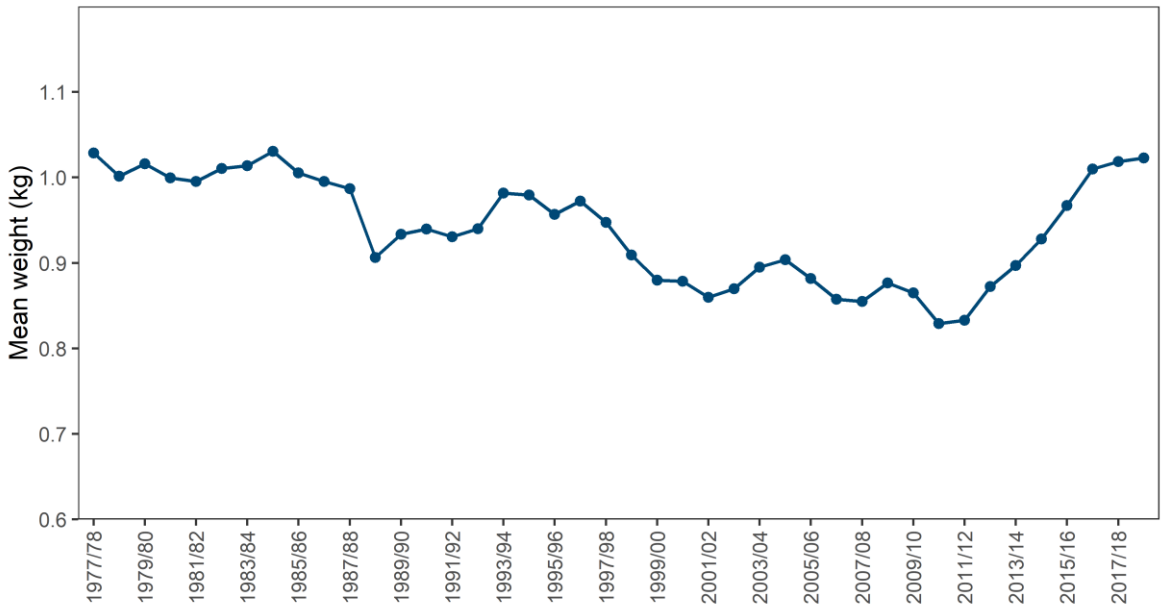



*Figure 7: Mean weight of legal sized lobster in the Western Zone fishery.*

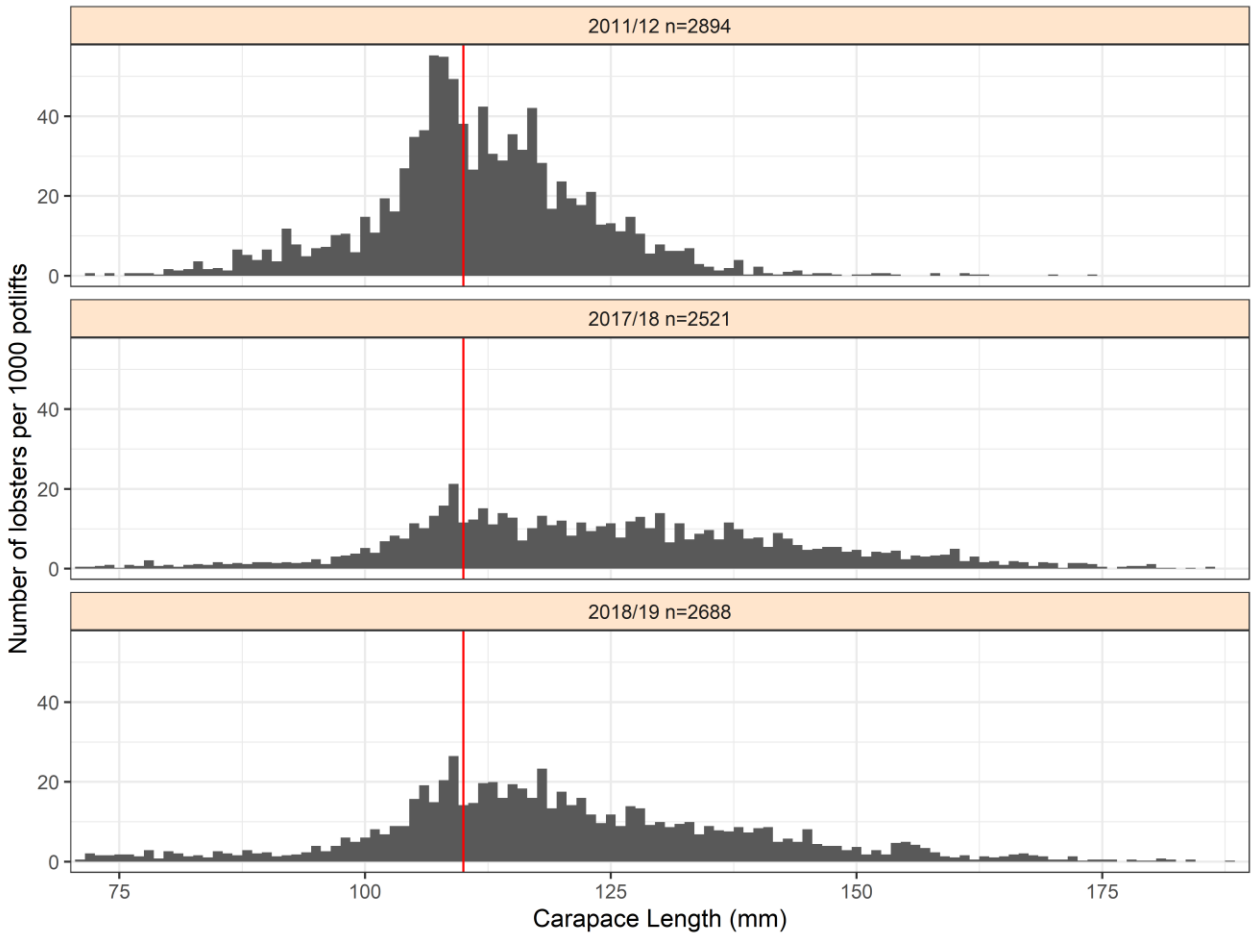



*Figure 8: Length-frequency plots for 2011/12 and the last two seasons for male lobsters measured by the Western Zone observer program to highlight the changes that have occurred.*

## 3.3 Model Outputs

### 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 9*). 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.

### Estimated egg production

The harvest strategy sets a model estimated egg production limit reference point of 20% of unfished levels. The Western Zone egg production has never fallen below the limit reference point. In 2018/19 egg production was at 23.5%, which is above the 20% limit reference point (*Figure 10*). There has been a gradual decline in egg production over the last two years from a high of 25.6% in 2015/16.

Egg production was also found to have a greater than 90% probability of being above the limit reference point as required by the harvest strategy. The method used for this calculation will be reviewed for the 2019/20 stock assessment process.

### 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 fluctuating around 820t between 1987/88 to 2003/04. 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 2018/19, the estimated available biomass decreased by 8% to 728t, with a corresponding fishing exploitation rate of 34.4% (*Figure 11*).

### Model diagnostics and potential biases

Two key datasets that the stock assessment model is fitted to are the standardised CPUE data and length-frequency data. Selected model diagnostics for both data sets are shown in *Figure 29* and *Figure 30*. These show that the model generally fits well to both datasets (note that CPUE fits in the lower catch periods (e.g. period 10) are of less importance). However as shown in *Figure 12*, CPUE in the most recent year is slightly under-estimated and consequently the 2018/19 biomass and egg production estimates are likely to be similarly slightly under-estimated.

The reason for this bias is that in recent years CPUE has continued to increase whilst the abundance of undersize lobsters has been extremely low. This has been partly possible due to a large cohort of lobsters from the higher recruitment period in the late 2000s -- as this group of lobsters continues to grow, the increased weight of individual animals in this group has a positive influence on CPUE. However, this is insufficient in itself to completely explain the ongoing increase in CPUE despite low recruitment. This inconsistency between the two datasets causes the bias in the model and is being investigated further for the 2019/20 assessment.

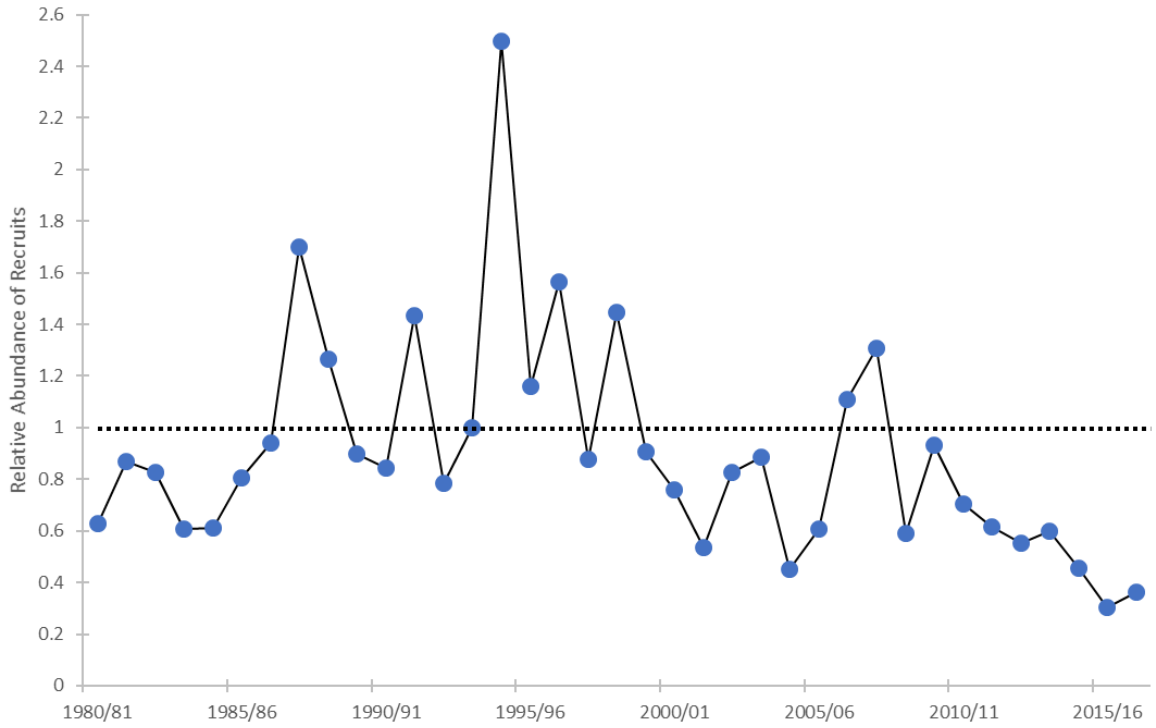



*Figure 9: Relative number of recruits (to 60 mm in CL) in the Western Zone Fishery. These results are generated by the stock assessment model. The long-term average is indicated by the dotted black line.*

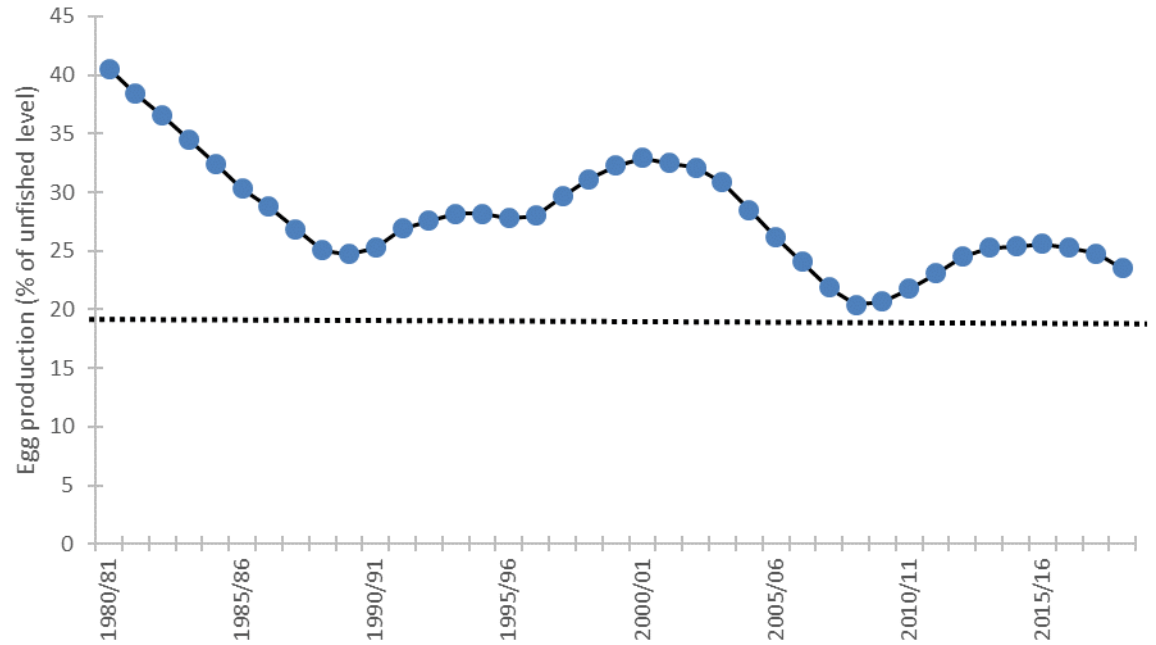



*Figure 10: Model estimated level of egg production through time in the Western Zone fishery. The limit reference point (dotted line) is 20% of unfished levels.*

