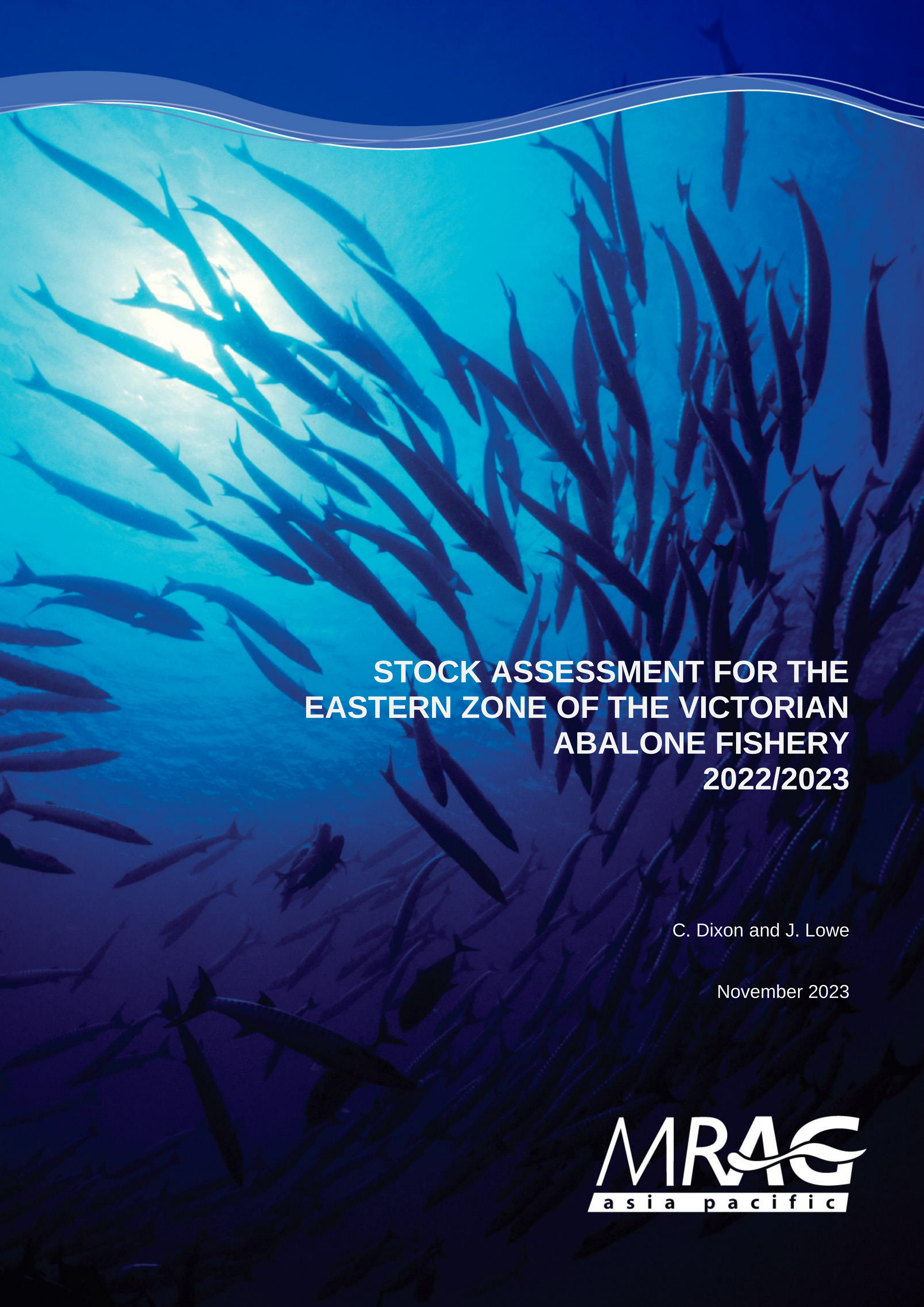

STOCK ASSESSMENT FOR THE EASTERN ZONE OF THE VICTORIAN ABALONE FISHERY 2022/2023

C. Dixon and J. Lowe

November 2023

About MRAG Asia Pacific

MRAG Asia Pacific is an independent fisheries and aquatic resource consulting company dedicated to the sustainable use of natural resources through sound, integrated management practices and policies. We are part of the global MRAG group with sister companies in Europe, North America and the Asia Pacific.

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Executive Summary

This report sets out the 2023 stock assessment for the Victorian Eastern Zone Abalone Fishery. Three primary analytical frameworks are used in this assessment of stock status to inform TACC decision making; (i) a weight of evidence assessment, (ii) analysis of trends against Performance Indicators set out in the in the Victorian Wild Harvest Abalone Fishery Management Plan and (iii) performance of the fishery against the Draft Harvest Strategy. Divers' observations are presented at the TACC setting meeting and approaches to incorporating these data into the formal stock assessment should be considered for future reports.

As discussed in recent Stock Assessment Reports and review documents, there are substantial issues associated with the two primary sources of data. CPUE is positively biased due to hyperstability, while FIS data are negatively biased because FIS site locations are not representative of the entire stock, and in particular the current fished stock. As a result, the research and management framework for the fishery is currently undergoing review and further refinement. In that context, industry's role as stewards of the resource and VFA's obligation to act precautionarily in the face of uncertainty will be particularly important until a more robust assessment framework is in place.

The available data for the weight of evidence assessment look pessimistic for the fishery. The total catch of 330.5 t for the zone was 20 t below the TACC (350.5 t). While CPUE remains high in an historic context, it has declined over the last three years at most SMUs, with >5% decreases between 2021/22 and 2022/23 that led to Decreasing Final categories in the Draft Harvest Strategy at 6 of 7 SMUs. Mean daily catches are at low levels from an historic perspective. Trends in FIS data at the Top 15 sites adjacent to the main fishing areas showed substantial reductions in the abundance of recruits across the zone. On a positive note, there was an equally substantial increase in pre-recruit abundance.

