

Victorian Rock Lobster Fishery

Stock Assessment Report

2021/22 Season

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Published by the Victorian Fisheries Authority (VFA), April 2023

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

Printed by VFA Melbourne, Victoria.

Preferred way to cite this publication:

VFA (2023) 2021/22 Victorian Rock Lobster Stock Assessment. Victorian Fisheries Authority Report Series No.36

ISBN 978-0-6455802-6-6 (Print)
ISBN 978-0-6455802-7-3 (pdf/online/MS word)

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Victorian Rock Lobster Fishery

Stock Assessment Report for the 2021/22 Season

1. EXECUTIVE SUMMARY

Overview

This report details the results of the 2021/22 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 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. A new harvest strategy is currently under development which is likely to be used in subsequent years. This 2021/22 assessment will be used to support the TACC setting process for 2023/24.

Western Zone Rock Lobster Fishery

The TACC for the Western Zone in 2021/22 was 246 tonnes (t), plus an additional 3.4 t, comprised of 10% of uncaught quota for 2020/21 and the uncaught quota of those fishers impacted by the abalone virus. The subsequent 2022/23 TACC was also set to 246t with no carry-over applied.

Overall, the stock indicators in the Western Zone continue to show improvement. The standardised catch per unit effort (CPUE) improved from 0.68kg/pot-lift in 2020/21 to 0.74 in 2021/22. The pre-recruit index (PRI) indicates the abundance of undersize lobsters. This reached a record low in 2015/16. Despite increasing slowly, it remained close to this record low over the subsequent three years. In the last two years the PRI has been at a level marginally above the threshold level (1.87 in 2021/22 compared with the 1.81 undersize / potlift trigger point).

Egg production has been relatively consistent at 23-24% in the last seven years, in 2021/22 egg production was at 22.0% which is above the 20% limit reference point. A new alternative method used for calculating egg production confirms that egg production is above the 20% reference point with near certainty. Biomass has been increasing slowly from a recent low in 2008/09, however had a decrease in 2021/22. The most recent decline is in part due to a known inconsistency between the length-frequency data and CPUE. Recruitment has been below the long-term average since 2007/08. The pre recruit index has been near the threshold level in the last two years indicating an increase of recruitment from the low levels experienced in the previous 13 years. This is a positive sign and should lead to notable CPUE increases under the current TACC, however recruitment remains below the long-term average level.

Eastern Zone Rock Lobster Fishery

The 2021/22 TACC for the Eastern Zone was reduced to 32 t (plus an additional 1 t which was 10% of uncaught quota for 2020/21), following a previous reduction to 40t in 2019/20. These reductions occurred because standardised CPUE reduced from a recent high of 0.64kg/pot-lift in 2012/13 to 0.37kg/pot-lift in 2019/20 (the year used to set the 2021/22 TACC). CPUE increased in the last assessment report for the 2020/21 season, however the PRI remained below the threshold, hence a TACC of 32t was retained for the 2022/23 season that is currently underway.

The 2021/22 standardised CPUE increased to 0.49kg/potlift from 0.37 kg/potlift in 2019/20. PRI increased to 0.32 undersize/potlift in 2021/22, a significant increase from the 2018/19 level of 0.08, and is equivalent to the threshold level of 0.32 undersize/potlift.

Egg production has fallen from a recent high of 27.2% in 2013/14 to 22.9% in 2021/22 – however this remains above the 20% limit reference point. A new alternative method used for calculating egg production confirms that egg production is above the 20% reference point with near certainty. Biomass has followed a similar trajectory, decreasing 37% from the recent 2013/14 high. Compared to the previous season, biomass in 2021/22 increased 8% (13t), the second increase since 2013/14. Recruitment has been below the long-term average since 2008/09 but there is some evidence of recent higher recruitment (albeit, still below the long-term average) in 2015/16 - 2017/18 which is also apparent in the PRI.

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 legal-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 (26.3% 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 2021/22 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 for the Western Zone in 2021/22 was 246 tonne (t), this was unchanged from 2019/20 when a 1t increase from the previous TACC was implemented due to a revision of the CPUE-TACC table in the harvest strategy (Table 3). This follows on from four years of 230t TACCs.

CPUE has increased in the Western Zone and would have enabled a higher TACC in 2021/22 and 2022/23 (the year currently underway). However, low PRI values have caused concern about future recruitment, resulting in retention of the TACC at the 246t level (see 2019/20 and 2020/21 assessments for more details).

The effort required to take the catch was 240,554 pot-lifts, which is the lowest on record (Table 2, Figure 1). The reduction was largely attributable to increasing CPUE. Nominal CPUE has almost tripled since the lowest level in 2009/10, consequently effort to take the same amount of catch has reduced by a third. The reduction in the number of potlifts required to catch the TACC drove the consolidation of the fleet from approximately 100 active vessels through the 1990s to 38 active vessels in 2021/22.

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 has reached 0.74 kg/pot-lift in 2021/22. This increased CPUE is now at levels not experienced since the 1980s (Table 2, Figure 2). Nominal and standardised CPUE have diverged in recent years – this is primarily due to a shift to a more efficient fleet (and fishing characteristics) 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, there was a reduction in catch in Portland of 23t from the previous year and increases in the other areas, most notably Apollo Bay. The highest catch in 2021/22 came from the Portland region at 134t, followed by Apollo Bay at 71t and Warrnambool at 51t. Standardised catch rate increased in all regions, most significantly in Apollo Bay (Figure 3).

Recreational Catch

On 1 July 2017, the VFA implemented a three-year pilot program requiring all recreational fishers to tag the lobsters they catch and keep and report the use of tags. The objective of the program was to obtain an estimate of the annual recreational catch by using the number of tags used in that season to represent the number of rock lobsters removed from the stock and ascertain whether the actual catch is in line with the assumed notional catch share.

On the back of the success of the trial, the Minister committed to transitioning the trial to an ongoing program. This has resulted in the annual collection of recreational catch data feeding into annual stock assessments, rather than relying on notional assumptions. Since the start of the 2021 recreational lobster season, the rock lobster reporting program has utilised GoFishVic, a smartphone App from the Victorian Fisheries Authority, and all reporting is now completed digitally by fishers in GoFishVic.

Recreational catch estimates produced by this program are now intended for use in the stock assessment model. However, due to the disruptions from bushfires, COVID, and the data collection challenges from the recent transition to digital tagging, the most recent season of data that is considered reliable is the

2018/19 season[1]. In the 2018/19 season 6346 kg were reported as caught and retained by recreational fishers in the Western Zone. Weight was calculated by multiplying the average citizen science weight in the Western Zone (1.7kg in 2018/19) by the total number of tags reported (3734 tags in 2018/19). (This is equivalent to 2.6% of the TACC in 2021/22 quota year.

For context, in the 2021/22 season 1,018 lobsters were reported as caught and retained by recreational fishers in the Western Zone. Using a length / weight relationship (derived from 165,000 lobsters measured and weighed in fish processors from 1995 – 2017), the estimated mean weight was 1.47 kg and 0.97 kg for male and female lobsters, respectively. The estimated total weight of lobsters caught was 1,389 kg, equivalent to 0.6 % of the TACC in 2021/22. This data was however, not considered reliable due to the transition to electronic reporting.

By applying the length /weight relationship (with the same average weights and sex ratio used for the WZ in 2021/22) to the reported catch for 2018/19, the estimated total weight landed was 5,070 kg, equivalent to 2% of the TACC in 2021/22 quota year.

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 to a record low 38 vessels in 2021/22 (Figure 5). During the same period the average annual catch increased from a record low of 2.4t per vessel in 1988/89 to 5.9t per vessel in 2000/01 and up to 6.8t in 2021/22 (Figure 6). 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 and 53 days in 2021/22, this has occurred as the fleet contracted and the catch per vessel increased (Figure 6).

In the 2021/22 season, high CPUE and a reduction in fleet size to 38 (the lowest on record) led to an increase in the average annual catch to 6.8t and 53 days of fishing, both of which are the highest on record. 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.

Note that the numbers reported in this section are for the fishing season and will differ from the licensing year summaries provide in Table 5.

[1] https://vfa.vic.gov.au/__data/assets/pdf_file/0008/907433/RLRAG-Minutes-Meeting-36.pdf

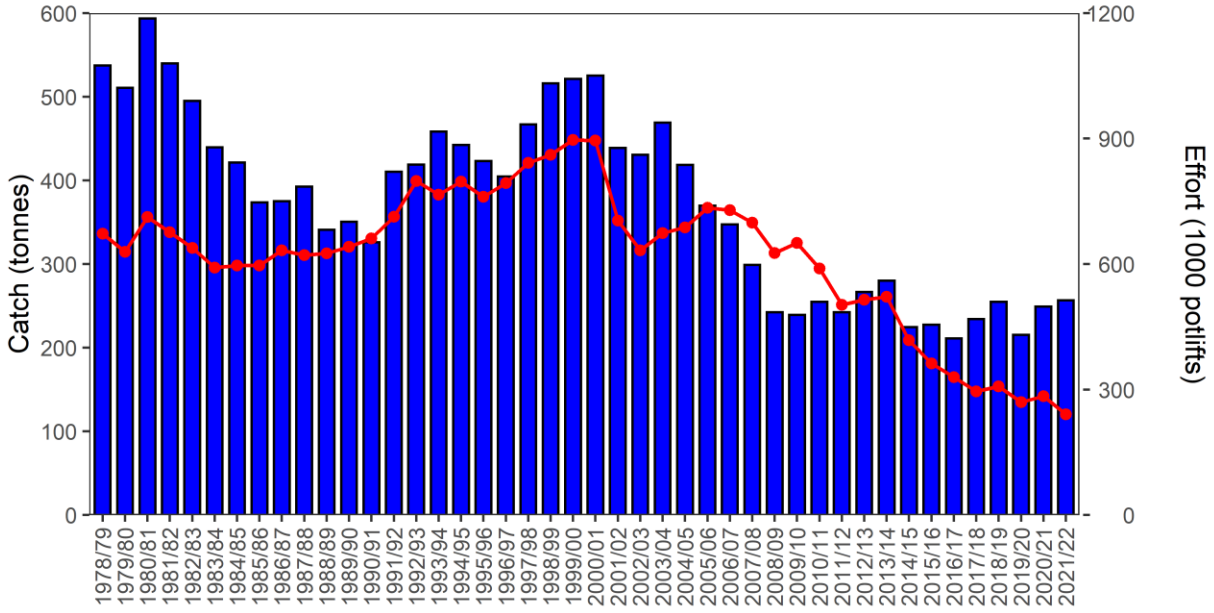


Figure 1: Total catch (blue bars; tonnes) and nominal effort (red line; x1000 pot-lifts) in the Western Zone.

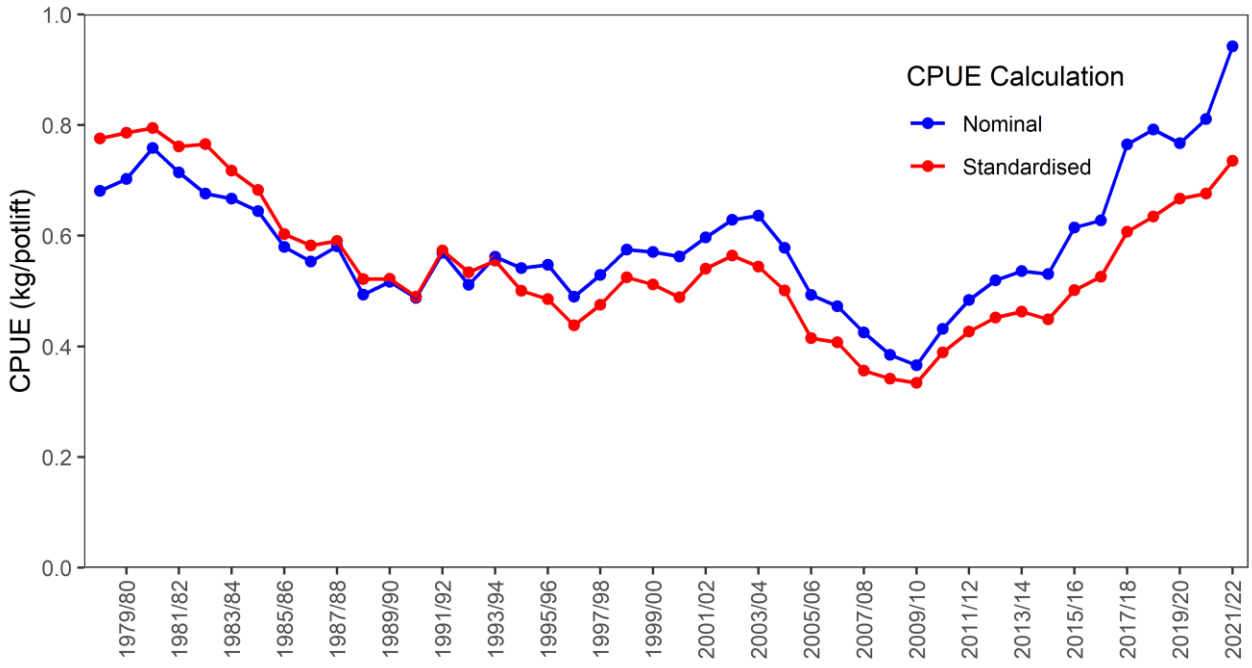
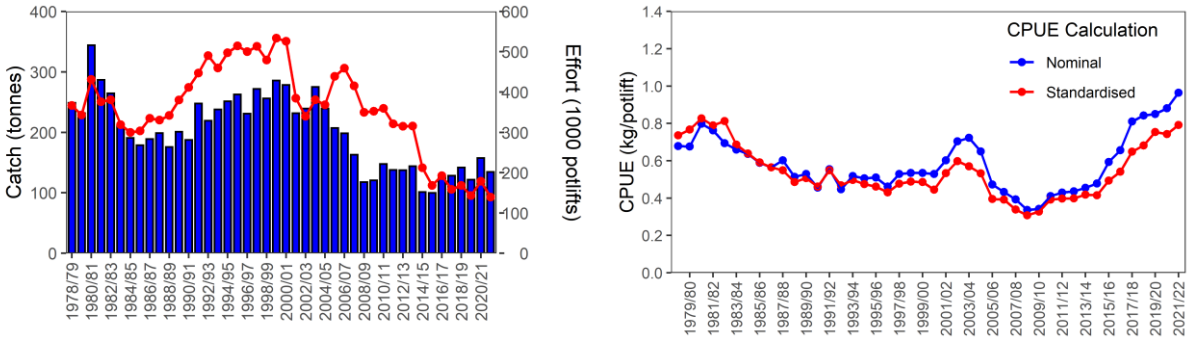
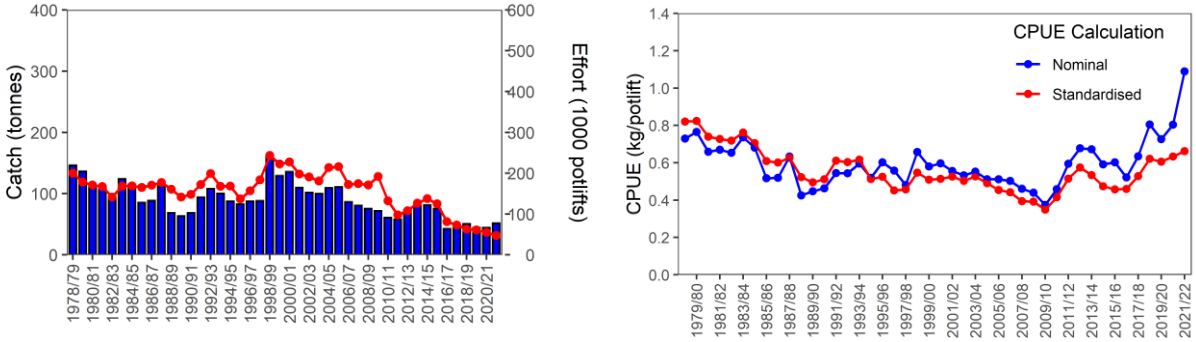


Figure 2: Standardised (red) versus nominal (blue) CPUE (kg/potlift) in the Western Zone. Note that standardised CPUE values differ slightly from one assessment to the next as the depth, seasonal and fisher coefficients are shared across years and are re-estimated including the new data.

PORTLAND



WARRNAMBOOL



APOLLO BAY

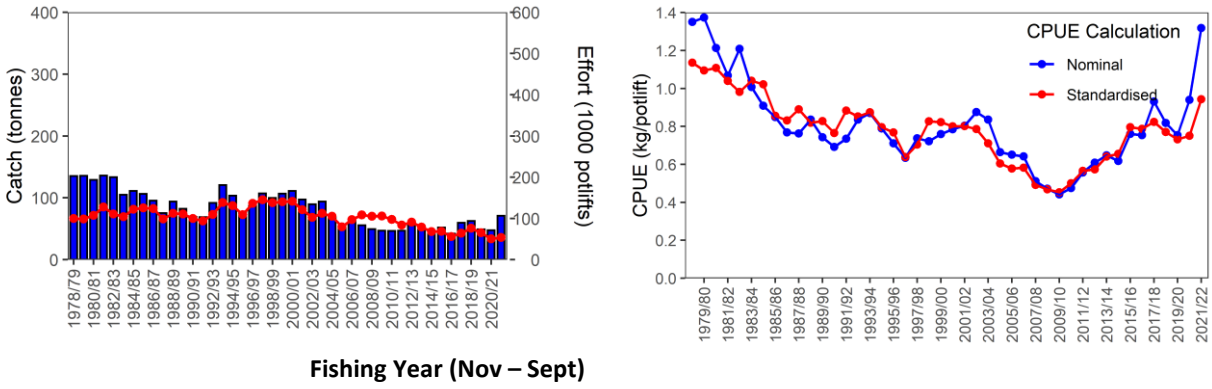


Figure 3: Regional catch (blue bars), effort (red line), and standardised (red) and nominal (blue) CPUE (kg/potlift) in the Western Zone.

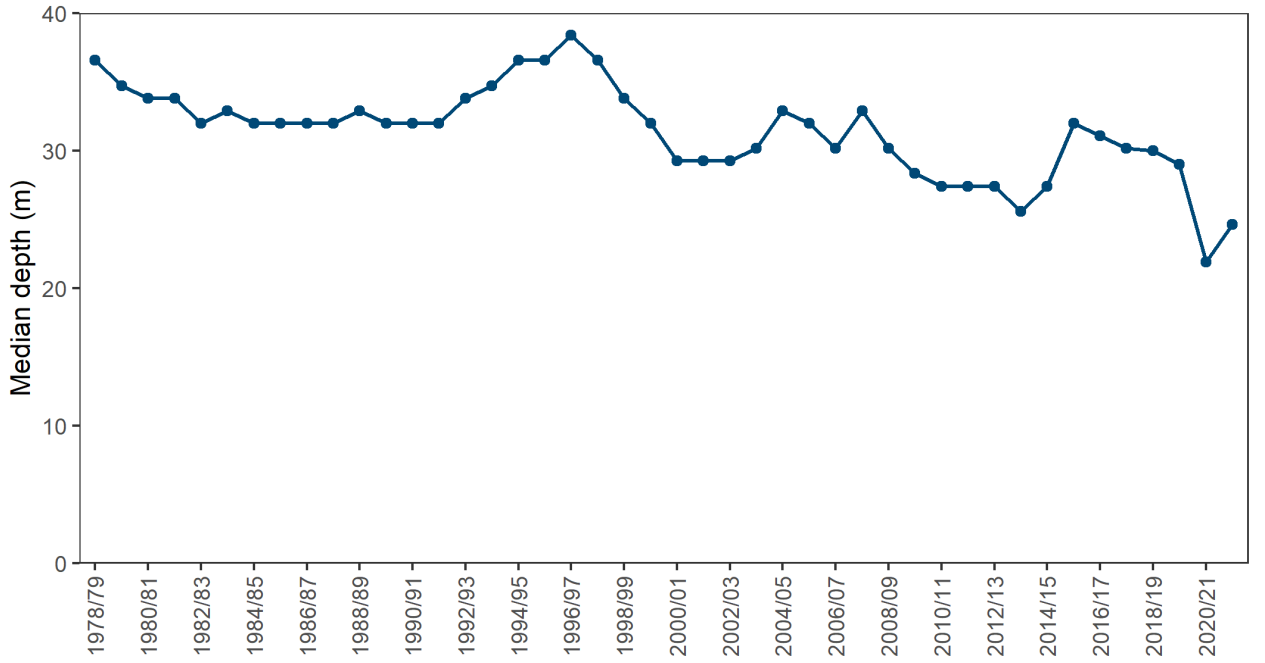


Figure 4: Annual median pot depth as recorded from logbooks in the Western Zone.