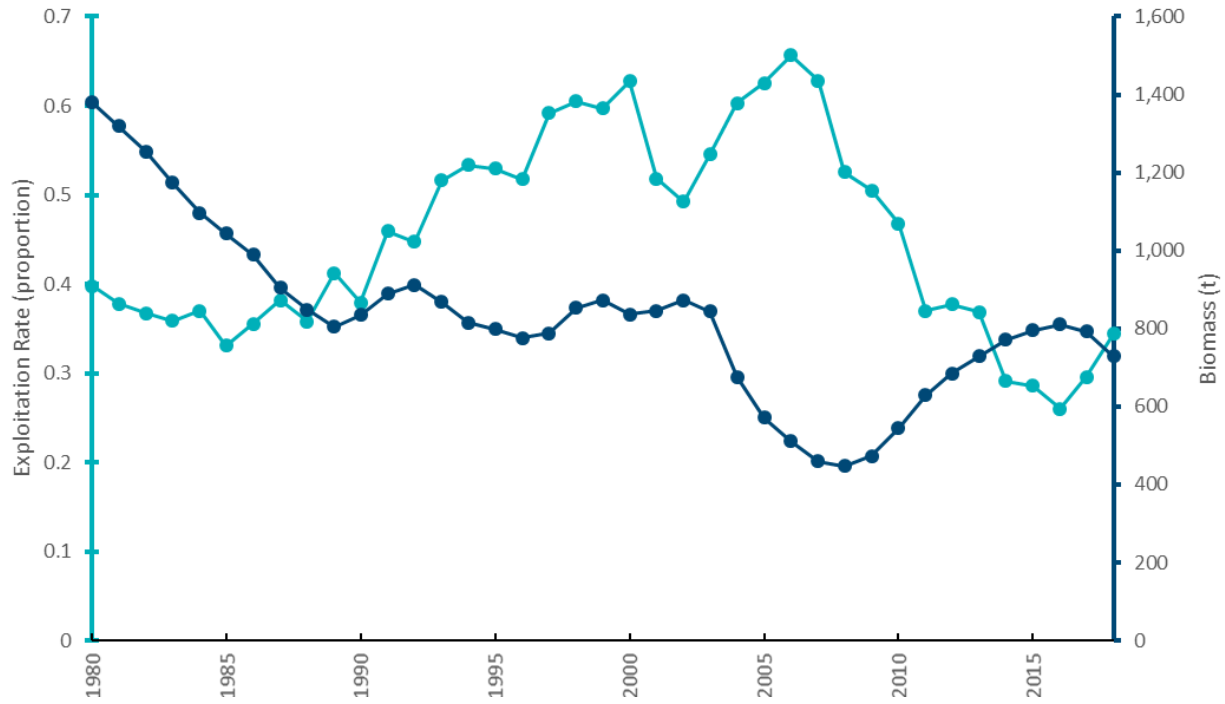



*Figure 11: Model estimated levels of available biomass and associated fishing exploitation rates in the Western Zone fishery.*

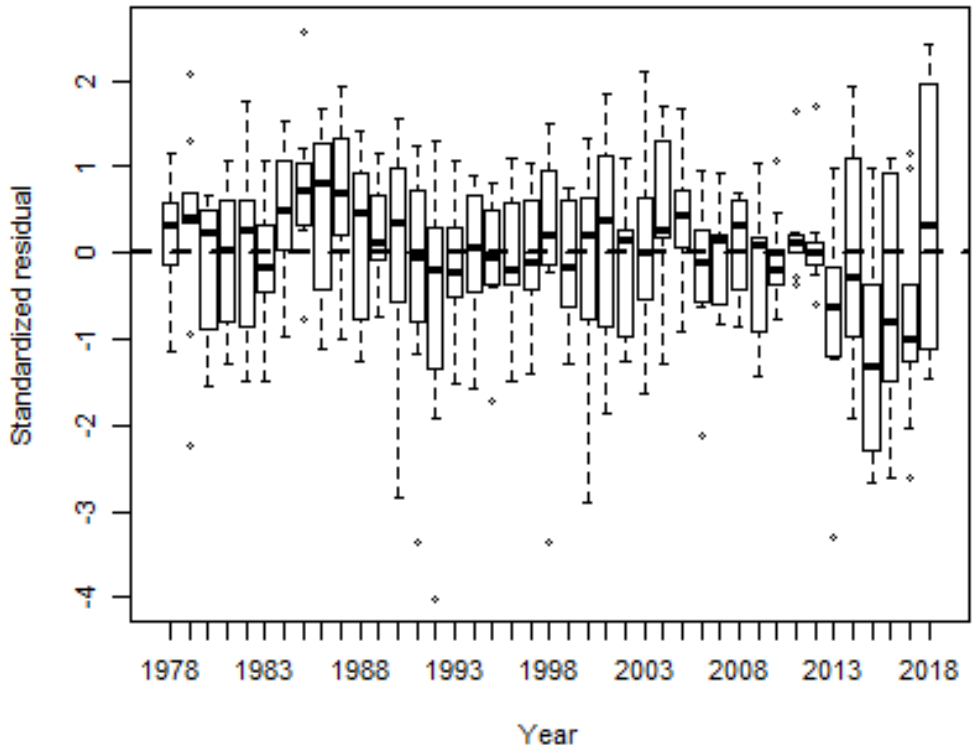



*Figure 12: Standardized residuals for CPUE in the Western Zone. Positive values indicate that the model is under-estimating CPUE.*

## 3.4 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 | 2018/19 Stock Indicator Level | Outcome |
|---|---|---|
| **1. Egg Production** | | |
| **Is the model estimated egg production above the limit reference point of 20% of unfished levels?** | The 2018/19 egg production level is estimated at 23.5% of unfished levels. | Decision rule has been met. Go to Rule 2 |
| **2. TACC Determination** | | |
| **a. What is the standardised CPUE relative to the preceding season** | Standardised CPUE is 0.64kg/pot-lift in 2018/19 | Standardised CPUE has increased from 0.62 in 2017/18 to 0.64 in 2018/19 |
| **b. Is the 2018/19 PRI at or above the reference point of 1.81 undersize/pot-lift?** | The PRI is 1.59 undersize/pot lift | Decision rule not met. No further decision rules considered |
| | **RESULT** | **NO INCREASE IN TACC** |

**Establishing the WZ TACC for 2020/21**

Due to the PRI rule not being met, the decision rules in the harvest strategy specify that the TACC will remain unchanged for the upcoming season.

**A TACC of 246t for the 2020/21 season is determined through the application of the harvest strategy.**

# 4. EASTERN ZONE ROCK LOBSTER FISHERY

## 4.1 Fishery Statistics

### Trends in catch, effort and CPUE

In 2018/19, the Eastern Zone TACC was 47t (*Table 4*) following four years with a 59t TACC. This reduction was due to the inaugural application of the harvest strategy which set the TACC corresponding to the low 2016/17 CPUE. For the subsequent 2019/20 season the TACC was substantially reduced to 40t as a result of a further CPUE decline in 2017/18. Direct application of the harvest strategy would have resulted in a TACC of 32t in 2019/20, however as a result of industry consultation and early positive indications in CPUE a lesser reduction to 40t was implemented.

Standardised CPUE reached a twenty year peak of 0.63kg/pot-lift in 2012/13 but has since fallen rapidly to a record low of 0.36 in 2017/18. From this record low the CPUE rose for the first time in six years to 0.41kg/pot lift in 2018/19 (*Figure 13*, *Table 3*).

Regionally, in 2018/19 most of the catch reduction (due to the decreased TACC) took place in the Queenscliff area. The majority of catch was taken in the Queenscliff region (21.9t), followed by San Remo (15.8t) and 4.9t in Lakes Entrance. After ongoing CPUE declines in the Queenscliff and San Remo regions, in 2018/19 there was a slight CPUE increase in all three regions (*Figure 14*).

It should be noted that the reduction to the current fleet size of 21 vessels increases the potential for biased reporting. This could arise from 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). An analysis of the CPUE standardisation method was undertaken for the 2017/18 assessment and found that the index was robust in this aspect.

### Trends in the commercial fleet

The number of active fishing vessels decreased from 90 in 1978/79 to approximately 50 through the 1990s and further declined to the current record low of 21 vessels in 2018/19 (*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 2018/19 the average annual catch was 2.0t / 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 32 days.

It should be noted that these statistics include only the Eastern Zone catch, but include vessels that fish both zones, thereby the catch per vessel is lower than may be expected.

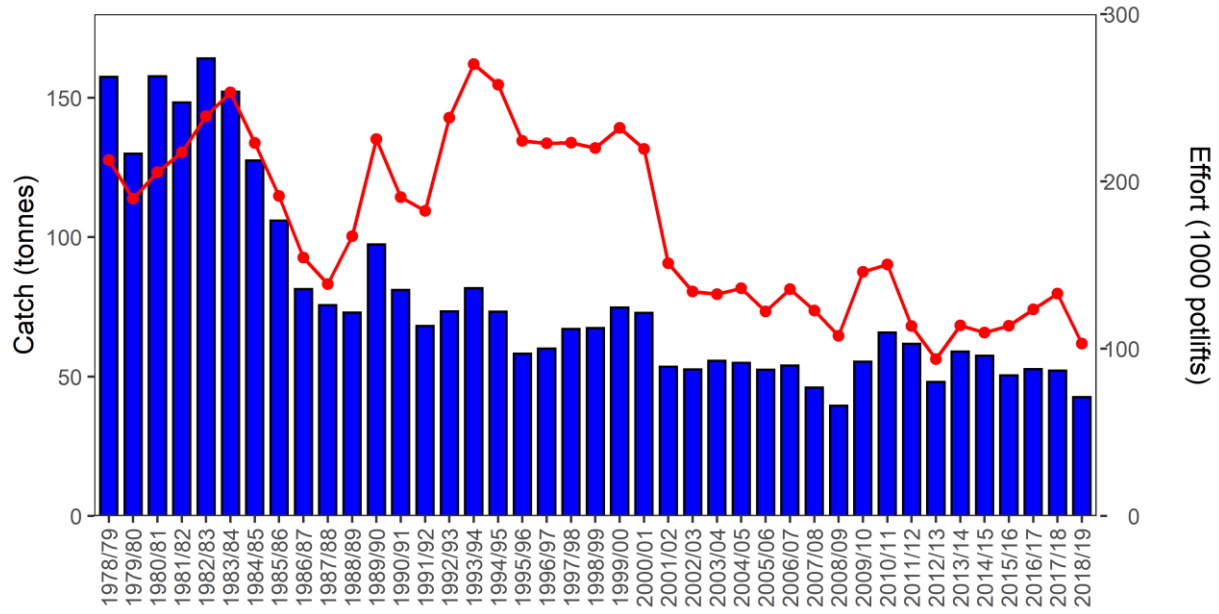



*Figure 13: Total catch (blue bars; tonnes) and nominal effort (red line; x1000 pot-lifts) in the Eastern Zone.*

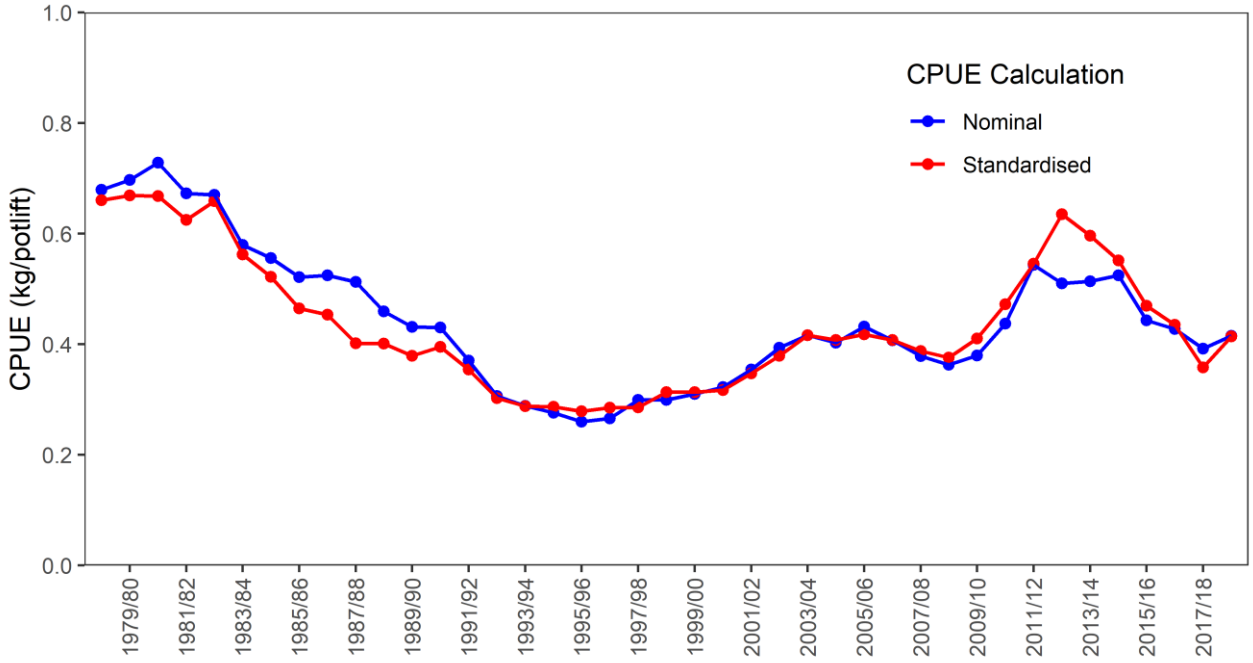
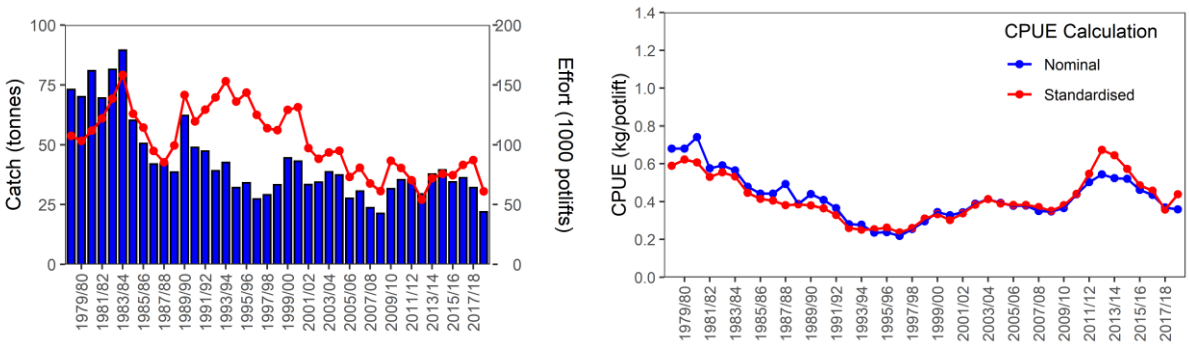
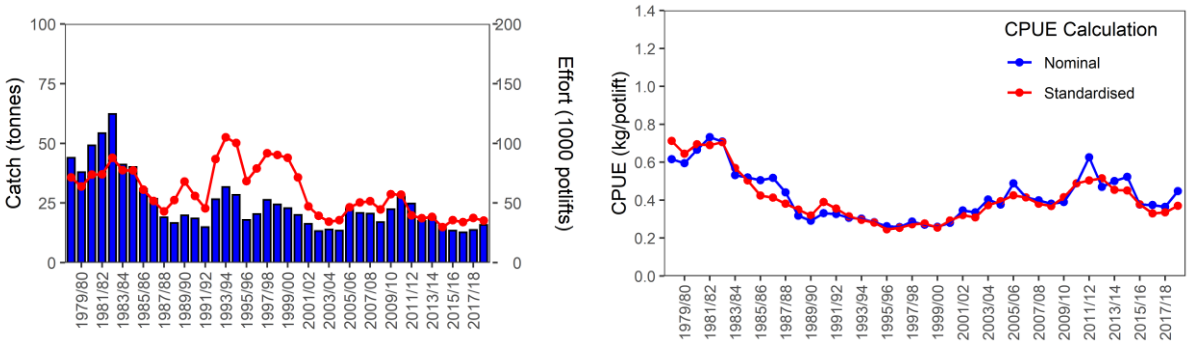