The FIS review provided evidence that the decline in FIS abundance from 2003 to around 2010 represents serial depletion of the stocks in the offshore and mid depth reefs. Currently, the fishery is reliant primarily on shallow water reefs that are not currently surveyed, although improvements are in development. There is currently no data to assess biomass in shallow reefs, and therefore total or relative biomass estimates cannot be made for the entire stock.

The 2022 Stock Assessment Report identified large discrepancies in catches and OTs at both the SMU and reefcode levels. These discrepancies continued at both spatial scales in this current assessment. Given the objective of TACC setting for the Eastern Zone is to follow a "bottom-up" approach by determining sustainable levels of catch at the reefcode scale, a review of reefcode level catches is required and more robust monitoring of catches against targets by reefcode is needed.

In summary, the previously positive short-term assessments of stock status from 2020 and 2021 were based on biased measures of CPUE and FIS abundance following the Draft Harvest Strategy outputs. In the 2022 report, the assessment was more concerning, concluding that the stable catches in recent years were likely to have further impacted on an already declining biomass. Reductions in the TACC were recommended, and were implemented, for the 2023/24 quota year despite stable Draft Harvest Strategy results. Given this assessment is based on data from 2022/23, the impact of the TACC reductions on the biomass are currently unknown, however a precautionary approach to TACC setting should be continued. The weight of evidence assessment and Draft Harvest Strategy results suggest that further reductions in TACC are likely required to prevent further declines in biomass, however the magnitude of required reductions is difficult to determine from the available information, and thus individual diver observation reports from industry will be critical in determining where reductions are needed and of what magnitude. The status of the Eastern Zone stock remains 'declining'. It is not possible to determine how close the stock is to a point where future recruitment may be impaired, however the risk is not negligible.

1. General Introduction

1.1 Overview

This Stock Assessment Report builds on previous reports for the Eastern Zone Abalone Fishery (e.g. VFA 2018; Dixon and Dichmont 2019; Dixon, Potts and Dichmont 2020; Dixon, Potts and Dichmont 2021, Dixon, Lowe and Potts 2022). It is the fifth Eastern Zone Stock Assessment Report prepared by MRAG Asia Pacific. The report analyses fishery-dependent catch and effort data (up to 31 March 2023) to assess the blacklip fishery against long- and short-term performance indicators. FIS data were collected from 15 sites in June 2023 and the historic data from these 15 sites are used to assess against the Performance Indicators. Catch, effort, CPUE and FIS data are presented in various manners for assessment of stock status in a multiple lines of evidence approach at the Zone level and for each Spatial Management Unit (SMU). Summary results from the Eastern Zone Draft Harvest Strategy 2023 are provided in Appendix 1 and discussed for each SMU. This report also provides advice for components of the stock assessment process going forward.

1.2 Description of the Eastern Zone Abalone Fishery

The Eastern Zone Abalone Fishery extends along the coast of Victoria from Lakes Entrance to the Victorian / New South Wales border (Figure 1). The fishery is limited entry and the primary method for managing commercial abalone fishing is to set an annual Total Allowable Commercial Catch (TACC) for each management Zone. There are 23 Abalone Fishery Access Licences (AFALs) and 460 quota units in the Eastern Zone fishery. Licences and quota units are transferable (i.e. they can be leased or sold) amongst licence and non-licence holders. A minimum of five quota units must be attached to each AFAL. Fishers may be owner-operators or contract divers.

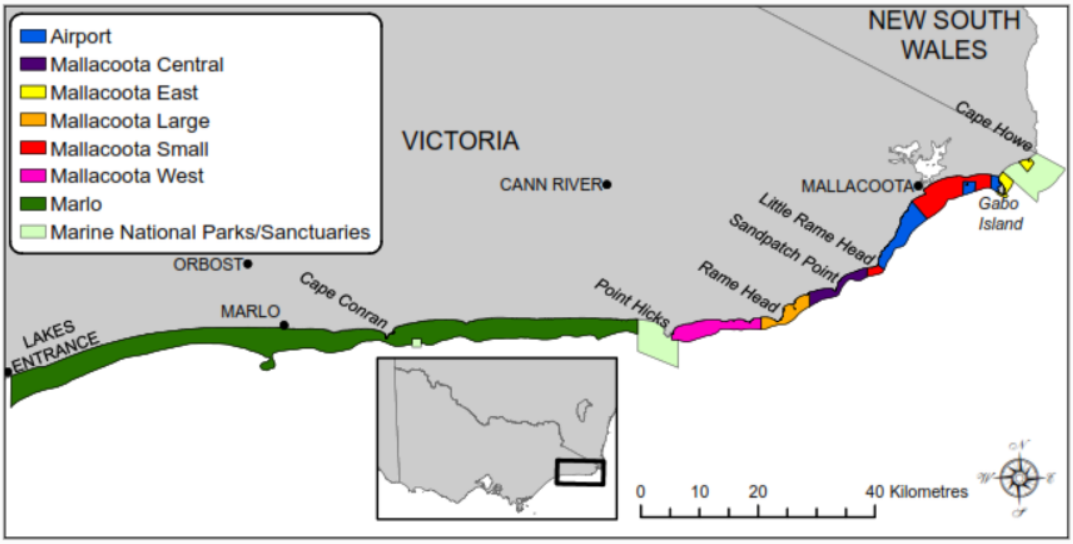

Figure 1: Map of the Eastern Zone Abalone Fishery showing the Spatial Management Units and Marine Protected Areas.