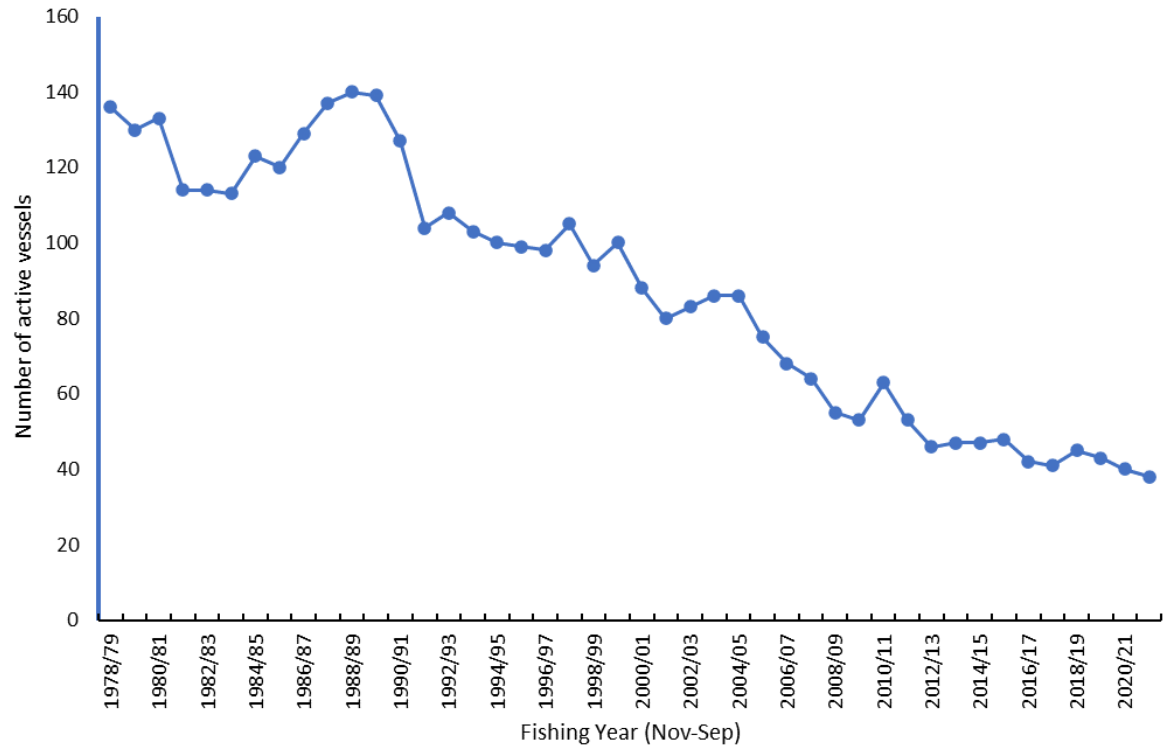


Figure 5: The number of active vessels in the Western Zone in each fishing year.

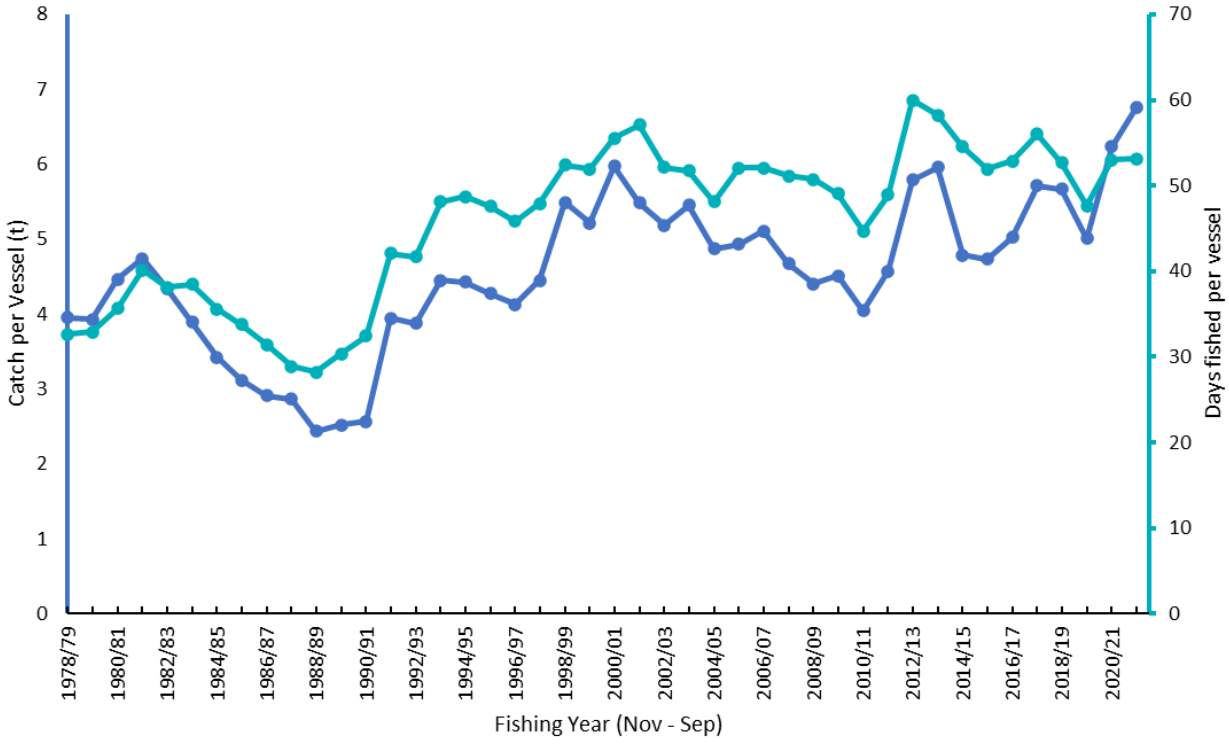


Figure 6: The annual mean catch (dark blue) and mean number of days fished (light blue) per active fishing vessel in the Western Zone

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.

Undersize catch rates differ between areas and between the fixed site surveys and the on-board observer program. Consequently, calculating a pre-recruitment index (PRI) by simply averaging across the entire dataset would result in changes in observer coverage influencing the PRI value in a way that is unrelated to real changes in undersize abundance. To address this both the observer and fixed site PRIs are calculated for a number of pre-determined areas which are then combined ensuring that the contribution of each area remains consistent through time. The observer based PRI is also scaled so that its mean value matches that of the fixed site PRI, this enables these two data sources to be combined in a way that gives them equal importance.

The PRI indices calculated from both data sources show similar trends with a rapid decline from the recent peak in 2011/12 to a record low in 2015/16. Since that time PRI has been trending upwards with values in the last two years at around the threshold level of 1.81 undersize per potlift (Figure 7). The most recent 2021/22 value is 1.87 undersize per potlift. Observer and fixed site PRI have been highly correlated indicating consistent signals in both data sources and providing confidence in the representativeness of these indices.

As a consequence of COVID restrictions, full coverage was not obtained in the observer program in 2019/20. The observer sites that were completed are by chance those with typically the lowest PRI (Port Fairy and Warrnambool), consequently the PRI was considered incomplete for the 2019/20 assessment period. For the 2020/21 and 2021/22 assessment coverage was complete.

Mean weight

The mean weight of legal sized lobsters increased between 2011/12 and 2019/20 to a record high of 1.04kg (Figure 8). It has slowly decreased in the last two years (to 1.01kg in 2021/22). The overall increase in average lobster weight observed between 2011/12 and 2019/20 is an additional indicator of low recruitment to the fishery and, consequently, the decrease in the last two years could be an indication of increased recruitment. However, it has been noted that mean weight may also have increased as a result of lower yearly effort due to the lower TACCs in recent years 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 2019/20 there was 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. This dramatic change is highlighted in Figure 9 with full length-frequency details provided in Figure 29 to Figure 32. The exception to this general trend occurred in the last two seasons which have showed an increase across animals below the LML in both observer and fixed sites.

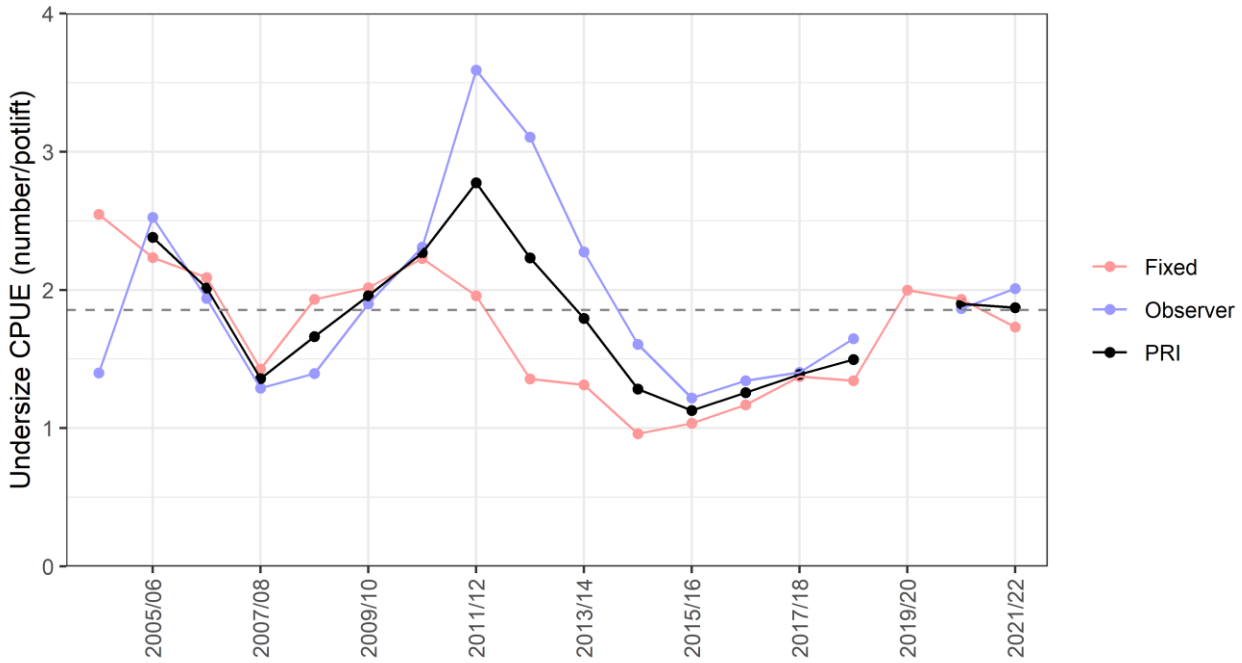


Figure 7: The undersize catch rate (kg/potlift) for the Western Zone as calculated from fixed sites (red), observer coverage (blue) and the final combined PRI (black). The dashed line shows the trigger point (1.81 undersize/potlift). A PRI value for 2019/20 was unavailable due to limited coverage resulting from COVID restrictions.

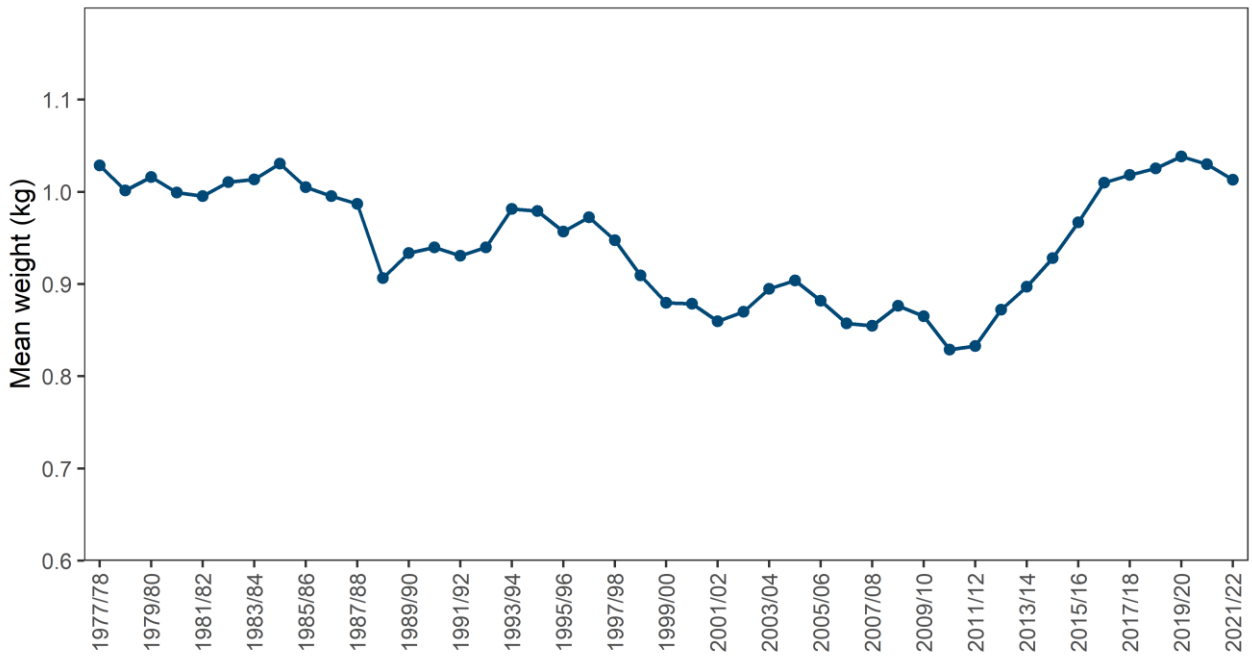


Figure 8: Mean weight of legal-sized lobster in the Western Zone fishery.

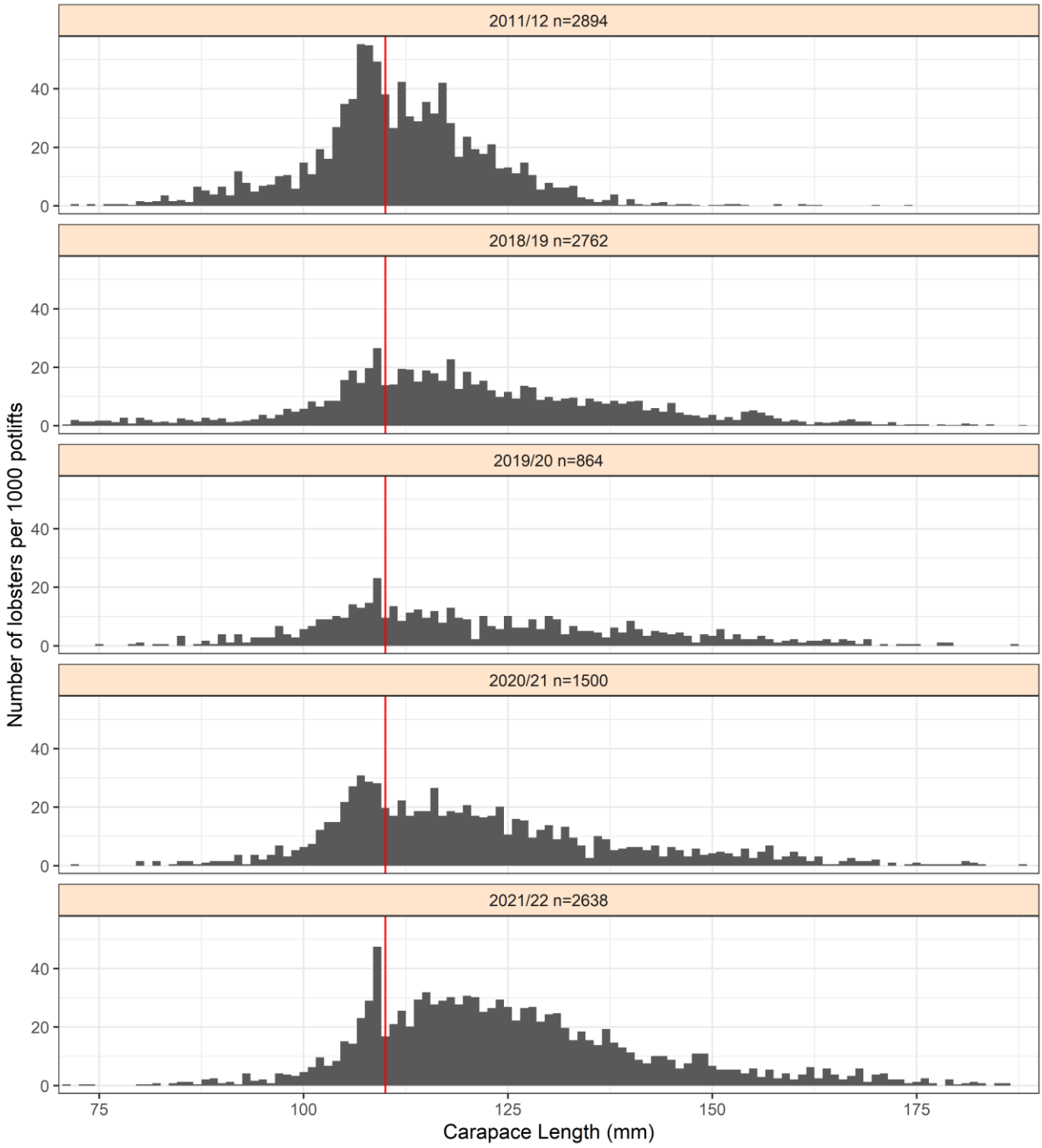


Figure 9: Length-frequency plots for 2011/12 and the last four seasons for male lobsters measured by the Western Zone observer program to highlight the changes that have occurred. The red line indicates the legal size limit.

3.3 MODEL OUTPUTS

Estimated recruitment

Recruitment is reported as the number of new lobsters passing the 60mm CL size in a given year. It is difficult to obtain information about lobsters of this size directly as they are much less likely to be retained in pots (as recorded on observer and fixed site sampling trips) and do not influence the commercial CPUE. Consequently, reliable estimation of the recruitment in a given year requires observation of that age class over several years. As the lobsters grow they are observed through multiple fixed site surveys and observer trips and ultimately influence commercial CPUE. These multiple observations are combined with information about lobster growth through the stock assessment model to give the best estimate of recruitment in each year. Due to this the most recent recruitment estimates (e.g. for 2021/22) are highly uncertain and are not shown, whilst the most recent estimates shown (e.g. 2017/18) are more likely to change in future years as more information becomes available about these year classes.

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 10). It is for this reason that stock recovery under the lower catch levels implemented in the last 15 years has been slow.

Estimated egg production

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

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 2021/22 egg production was at 22.0%, which is above the 20% limit reference point (Figure 11). There has been a gradual decline in egg production over the last two years from a high of 23.5% in 2017/18 (revised from previous assessment). However some of this decline is due to the negative bias in the most recent egg production estimate.

In addition to the existing approach for calculating egg production, a new method was applied in parallel in this assessment. This method gives a more consistent probabilistic evaluation of egg production. The key benefits are that i) the estimate of the unfished pre-exploitation level of egg production is updated in each stock assessment on the basis of new information and ii) the current level of egg production is evaluated against this in a probabilistic manner that takes into account recruitment variability. A probability distribution derived from this method is shown in Figure 12. This provides additional evidence that egg production exceeds the 20% limit reference point with a >90% probability as required by the harvest strategy. Note that the two methods produce somewhat different results in magnitude but are broadly consistent and both meet the requirements of the harvest strategy.

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 65% in 2006/07. The corresponding

available biomass decreased and reached a low of 453t in 2008/09. After 2006/07, the exploitation rate dropped significantly, and the available biomass improved. In 2021/22, the estimated available biomass decreased to 783t, with a corresponding fishing exploitation rate of 32.8% (Figure 13).

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. In the Western Zone data set there has long been a level of inconsistency between undersize lobster estimates from length-frequency data and stock productivity in subsequent years. The CPUE in future years tends to be higher than expected given the catch and the level of undersize observed at present. Consequently model biomass and egg production estimates for the most recent year tend to be underestimates and tend to be revised upwards in subsequent years as new data becomes available. This known issue leads to a precautionary perspective and is being investigated in more detail as part of the trial of the new Australian Lobster model.

Selected model diagnostics for both data sets are shown in Figure 33 and Figure 34. 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 14, CPUE in the most recent year is slightly under-estimated and consequently the 2021/22 biomass and egg production estimates are likely to be similarly slightly under-estimated.

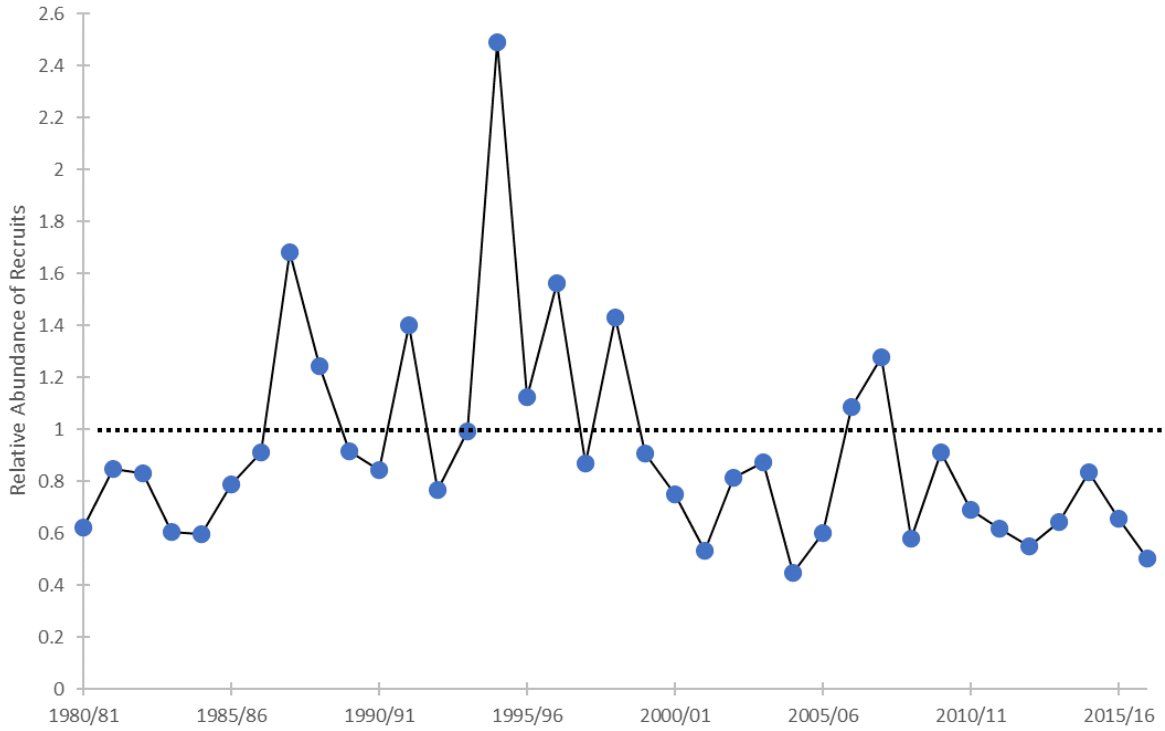


Figure 10: Relative number of recruits (to 60 mm in CL) in the Western Zone Fishery. These results are generated by the stock assessment model. The long-term average is indicated by the dotted black line. The most recent values are based on fewer observations and are therefore more likely to change in future stock assessments as more information about that year class becomes available.