*Figure 14: Standardised versus nominal CPUE (kg/potlift) in the Eastern Zone. Note that standardised CPUE values differ slightly from one assessment to the next as the depth, seasonal and fisher coefficients are shared across years and are re-estimated including the new data.*

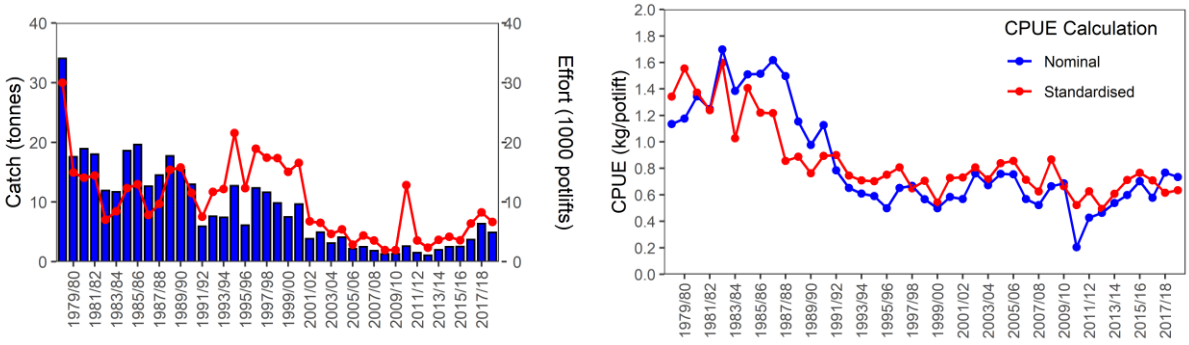
***QUEENSCLIFF***




***SAN REMO***




***LAKES ENTRANCE***




**Fishing Year (Nov – Sept)**

*Figure 15: Regional catch (blue bars), effort (red line), and standardised CPUE (kg/potlift) in the Eastern Zone.*

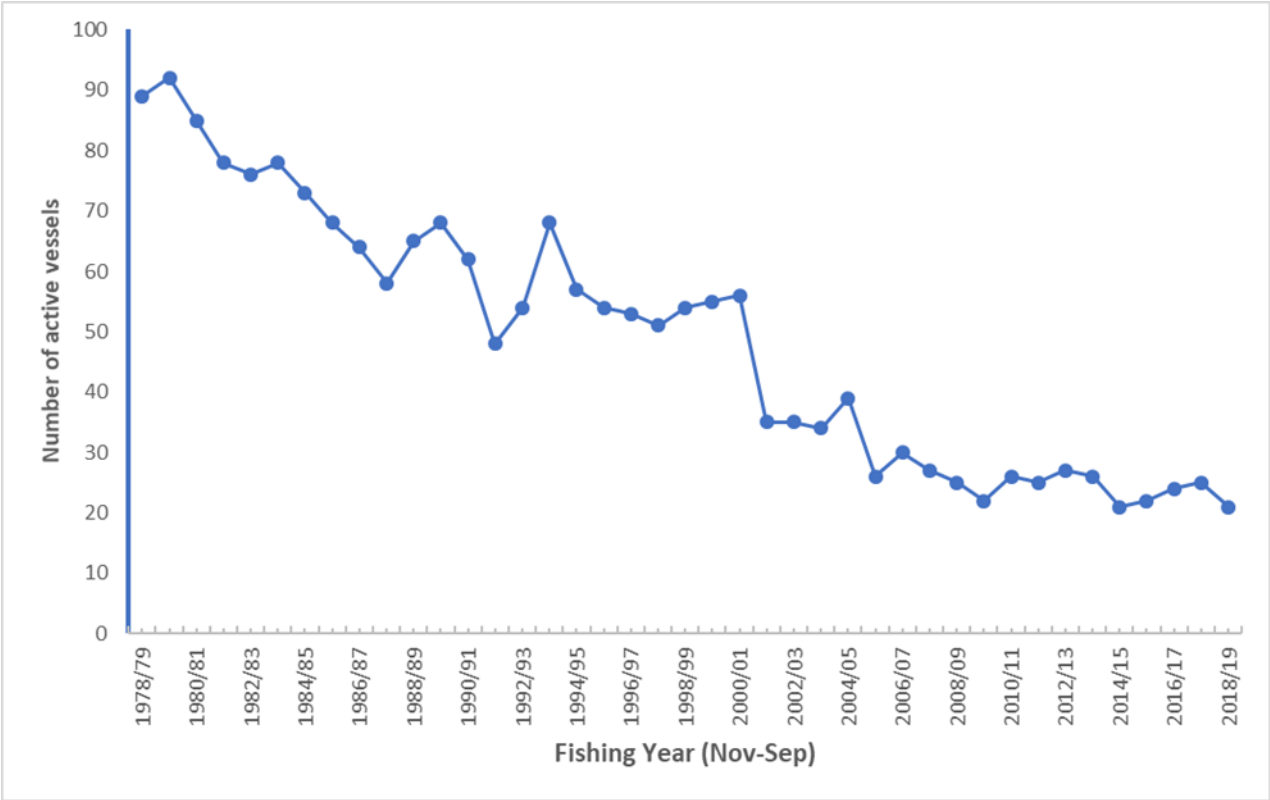



*Figure 16: The number of active vessels in the Eastern Zone in each fishing year.*

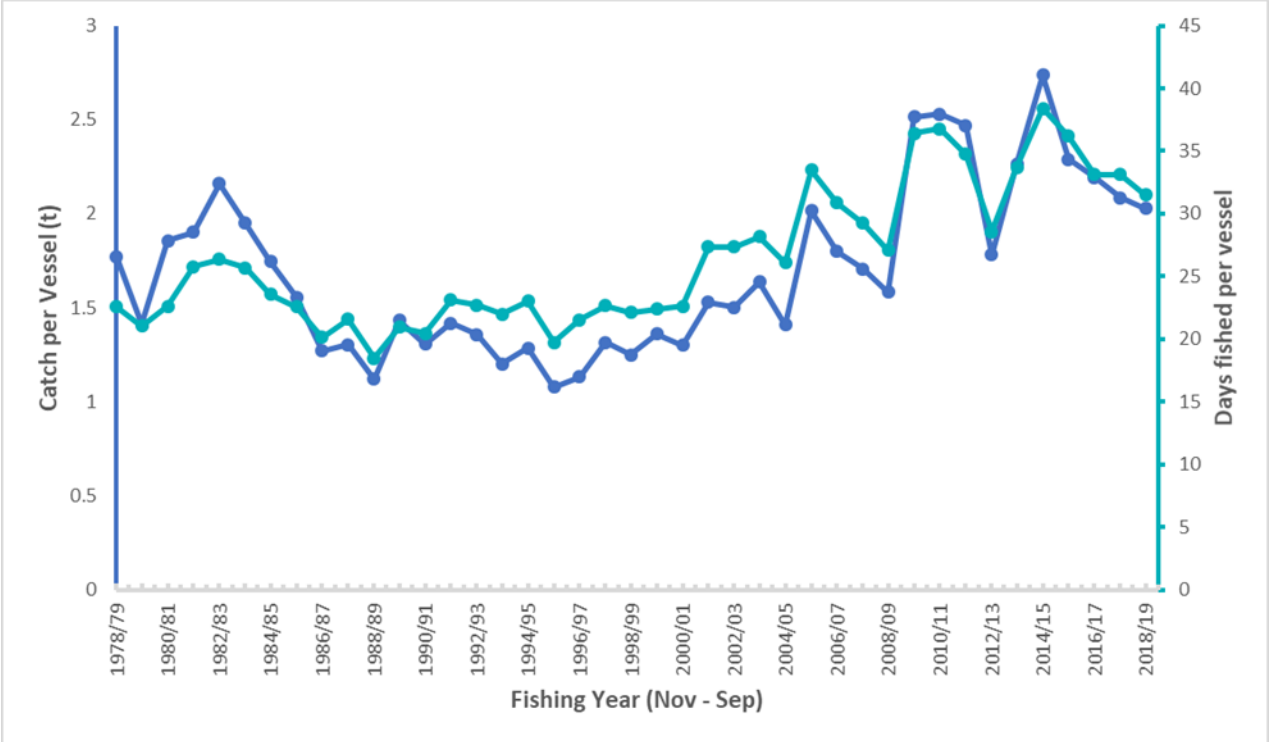



*Figure 17: The annual mean catch and mean number of days fished per active fishing vessel in the Eastern Zone*

## 4.2 Stock structure data

### 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 four years. In 2018/19, the PRI was at a record low of 0.08 undersize/pot-lift which is well below the reference point of 0.32 undersize/pot-lift (*Figure 18*).

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 due to 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 1.49kg/lobster in 2018/19 (*Figure 19*). 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.

It should also 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. Both programs have shown a dramatic decrease in catch rates of lobsters less than approximately 150mm. This change is highlighted in *Figure 20* and full details are given in *Figure 31* to *Figure 34*.

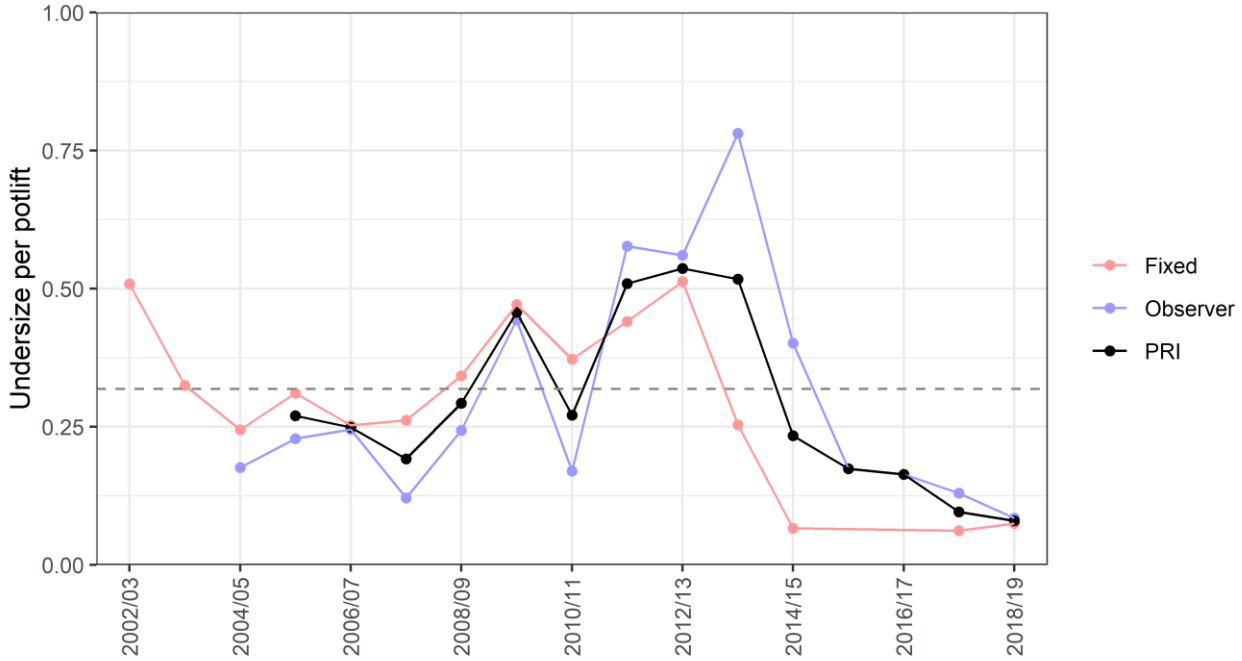



*Figure 18: The undersize catch rate (number undersize/potlift) for the Eastern Zone as calculated from fixed sites, observer coverage and the final combined PRI. The dashed line shows the trigger point (0.32 undersize/potlift).*