The TACC for the Eastern Zone fishery is set at a Zonal scale, but management of the fishery occurs at a finer spatial scale defined by the seven SMUs (Figure 1). An Optimum Target (OT) catch is set for each SMU based on current quota reference points, catch history and stock assessment outputs. The combined value of all OTs represents the TACC. Total catches for each SMU for the following fishing season are intended to meet the OT for that SMU. During the 2022/23 season, SMUs were closed via a Fisheries Notice once the OT threshold had been reached or exceeded, and reef codes were closed when the specified upper limit had been reached. Further details regarding the history of the fishery and current management goals and arrangements are described in the Victorian Wild Harvest Abalone Fishery Management Plan (DEDJTR 2015).

1.3 Objectives

The Victorian Government's overarching policy objective is to optimise the commercial, social and cultural value to Victoria derived from the use of fisheries resources and associated ecosystems. This objective is pursued within the context of the broader policies and instruments applicable to fisheries including: the Fisheries Act 1995 and subordinate legislation; Offshore Constitutional Settlements; commitments made by all Australian governments to manage fisheries according to the principles of ecologically sustainable development; and Victorian Government policies to facilitate economic productivity (including reducing regulatory burden) and to conserve environmental assets.

A TACC is set for each management Zone which aims: *"To obtain optimum harvests from the fishery, whilst conserving sufficient reproductive capacity to maintain or rebuild population recruitment and ensuring that sufficient aggregations remain on reefs to preclude habitat loss"* (DEDJTR 2015). A reference to habitat is included in the context of evidence indicating that the presence of abalone on reefs helps to ensure that the habitat remains suitable for post-larval settlement and survival, and this means that more abalone may need to be retained on reefs than the minimum required to maintain levels of reproduction (Miner et al. 2006; Mundy and Jones 2017).

The Victorian Wild Harvest Abalone Fishery Management Plan (DEDJTR 2015) specifies the objectives, strategies and actions for managing the fishery for at least five years from the declaration of the plan. Objectives include:

- Objective 1: Rebuild or maintain abalone stocks
- Objective 2: Secure access to the resource
- Objective 3: Enable improvements in economic productivity
- Objective 4: Empower effective industry representation, organisation and funding
- Objective 5: Ensure fisheries compliance
- Objective 6: Ongoing monitoring and targeted research.

2. Methods

2.1 Data sources and uncertainties in the assessment

2.1.1 Catch, effort, and CPUE

The Eastern Zone fishery began around 1966, however commercial logbook data were only gathered from 1 January 1969. Catch and effort logbook data were sourced from three different datasets provided by VFA. These data were merged and validated, with the final dataset comprised of the following subsets of data:

- 1 January 1969 to 31 May 1978
- 1 June 1978 to 31 March 2004
- 1 April 2004 to 31 March 2021

Catch per unit effort, referred to as CPUE, is a commonly used index of abundance for fisheries stock assessment. However, recent Stock Assessment Reports (Dixon et al 2020, 2021, 2022) and a review of the current CPUE standardisation approach (Dichmont et al 2022) have discussed in detail the limitations of CPUE data as an index of abundance for the Eastern Zone abalone fishery. The key issues include:

- hyperstability due to their cryptic nature and aggregating behaviour,
- changes in the spatial or temporal distribution of the catch,
- effort creep due to improvements in technology,
- reliability of reporting,
- environmental conditions.

In summary, because abalone aggregate and divers generally target the densest visible aggregations, CPUE can be maintained even if overall population abundance is declining. As a result of these circumstances, stable or increasing trends in CPUE may not be reflective of trends in stock abundance. Declines in CPUE are generally considered to reflect declining abundance, however they are also unlikely to be linear, with rates of decline potentially more severe than CPUE data would suggest. Complicating these issues, declines in CPUE in the short-term may also be attributed to other influencing factors such as an increase in size limit, or changes in market forces. Other factors such as diver experience can also affect abalone CPUE trends.

The CPUE data in this report are standardised following VFA (2019) in an attempt to address these issues. Nevertheless, the current approach does little to improve the index of abundance as there is little difference between nominal and standardised trends at all spatial and temporal scales. Several alternative standardisation models were recently tested, with little to no improvement in the outcomes (Dichmont et al 2022). It is expected that a revised standardisation approach for future stock assessments will be agreed between stakeholders through a Working Group within the next year.

The assessment in this report relies heavily on the CPUE that is positively biased due to hyperstability. Thus, there is substantial uncertainty in the interpretation of the data that drive the stock status assessment and Harvest Strategy outcomes. Given the positive bias in the CPUE measure, declines in CPUE that result in suggested reductions in catch through Harvest Strategy and weight of evidence outcomes should not be ignored.

In addition to catch, effort and CPUE trends, this report is the first to examine trends in mean daily catch. This measure only includes days when divers fished a single SMU and more than 50 kg of abalone was recorded.

2.1.2 Fishery-independent survey abundance

Several fishery-independent survey (FIS) approaches have been developed for abalone fisheries in Australia. Commencing in 1992, the Victorian FIS provides a long-term, annual dataset measuring recruit and pre-recruit abundance (standardised using GLMM following VFA 2019), along with size structure data. The Victorian FIS is currently under review, with milestones from Year 1 recently being published (Dixon 2023). Several outcomes from the review are critical to this report and the assessment of stock status for the Eastern Zone.

Of greatest importance, both commercial fishing effort and FIS locations were mapped using GIS software to obtain an understanding of how well (or otherwise) FIS sites represented the biomass upon which the Eastern Zone fishery is currently based. In general, the results of this analysis suggested that FIS sites are a very poor representation of the current fishing grounds. As hypothesized in previous Stock Assessment Reports, declines in FIS abundance observed over a decade from around 2003 represented declines in abundance on intermediate and deeper water reefs. During this period, CPUE actually increased as fishing became concentrated in the shallower, more productive reefs where FIS sites were not located (due to logistic reasons). On this basis, the declines in abundance during this period do reflect a reduction in biomass from intermediate and deeper reefs, however the rate of decline in abundance is much greater than the rate of decline in total biomass because the FIS sites are negatively biased.