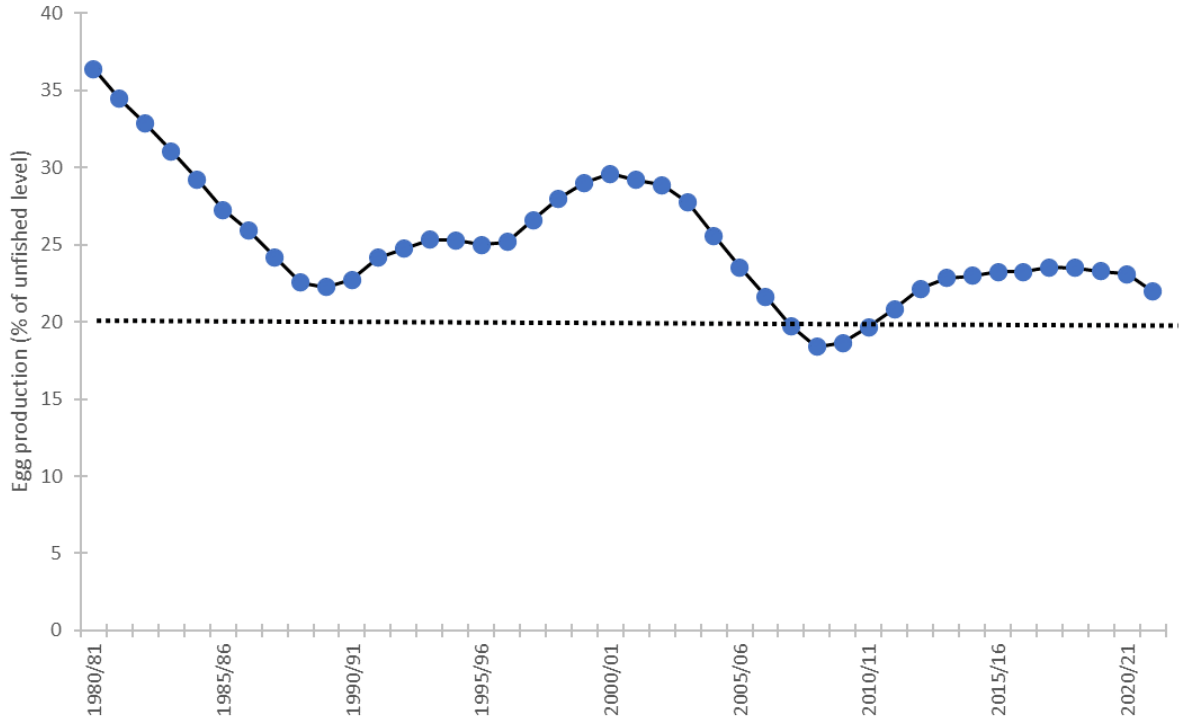


Figure 11: Model estimated level of egg production through time in the Western Zone fishery. The limit reference point (dotted line) is 20% of unfished levels.

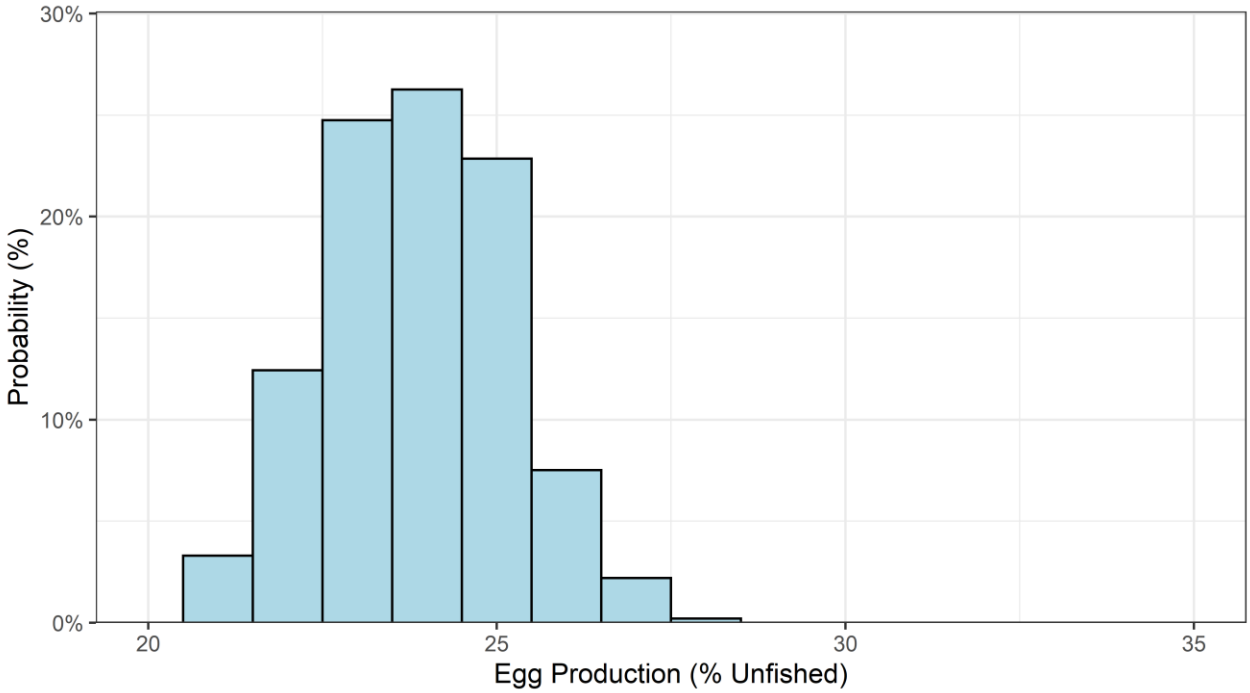


Figure 12: Probability distribution of model estimated egg production in 2022 compared to the unfished level of egg production in the Western Zone.

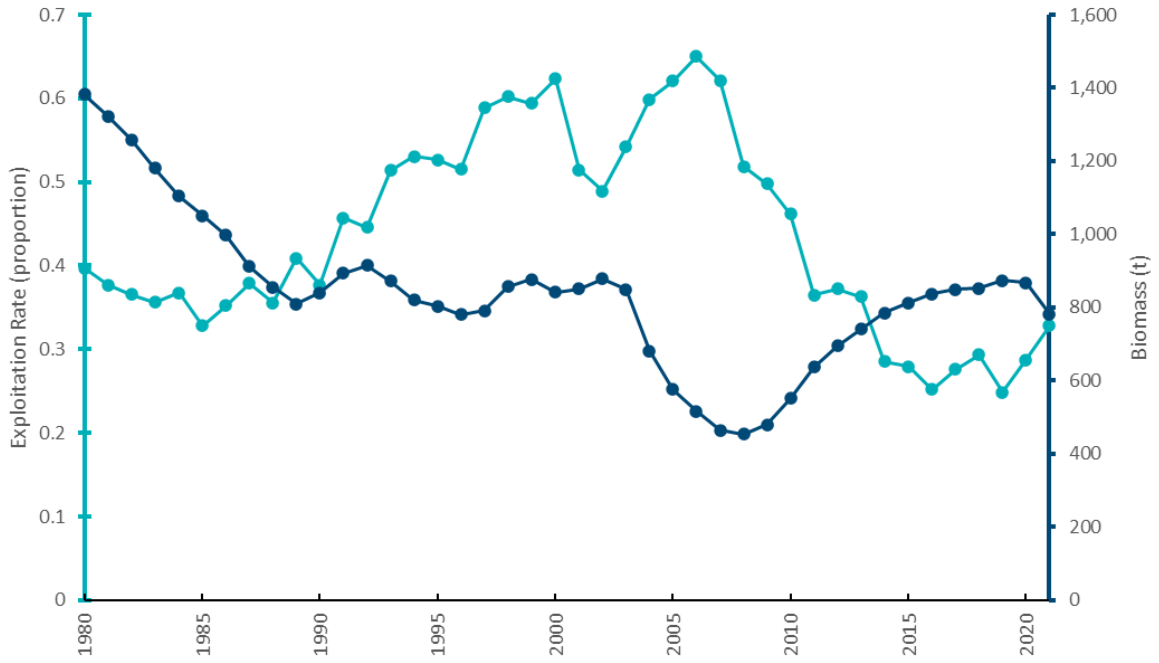


Figure 13: Model estimated levels of available biomass (dark blue) and associated fishing exploitation rates (light blue) in the Western Zone fishery.

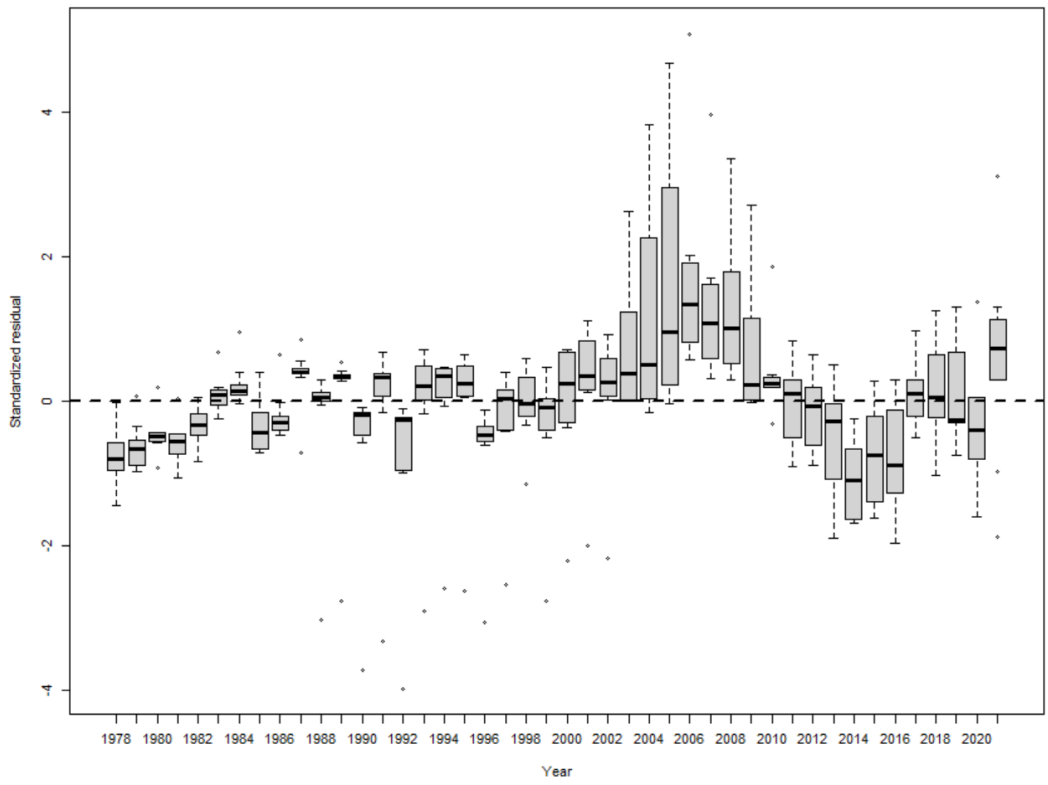


Figure 14: Standardized residuals for CPUE in the Western Zone. Where values are positive they indicate that the model is under-estimating CPUE and negative values indicate that the model is over-estimating CPUE.

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 harvest strategy (Appendix 1) as described below.

Decision Rule	2021/22 Stock Indicator Level	Outcome
1. Egg Production **Is the model estimated egg production above the limit reference point of 20% of unfished levels?**	The 2021/22 egg production level is estimated at 22.0% 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 0.74kg/pot-lift in 2021/22.	Standardised CPUE has increased from 0.68 in 2020/21 to 0.74 in 2021/22.
b. Is the 2020/21 PRI at or above the reference point of 1.81 undersize/pot-lift?	The combined PRI was 1.87 in 2021/22. This was a slight reduction from 1.90 in 2021/22 but remains above the threshold level.	The combined PRI is slightly above the 1.81 reference point by 0.06.
	RESULT	**INCREASE IN TACC TO 270t**

Establishing the WZ TACC for 2023/24

A direct application of the decision rules in the harvest strategy specifies that the TACC can increase to the 0.65 - <0.70 CPUE band resulting in a 270t TACC. However, it should be noted that the current TACC of 246t corresponds to an estimated exploitation rate of 33% in 2023/24 (the year for which the TACC is being set) and an increase to 270t would result in an exploitation rate of 37% which is well in excess of the 26.3% target of the harvest strategy (even allowing for the known bias in the most recent biomass estimate). Thus, whilst a TACC increase is available through the current harvest strategy it is inconsistent with the harvest strategy target exploitation rate.

It is important to note that at the time of writing this report, a formal review of the Rock Lobster Fishery Management Plan, including the current harvest strategy, is underway. This is being conducted in close consultation with the Management Plan Steering Committee and the Rock Lobster Resource Assessment Group and significant progress has been made. As such, the strategic direction of the draft harvest strategy being developed should also be considered when setting TACCs in the interim to provide more certainty for stock rebuilding.

A TACC increase to 270t for the 2023/24 season is available through the application of the harvest strategy.

4. EASTERN ZONE ROCK LOBSTER FISHERY

4.1 FISHERY STATISTICS

Trends in catch, effort and CPUE

In 2021/22, the Eastern Zone TACC was reduced to 32t (Table 5). Only 20.7 t was taken during the 2021/22 season. This is a reduction from 40t in 2020/21 and 47t in 2018/19 following a previous extended period of TACCs in the 59-66t range. The TACC reductions since 2018/19 have been due to ongoing declines in CPUE resulting from reduced recruitment.

Standardised CPUE reached a twenty-year peak of 0.63kg/pot-lift in 2012/13 but fell rapidly to a record low of 0.36 in 2017/18. From this record low the CPUE has gradually risen to 0.49 in 2021/22 (Figure 16, Table 4).

In addition to the substantial TACC decreases there has been a significant undercatch of the TACC. This reduction has been most significant in San Remo (3.7t in 2021/22) and Lakes Entrance (0.6t). In 2021/22 standardised CPUE increased in all areas (Figure 17), however the data available for calculating the standardised CPUE in San Remo and Lakes Entrance is increasingly limited.

Recreational Catch

On 1 July 2017, the VFA implemented a three-year pilot program requiring all recreational fishers to tag the lobsters they catch and keep and report the use of tags. The objective of the program was to obtain an estimate of the annual recreational catch by using the number of tags used in that season to represent the number of rock lobsters removed from the stock and ascertain whether the actual catch is in line with the assumed notional catch share.

On the back of the success of the trial, the Minister committed to transitioning the trial to an ongoing program. This has resulted in the annual collection of recreational catch data feeding into annual stock assessments, rather than relying on notional assumptions. Since the start of the 2021 recreational lobster season, the rock lobster reporting program has utilised GoFishVic, a smartphone App from the Victorian Fisheries Authority, and all reporting is now completed digitally by fishers in GoFishVic.

Recreational catch estimates produced by this program are now intended for use in the stock assessment model. However, due to the disruptions from bushfires, COVID, and the data collection challenges from the recent transition to digital tagging, the most recent season of data that is considered reliable is the 2018/19 season[2]. In the 2018/19 season 6202 kg were reported as caught and retained by recreational fishers in the Eastern Zone. This is equivalent to 19.4 % of the TACC in 2021/22. Weight was calculated by multiplying the average citizen science weight in the Eastern Zone (2.0kg in 2018/19) by the total number of tags reported (3101 tags in 2018/19).

For context, in the 2021/22 season 545 lobsters were reported as caught and retained by recreational fishers in the Eastern Zone. Using a length / weight relationship (derived from 165,000 lobsters measured and weighed in fish processors from 1995 – 2017), the estimated mean weight was 1.87 kg and 1.21 kg for male and female lobsters, respectively. The estimated total weight of lobsters caught was 881 kg, equivalent to 2.8 % of the TACC in 2021/22, however not considered reliable due to transition to electronic reporting.

[2] https://vfa.vic.gov.au/__data/assets/pdf_file/0008/907433/RLRAG-Minutes-Meeting-36.pdf

By applying the length /weight relationship (with the same average weights and sex ratio used for the EZ in 2021/22) to the reported catch for 2018/19, the estimated total weight landed was 5,025 kg, equivalent to 15.7% of the TACC in 2021/22 quota year.

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 14 active vessels in 2021/22 (Figure 19). 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 20). The number of days fished was also at a record low in 1988/89 at 18 days per vessel (Figure 20). This subsequently increased as the fleet contracted and the catch per vessel increased. In 2021/22 the average annual catch was 1.4t / vessel whilst in the last seven years the average number of days fished per vessel has decreased from a record high of 38 days to 27 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. Also note that the numbers reported in this section are for the fishing season and will differ from the licensing year summaries provide in Table 5.

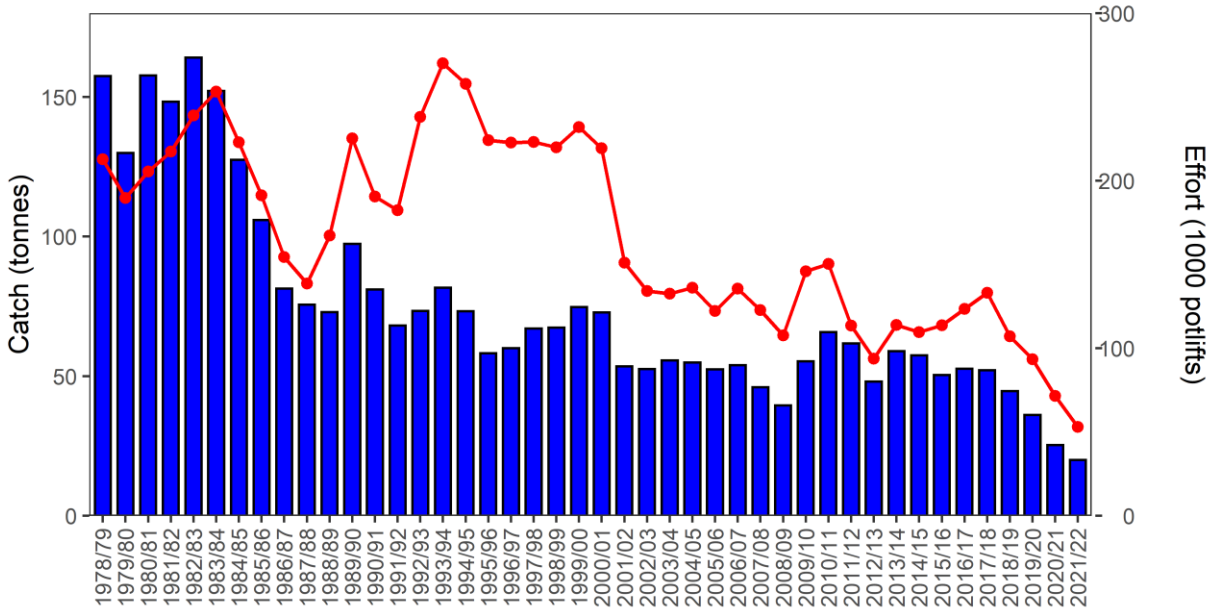


Figure 15: Total catch (blue bars; tonnes) and nominal effort (red line; x1000 pot-lifts) in the Eastern Zone.