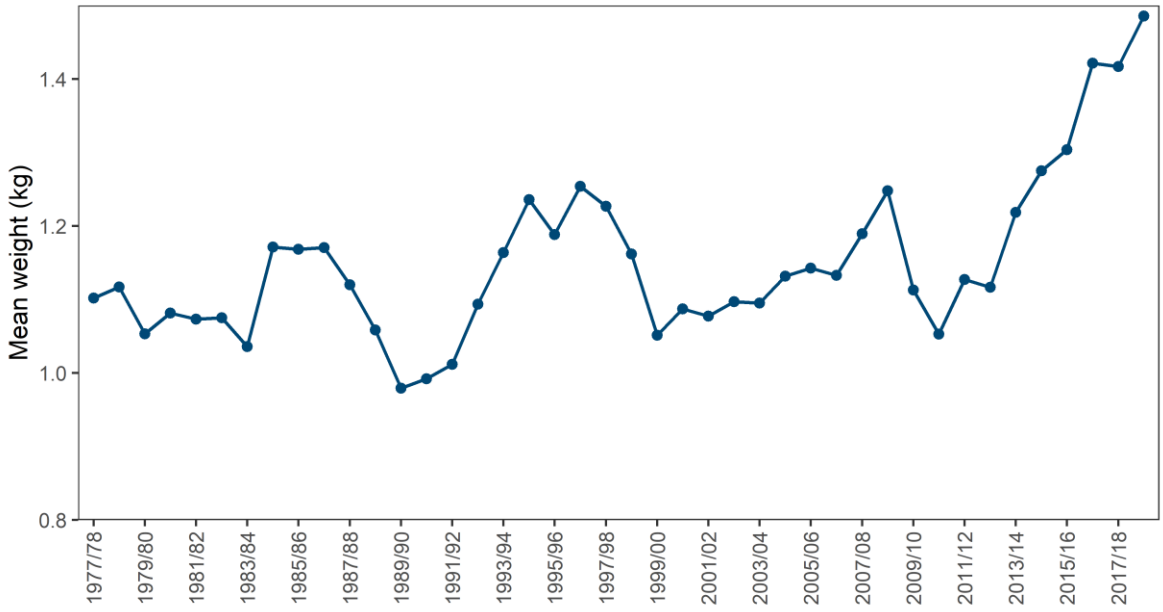



*Figure 19: Mean weight of legal sized lobster in the Eastern Zone fishery.*

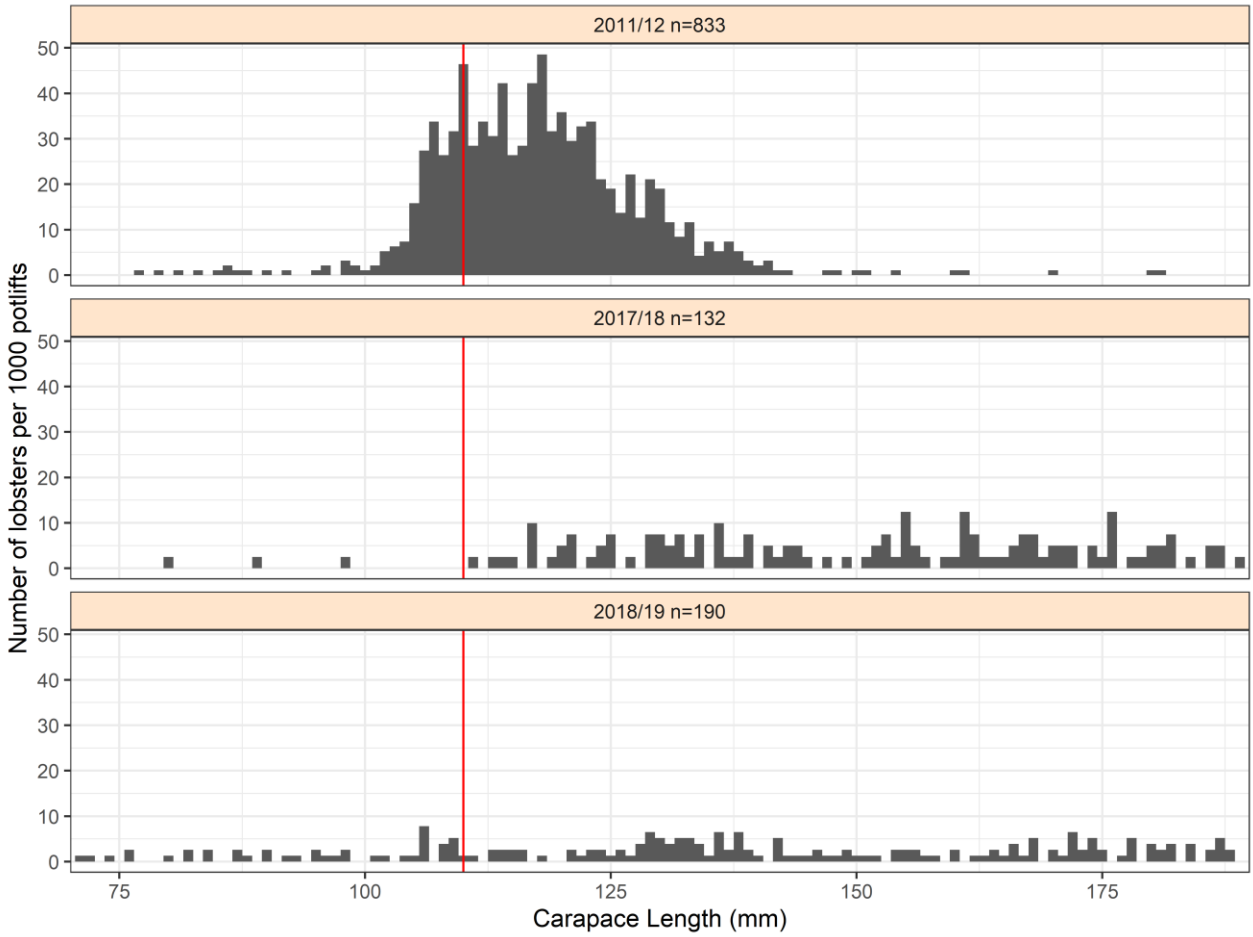



*Figure 20: Length-frequency plots for 2011/12 and the last two seasons for male lobsters measured by the Eastern Zone fixed site program to highlight the changes that have occurred.*

## 4.3 Model outputs

### 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 33% of the long-term average in 2013/14. This increased to 50% in 2014/15 – the most recent year for which a reliable estimate is available (*Figure 21*). There is a substantial lag in this estimate due to the time that passes before a lobster of 60mm reaches legal size and starts influencing datasets like CPUE. This lag is greater in the Eastern Zone than the Western Zone due to the smaller amount of available data.

### Estimated egg production

Eastern Zone egg production levels reached a historical low in 1995/96 of 18.5% of unfished levels. After this time there was a steady increase to a recent high of 29.7% in 2013/14. Since 2013/14 there has been an ongoing decline to 25.1% in 2018/19, which is above the 20% limit reference point (*Figure 22*).

Egg production was also found to have a greater than 90% probability of being above the limit reference point as required by the harvest strategy. The method used for this calculation will be reviewed for the 2019/20 stock assessment process.

### 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.

After a long period of stability at around 210t, biomass increased between 2009/10 and 2013/14 to a peak of 289t. Over the past five years biomass has decreased back to 205t in 2018/19. As a result of the decreased biomass the exploitation rate rose to 23.7% in 2017/18; the subsequent TACC reduction resulted in this decreasing back to 20.8% in 2018/19. (*Figure 23*).

### Model diagnostics and potential biases

The length-frequency data input to the model (*Figure 31* to *Figure 34*) is highly variable due in part to low sample sizes. Given this level of variability, the stock assessment model provides a reasonable fit to CPUE and length-frequency data (*Figure 35* and *Figure 36*).

As shown in *Figure 24,* there has been a shifting bias through time in the stock assessment model CPUE estimates. This is unsurprising for a model of this complexity when fitted to a fishery like the Eastern Zone, which is comparatively small in production but large in spatial extent (hence has high variability) and for which only limited data is available.

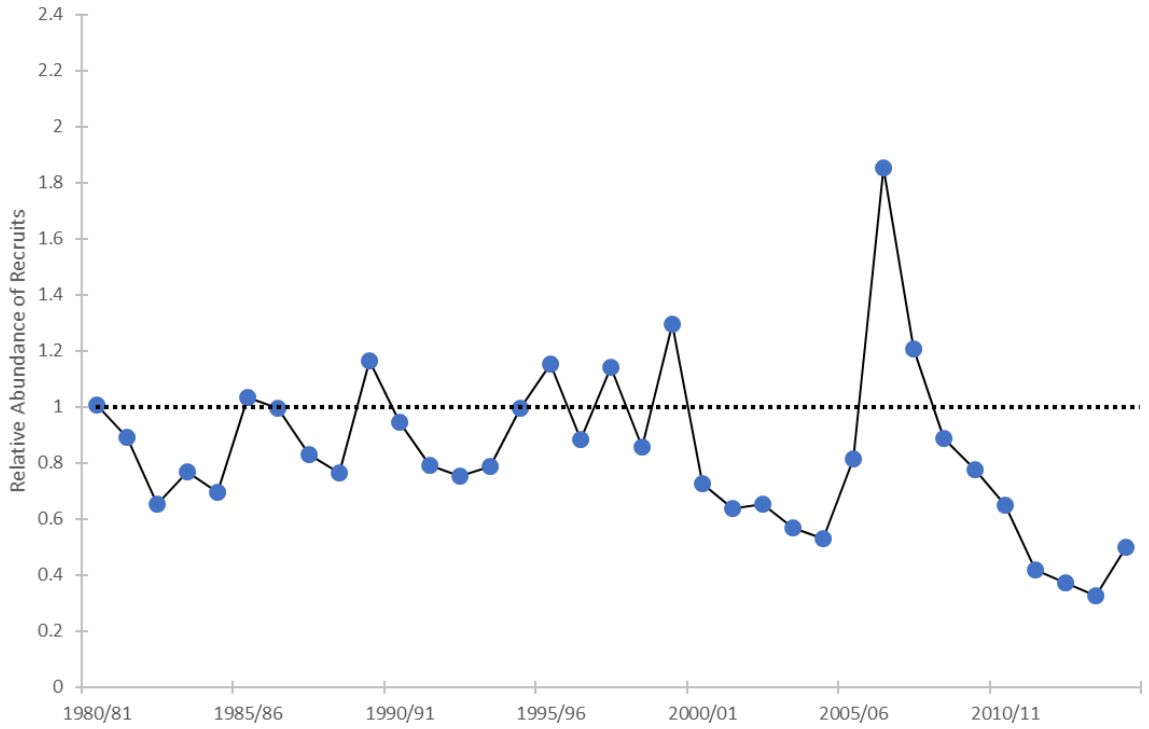



*Figure 21: Relative number of recruits (to 60 mm in CL) in the Eastern Zone Fishery. These results are generated by the stock assessment model. The long-term average is indicated by the dotted black line.*

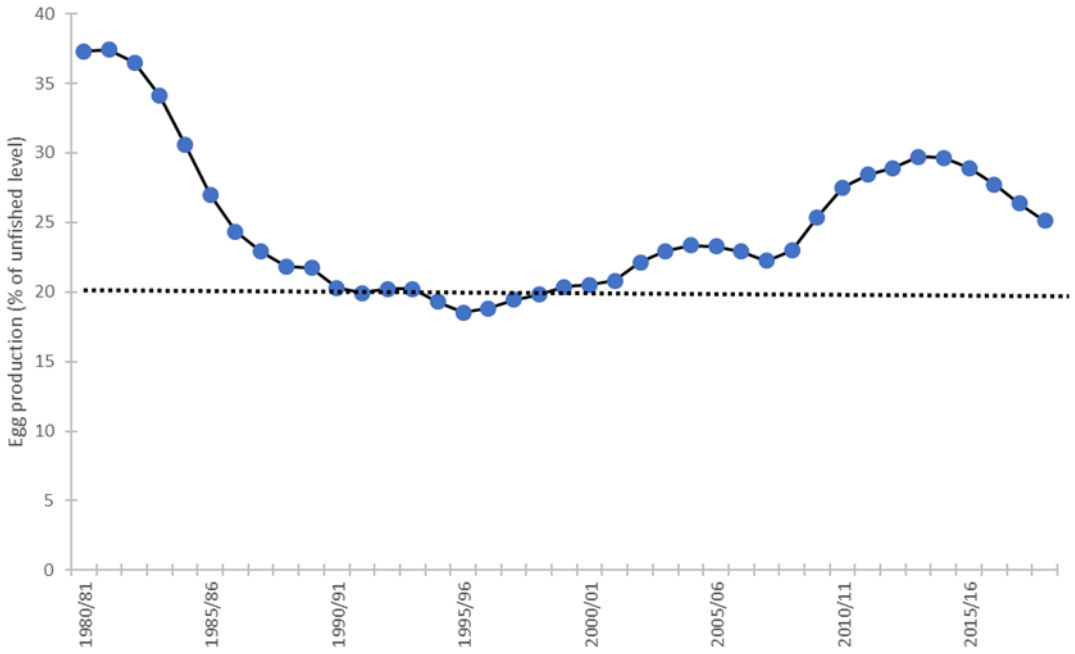



*Figure 22: Model estimated level of egg production through time in the Eastern Zone fishery. The limit reference point (dotted line) is 20% of unfished levels.*

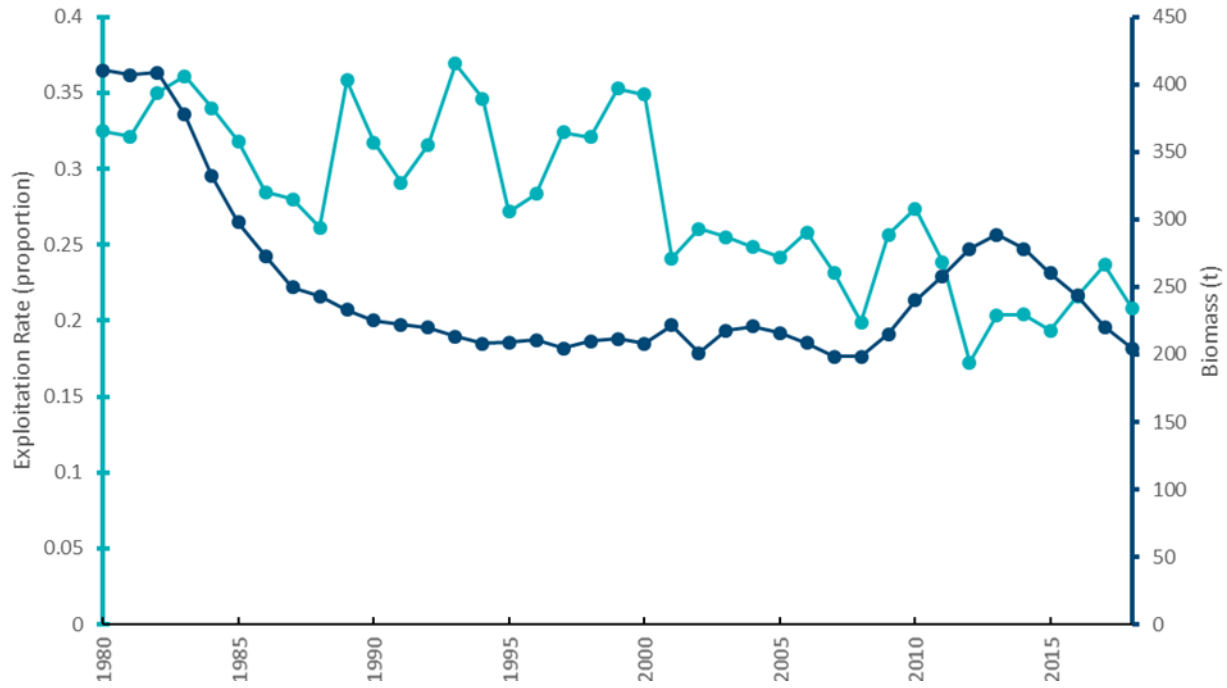



*Figure 23: Model estimated levels of available biomass and associated fishing exploitation rates in the Eastern Zone*

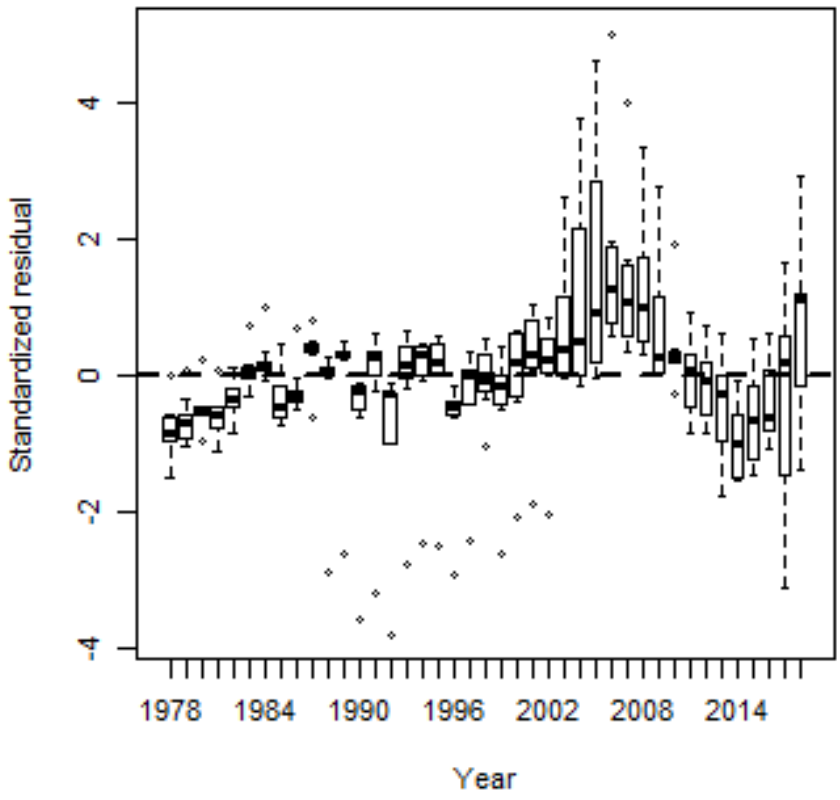



*Figure 24: Standardized residual for CPUE in the Eastern Zone. Positive values indicate that the model is under-estimating CPUE.*

## 4.4 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 | 2018/19 Stock Indicator Level | Outcome |
|---|---|---|
| **1. Egg Production** | | |
| **Is the model estimated egg production above the limit reference point of 20% of unfished levels?** | The 2018/19 egg production level is estimated at 25.1% of unfished levels. | Decision rule has been met. Go to Rule 2 |
| **2. TACC Determination** | | |
| **a. What is the standardised CPUE relative to the preceding season** | Standardised CPUE is 0.41kg/pot-lift in 2018/19 | Standardised CPUE has **increased** from 0.36 in 2017/18 to 0.41 in 2018/19. |
| **b. Is the 2018/19 PRI at or above the reference point of 0.32 undersize/pot-lift?** | The PRI is 0.08 undersize/pot lift | Decision rule not met. No further decision rules considered |
| | **RESULT** | **NO INCREASE IN TACC** |

**Establishing the EZ TACC for 2020/21**

Due to the PRI rule not being met, the decision rules in the harvest strategy specify that the TACC will remain unchanged for the upcoming season.