With declines in FIS abundance providing overly pessimistic trends and CPUE providing overly optimistic trends, the contrasting signals from these data sources have caused substantial uncertainty in the assessment of stock status for many years. The relationship between these measures has been studied in detail in previous reports and has been included as an appendix in this report. To address these issues, the FIS review process has identified an urgent need to establish new FIS locations in shallow reefs that are representative of the current fishing grounds. It is anticipated that the first of these sites will be in place by 2024.

The FIS review process also resulted in a reduction in the number of historic FIS sites surveyed in the Eastern Zone. While no FIS was conducted in 2022, data were gathered from 15 old FIS sites referred to as the "Top 15" (Dixon 2023). While these sites are not representative of the primary fishing grounds, they were selected as they maintained reasonable levels of abalone abundance, and they were generally adjacent to areas of more intense fishing effort. While data from these sites are not considered to be representative of trends in biomass for the fishery, they contribute some useful information toward the assessment of stock status. Recruit and pre-recruit abundance as well as size frequency data are presented at the SMU scale, however the number of Top 15 FIS sites at this scale varies between 1 and 4 for 6 of the 7 SMUs, and there are no Top 15 sites for the Mallacoota Large SMU. Thus, interpretation of these trends should be treated with caution. Analyses from Dixon (2023) suggest that trends for the Top 15 sites at the zone scale are similarly precise to previous years when around 60 sites were surveyed.

2.1.3 Size structure data

Fishery-independent survey

Size structure data from FIS are available from 1992. However, the approach to collecting length frequency data changed in 2003 when abalone were removed after the transect survey counts from areas immediately outside of the site radius in a "timed swim" approach, rather than removing all abalone encountered on the transects themselves.

Data are weighted by the standardized abundance at each site to ensure that the size distribution is representative of the sampled population, rather than the samples measured, which reduces bias. Length frequency samples from each site were converted from counts to percentage frequency and were then scaled by the total count at each site to determine the percentage length frequency at the SMU scale. The percent frequency was then multiplied by the standardized total abundance (i.e. standardized pre-recruit abundance + standardized recruit abundance) for each year. These data are then presented graphically with associated statistics and reported in Appendix 3. Data from all FIS sites are presented at the SMU level from 2003 to 2021, and data from the Top 15 FIS sites are presented at the SMU level from 2003 to 2023, except for Mallacoota Large where there are no Top 15 sites. Interpretations of the data are included in the summary assessment for each SMU.

FIS length frequency data also enable abundance measures to be split into pre-recruit indices for the harvest strategy. Interpretation of size data is difficult as small changes can be quite influential in size-structured models. Thus, only crude changes can be investigated with the broad statistics obtained from these data, so when there are clear trends these should be considered important.

To examine the effect of the change in the method of length-frequency data collection, Dixon (2023) compared the ratio of recruit to pre-recruit abundances on transects versus timed collections and found that length frequency gathered since 2003 was strongly biased toward the collection of larger abalone. The results from this analysis are presented in Appendix 3. It is considered unlikely that bias in size structure would result from the in situ transect counts as abalone are encountered in a systematic manner. This view is supported by Gorfine (1998) who states "*Because the application of radial transacts avoids targeting some emergent abalone to the exclusion of others, there is less potential for divers to bias their sample towards larger abalone as may occur with time searches….*

Time searches do not necessarily permit this separation of pre recruits from post recruits because of the potential for divers to collect larger, more accessible abalone at the expense of smaller abalone".

Therefore, there are two sources of bias that have recently been identified in the FIS length-frequency data. Firstly, as previously described, FIS site locations are not representative of the entire stock. And secondly, changes in the approach to collecting length frequency data has biased the size data towards larger abalone. On this basis, the length-frequency data presented in this report are not representative of the abalone population and trends in FIS length frequency should be given little weight in the assessment.

Commercial length frequency

Data on size structure of the commercial catch are a very important data source to monitor changes in the fished population. While interpretation of these data can be affected by changes in size limits or changes in market demands, a shift towards "knife-edge fishing", where more abalone are being caught closer to the size limit, can reflect higher levels of fishing mortality on a stock.

Commercial length frequency data were gathered by the Mallacoota Co-op from 2010/11 to 2013/14 and 2015/16 to 2018/19, and these data are presented in this report. Unfortunately, the Mallacoota Co-op was lost in the 2020 bushfires and the sampling program was discontinued. The data that were gathered provided some useful insights into commercial size structure, however inconsistent sampling and low sample size numbers in later years complicate their interpretation.

There is an urgent need to gather size structure data that are representative of the commercial catch.

2.1.4 Size limits

Spatial and temporal changes in size limits impacts fishing selectivity (availability) which makes it difficult to interpret temporal trends in CPUE and the impact that changes in TACCs have on exploitable biomass. For example, a decrease in the LML generally allows access to a larger biomass of smaller abalone and may result in a consequent increase in fishery CPUE over a short time frame and a reduction in mean length of the catch. Changes in LML need to be factored into the interpretation of all data, particularly trends in CPUE over time. Examples of LML changes are the LML at the Mallacoota Large SMU which was progressively increased from 120 mm to 138 mm from 2009/10 to 2016/17 because of the exceptionally high growth and large size at maturity among many of its abalone populations (VFA 2018). The LML was reduced at Mallacoota Large to 135 mm for 2019/20.

While size limits have been stable since 2019/20, there were numerous size limit changes, regulated and voluntary, within the Eastern Zone during the previous decade. These changes were often applied at the reef code scale; however, more recently changes have been applied at SMU scale recognising the practical implications for enforcement and administrative burden. A table representing the history of LML changes is provided in Appendix 2. Compliance levels with voluntary size limit changes are relatively unknown.