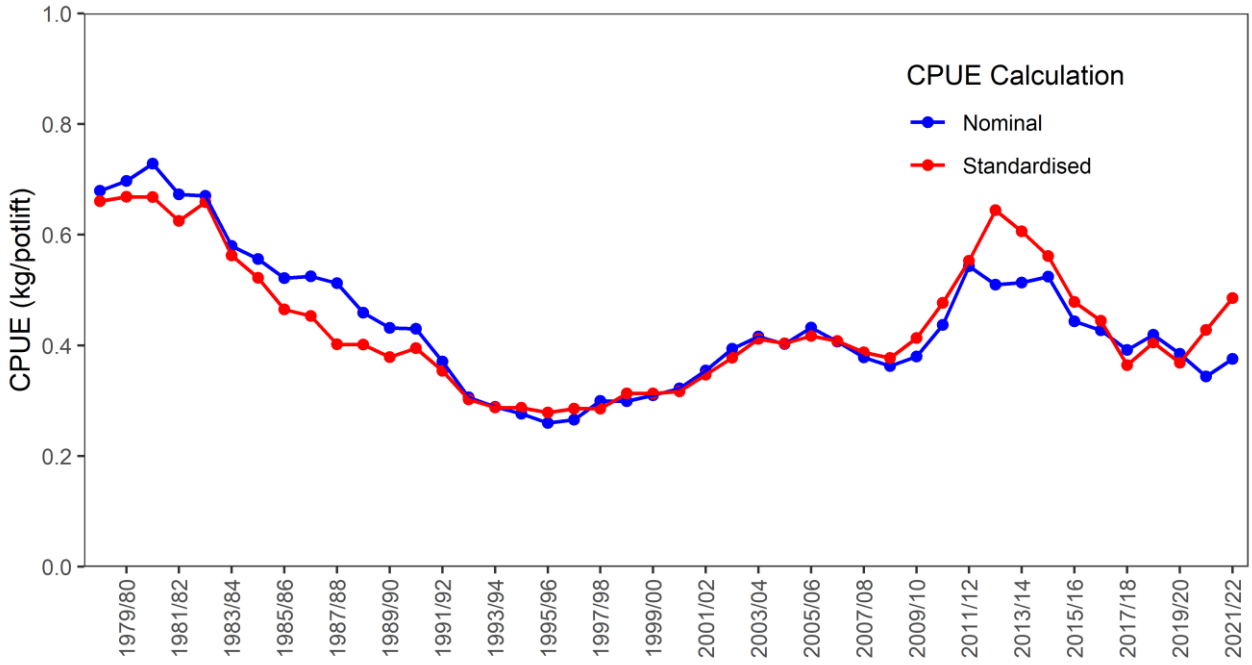
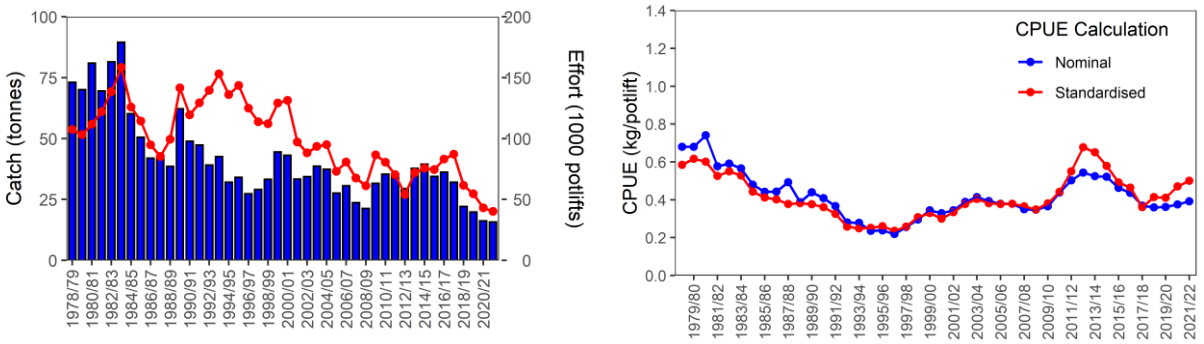
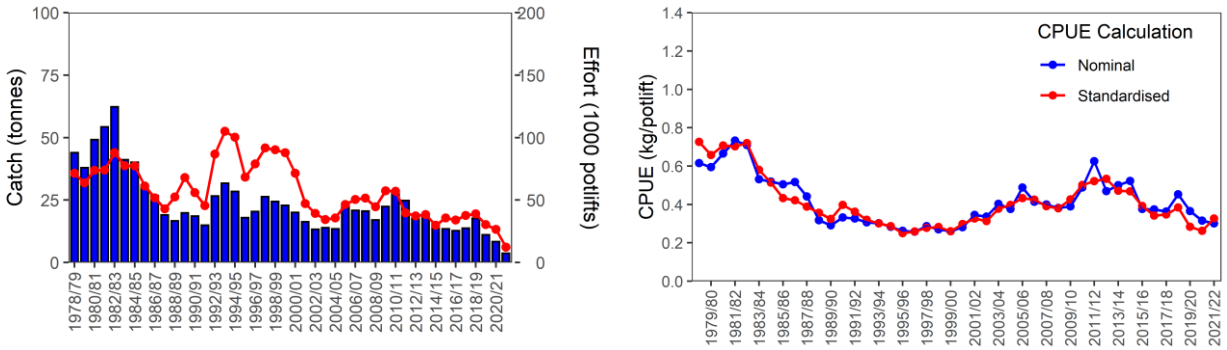


Figure 16: Standardised (red) versus nominal (blue) CPUE (kg/potlift) in the Eastern Zone. Note that standardised CPUE values differ slightly from one assessment to the next as the depth, seasonal and fisher coefficients are shared across years and are re-estimated including the new data.

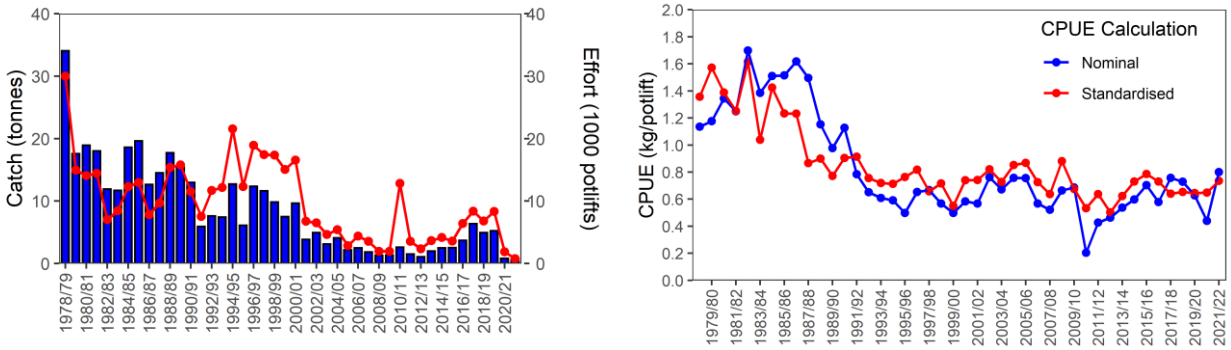
QUEENSCLIFF



SAN REMO



LAKES ENTRANCE



Fishing Year (Nov – Sept)

Figure 17: Regional catch (blue bars), effort (red line), and standardised (red) and nominal (blue) CPUE (kg/potlift) in the Eastern Zone.

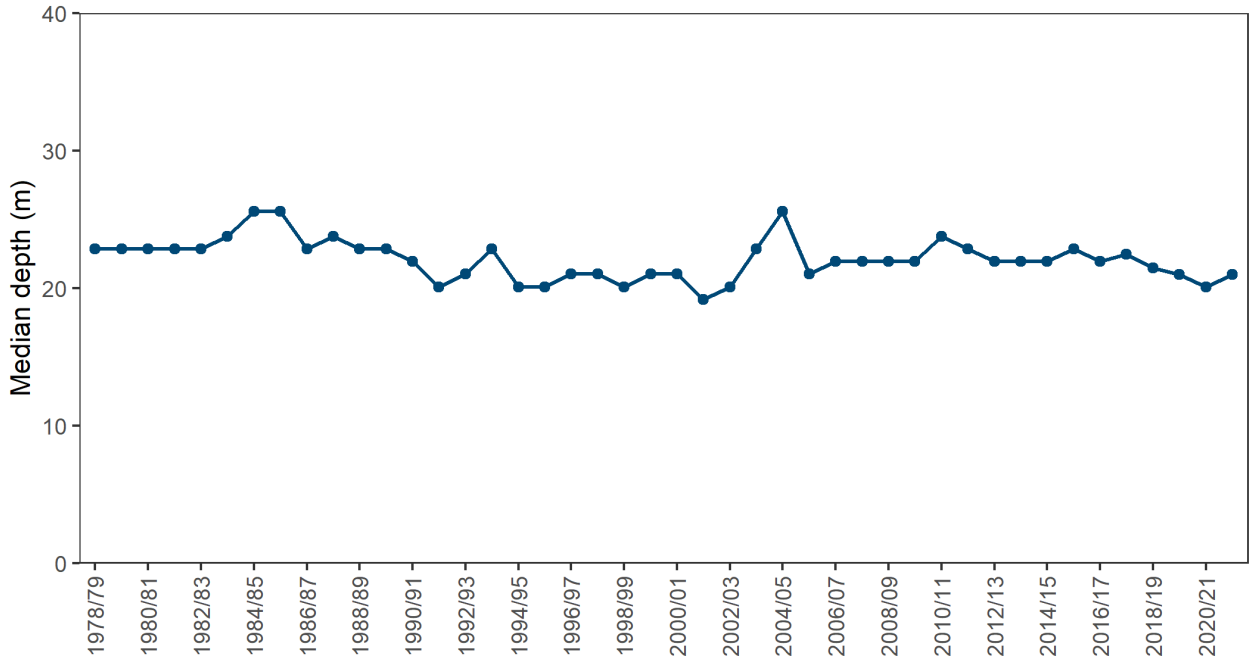


Figure 18: Annual median pot depth as recorded from logbooks in the Eastern Zone.

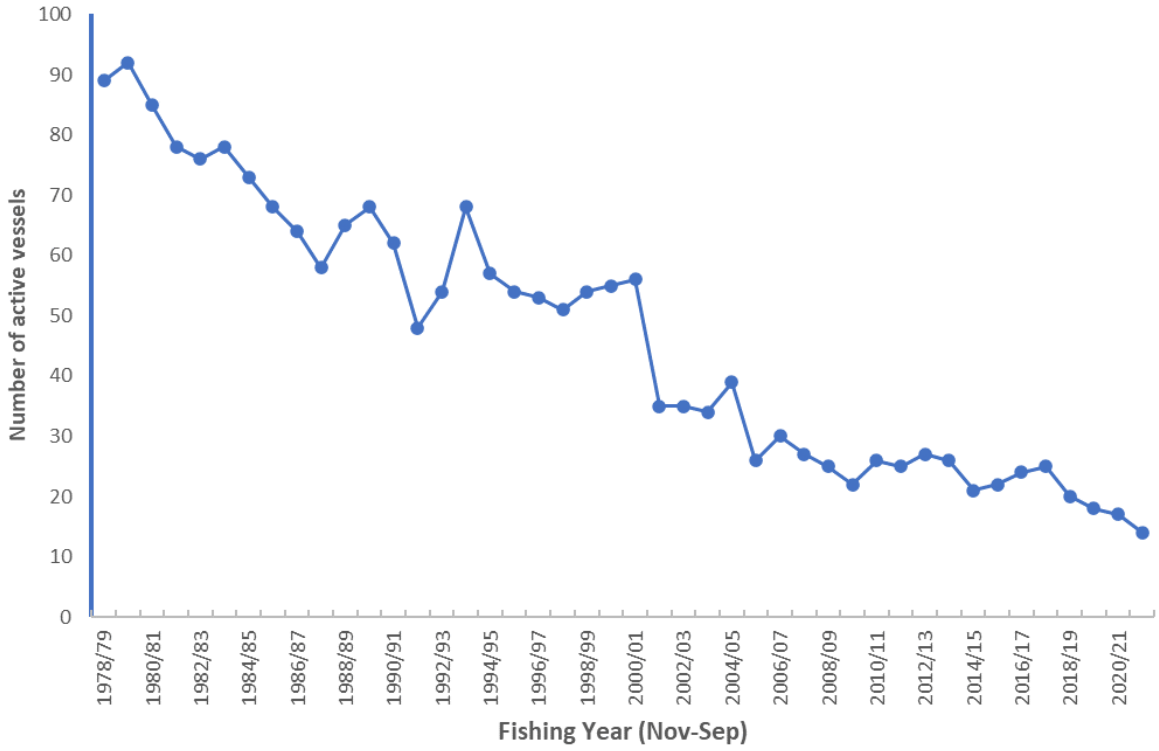


Figure 19: The number of active vessels in the Eastern Zone in each fishing year.

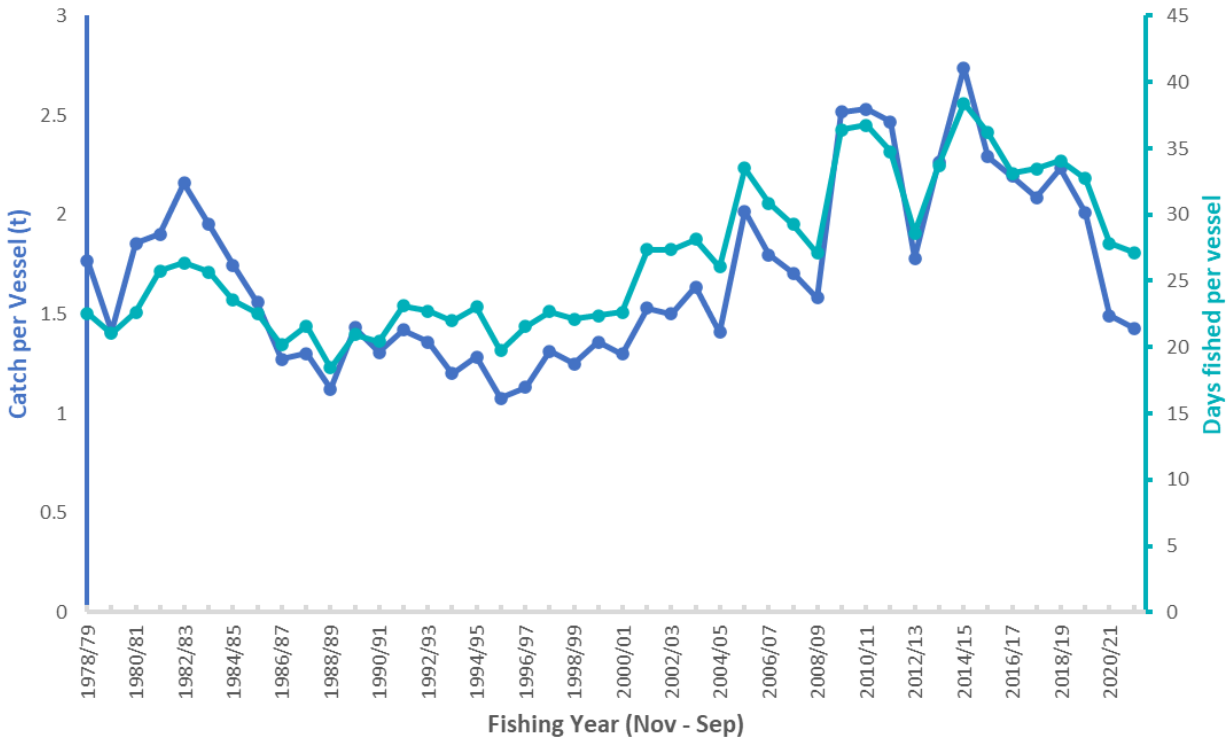


Figure 20: The annual mean catch (dark blue) and mean number of days fished (light blue) per active fishing vessel in the Eastern Zone

4.2 STOCK STRUCTURE DATA

Trends in recruitment

Undersize catch rates differ between areas and between the fixed site surveys and the on-board observer program. Consequently, calculating a pre-recruitment index (PRI) by simply averaging across the entire dataset would result in changes in observer coverage influencing the PRI value in a way that is unrelated to real changes in undersize abundance. To address this both the observer and fixed site PRIs are calculated for a number of pre-determined areas which are then combined ensuring that the contribution of each area remains consistent through time. The observer based PRI is also scaled so that its mean value matches that of the fixed site PRI, this enables these two data sources to be combined in a way that gives them equal importance.

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 a record low of 0.08 undersize/pot-lift in 2018/19. Over the last three seasons PRI has increased considerably, reaching 0.32 undersize per potlift in 2021/22. This is the highest value in eight years and is equal to the threshold level (Figure 21).

Mean weight

The mean weight of Eastern Zone lobsters has always been higher than those from the Western Zone due to faster growth rates in the eastern area. However, since 2012/13 (when CPUE peaked), the mean lobster weight has increased from 1.12 kg/lobster to the highest mean lobster weight on record for the Eastern Zone of 1.51kg/lobster in 2019/20 (Figure 22). This high mean lobster weight 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. The mean lobster weight decreased to 1.36kg in 2021/22. In combination with an increased CPUE and a broader spread of size classes evident in the length-frequency data this is indicative of the stock structure returning to a broader range of 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 through to 2018/19. This change is highlighted in Figure 23 and full details are given in Figure 35 to Figure 38. In the subsequent three years there has been an increase in abundance of smaller lobsters, this is most evident in the fixed site survey data.

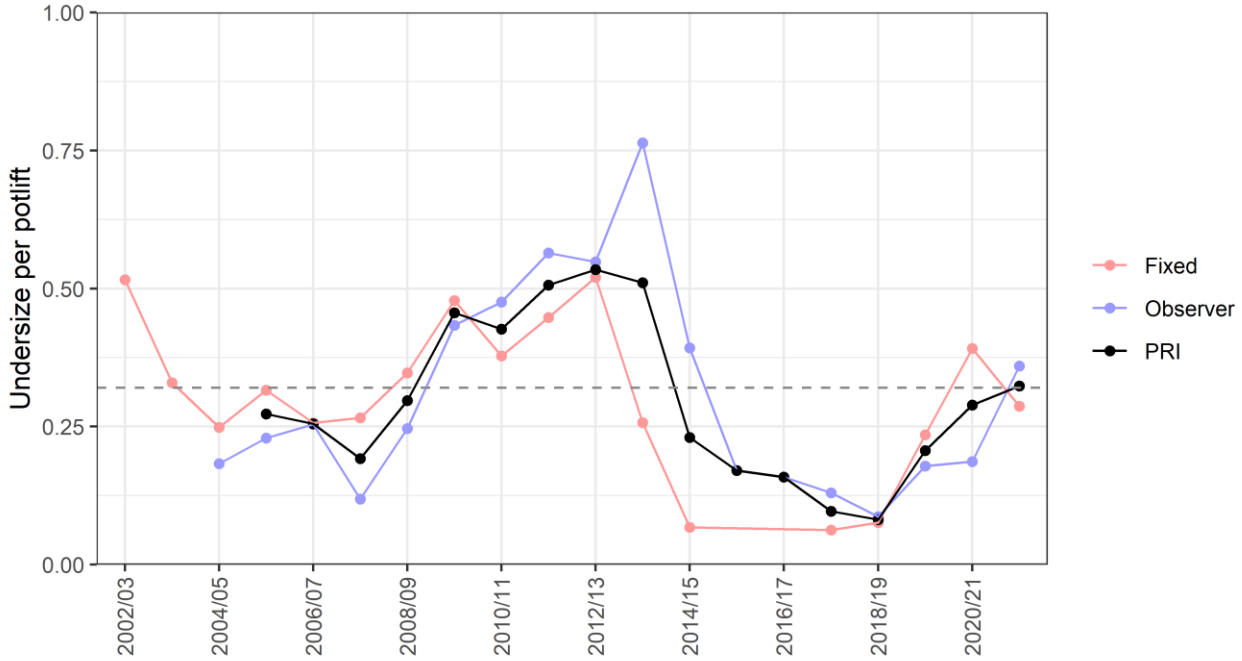


Figure 21: The undersize catch rate (kg/potlift) for the Eastern Zone as calculated from fixed sites (red), observer coverage (blue) and the final combined PRI (black). The dashed line shows the trigger point (0.32 undersize/potlift).

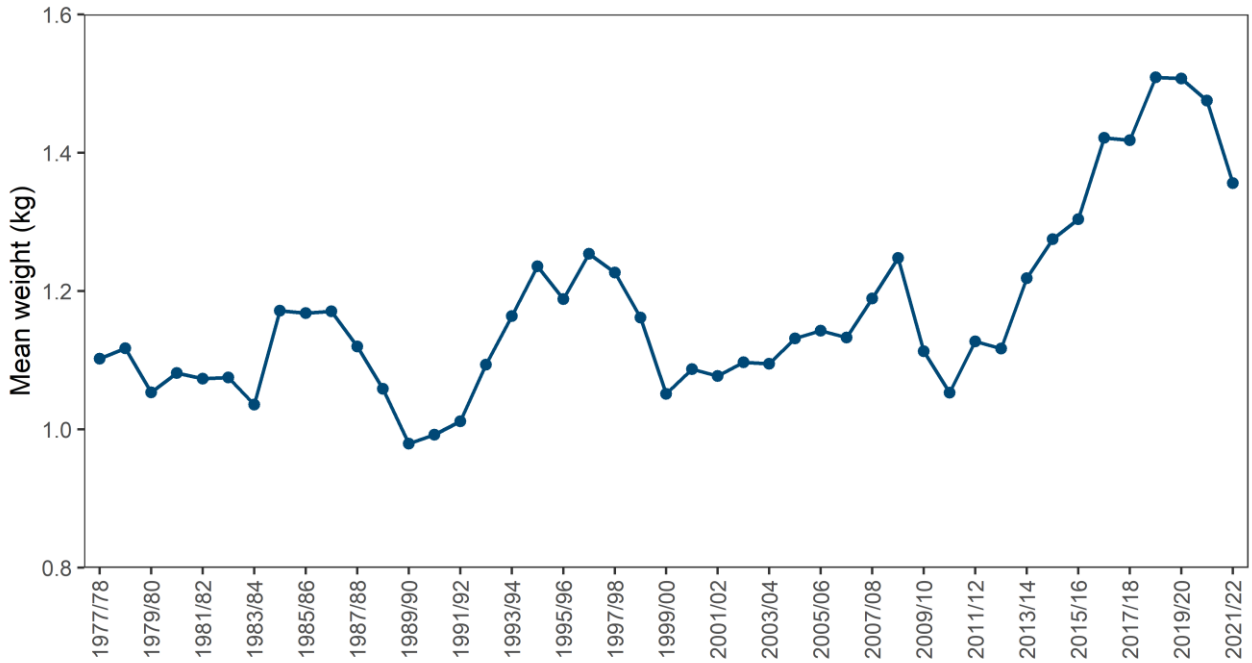


Figure 22: Mean weight of legal-sized lobster in the Eastern Zone fishery.