**A TACC of 40t for the 2020/21 season is determined through the application of the harvest strategy.**

# 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.

It should be noted that the approach taken to create the overall standardised index for a zone calculates the predicted CPUE for each region in each year and weights these by their relative catches. Consequently, the standardised index contains trends due to spatial shifts in catch (at a region level) that are unrelated to biomass changes. For example, the increase in catch in Lakes Entrance in 2017/18 and 2018/19 (which has the highest CPUE out of the Eastern regions) had a small positive effect on CPUE.

## 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 standardised 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.

# 6. REFERENCES

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Hobday, D., and Punt, A. E. (2009). How much spatial structure can data for rock lobster off Victoria, Australia support? New Zealand Journal of Marine and Freshwater Research 43, 373–385.

Hobday, D., Punt, A. E., and Smith, D. C. (2005). Modelling the effects of Marine Protected Areas (MPAs) on the southern rock lobster (Jasus edwardsii) fishery of Victoria, Australia. New Zealand Journal of Marine and Freshwater Research 39, 675–686.

Walker, T.I., Giri, K., Trinnie, F.I., and Reilly, D.J. (2012). CPUE data screening, selection and standardisation for stock assessment of southern rock lobster (Jasus edwardsii) in Victoria. pp 23−74. In 'Sustainability of the rock lobster resource in south-eastern Australia in a changing environment: implications for assessment and management.' Final report to Fisheries Research and Development Corporation. November 2012. South Australian Research and Development Institute (Aquatic Sciences), Adelaide, South Australia, Australia.

Victorian Fisheries Authority (2017). Victorian Rock Lobster Fishery Management Plan 2017. '. vi + 37 pp. Victorian Fisheries Authority, Melbourne, Victoria, Australia.

# 7. SUPPLEMENTARY WESTERN ZONE DATA

*Table 1: Western Zone catch, fishing effort and CPUE (Fishing Year: Nov-Sep; 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 | 0.79 | 1.00 |
| 1979/80 | 451 | 442 | 576 | 0.78 | 0.80 | 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 | 0.73 | 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 | 0.59 | 0.99 |
| 1987/88 | 345 | 349 | 557 | 0.62 | 0.60 | 0.99 |
| 1988/89 | 303 | 321 | 577 | 0.52 | 0.53 | 0.94 |
| 1989/90 | 332 | 355 | 613 | 0.54 | 0.53 | 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 | 0.54 | 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 | 0.42 | 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 |

| Fishing Year | Catch *(tonne)* | Catch *('000)* | Nominal Effort *('000 potlifts)* | Nominal CPUE *(kg/potlift)* | Standardised CPUE *(kg/potlift)* | Mean Mass *(kg/lobster)* |
|---|---|---|---|---|---|---|
| 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 | 211* | 209 | 330 | 0.64 | 0.54 | 1.01 |
| 2017/18 | 234 | 230 | 296 | 0.79 | 0.62 | 1.02 |
| 2018/19 | 250 | 245 | 300 | 0.84 | 0.64 | 1.02 |

** The 2016/17 catch was reduced 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 2018-19 (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 | 55 |
| 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 | 46 |
| 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 |
| 2017-18 | 1 Jul - 30 Jun | 230 | 230 | 100 | 12 | 41 | 41 |
| 2018-19 | 1 Jul - 30 Jun | 245 | 245 | 100 | 12 | 42 | 43 |

** 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.*

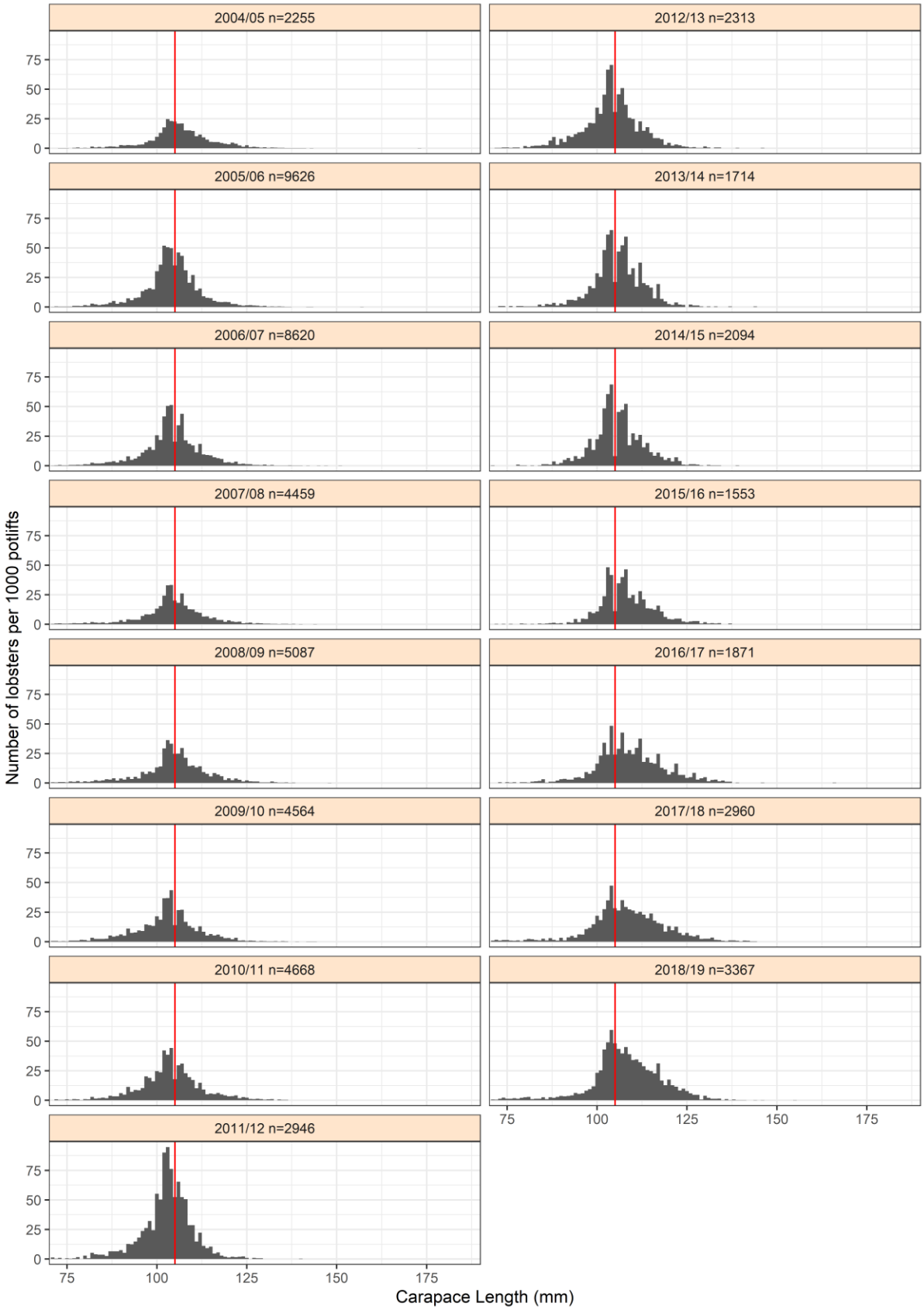


*Figure 25: Length-frequency distribution of the number of female rock lobsters per 1,000 pot-lifts caught in the Western Zone on-board observer program from 2004–05 to 2018-19 fishing years (Nov–Sept). n, total number of lobsters measured.*

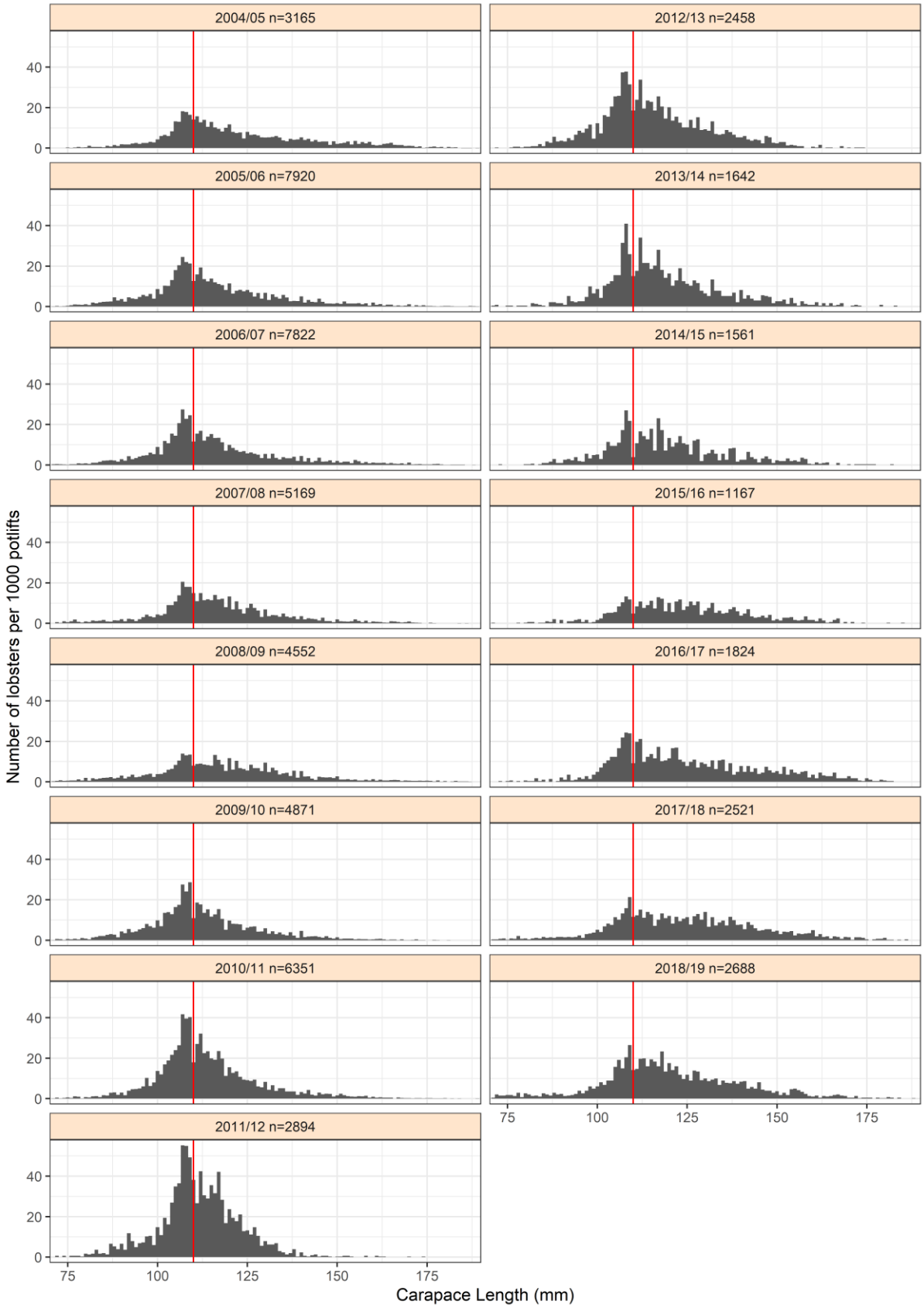


*Figure 26: Length-frequency distribution of the number of male rock lobsters per 1,000 pot-lifts caught in the Western Zone on-board observer program from 2004–05 to 2018-19 fishing years (Nov–Sept). n, total number of lobsters measured.*