The regulatory changes to LML have included both increases and decreases. Size limits have been increased due to stakeholder and government concern about the state of the resource, but they have also been decreased to manage fishing effort more sustainably across SMUs (VFA 2018).

2.2 Approaches to assessment of stock status

Performance Indicators

The first approach for assessing stock status is assessment against the Performance Indicators (PIs) and associated reference points described in the Victorian Wild Harvest Abalone Fishery

Management Plan (Table 1, DEDJTR 2015). The primary PIs are standardised CPUE and FIS recruit and pre-recruit abundance and are intended to be used as indicators of biomass and fishing mortality to infer stock status at Zone and SMU scales. The 2016 Victorian Abalone Science - Methods Used for Fishery Assessment report (VFA 2019) describes how the different data types are acquired, processed, and analysed.

The primary PIs are assessed across two spatial scales (Zone and SMU) and two temporal scales (long-term: 2003/04 to current, and short-term: 2009/10 to current). In this report, the long and short-term PIs for recruit and pre-recruit abundance are presented at the Zone scale for the "Top 15" sites only (Dixon 2023). As described above, there are many issues with these measures that result in substantial uncertainty in the interpretation of the PIs. On this basis, recent Stock Assessment Reports have recommended that the PIs be reviewed (Dixon et al 2021, 2022).

Table 1: Performance indicators used in the assessment of the Eastern Zone abalone fishery. LML = Legal Minimum Length.

Performance Indicator	Description	Units	Source and time series
Catch	Commercial catch reported at Zonal and SMU scale	Tonnes	FA Commercial catch returns 1992 – current
Catch per unit effort (CPUE)	Catch / Effort for individual fishers. Average and standard error (nominal only) calculated at Zonal and SMU scale Used as a proxy indicator of legal biomass Primary and secondary indicator in draft HS	Nominal kg/hr Standardised kg/hr	VFA Commercial catch returns 1979 - current
Short and long-term trend analysis of CPUE	Objective statistical method used to determine if a change in trend occurs and if the trend is positive, negative, or statistically non-significant	Significant or non-significant trend Positive or negative percentage change	VFA Commercial catch returns 1992 – current
Pre-recruit abundance	Used as an indication of the strength of recruitment. Tertiary indicator in draft HS	Average number of abalone per 30 m transect. Nominal and Standardised	VFA FIS 1992-current
Recruit abundance	Used as an indicator of adult abundance	Average number of abalone per 30 m transect. Nominal and Standardised	VFA FIS 1992-current
Short and long-term trend analysis of pre-recruit and recruit abundance	Objective statistical method used to determine if a change in trend occurs and if the trend is positive, negative, or statistically non-significant	Significant or non-significant trend Positive or negative percentage change	VFA FIS 1992-current
Length frequency statistics (FIS)	Used to show changes in size composition of the abalone populations at Zone/ SMU relative to the LML from survey data	%<LML Median calculated as the mid-point of the length distribution	VFA FIS 2003-current

Weight of evidence

The second approach used to assess stock status is the weight of evidence approach that considers all sources of available scientific data. As discussed above, for the Eastern Zone these data sources include catch, effort, CPUE data, FIS abundance and size-structure, as well as size structure of the commercial catch. Note that formal weightings to each of these data sources has not been agreed, thus trends in all these data sources are considered subjectively in an overall manner to determine a likely stock status. Future assessments need to integrate additional data sources into the weight of evidence approach, in particular data collected from new FIS sites and data collected through the commercial data logger programs (VMS, length-frequency and depth data).

Draft Harvest Strategy

A Draft Harvest Strategy has been developed for the Victorian Abalone Fishery (Central and Eastern Zones) and a summary of the 2022/23 results is provided in Section 3.2.3. The Harvest Strategy comprises operational objectives, performance indicators, reference levels and decision (or control) rules which directly link to TACC setting. The Draft Harvest Strategy requires further validation before it is formally integrated into the TACC setting process. In this report, we compare the independent weight of evidence assessment of stock status at the SMU scale with the outcomes of the Draft Harvest Strategy.

Both the stock assessment and Draft Harvest Strategy results are presented at the annual TACC setting workshop. The TACC will continue to be set this year based upon a ‘bottom up’ multiple lines of evidence approach as detailed in the Victorian Wild Harvest Abalone Fishery Management Plan (DEDJTR 2015). Catch targets for each SMU are to be reviewed during the annual workshops and these will directly influence the recommended TACC for the following season. Additional evidence that underpins the rationales for agreed catch target at the TACC setting meeting will be recorded and compared to both the stock assessment and Harvest Strategy outcomes as part of the validation of the Draft Harvest Strategy.

2.3 Quality Control

Raw catch effort and CPUE data were received by MRAG Asia Pacific on 8 September 2023. Data were provided by VFA in a validated form. Standardised CPUE analyses were validated by repeating 2022 analyses using Genstat software.

Raw FIS data (abundance and length frequency) were received by MRAG Asia Pacific on 24 September 2023. Data were provided by VFA in a validated form. Standardised CPUE analyses were validated by repeating 2022 analyses using Genstat software.

3. Results

3.1 Eastern Zone Blacklip Assessment

3.1.1 Catch and effort

The Eastern Zone fishery commenced in 1962 (Gorfine et al 2008), however daily logbooks were not introduced until January 1969. As a result, figure 2 shows a catch of only 200 t in 1968 (i.e. 1968/69 quota year) because it included only catches from 1 January to 30 March 1969. Catches exceeded 700 t in 1969, 1970 and 1972 before declining rapidly to below 400 t in 1977. An increase to around 550 t in 1979 was immediately followed by another decline to around 400 t in 1982. Catches remained around 550 t from 1983 to 1987 before the introduction of quota in 1988. Catches remained relatively stable until 2002 before an increase in quota led to higher catches until 2008. Thereafter, catches (and quotas) have generally declined. Currently, reported catch is less than half of the 1970 peak.