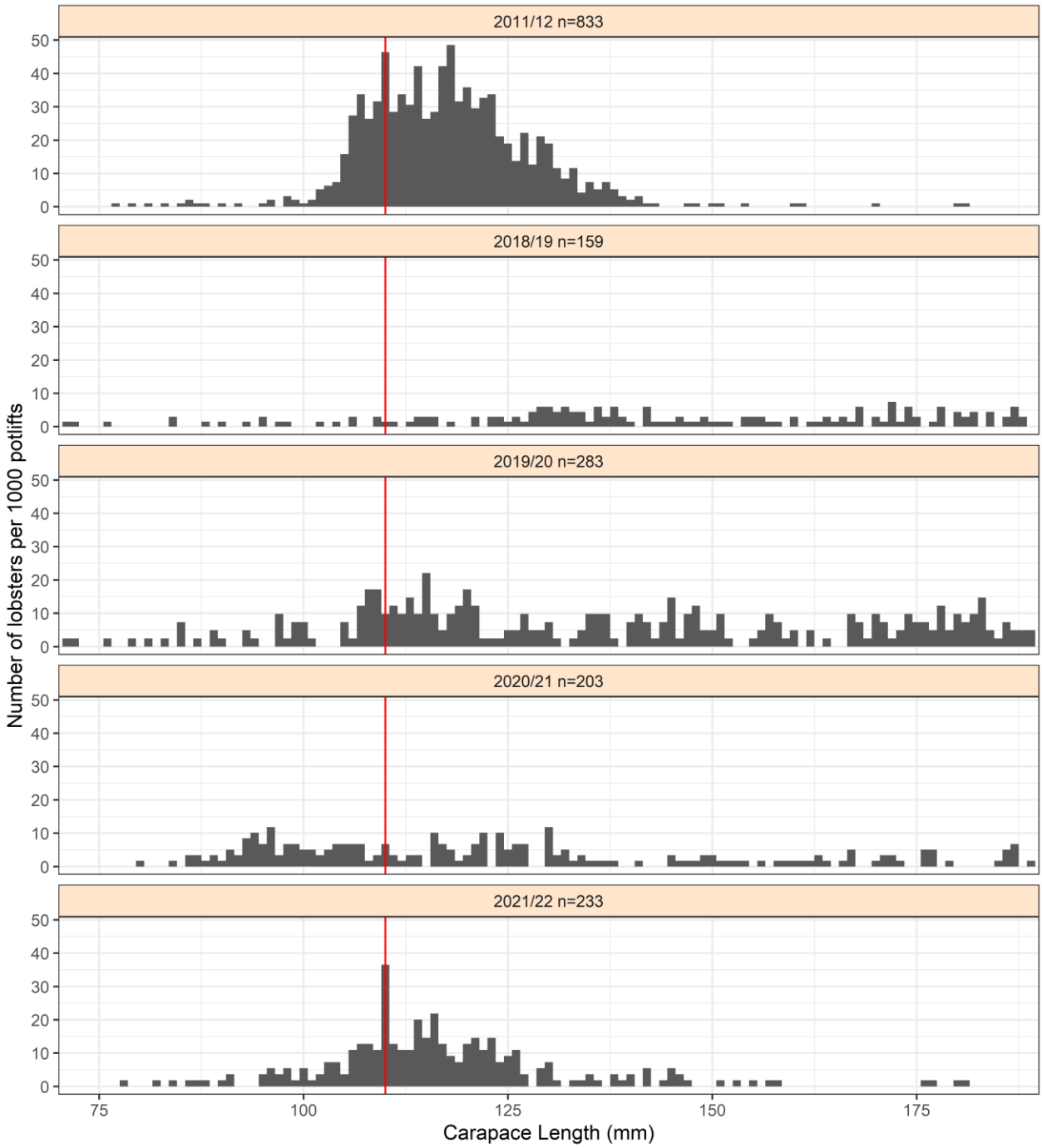


Figure 23: Length-frequency plots for 2011/12 and the last four seasons for male lobsters measured by the Eastern Zone fixed site program to highlight the changes that have occurred. The red line indicates the legal size limit.

4.3 MODEL OUTPUTS

Estimated recruitment

Recruitment is reported as the number of new lobsters passing the 60mm CL size in a given year. It is difficult to obtain information about lobsters of this size directly as they are much less likely to be retained in pots (as recorded on observer and fixed site sampling trips) and do not influence the commercial CPUE. Consequently, reliable estimation of the recruitment in a given year requires observation of that age class over several years. As the lobsters grow they are observed through multiple fixed site surveys and observer trips and ultimately influence commercial CPUE. These multiple observations are combined with information about lobster growth through the stock assessment model to give the best estimate of recruitment in each year. Due to this the most recent recruitment estimates (e.g. for 2021/22) are highly uncertain and are not shown, whilst the most recent estimates shown (e.g. 2017/18) are more likely to change in future years as more information becomes available about these year classes.

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 27% of the long-term average in 2013/14. Values have been higher in the last three years for which estimates are available but remain well below the long-term average (Figure 24). The higher recruitment estimates are in line with the recent increase in PRI from record low levels.

Estimated egg production

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

Eastern Zone egg production levels reached a historical low in 1995/96 of 20.4% of unfished levels. After this time there was a steady increase to a recent high of 33% in 2013/14. Since 2013/14 there has been an ongoing decline to 22.9% in 2021/22, but this remains above the 20% limit reference point (Figure 25).

In addition to the existing approach for calculating egg production, a new method was applied in parallel in this assessment. This method gives a more consistent probabilistic evaluation of egg production. The key benefits are that i) the estimate of the unfished pre-exploitation level of egg production is updated in each stock assessment on the basis of new information and ii) the current level of egg production is evaluated against this in a probabilistic manner that takes into account recruitment variability. A probability distribution derived from this method is shown in Figure 26. This provides additional evidence that egg production exceeds the 20% limit reference point with a >90% probability as required by the harvest strategy. Note that the two methods produce somewhat different results in magnitude but are broadly consistent and both meet the requirements of the harvest strategy.

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 295t. As a result of low recruitment, biomass then decreased to 172t in 2019/20. In 2021/22 an increase to 186t was estimated. As a result of the low catches and the modest increase in biomass, the exploitation rate fell to 10.7% in 2021/22 (Figure 27).

Model diagnostics and potential biases

The length-frequency data input to the model (Figure 35 to Figure 38) 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 39 and Figure 40).

As shown in Figure 28, 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. Notably recent estimates have a high degree of uncertainty partly due to the further reduction in data resulting from reduced catches.

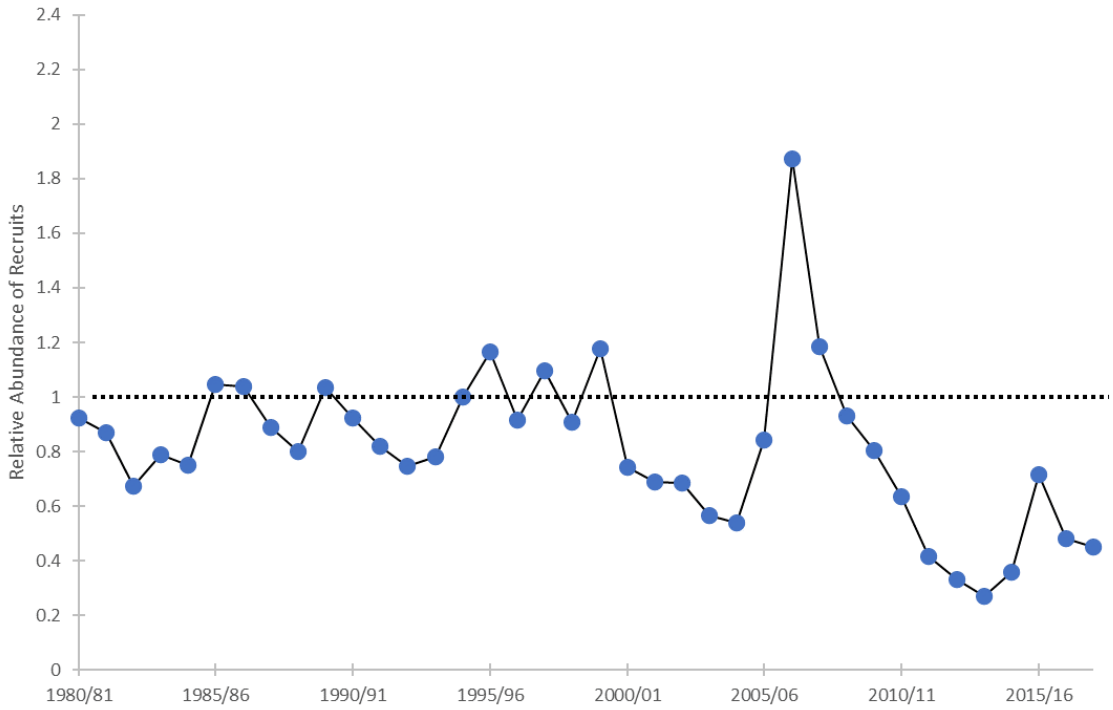


Figure 24: Relative number of recruits (to 60 mm in CL) in the Eastern Zone Fishery. These results are generated by the stock assessment model. The long-term average is indicated by the dotted black line. The most recent values are based on fewer observations and are therefore more likely to change in future stock assessments as more information about that year class becomes available.

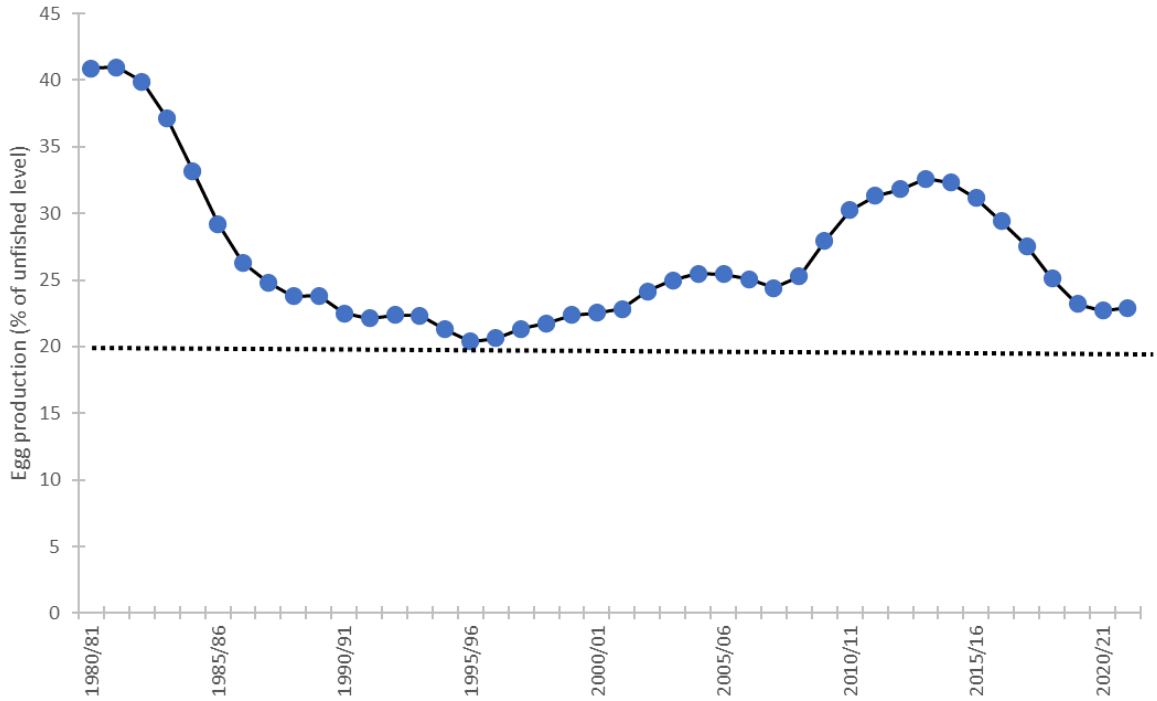


Figure 25: Model estimated level of egg production through time in the Eastern Zone fishery. The limit reference point (dotted line) is 20% of unfished levels.

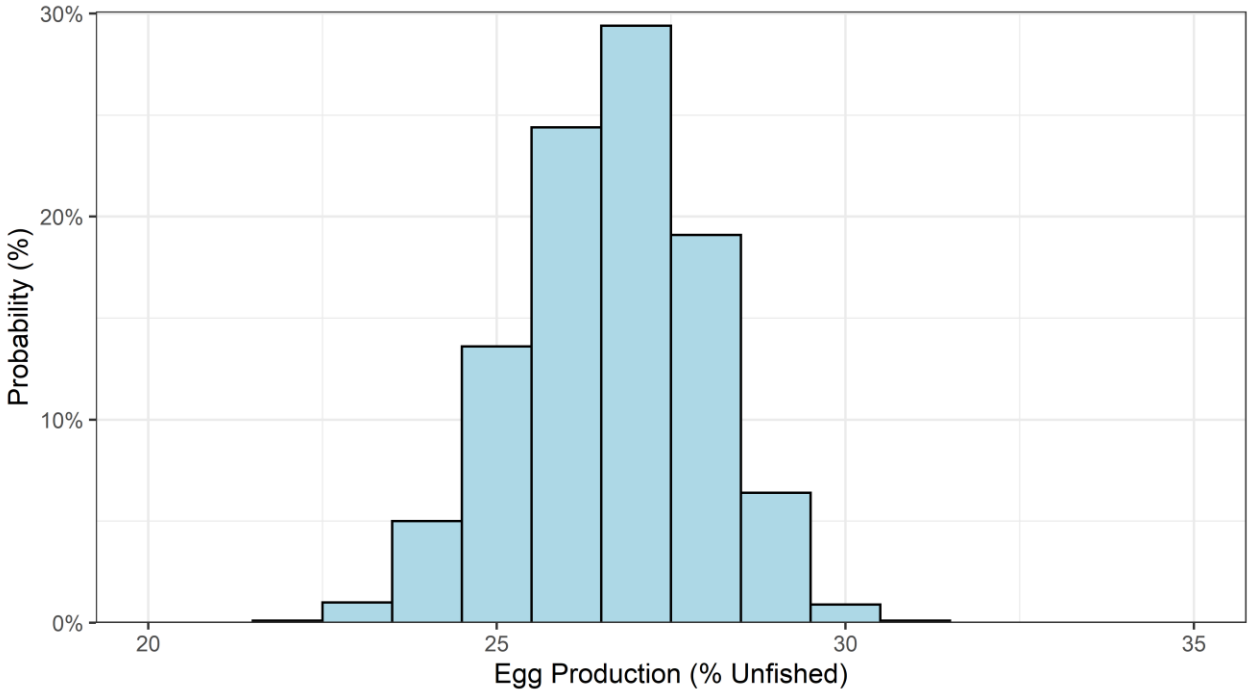


Figure 26: Probability distribution of model estimated egg production in 2022 compared to the unfished level of egg production in the Eastern Zone.

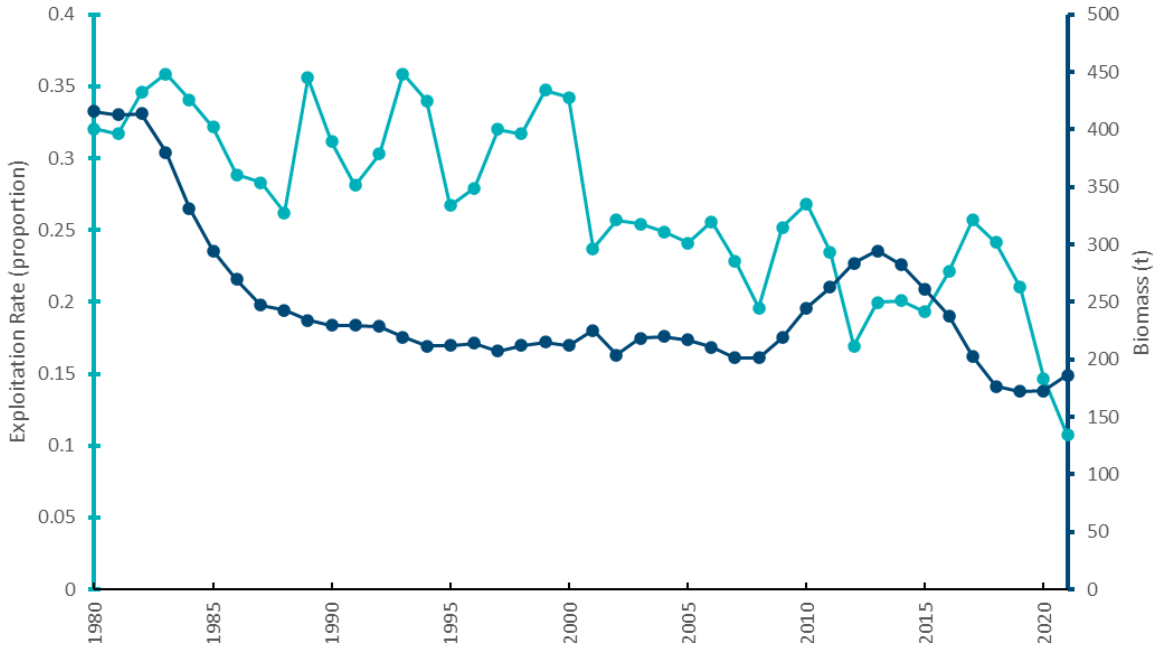


Figure 27: Model estimated levels of available biomass (dark blue) and associated fishing exploitation rates (light blue) in the Eastern Zone

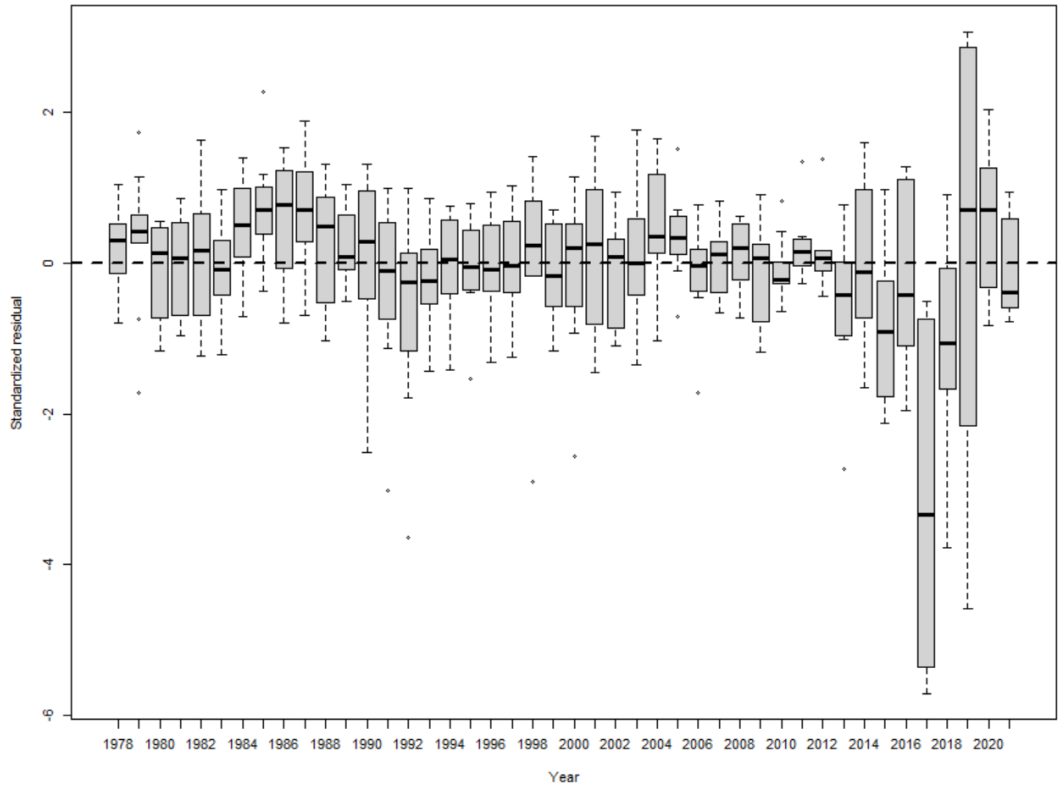


Figure 28: Standardized residual for CPUE in the Eastern Zone. Where values are positive they indicate that the model is under-estimating CPUE and negative values indicate that the model is over-estimating CPUE.

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 harvest strategy (Appendix 1) as described below.

Decision Rule	2021/22 Stock Indicator Level	Outcome
1. <u>Egg Production</u> **Is the model estimated egg production above the limit reference point of 20% of unfished levels?**	The 2021/22 egg production level is estimated at 22.9% of unfished levels.	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 0.49kg/pot-lift in 2021/22	Standardised CPUE has increased from 0.374 in 2019/20 to 0.49 in 2021/22. This corresponds to a higher CPUE band than that corresponding to the current TACC.
b. Is the 2020/21 PRI at or above the reference point of 0.32 undersize/pot-lift?	The PRI is 0.32 undersize/pot lift	The PRI has increased from 0.26 in 2020/21 to 0.32 in 2021/22 which is equal to the threshold level.
	RESULT	**INCREASE IN TACC TO 40 t**

Establishing the EZ TACC for 2023/24

The CPUE of 0.49kg/potlift corresponds to a higher CPUE band than that for the current TACC and the PRI rule has just been met. Application of the harvest strategy indicates that a TACC increase would be permitted. The resulting exploitation rate is estimated to be marginally (approximately 1%) higher than the 20.5% exploitation rate aimed for by the harvest strategy. The PRI is only just met and given the extended history of stock issues in this zone caution is advised when considering the TACC increase permitted by the harvest strategy.