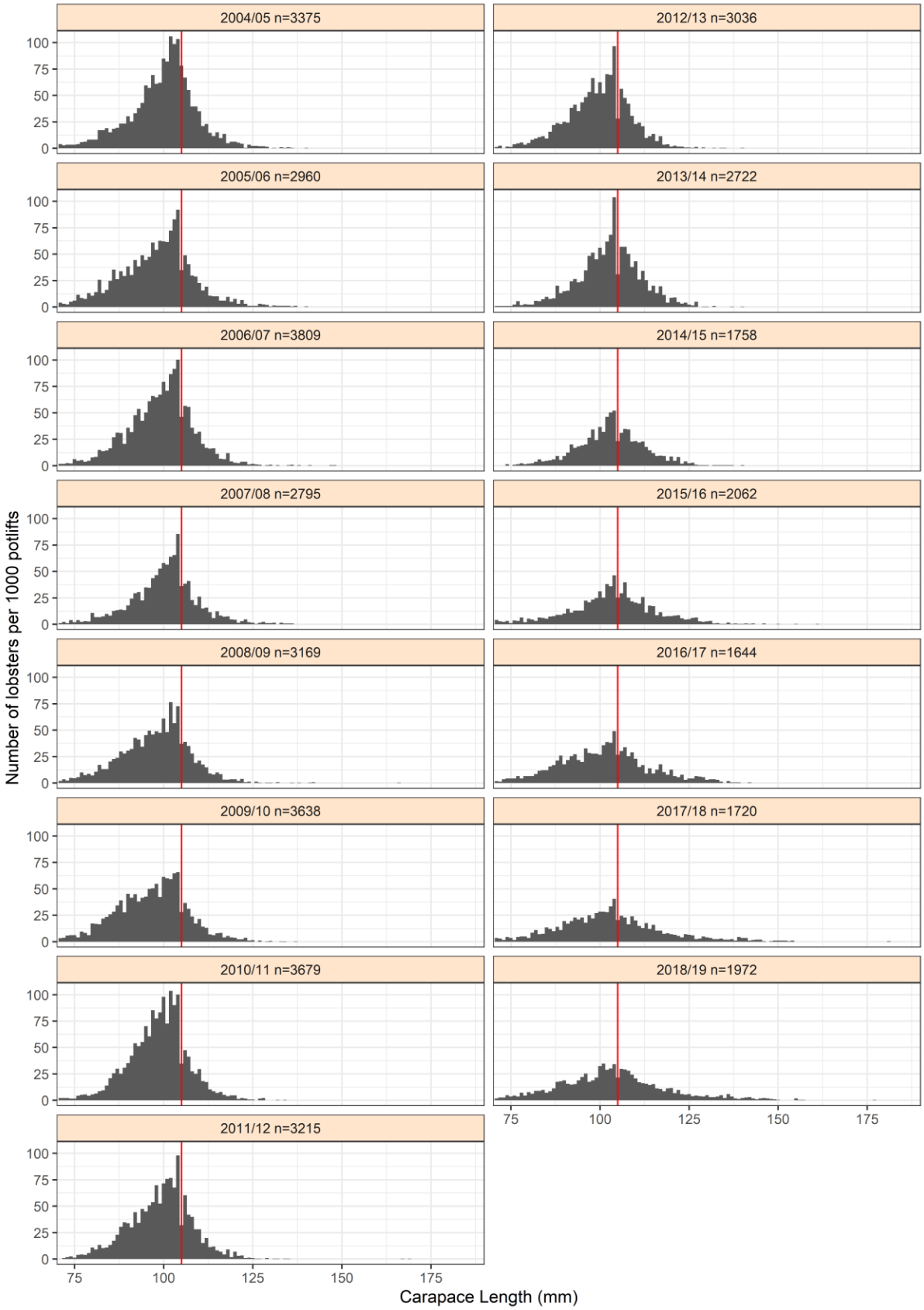


*Figure 27: Length-frequency distribution of the number of female rock lobsters per 1,000 pot-lifts caught in the Western Zone fixed-site survey program from 1995–96 to 2018-19 fishing years (Nov–Sept). n, total number of lobsters measured.*

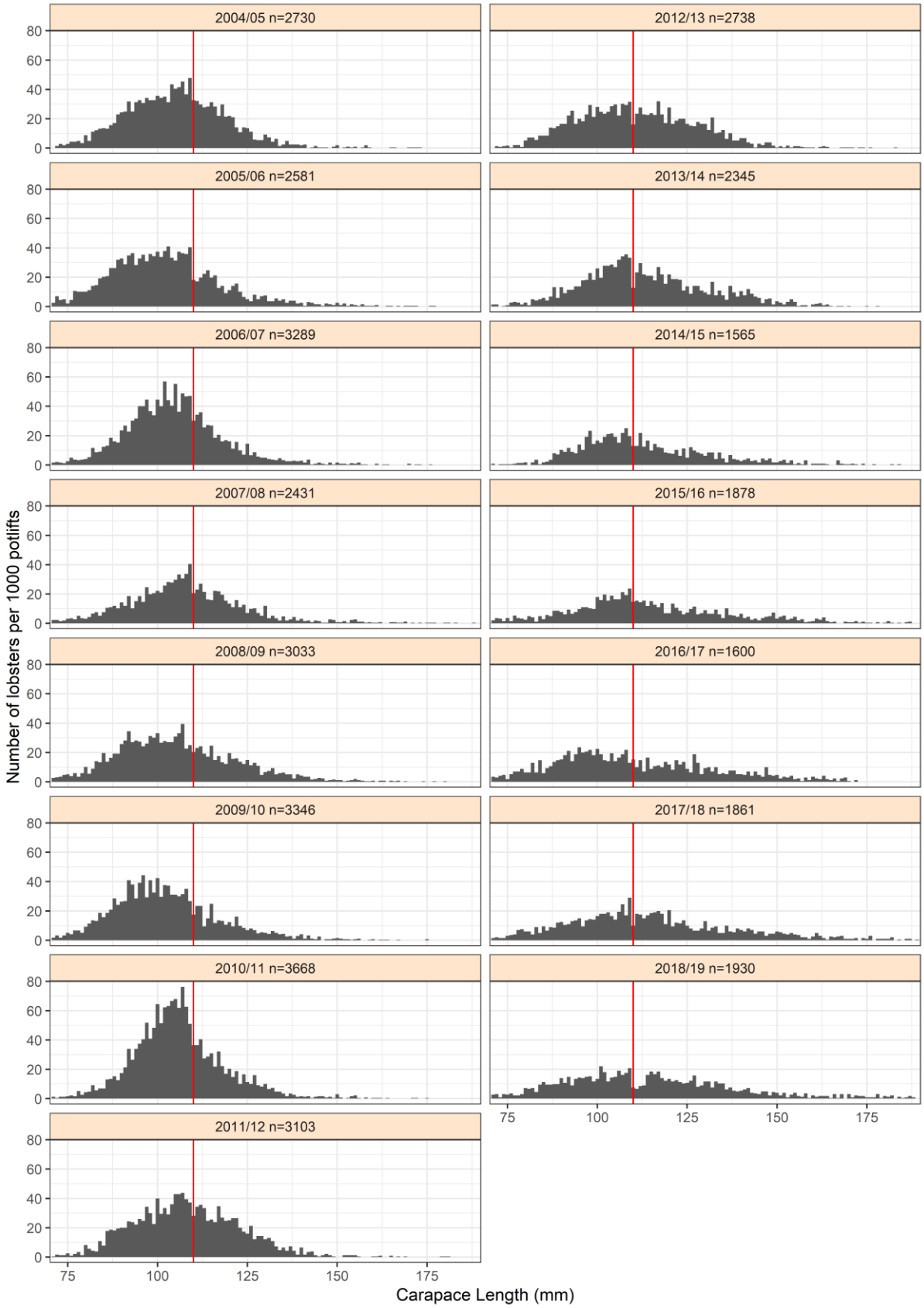


*Figure 28: Length-frequency distribution of the number of male rock lobsters per 1,000 pot-lifts caught in the Western Zone fixed-site survey program from 1995–96 to 2018-19 fishing years (Nov–Sept). n, total number of lobsters measured.*

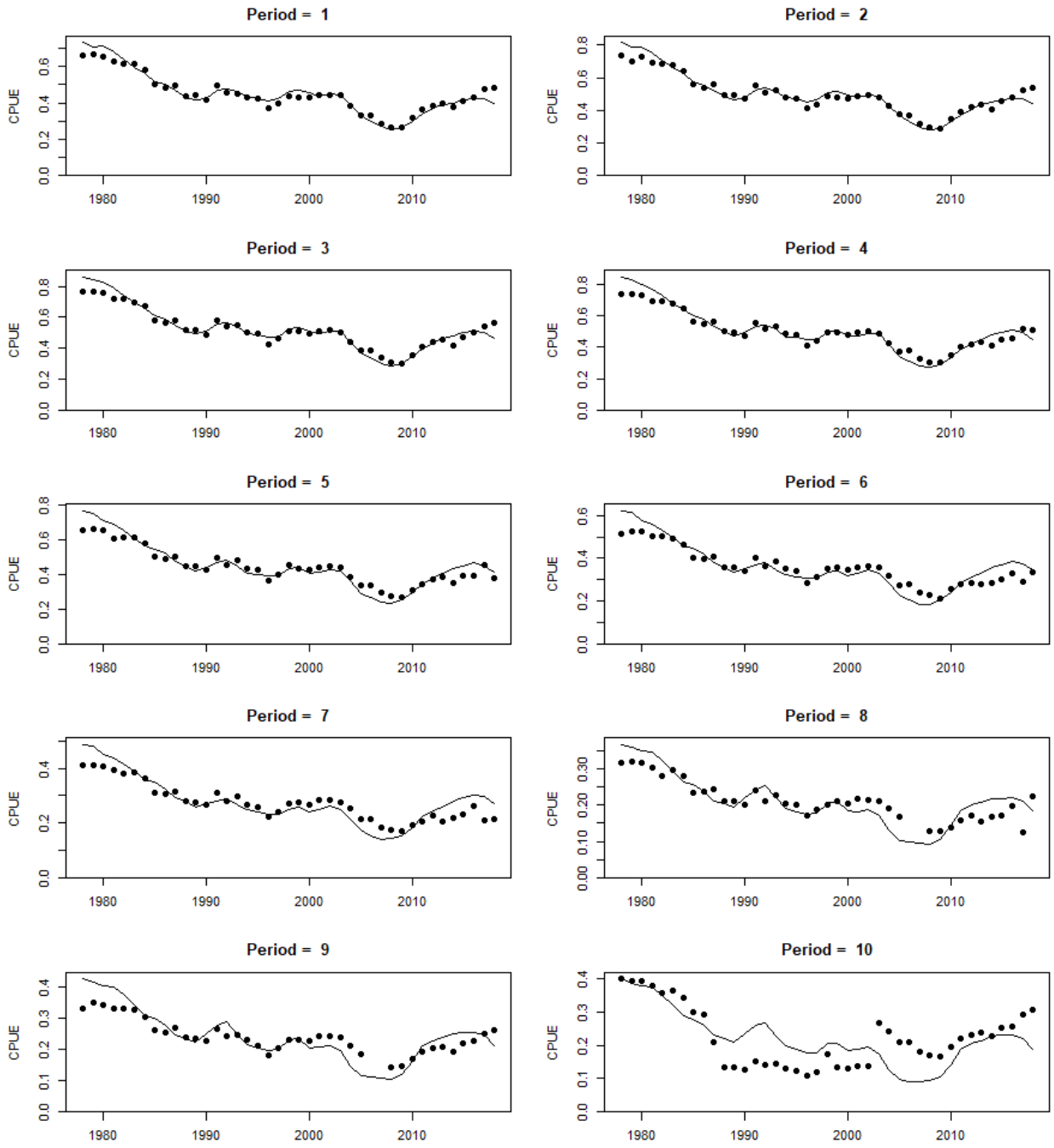


*Figure 29: Comparison between standardised CPUE (dots) and CPUE estimated by the stock assessment model (line) for the Western Zone. Periods 1 to 9 are November to July, period 10 is August and September*

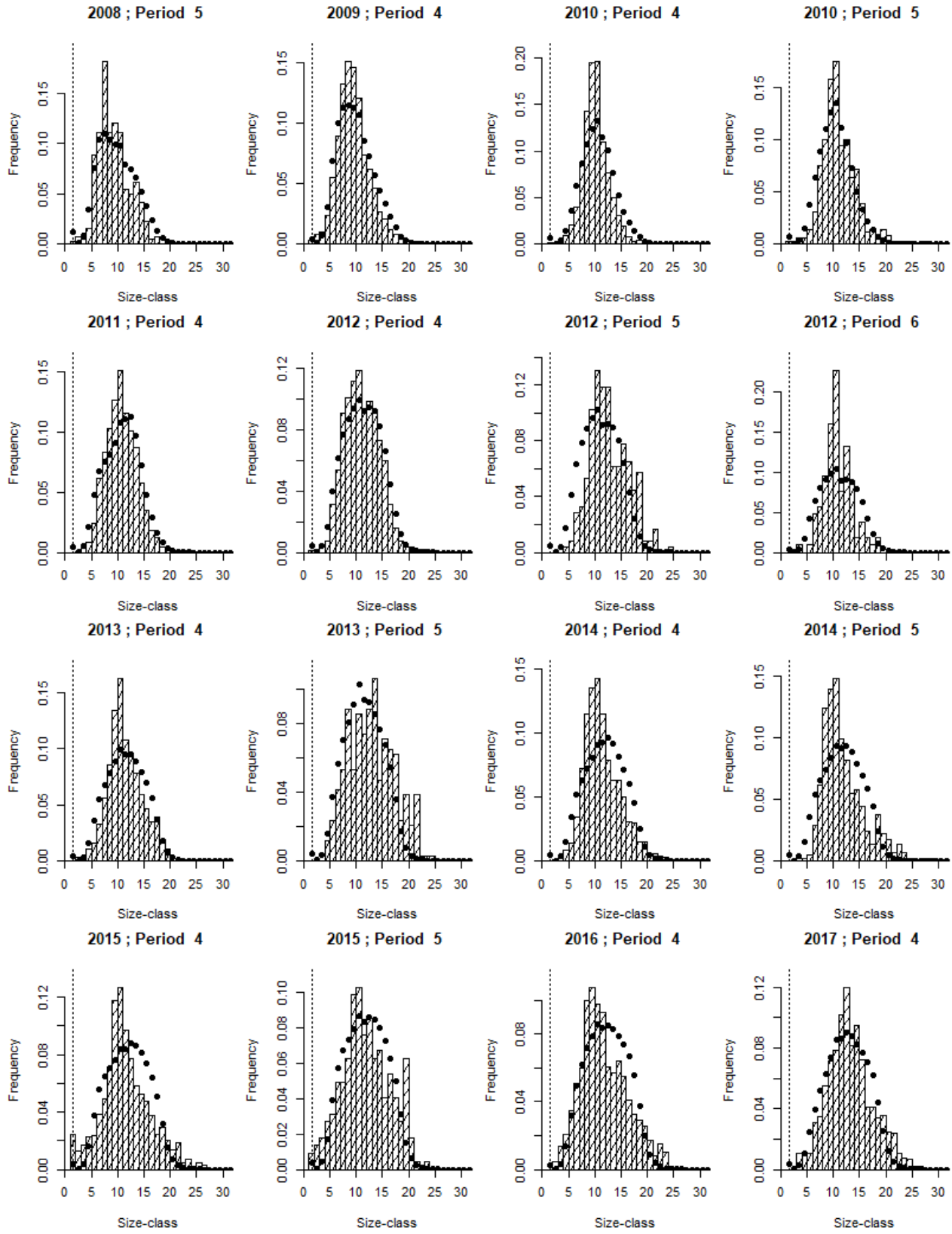


*Figure 30: Comparison between length-frequency measurements (bars) and abundance estimated by the stock assessment model (dots) for a selection of years and periods for the Western Zone. Periods 1 to 9 are November to July, period 10 is August and September. Size classes are from 60mm increasing in 5mm increments.*