Dive effort peaked around 600,000 minutes in the early part of the fishery (1969 to 1973) and fluctuated thereafter until the introduction of quota in 1988. Thereafter, effort has generally declined, reaching a historic low in 2019 and 2020 due primarily to impacts from Covid-19 on markets. Currently, reported effort is around one third of the historic peak.

The total catch in 2022/23 was 330.5 t, which was 94.3% the TACC of 350.5 t. This was a decrease of 7% compared to the previous years' catch (357 t).

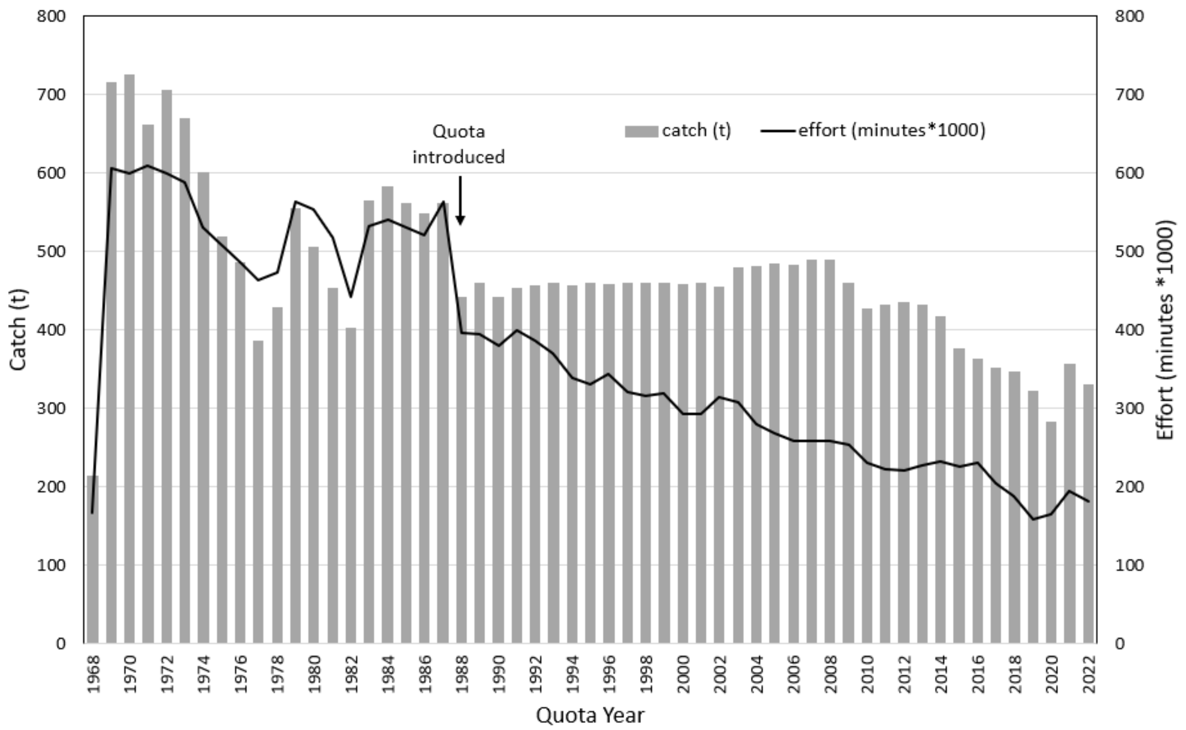

Figure 2: Historic catch (t) and effort (minutes) from 1968 to 2022. Quota was introduced in 1988 with the quota year running from April to March. Data are reported in quota years.

Mean daily catch ranged from 300-350 kg per day from 1979 to the introduction of quota in 1988 before increasing to a peak of around 470 kg per day in 1996 (Figure 3). Mean daily catches were relatively stable for the next 16 years but declined from 450 kg per day in 2012 to 380 kg per day in 2015 before recovering again from 2017 to 2019 at around 440 kg per day. Impacts from Covid-19 in 2020 saw a dramatic reduction to around 280 kg per day, with mean daily catches increasing in the last two years, albeit remaining below 400 kg per day.