It is important to note that at the time of writing this report, a formal review of the Rock Lobster Fishery Management Plan, including the current harvest strategy, is underway. This is being conducted in close consultation with the Management Plan Steering Committee and the Rock Lobster Resource Assessment Group and significant progress has been made. As such, the strategic direction of the draft harvest strategy being developed should also be considered when setting TACCs in the interim to provide more certainty for stock rebuilding.-

A TACC increase to 40t for the 2023/24 season is available 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 PRE RECRUIT INDEX

The pre-recruit index (PRI) provides an index of the abundance of undersize lobster in each zone. This is based on two data sources: observer based records and fixed site data. These data sources have different characteristics and their spatial coverage varies over time. Hence the steps listed below are applied to calculate an index that is consistent across years and as representative as possible of undersize abundance. One key implication is that the observer component of the PRI is scaled to match the fixed site program. Consequently the magnitude of the index may not match that experienced by individual operators, however the same trends in undersize abundance should be observed.

1. Weighting of fixed sites

Western Zone: To obtain an overall undersize catch rate from the fixed sites, the average must be calculated. Each site corresponds to different areas of the fishery with different productivity and importance to the commercial fleet. To obtain a representative undersize index each site is therefore weighted by the productivity or importance of the area it represents. This is achieved by weighting each area according to the proportion of the overall commercial catch it provided between 2010 and 2015. For consistency this year range has not been updated since the PRI was first calculated.

Eastern Zone: Due to the limited regional coverage, each site is given the same weight. To ensure the sites contribute evenly they are normalised before calculating their combined mean and then scaled back to the overall regional mean.

2. Weighting of observer based PRI

Western Zone: The spatial coverage of the observer data varies substantially from year to year. Consequently, simply computing the average would result in spatial shifts affecting the PRI. To address this, the same approach was taken as for the fixed sites whereby the data is divided into different spatial areas and combined, weighting by the average catch for 2010-2015 in these areas.

Eastern Zone: Spatial coverage in the Eastern zone is limited across all years and does not exhibit the same level of spatial variability as seen in the Western Zone. Hence a simple annual mean for undersize catch rates is calculated.

3. Scaling the observer based PRI

The observer and fixed site components of the PRI have very different magnitudes due to the methods employed (including pots, fishing locations and times). Consequently, if they were combined by simple averaging the trend in the fixed site component of the PRI would dominate that in the observer based PRI. To overcome this the observer based PRI is scaled up to have the same magnitude as the fixed site survey index.

Threshold level

The PRI is compared against a threshold level. This level is based on a normal distribution fitted to a reference period from 2008/09 to 2020/21. The threshold level is set at the 40th percentile of this distribution. This means that if future PRI values are similar to those in the reference period, then twice in every 5 years the PRI would be below the threshold level and the harvest control rule would prevent a TACC increase (if this were permitted by the CPUE).

It is important to note that PRI in each year includes some of the age classes that contributed to the PRI in the previous year. Thus PRI changes gradually and there can be extended periods during which the PRI remains below the threshold (as has happened in recent years).

5.3 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.

5.4 CONTINUAL IMPROVEMENT REPORT

This section provides a brief overview of key work that was conducted towards the objective of continually improving the stock assessment and associated processes. The issues below were analysed and then discussed through the RLRAG process and cover the period from February 2022 (RLRAG 34) to February 2023 (RLRAG 36). Further details are available in the papers distributed to those meetings and in the meeting minutes.

- Egg production calculation improved (RLRAG 34)

The egg production estimation has now been improved as described in egg production section of this report. This methodology provides a more consistent way of accurately evaluating the egg production decision rule.

- Revision of the Queenscliff boundary (RLRAG 34)

A substantial change in the spatial distribution of catch in the San Remo and Queenscliff regions was observed. This resulted in a suggestion to shift the boundary. Analyses found that CPUE in the two areas is reasonably well correlated and that shifting the boundary would create minimal change whilst necessitating substantial revision of other elements in the assessment. Hence it was not pursued.

- Development of new target and limit reference points (RLRAG 34, 35, 36)

New reference points were developed for the new harvest strategy that meet the management plan objectives and are consistent with the requirements for export accreditation and Marine Stewardship Council certification.

- Consideration of alternative size limits (RLRAG 34)

Alternative size limits to support the new management plan were considered. Whilst these would allow marginally higher TACCs it was found that the impact on fishers' catch rates would negate the benefit of higher catches and this was not pursued.

- Vessel efficiency factor (RLRAG 36)

CPUE analyses in the Western Zone indicate an increase in vessel efficiency of 33% over the last 41 years. In the Eastern Zone no efficiency increase was detectable, however this is likely a factor of the smaller fleet size limiting the capacity of the statistical approach to detect this change. This same limitation likely leads to an underestimate of the efficiency increase in the Western Zone.

Approaches for better quantifying the vessel efficiency increase (which in turn impacts the standardised CPUE index) were considered. However, no statistically rigorous approaches were identified. The main potential was through fixed site surveys however the protocol used when conducting these is insufficient to allow efficiency increases to be quantified. This stems from their design having been based primarily around collection of length-frequency data rather than consistent CPUE data.

- PRI recruit index (RLRAG 35, 36)

Several alternative pre recruit indices and rules for incorporating the PRI in the harvest control rule were developed and considered. This aimed to better match the PRI threshold level with the TACC decision under consideration. Ultimately due to the lower exploitation rates likely to be utilised in the in the new management plan, the reliance on the PRI is likely to reduce. Hence the more complicated approaches were deemed un-necessary.

- Weather impact on catch rates (RLRAG 37)

A trial was conducted to incorporate weather data in the CPUE standardisation process. This found that weather had a statistically significant impact on CPUE when considering daily fishing activity. However once averaged over the course of the year, the overall impact on the annual CPUE index was minimal. Consequently, at this point it was considered un-necessarily complicated to incorporate weather in the CPUE standardisation process.

- An index based on Summer data (RLRAG 37)

A CPUE index based on summer data only would allow more recent CPUE data to be used for setting the TACC. An analysis showed a high degree of correlation between a summer only CPUE and the annual CPUE index. However, there is concern about this approach since a temporal shift in fishing (e.g. due to markets) could readily undermine a summer CPUE index.

- Australian lobster model (RLRAG 37)

Work has continued to apply the newly developed Australian Lobster model (which is being used in Western Australia) to this fishery. The same model is also likely to be adopted in Tasmania. Using a consistent modelling framework would allow greater sharing of knowledge between jurisdictions and the development of a community of practice. This would result in a more reliable and tested modelling framework and outputs for this fishery. The model is now running for the Western Zone with further consistency testing between the modelling frameworks to be conducted. The focus for the RAG in this last year has been on issues related to the development of the management plan, hence this component has not progressed as far through the RAG as planned.

- Management plan review (all RLRAGs and RLMPRSCs)

Many of the above elements supported the development of the new management plan and harvest strategy. The end result will be captured in the final management plan document. Significant additional modelling of alternative management concepts (in addition to those described above) was conducted as different ideas were explored through and proposed by the RLRAG and RLMPRSC members.

6. REFERENCES

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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 2: 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	0.77	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	0.69	1.03
1985/86	345	346	569	0.61	0.61	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	0.58	0.93
1992/93	408	433	779	0.52	0.54	0.94
1993/94	449	456	754	0.59	0.56	0.98
1994/95	435	444	789	0.55	0.51	0.98
1995/96	423	442	761	0.56	0.49	0.96
1996/97	402	414	787	0.51	0.44	0.97
1997/98	467	493	842	0.55	0.48	0.95
1998/99	517	569	864	0.60	0.53	0.91
1999/00	523	596	901	0.58	0.52	0.88
2000/01	526	599	898	0.59	0.49	0.88
2001/02	438	510	703	0.62	0.55	0.86
2002/03	431	495	631	0.68	0.57	0.87
2003/04	460	514	658	0.70	0.55	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	0.41	0.86
2007/08	289	338	668	0.43	0.36	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	0.39	0.83
2011/12	233	279	475	0.49	0.43	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	0.45	0.93
2015/16	227	235	362	0.63	0.51	0.97
2016/17	211*	209	330	0.64	0.53	1.01
2017/18	234	230	296	0.79	0.61	1.02
2018/19	254	247	307	0.83	0.64	1.03
2019/20	217	208	270	0.80	0.67	1.04
2020/21	249	242	284	0.88	0.68	1.03
2021/22	257	254	241	1.07	0.74	1.01

* *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 3: Western Zone history of TACCs for each quota period from 2001-02 (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	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
2017-18	1 Jul - 30 Jun	230	230	100	12	42	41
2018-19	1 Jul - 30 Jun	245	245	100	12	43	44
2019-20	1 Jul - 30 Jun	246	225.6	92	12	42	44
2020-21**	1 Jul - 30 Jun	246 (264.3)	255	97	12	38	37
2021-22***	1 Jul – 30 Jun	246 (249.4)	249.3	100	12	41	39
2022-23	1 Jul - 30 Jun	246	2022/23 season underway at time of writing				

** 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.*

*** TACC of 246 t + 18.3 t of uncaught quota carried over from 2019/20 due to COVID market impacts in 2019/20*

**** TACC of 246 t + 3.4 t comprised of 10% of uncaught quota for 2020/21, plus uncaught quota of fishers impacted by the abalone virus.*

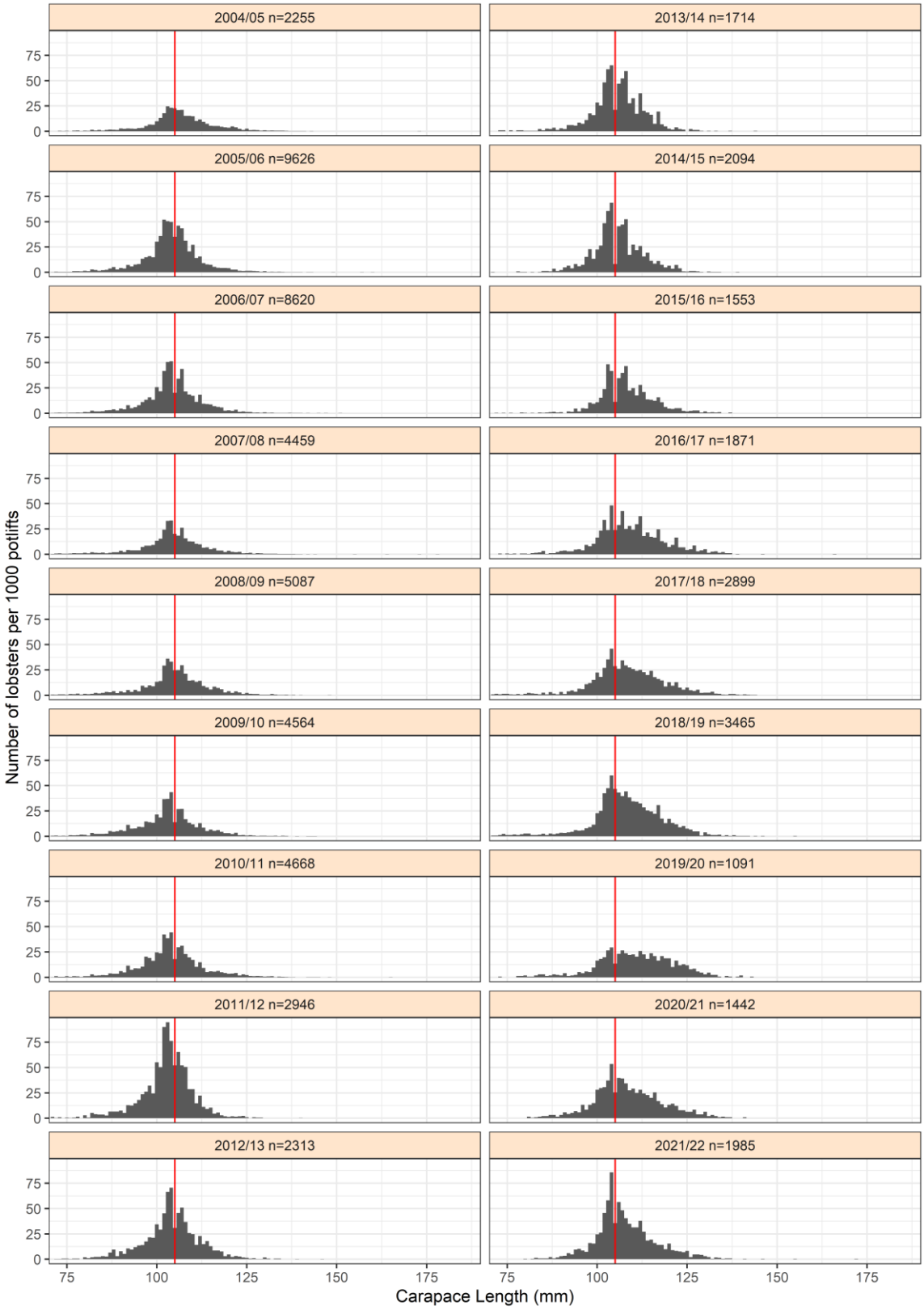

Figure 29: Length-frequency distribution of the number of female rock lobsters per 1,000 pot-lifts caught in the Western Zone on-board observer program from 2004–05 to 2021-22 fishing years (Nov–Sept). n, total number of lobsters measured. The red line indicates the legal size limit.

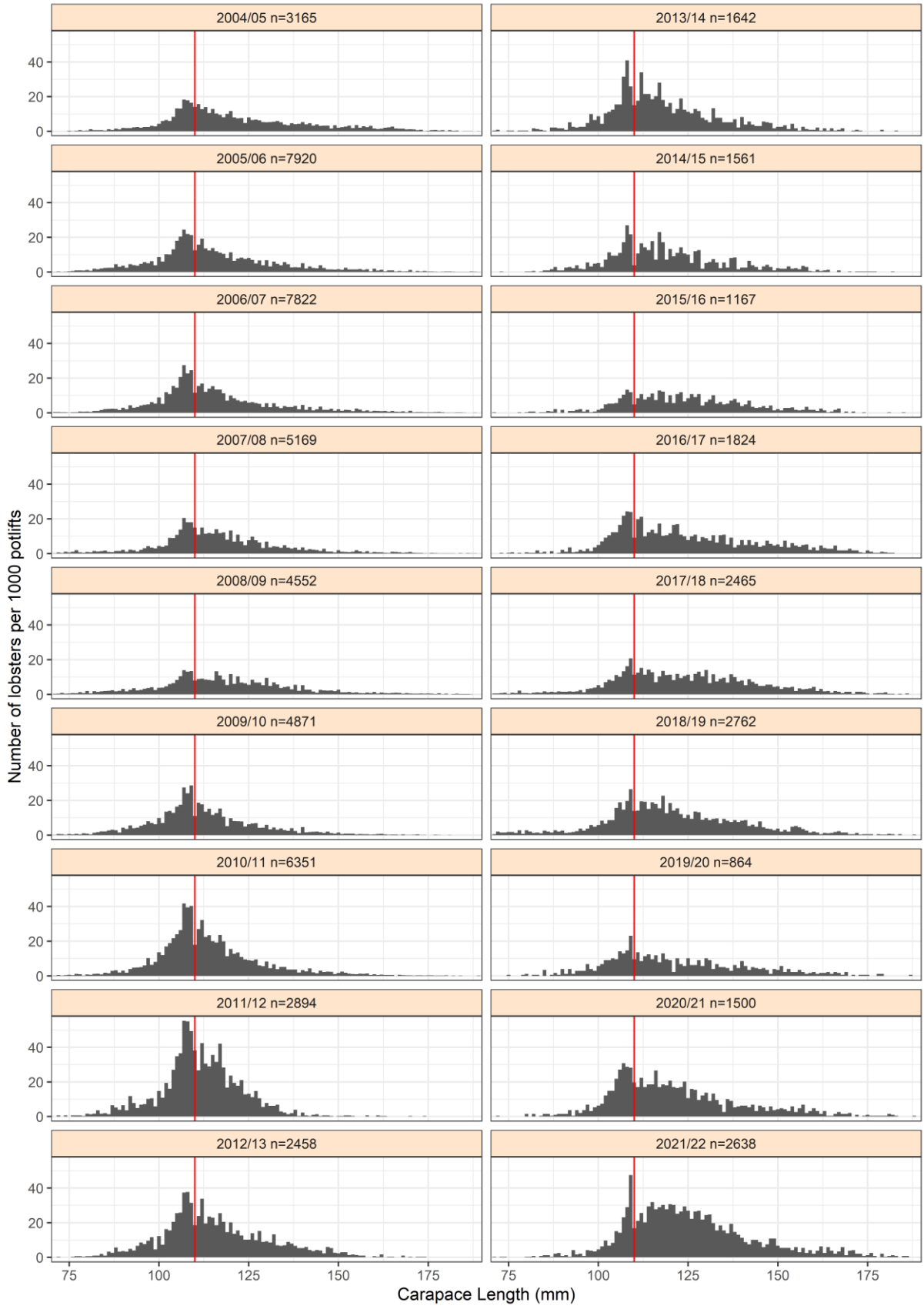

Figure 30: Length-frequency distribution of the number of male rock lobsters per 1,000 pot-lifts caught in the Western Zone on-board observer program from 2004–05 to 2021-22 fishing years (Nov–Sept). n, total number of lobsters measured. The red line indicates the legal size limit.

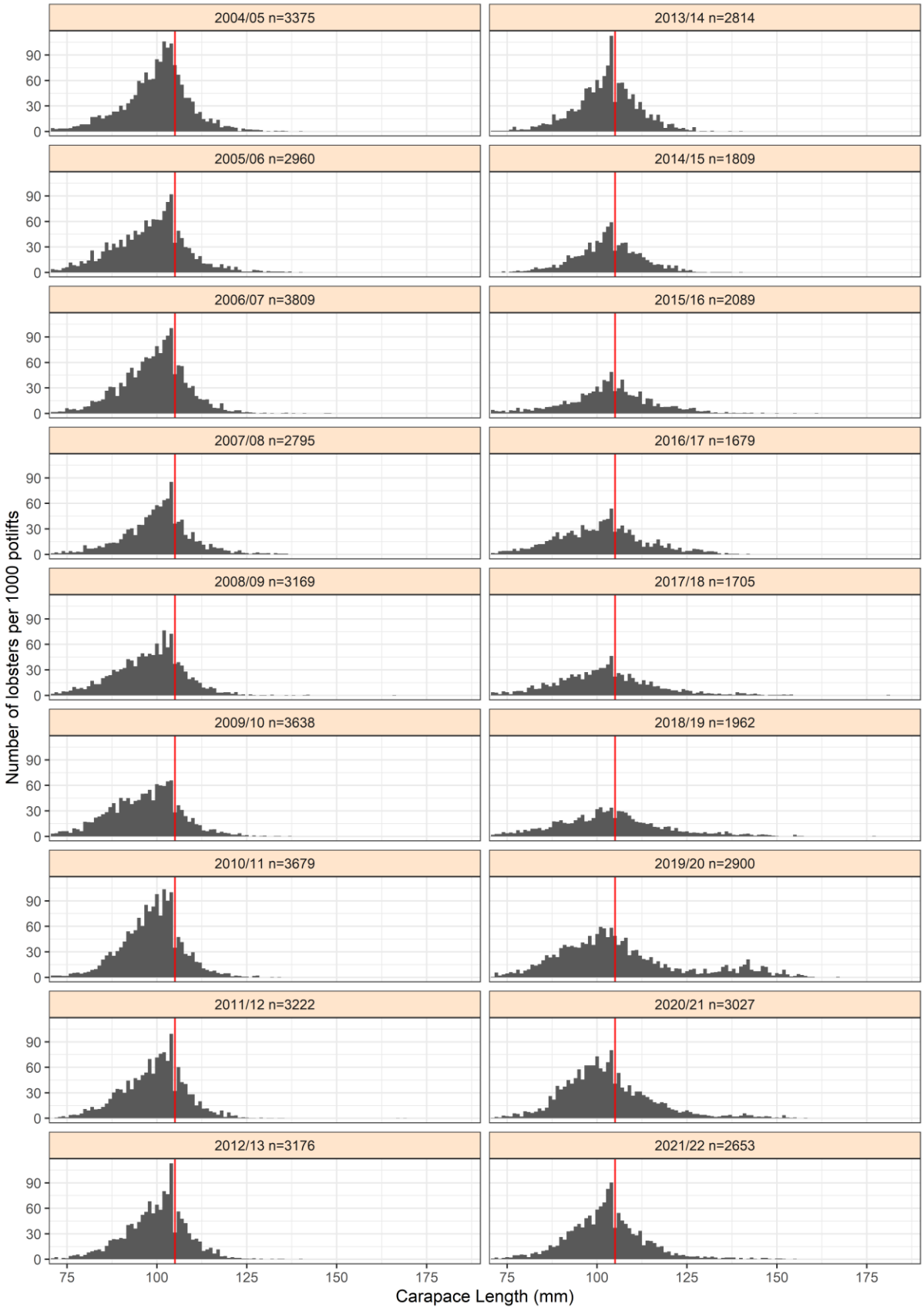

Figure 31: Length-frequency distribution of the number of female rock lobsters per 1,000 pot-lifts caught in the Western Zone fixed-site survey program from 1995–96 to 2021-22 fishing years (Nov–Sept). n, total number of lobsters measured. The red line indicates the legal size limit.