# 8. SUPPLEMENTARY 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 | 0.66 | 1.13 |
| 1979/80 | 115 | 108 | 171 | 0.67 | 0.67 | 1.07 |
| 1980/81 | 133 | 123 | 180 | 0.74 | 0.67 | 1.09 |
| 1981/82 | 131 | 120 | 193 | 0.68 | 0.62 | 1.09 |
| 1982/83 | 143 | 132 | 212 | 0.68 | 0.66 | 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 | 0.29 | 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 | 0.29 | 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 | 0.32 | 1.09 |
| 2001/02 | 54 | 50 | 151 | 0.36 | 0.35 | 1.08 |
| 2002/03 | 52 | 47 | 133 | 0.39 | 0.38 | 1.10 |
| 2003/04 | 56 | 52 | 133 | 0.42 | 0.42 | 1.09 |
| 2004/05 | 54 | 47 | 136 | 0.40 | 0.41 | 1.14 |
| 2005/06 | 52 | 46 | 122 | 0.43 | 0.42 | 1.14 |
| 2006/07 | 54 | 48 | 136 | 0.40 | 0.41 | 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 |

| Fishing Year | Catch (tonne) | Catch ('000) | Nominal Effort ('000 potlifts) | Nominal CPUE (kg/potlift) | Standardised CPUE (kg/potlift) | Mean Mass (kg/lob.) |
|---|---|---|---|---|---|---|
| 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 | 0.55 | 1.28 |
| 2015/16 | 50 | 39 | 114 | 0.44 | 0.47 | 1.30 |
| 2016/17 | 53 | 37 | 124 | 0.43 | 0.43 | 1.42 |
| 2017/18 | 52 | 37 | 133 | 0.39 | 0.36 | 1.42 |
| 2018/19 | 43 | 29 | 103 | 0.41 | 0.41 | 1.49 |

*Table 4: Eastern Zone history of TACCs for each quota period from 2001-02 to 2018-19 (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 | 27 |
| 2014-15 | 1 Jul - 30 Jun | 59 | 59 | 100 | 12 | 25 | 23 |
| 2015-16 | 1 Jul - 30 Jun | 59 | 58 | 98 | 12 | 21 | 21 |
| 2016-17 | 1 Jul - 30 Jun | 59 | 52.6 | 89 | 12 | 25 | 22 |
| 2017-18 | 1 Jul - 30 Jun | 59 | 57.2 | 97 | 12 | 24 | 25 |
| 2018-19 | 1 Jul - 30 Jun | 47 | 44.7 | 95 | 12 | 20 | 20 |

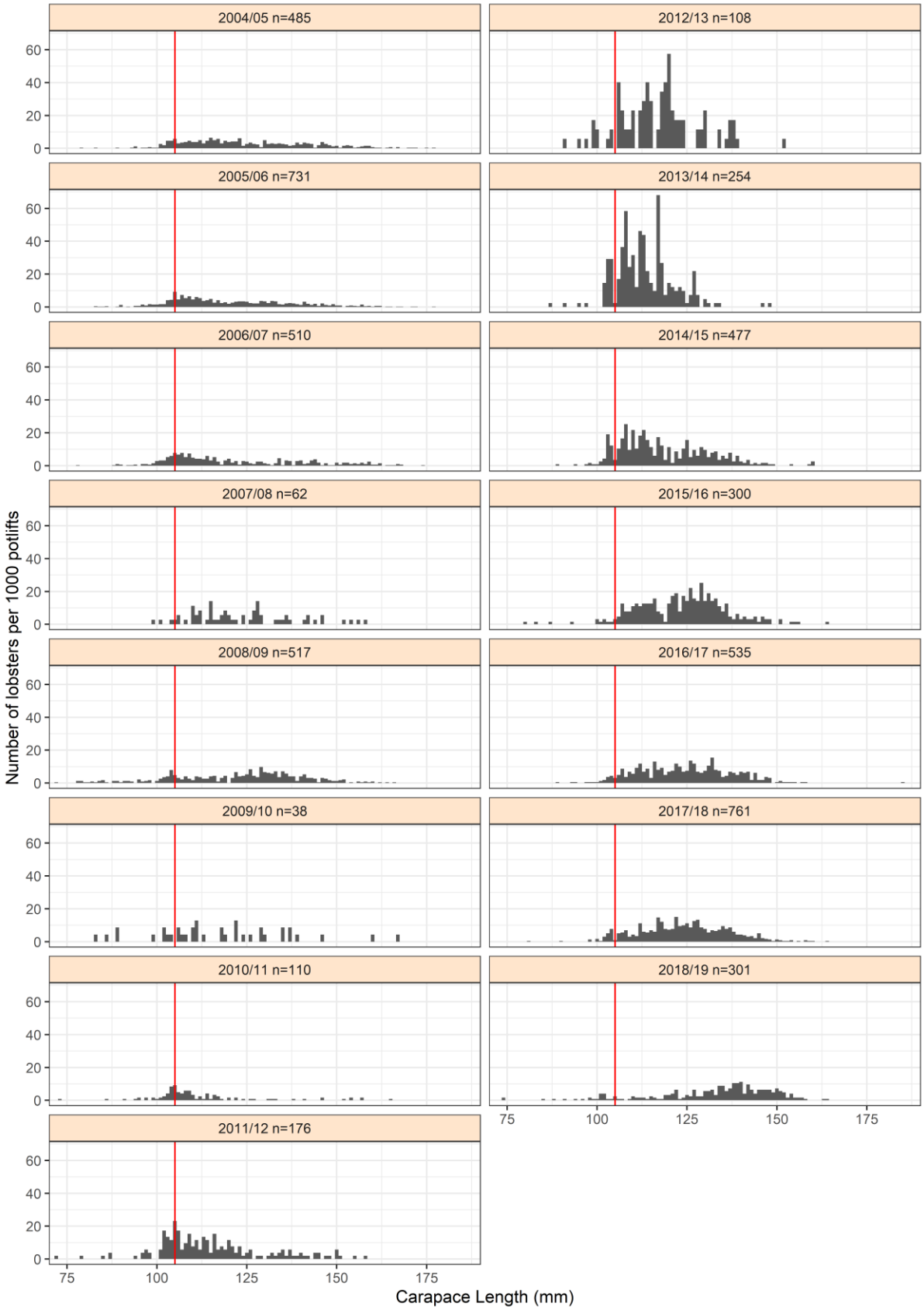


*Figure 31: Length-frequency distribution of the number of female rock lobsters per 1,000 potlifts caught in the Eastern Zone onboard observer program from 2004–05 to 2018-19 fishing years (Nov–Sept). n, total number of lobsters measured.*

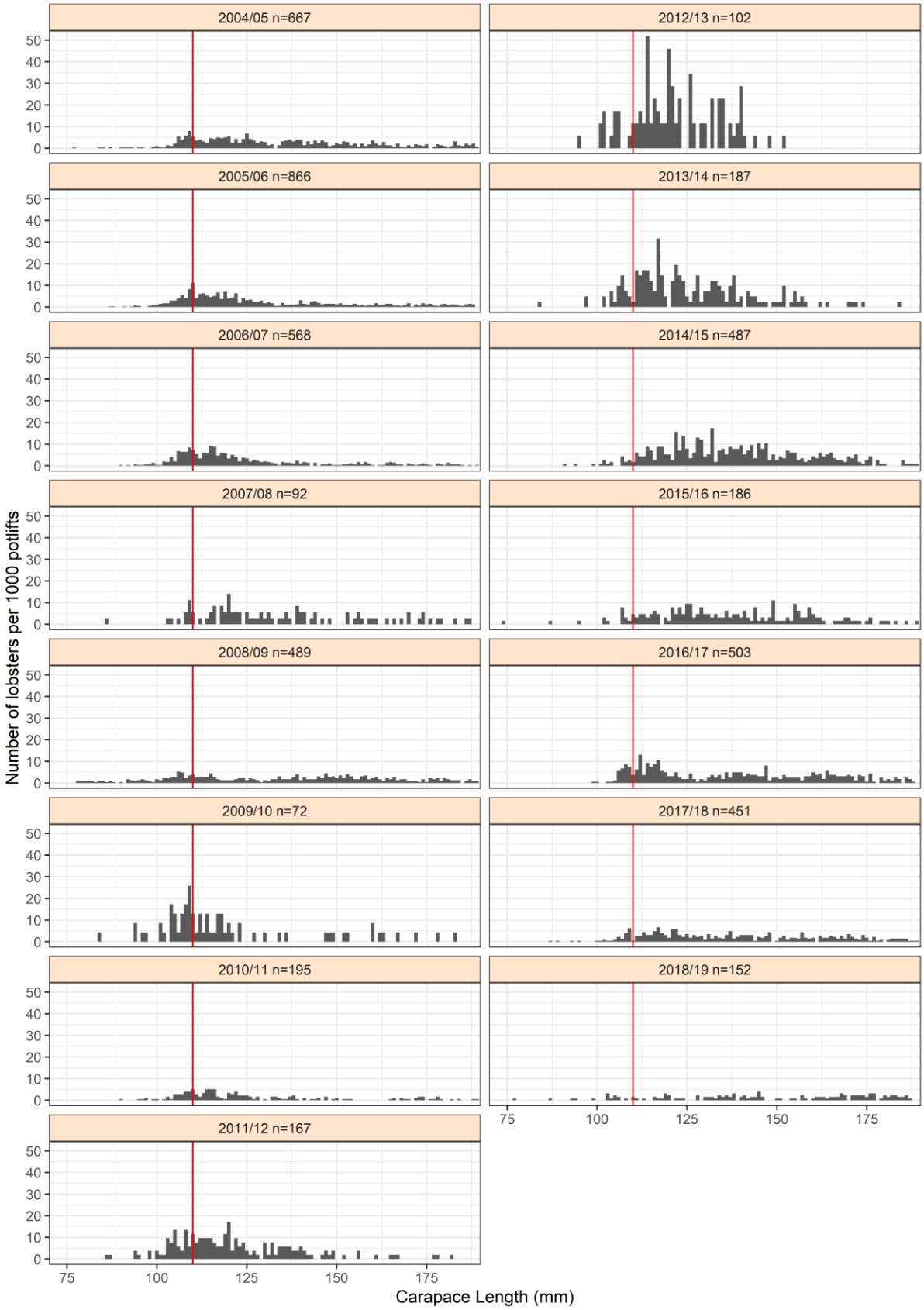


*Figure 32: Length-frequency distribution of the number of male rock lobsters per 1,000 pot-lifts caught in the Eastern Zone on-board observer program from 2004–05 to 2018-19 fishing years (Nov–Sept). n, total number of lobsters measured.*

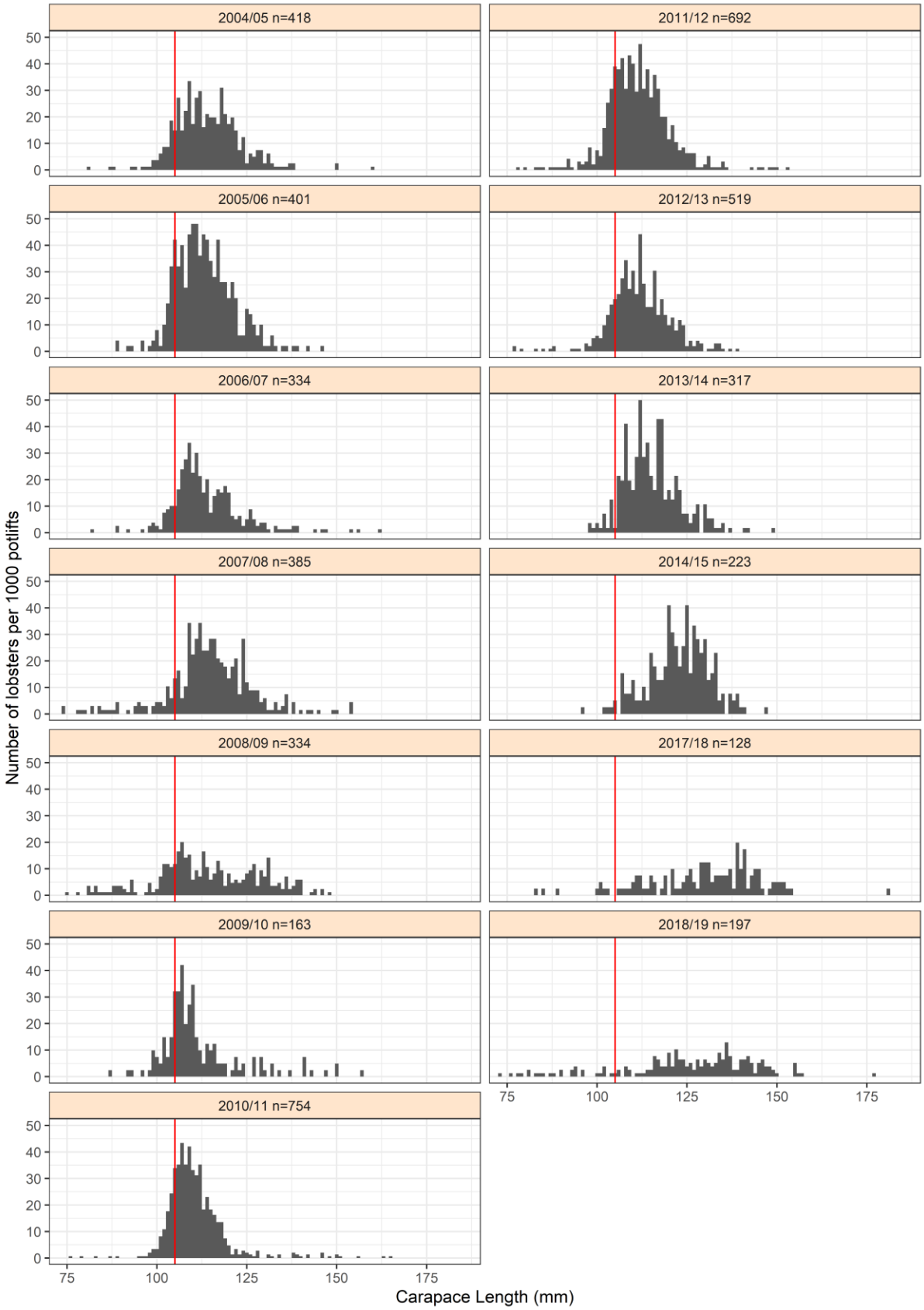


*Figure 33: Length-frequency distribution of the number of female rock lobsters per 1,000 potlifts caught in the Eastern Zone fixed-site survey program from 1995–96 to 2018–19 fishing years (Nov–Sept), n, total number of lobsters measured.*