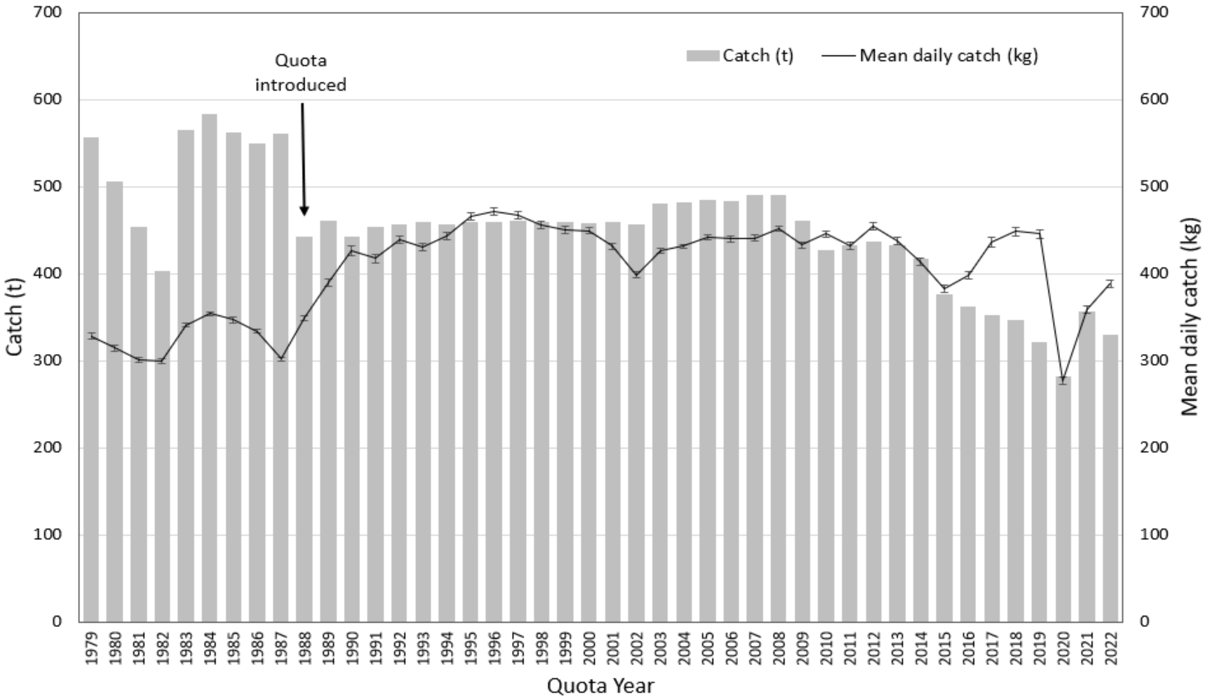

Figure 3: Historic catch (t) and mean daily catch (kg per fishing day +/- SE) from 1979 to 2022. Quota was introduced in 1988 with the quota year running from April to March. Data are reported in quota years.

3.1.2 Catch per unit effort (CPUE)

Nominal CPUE generally increased from 1992 to 2012, declined from 2012 to 2016, increased again from 2016 to 2019, and generally declined thereafter (Figure 4). Standardisation of the nominal CPUE made little difference to the trends over time. These trends have been broadly consistent across all SMUs as well (see following Chapters).

Figure 4: Eastern Zone catch and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Catch = bars, nominal CPUE = grey series (+/- SE), standardised series = black. MPs = introduction of Marine Parks.

3.1.3 FIS abundance

Recruit abundance

Figure 5 plots recruit abundance from FIS sites. The grey line is the nominal data from all FIS sites surveyed, with the black lines representing the nominal (dashed) and standardised (solid line) values for the Top 15 sites only. There was little difference between nominal and standardised trends. Recruit abundance at the Top 15 sites declined substantially from 2003 to 2008 before increasing the following two years. Thereafter recruit abundance has generally declined. Recruit abundance in 2023 was the lowest recorded, declining by 20% from 2021 levels.

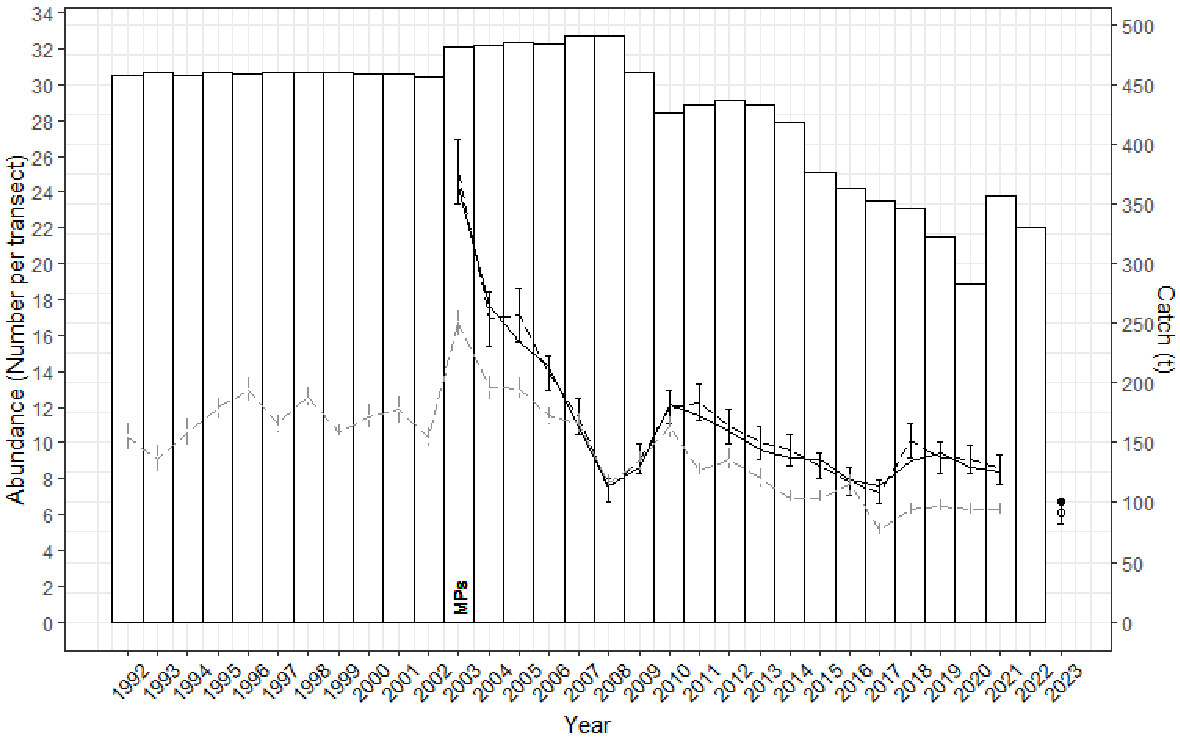

Figure 5: FIS recruit abundance (1992-2023) and catch (1992/93 – 2022/23) for the Eastern Zone. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line, open datapoint in 2023; +/- SE) and standardised (solid line, solid datapoint in 2023) abundance across the Top 15 sites only.

Pre-recruit abundance

Figure 6 shows pre-recruit abundance from FIS sites. As for Figure 5, the grey line is the nominal data from all FIS sites surveyed, with the black lines representing the nominal (dashed) and standardised (solid line) values for the Top 15 sites only. There was little difference between nominal and standardised trends. Pre-recruit abundance at the Top 15 sites declined consistently from 2003 to 2021. Pre-recruit abundance increased by 27% in 2023 and was the highest observed since 2017.