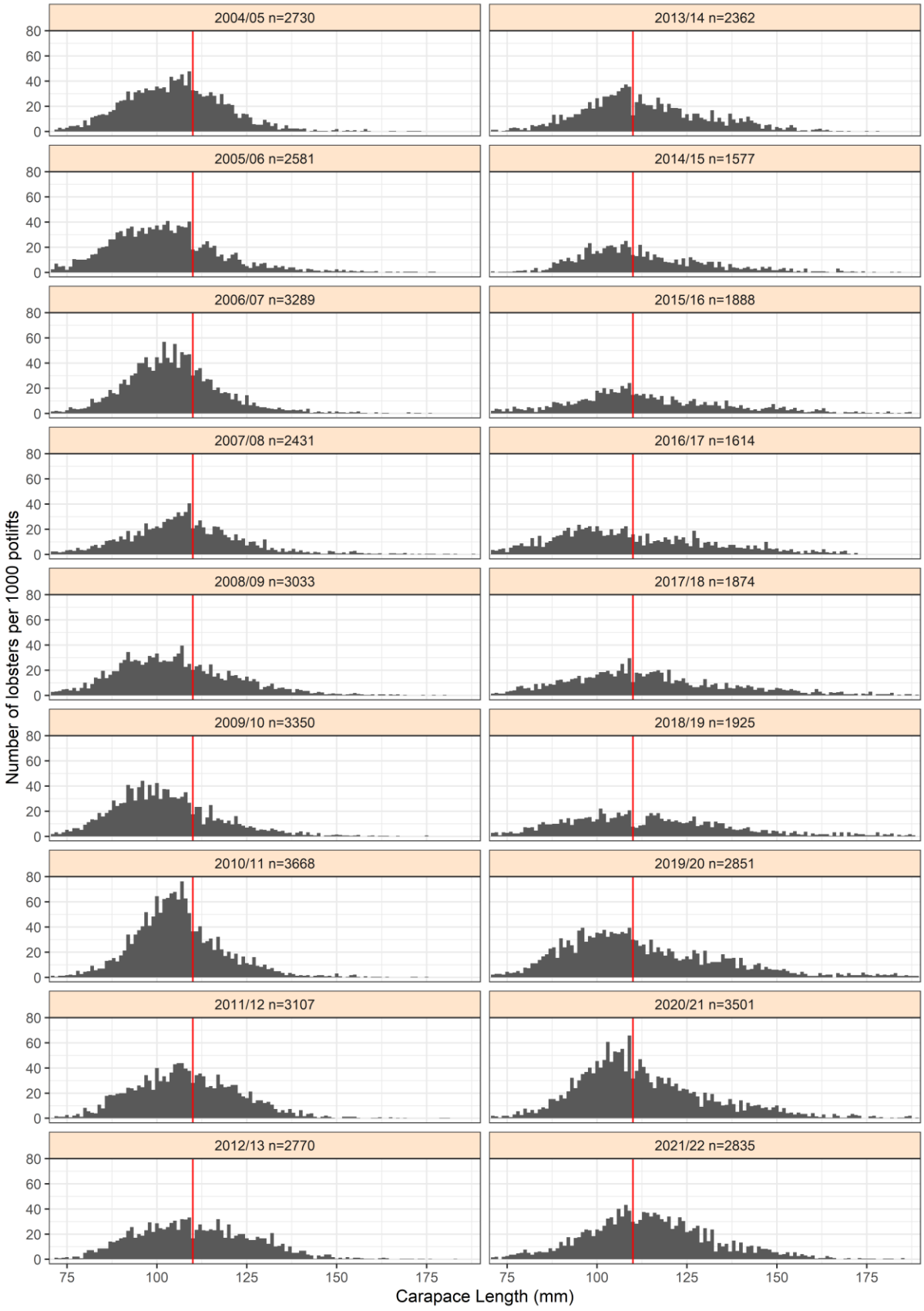

Figure 32: Length-frequency distribution of the number of male rock lobsters per 1,000 pot-lifts caught in the Western Zone fixed-site survey program from 1995–96 to 2021-22 fishing years (Nov–Sept). n, total number of lobsters measured. The red line indicates the legal size limit.

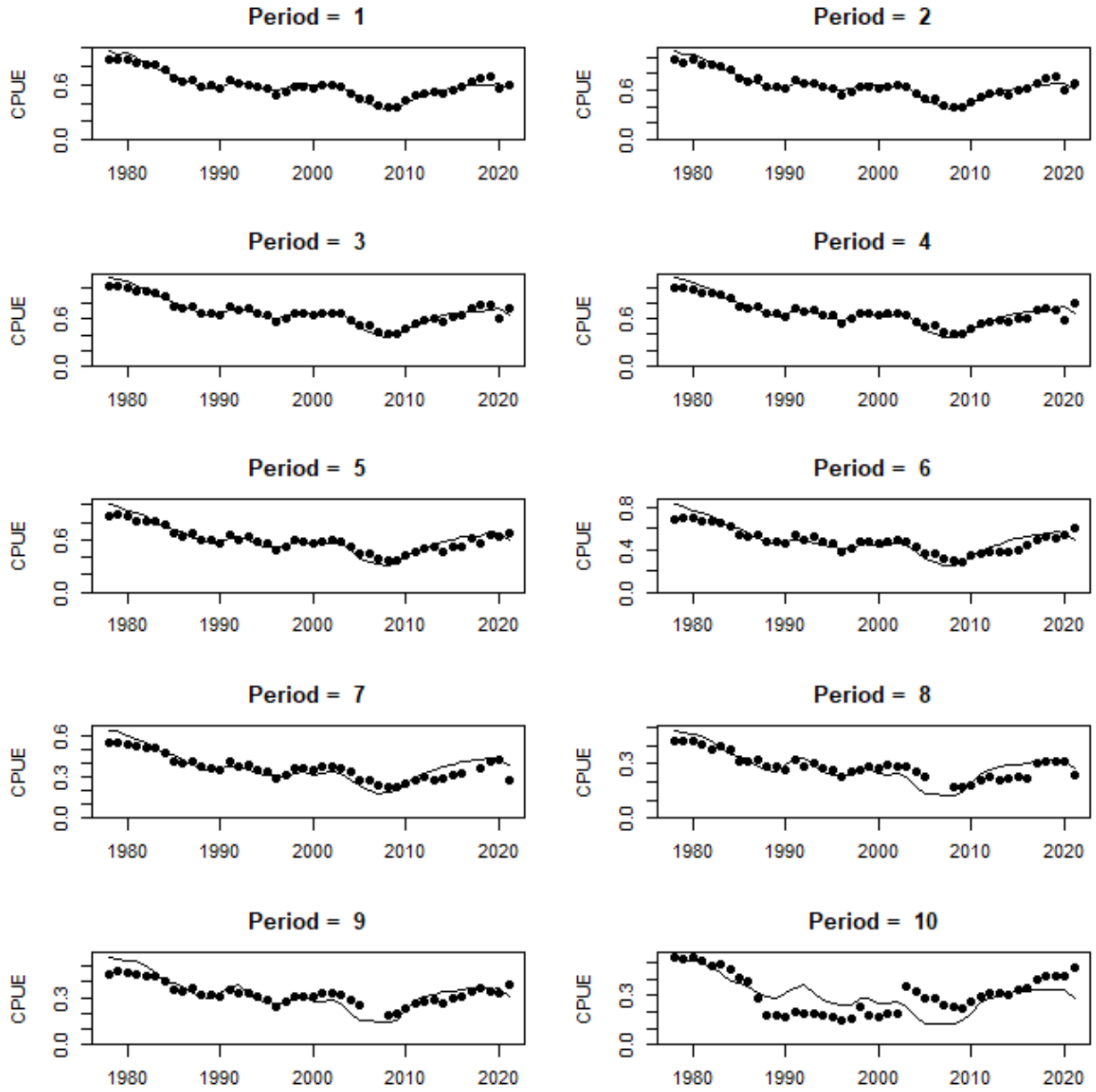

Figure 33: Comparison between standardised CPUE (dots) and CPUE estimated by the stock assessment model (line) for the Western Zone. Periods 1 to 9 are November to July, period 10 is August and September

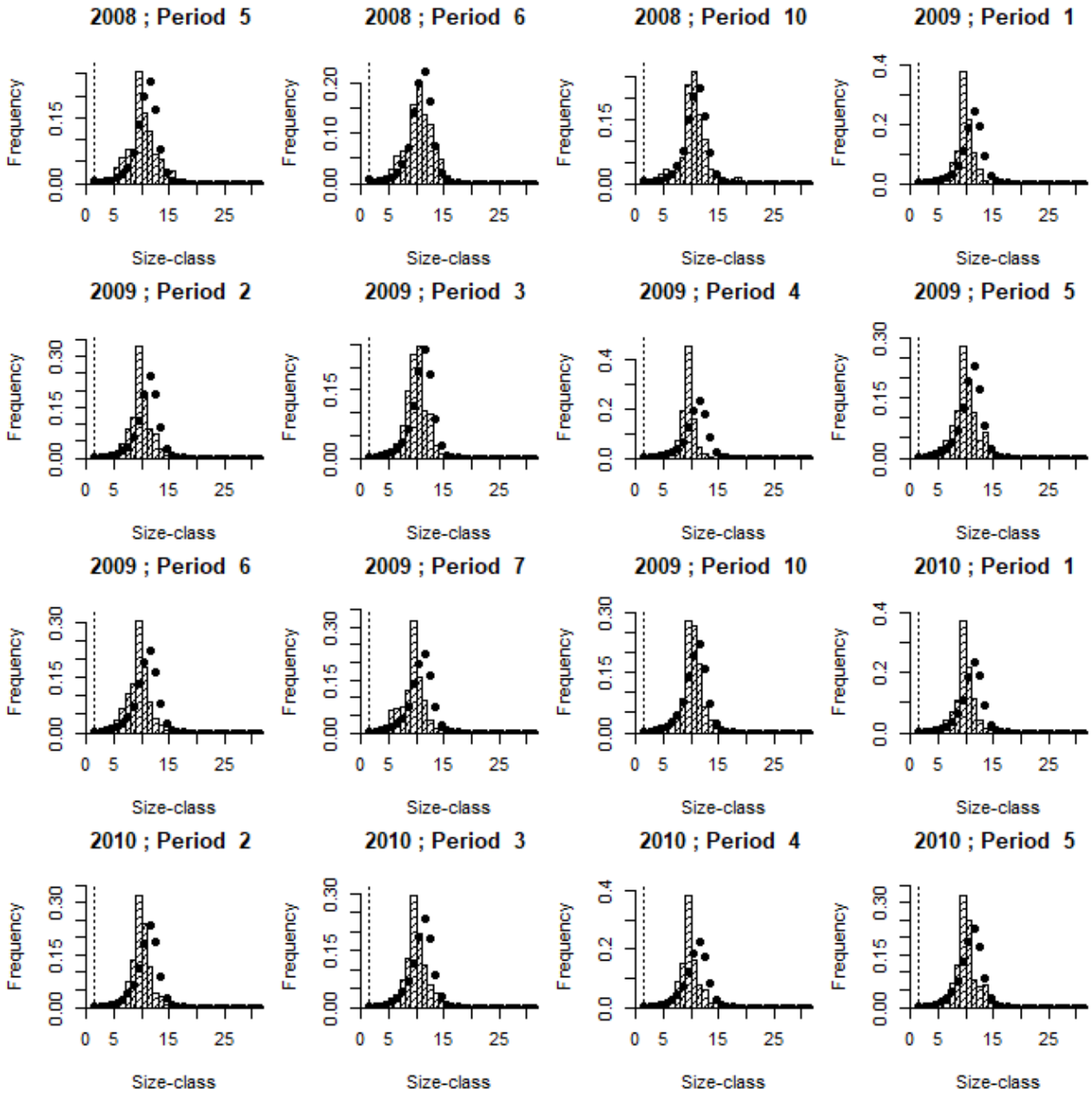

Figure 34: Comparison between length-frequency measurements (bars) and abundance estimated by the stock assessment model (dots) for a selection of years and periods for the Western Zone. Periods 1 to 9 are November to July, period 10 is August and September. Size classes are from 60mm increasing in 5mm increments.

8. SUPPLEMENTARY EASTERN ZONE DATA

Table 4: 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	0.63	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	0.47	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	0.40	1.00
1991/92	65	64	175	0.37	0.36	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	0.29	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	0.38	1.25

Fishing Year	Catch (tonne)	Catch ('000)	Nominal Effort ('000 potlifts)	Nominal CPUE (kg/potlift)	Standardised CPUE (kg/potlift)	Mean Mass (kg/lob.)
2009/10	55	49	145	0.38	0.41	1.11
2010/11	66	62	150	0.44	0.48	1.05
2011/12	62	55	114	0.54	0.55	1.13
2012/13	48	43	94	0.51	0.64	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	53	37	124	0.43	0.44	1.42
2017/18	52	37	133	0.39	0.36	1.42
2018/19	45	30	107	0.42	0.41	1.51
2019/20	36	24	94	0.39	0.37	1.51
2020/21	26	17	72	0.36	0.43	1.47
2021/22	20	15	53	0.38	0.49	1.36

Table 5: Eastern Zone history of TACCs for each quota period from 2001-02 (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
2019-20	1 Jul - 30 Jun	40	37.1	93	12	17	19
2020-21**	1 Jul - 30 Jun	40 (42.8)	31.7	74	12	17	17
2021-22***	1 Jul - 30 Jun	32 (33)	20.7	63	12	14	15
2022-23	1 Jul - 30 Jun	32	2022/23 season underway at time of writing				

*** TACC of 40 t + 2.8 t of uncaught quota carried over from 2019/20 due to COVID market impacts in 2019/20*

**** TACC of 32 t + 1 t comprised of 10% of uncaught quota for 2020/21.*

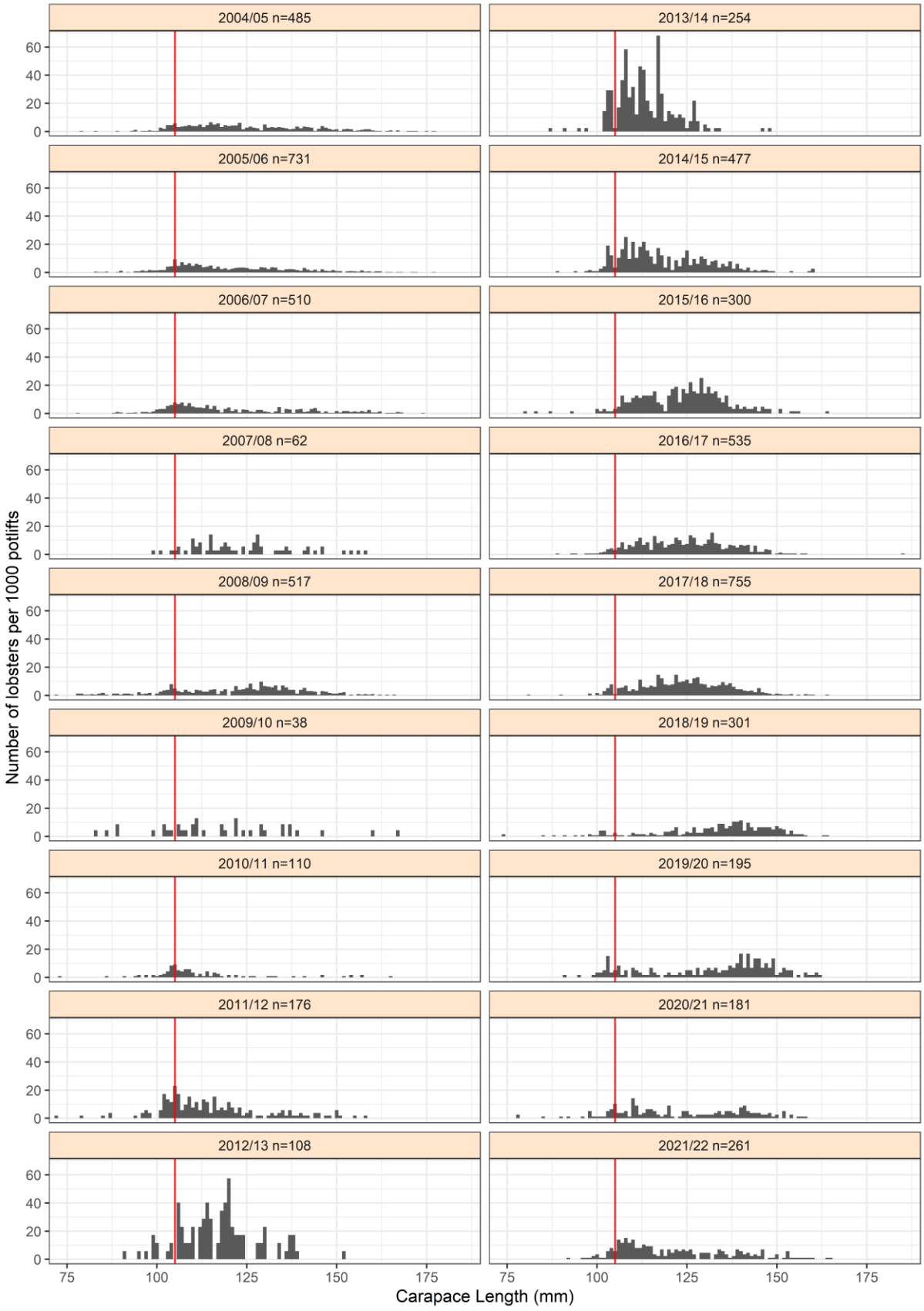

Figure 35: Length-frequency distribution of the number of female rock lobsters per 1,000 potlifts caught in the Eastern Zone onboard observer program from 2004–05 to 2021-22 fishing years (Nov–Sept). n, total number of lobsters measured. The red line indicates the legal size limit.

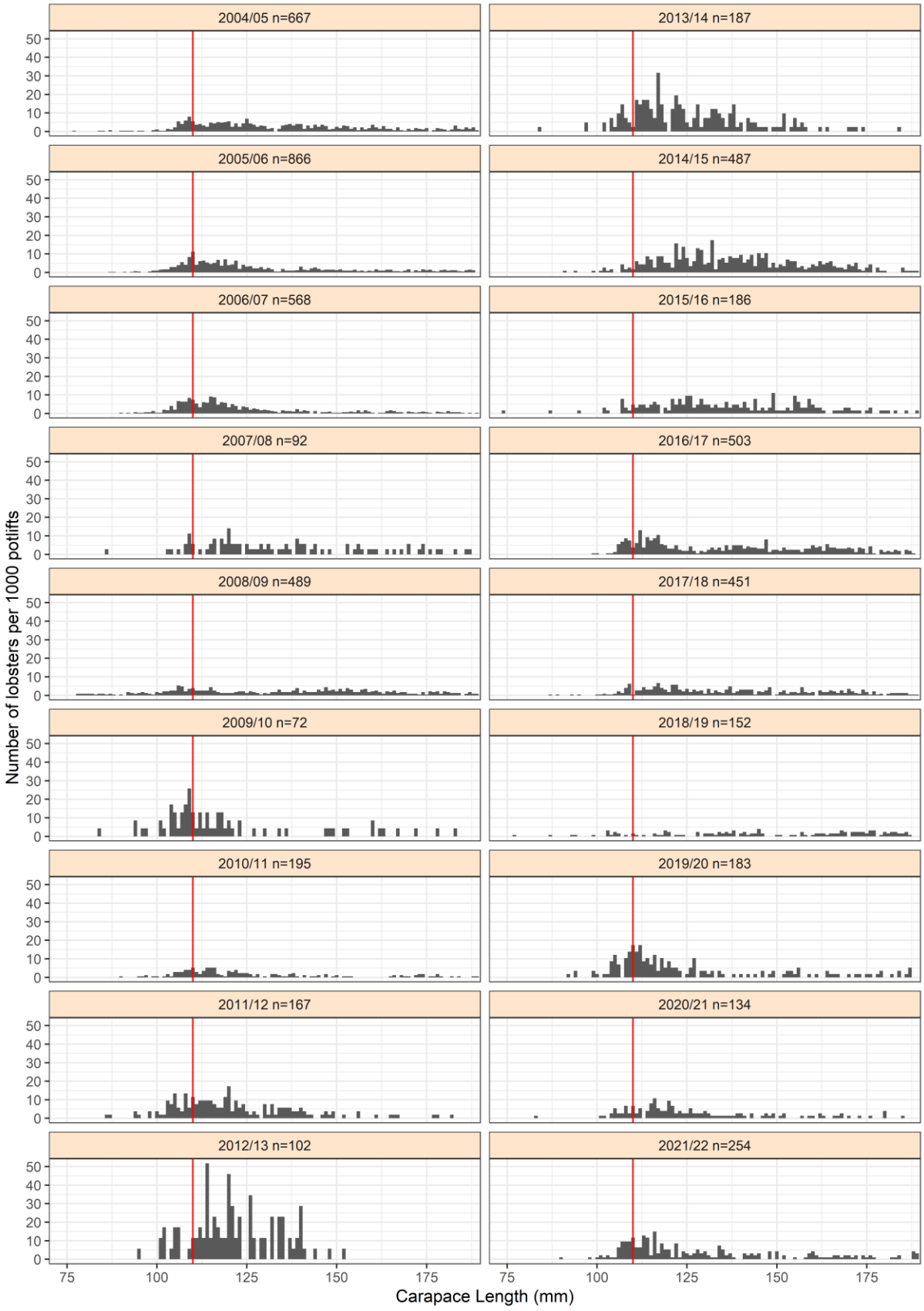

Figure 36: Length-frequency distribution of the number of male rock lobsters per 1,000 pot-lifts caught in the Eastern Zone on-board observer program from 2004–05 to 2021-22 fishing years (Nov–Sept). n, total number of lobsters measured. The red line indicates the legal size limit.