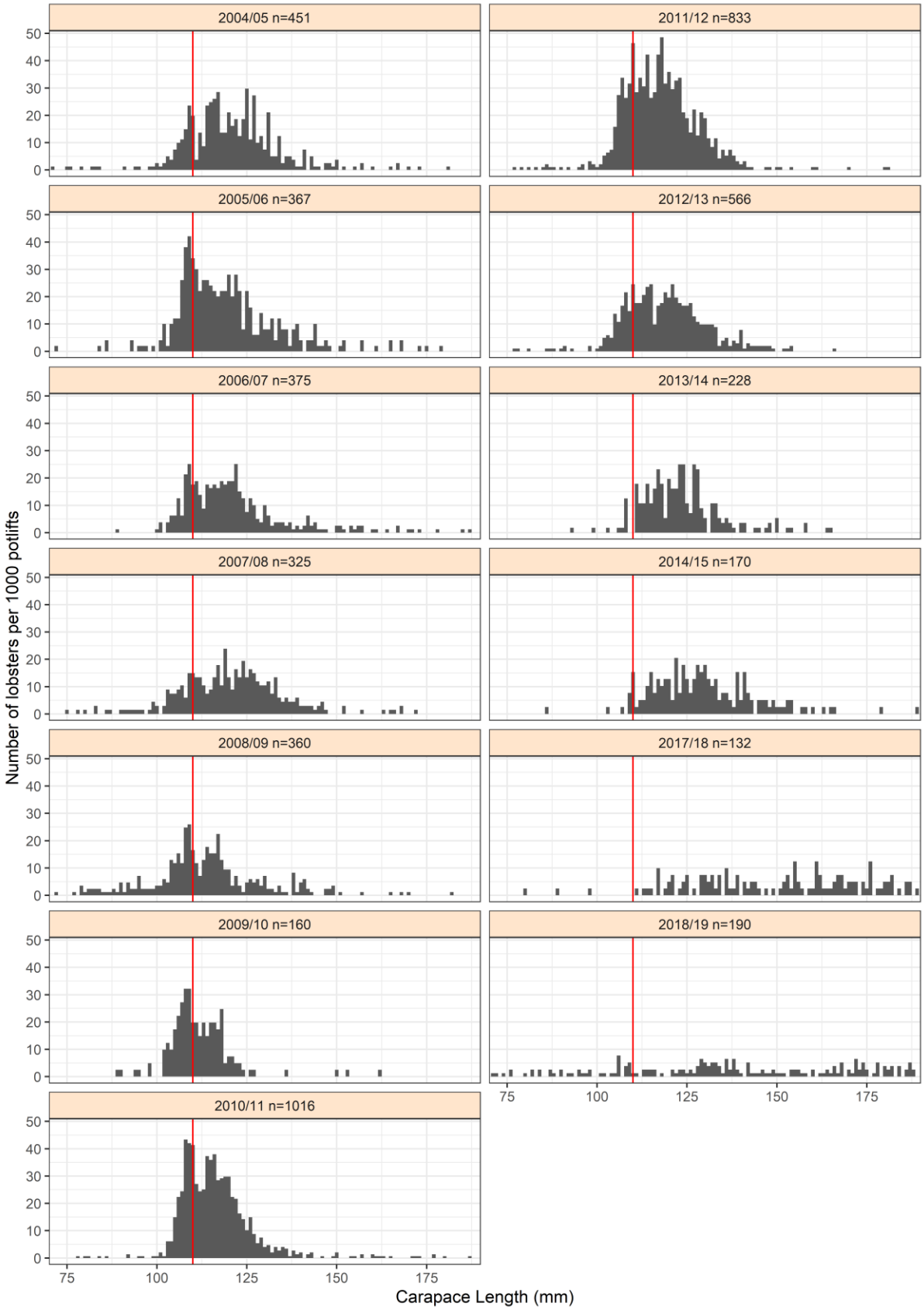


*Figure 34: Length-frequency distribution of the number of male rock lobsters per 1,000 potlifts caught in the Eastern Zone fixed-site survey program from 1995–96 to 2018–19 fishing years (Nov–Sept) ), total number of lobsters measured.*

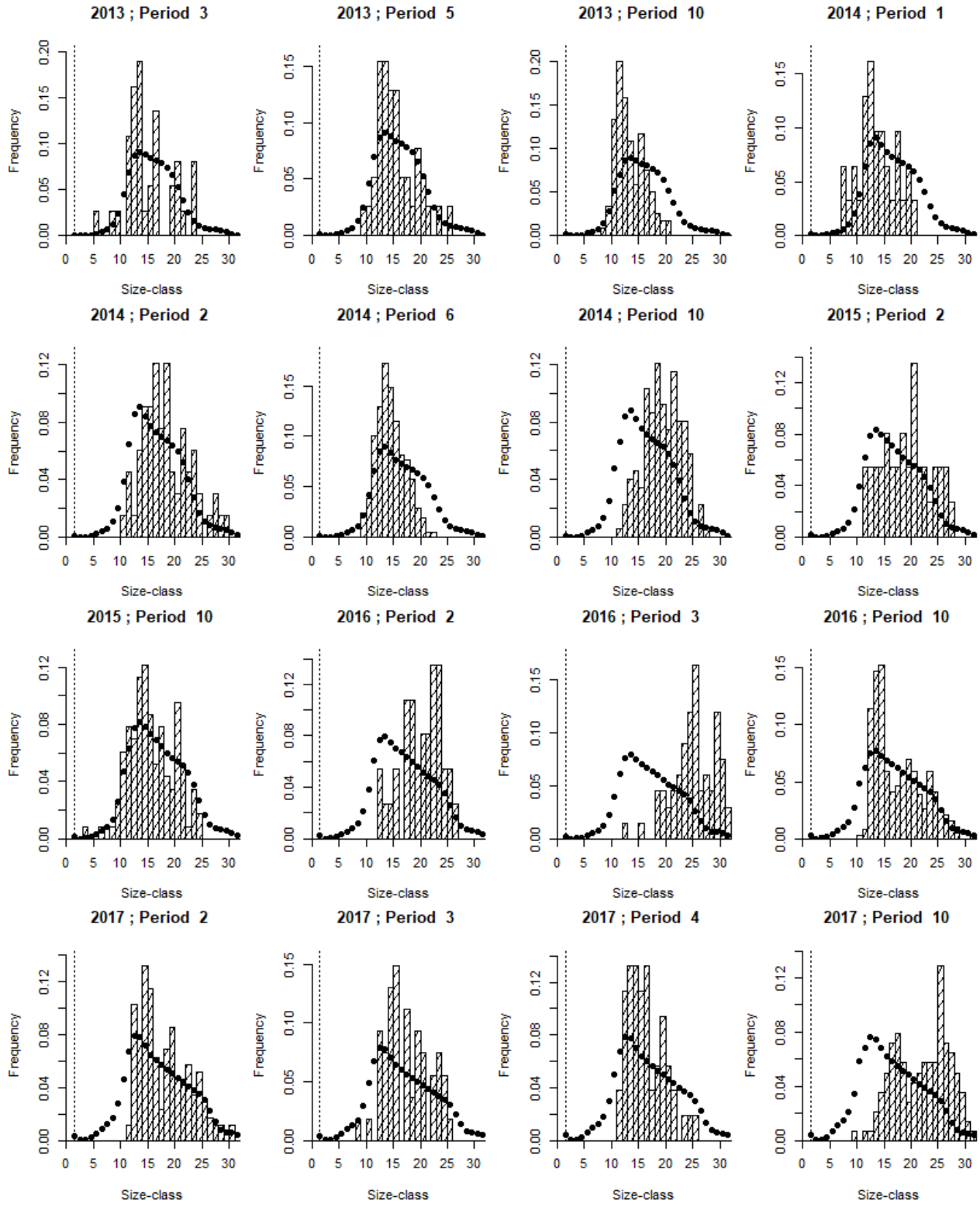


*Figure 35: Comparison between length-frequency measurements (bars) and abundance estimated by the stock assessment model (dots) for a selection of years and periods for the Eastern Zone. Periods 1 to 9 are November to July, period 10 is August and September. Size classes are from 60mm increasing in 5mm increments.*

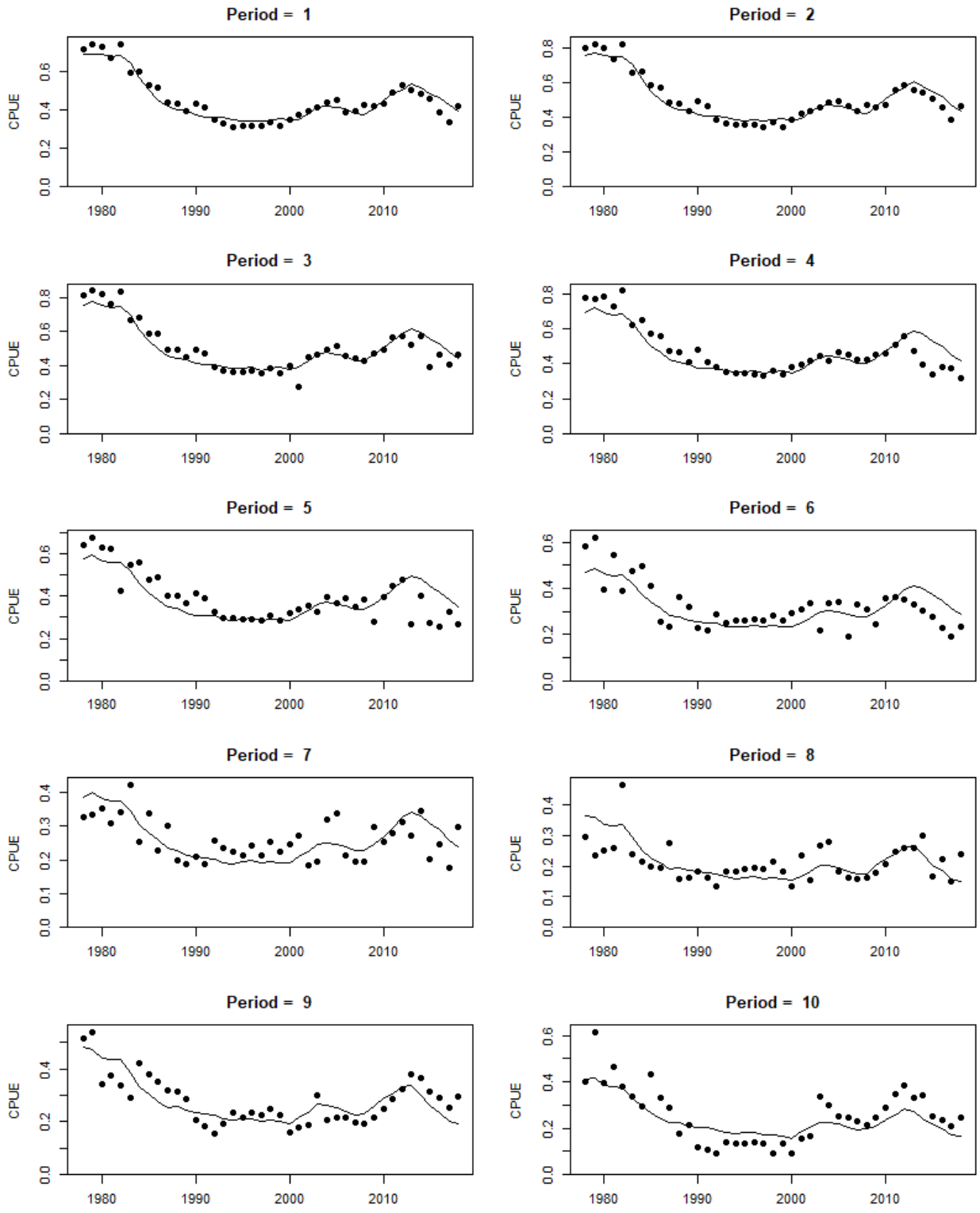


*Figure 36: Comparison between standardised CPUE (dots) and CPUE estimated by the stock assessment model (line) for the Eastern Zone. Periods 1 to 9 are November to July, period 10 is August and September*

# Appendix 1: Rock Lobster Fishery Harvest Strategy

**(excerpt from the Victorian Rock Lobster Fishery Management Plan 2017, amended to incorporate changes from 2019)**

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.

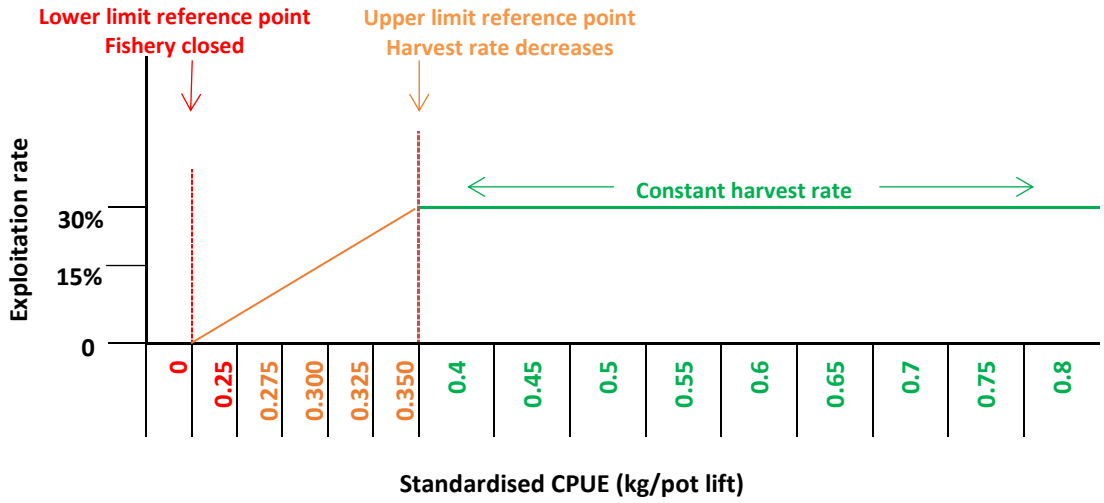


**Figure 9.** Theoretical construction of the proposed harvest strategy framework.

## 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
    - 20.5 % 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 unfished levels 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 the unfished level 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.**

| CPUE Band | TACC |
|---|---|
| <0.25 | 0 |
| 0.250 - <0.275 | 13 |
| 0.275 - <0.300 | 31 |
| 0.300 - <0.325 | 53 |
| 0.325 - <0.350 | 79 |
| 0.350 - <0.375 | 109 |
| 0.375 - <0.40 | 143 |
| 0.40 - <0.45 | 188 |
| 0.45 - <0.50 | 217 |
| 0.50 - <0.55 | 246 |
| 0.55 - <0.60 | 275 |
| 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.**

| CPUE Band | TACC |
|---|---|
| <0.25 | 0 |
| 0.250 - <0.275 | 5 |
| 0.275 - <0.300 | 10 |
| 0.300 - <0.325 | 17 |
| 0.325 - <0.350 | 24 |
| 0.350 - <0.375 | 32 |
| 0.375 - <0.40 | 40 |
| 0.40 - <0.45 | 51 |
| 0.45 - <0.50 | 56 |
| 0.50 - <0.55 | 61 |
| 0.55 - <0.60 | 66 |
| 0.60 - <0.65 | 70 |
| 0.65 - <0.70 | 70 |
| 0.70 - <0.75 | 70 |
| 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 20.5% in the Eastern Zone).
- Orange TACC values refer to standardised CPUE values below the upper LRP and have incrementally decreasing exploitation