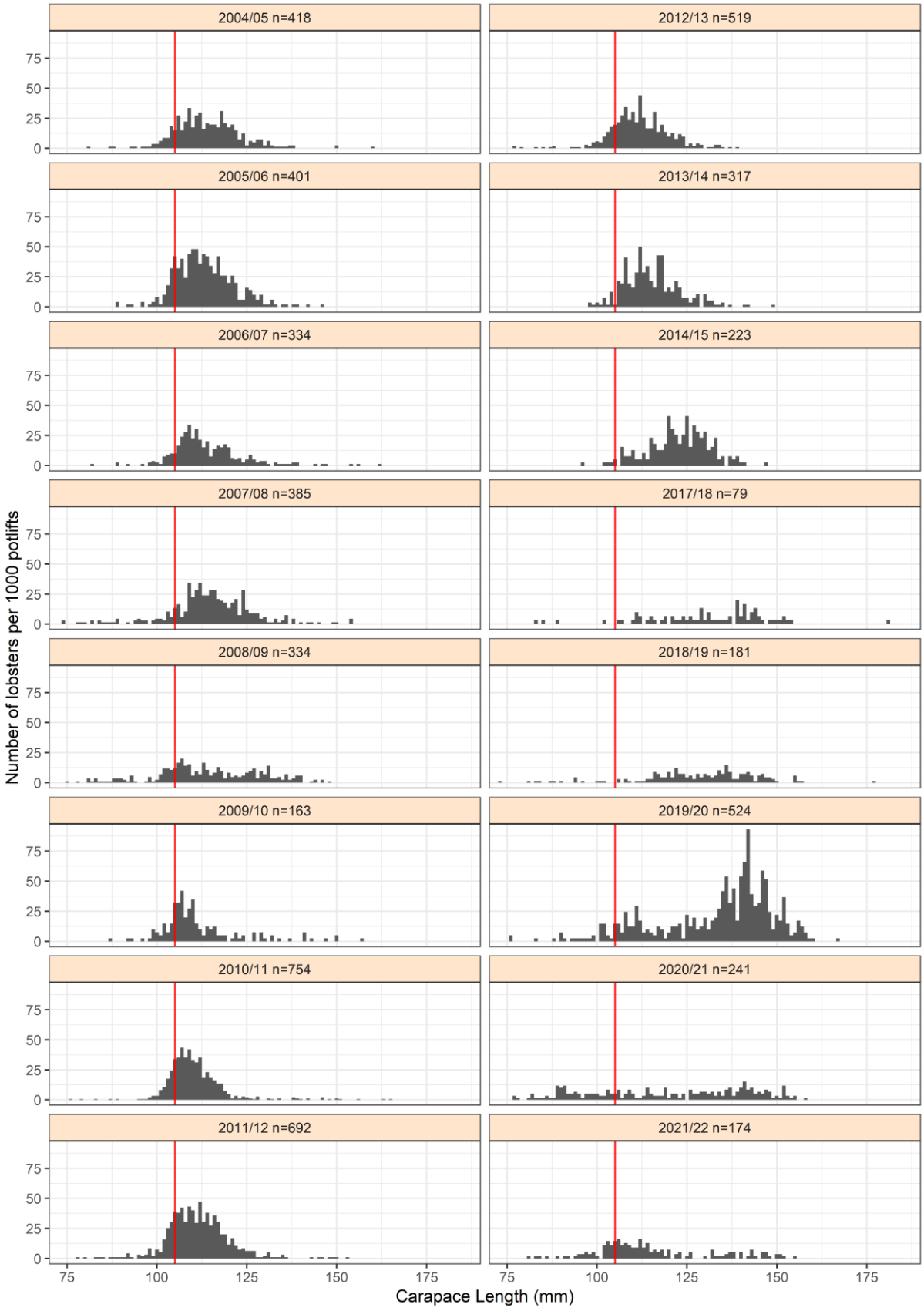

Figure 37: Length-frequency distribution of the number of female rock lobsters per 1,000 potlifts caught in the Eastern Zone fixed-site survey program from 1995–96 to 2021-22 fishing years (Nov–Sept), n, total number of lobsters measured. The red line indicates the legal size limit.

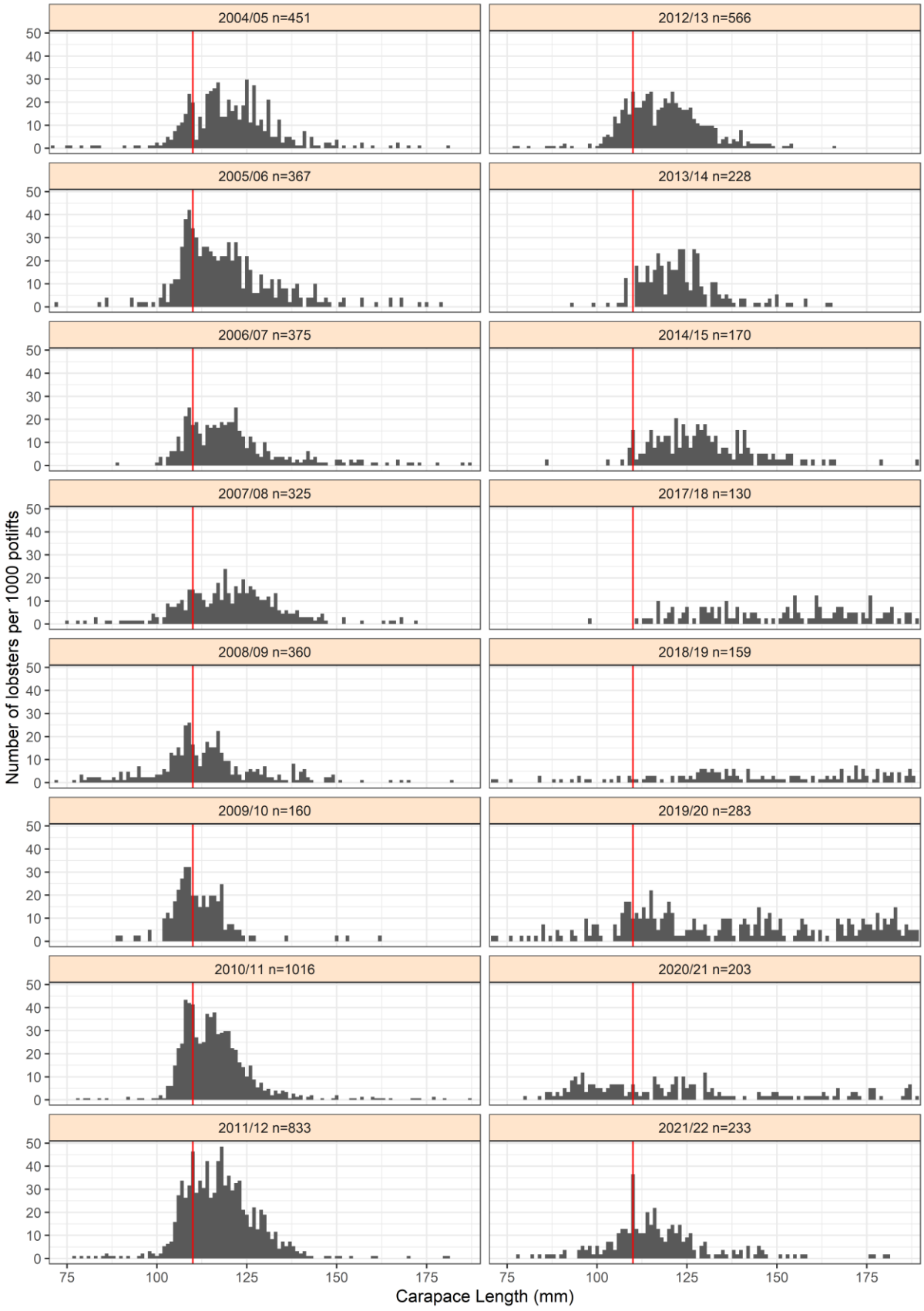

Figure 38: Length-frequency distribution of the number of male rock lobsters per 1,000 potlifts caught in the Eastern Zone fixed-site survey program from 1995–96 to 2021-22 fishing years (Nov–Sept), total number of lobsters measured. The red line indicates the legal size limit.

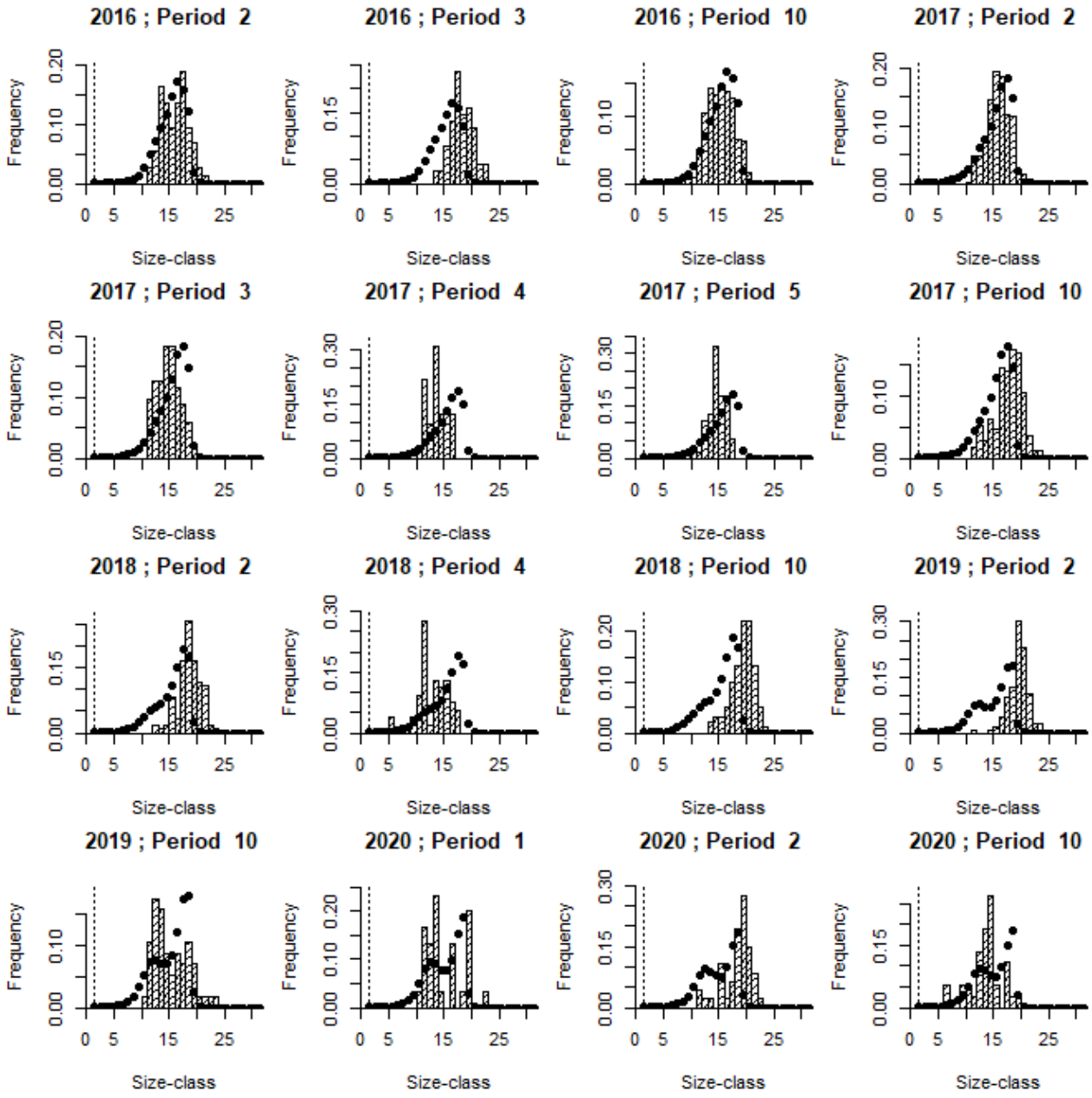

Figure 39: Comparison between length-frequency measurements (bars) and abundance estimated by the stock assessment model (dots) for a selection of years and periods for the Eastern Zone. Periods 1 to 9 are November to July, period 10 is August and September. Size classes are from 60mm increasing in 5mm increments.

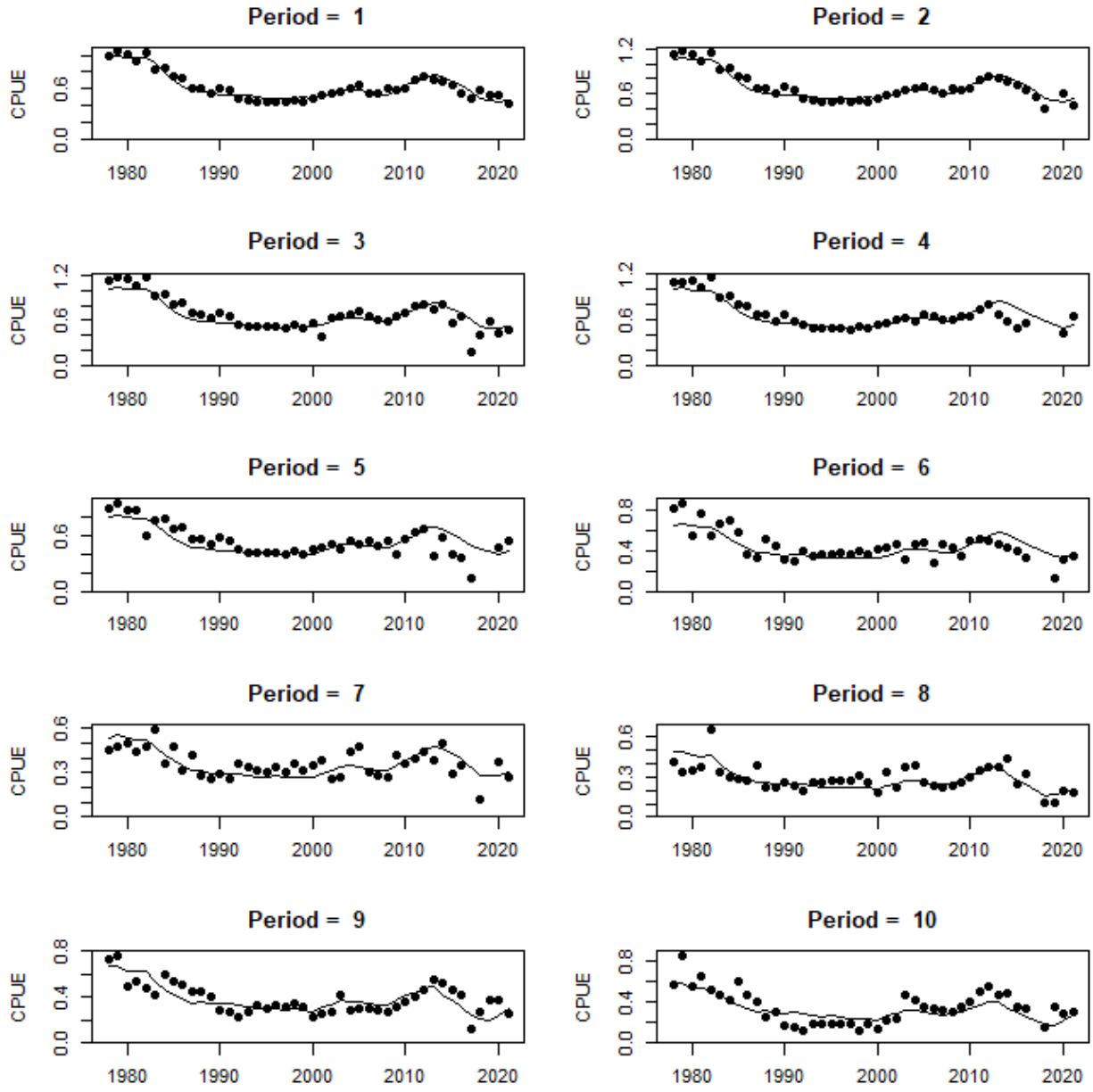

Figure 40: Comparison between standardised CPUE (dots) and CPUE estimated by the stock assessment model (line) for the Eastern Zone. Periods 1 to 9 are November to July, period 10 is August and September

Appendix 1: Rock Lobster Fishery Harvest Strategy

(excerpt from the Victorian Rock Lobster Fishery Management Plan 2017, amended to incorporate changes from 2019 and 2020)

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.

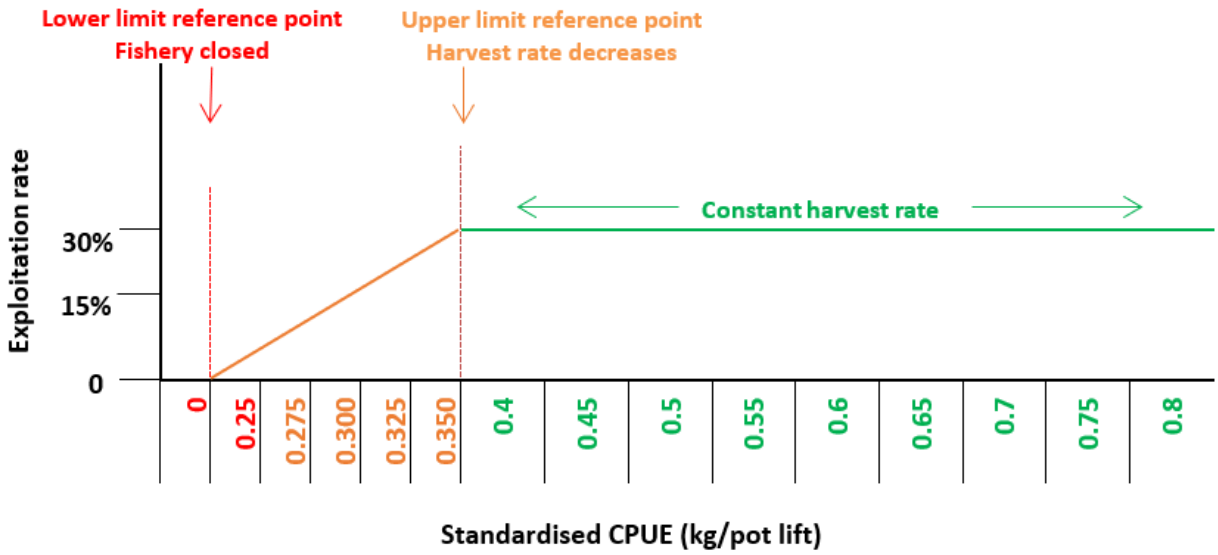

Figure 9. Theoretical construction of the proposed harvest strategy framework.

2.1 Exploitation rates

- The exploitation rates when the catch rate is at and above the upper reference point are:
    - 26.3% 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	11
0.275 - <0.300	25
0.300 - <0.325	43
0.325 - <0.350	64
0.350 - <0.375	88
0.375 - <0.40	115
0.40 - <0.45	152
0.45 - <0.50	176
0.50 - <0.55	199
0.55 - <0.60	223
0.60 - <0.65	246
0.65 - <0.70	270
0.70 - <0.75	293
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 (26.3% 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

Appendix 1: Rock Lobster Fishery Significant Events

Year	Licensing Season	Significant event
1934		Closed season female 1/6-30/11
1955		Sounders, radar and larger wells become available
1958		Closed season: female 1/6-31/10 (reduced), male 1/10-31/10 (introduced)
1959		Illegal to take females in berry, remove berry or take soft shelled crays
1961		Upgraded from cotton to nylon ropes
1968		Pot restrictions according to vessel length
1968		Limited entry to Rock Lobster Fishery and creation of Western and Eastern zones and 'Corridor'
1975		Bottom locked sounders
1980	1980-81	Colour sounders and sat nav
1982	1982-83	Western zone pot reductions + 20 % pot forfeiture on pot transfers
1985	1984-85	Creation of the 'Paddock'
1985	1985-86	5% pot forfeiture on pot transfers
1986	1986-87	Closed season male and female extended to 15/11
1987	1987-88	Closed season male extend to 1/9-15/11
1988	1988-89	GPS and GPS plotters
1990	1990-91	Introduction of escape gaps
1993	1992-93	Peak of giant crab
1996	1995-96	Rock lobster quota management discussions
2001	2001-02	Introduction of quota management rock lobster East and Western zones
2002	2002-03	Introduction of quota management Giant Crab Western zone
2002	2002-03	Introduction of marine protected areas Eastern Zone
2003	2003-04	Extension of open season 2 weeks into September and targeting of 'red' inshore lobsters
2003	2003-04	Extension of open season for males 2 weeks into September
2004	2004-05	Introduction of marine protected areas Western Zone
2004	2004-05	SARS epidemic results in beach price drop from over $40/kg to under $30/kg
2010	2010-11	November: Beach price reaches peak of $79/kg (Tas data)
2010	2010-11	December: Chinese export restrictions drop beach price to $40/kg (Tas data)
2017	2017-18	Victorian Rock Lobster Management Plan and harvest strategy introduced
2019	2019-20	Beach price frequently exceeding $100/kg (Tas data)
2020	2019-20	COVID-19 drops beach price significantly in early 2020 and from November 2020 onwards
2020	2019-20	Introduction of VMS and electronic logbook reporting
2020	2020-Ongoing	Loss of market access to China results in dramatic beach price reduction