Figure 6: Pre-recruit abundance (1992-2023) and catch (1992/93 – 2022/23) for the Eastern Zone. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line, open datapoint in 2023; +/- SE) and standardised (solid line, solid datapoint in 2023) abundance across the Top 15 sites only.

3.1.4 Eastern Zone Performance Measures

The catch in 2022/23 was 330.5 t, which was 94.3% the TACC (Table 2). Catch has declined by 31% in the long term (2003/04), 28% in the short-term (2009/10) and 6% in the last 4 years (2019/20). Mean daily catch in 2022/23 was 388.9 kg/h, which was 9% lower than the long-term, 11% lower than the short-term, and 13% lower than 4 years ago. CPUE in 2022/23 was 106.4 kg/h, which was 8% higher than the long-term, 2% lower than the short-term, and 11% lower than 4 years ago.

Recruit abundance at the Top 15 sites has declined by 62% in the long-term, 45% in the short-term and 23% in the last 4 years. Pre-recruit abundance has declined by 44% in the long-term, 45% in the short-term and has increased by 34% in the last 4 years.

Table 2: Performance measures used in the assessment of the Eastern Zone abalone fishery.

Measure	2022/23	Long term (since 2003/04)	Short term (since 2009/10)	Last 4 years (since 2019/20)
CPUE (kg/h)	106.4	98.9 (↑8%)	108.6 (↓2%)	119.4 (↓11%)
Recruit abundance (Top 15 n/transect)	6.7	17.7 (↓62%)	12.2 (↓45%)	8.6 (↓23%)
Mean daily catch (kg/day)	388.9	426.5 (↓9%)	433.3 (↓10%)	445.7 (↓13%)
Pre-recruit abundance (Top 15 n/transect)	8.1	14.6 (↓44%)	14.7 (↓45%)	6.1 (↑34%)
Catch (t)	330.5	480.7 (↓31%)	460.4 (↓28%)	352.5 (↓6%)
2022/23 TACC (t)	350.5			
2022/23 catch (%TACC)	94.3%			

3.2 Spatial management unit (SMU) blacklip assessment

3.2.1 SMU Performance Measures

Assessing SMUs on an individual basis provides a more detailed picture of spatial patterns of performance measures and distributions of effort and catch within the Zone. In 2022/23, the distribution of catches generally did not reflect the OTs established for several SMUs (Table 3). As for other recent years, the catch at Marlo (72.6 t) was well below (20%) the OT (91 t). Catches from Mallacoota West (31.9 t) were 28% below the OT. Catches in the Mallacoota Small SMU (16.4 t) were 22% below the OT (21 t). Catches were harvested within 15% of the OT at all other SMUs.

Mallacoota Large was the only SMU to show consistent declines in CPUE (standardised), with a significant long-term decline of 11%, short-term decline of 18%, and four-year decline of 14%. At all other SMUs, the long-term trends in CPUE ranged from no change at the Marlo SMU to a 23% increase at the Airport SMU. The short-term trends saw a significant increase of 17% at the Airport SMU, with all other SMUs showing non-significant declines of 1-12%. The four-year trends were in decline at all SMUs, ranging from 4% at the Airport SMU to 20% at the Mallacoota West SMU.

Table 3 also defines SMUs by their size following VFA (2018). Large SMUs are defined as those where total catches accounted for > 15% of the TACC, medium SMUs are defined as those where total catches accounted for 10-15% of the TACC, and small SMUs are defined as those where total catches accounted for <10% of the TACC.

In 2022/23, the Airport (26.7%), Marlo (20.7%) and Mallacoota Central SMUs (17.6%) were categorised as Large SMUs. Mallacoota East (10.2%) was the only medium SMU, while Mallacoota West (9.1%), Mallacoota Large (5.3%) and Mallacoota Small (4.7%) were defined as small SMUs. The following sections of the report present data and assessments of each SMU, ranked in order from the largest to the smallest contributors to catch.

Table 3: Performance measures used in the assessment of the Eastern Zone abalone fishery at the SMU scale (Zone totals repeated for reference). OTs include carry-over TACC.

Spatial Management Unit (SMU)	Catch				CPUE		
	Total Catch 2022/23		OT (t)	SMU Category	Long-term (2003/04)	Short-term (2009/10)	4 years (2019/20)
	(t)	(%) TACC					
Airport	93.6	26.7	85	Large	23	17	-4
Marlo	72.6	20.7	91	Large	0	-2	-5
Mallacoota Central	61.7	17.6	57	Large	3	-6	-16
Mallacoota East	35.8	10.2	32.5	Medium	10	-1	-8
Mallacoota West	31.9	9.1	44	Small	1	-12	-20
Mallacoota Large	18.6	5.3	20	Small	-11	-18	-14
Mallacoota Small	16.4	4.7	21	Small	14	-1	-14
Eastern Zone	330.5	94.3	350.5		8	-2	-11

Notes: Coloured shading indicates whether catch has been caught within the OT, Threshold or exceeded the Limit. Green (within OT range) indicates catch was <±15% of the OT, Yellow (within threshold range) indicates catch was ±15-30% OT, Red (exceeding limit range) indicates catch was >±30% of the OT for the 2018/19 quota year. SMU catch categories (% of zone catch): Large ≥ 15%, Medium 10-15%, Small < 10%.

3.2.2 Distribution of the catch

The distribution of catch by SMU in the Eastern Zone has been relatively stable since 2003 (Figure 7). The greatest contributions have traditionally come from the Airport and Marlo SMUs, which have both been consistently high in annual catch. Mallacoota Central and Mallacoota West were both significant contributors to total catch during the 2000s, with recent catches higher from Mallacoota Central. The Mallacoota Large and Mallacoota Small SMUs have always been the lowest contributors, with total catches variable over time.

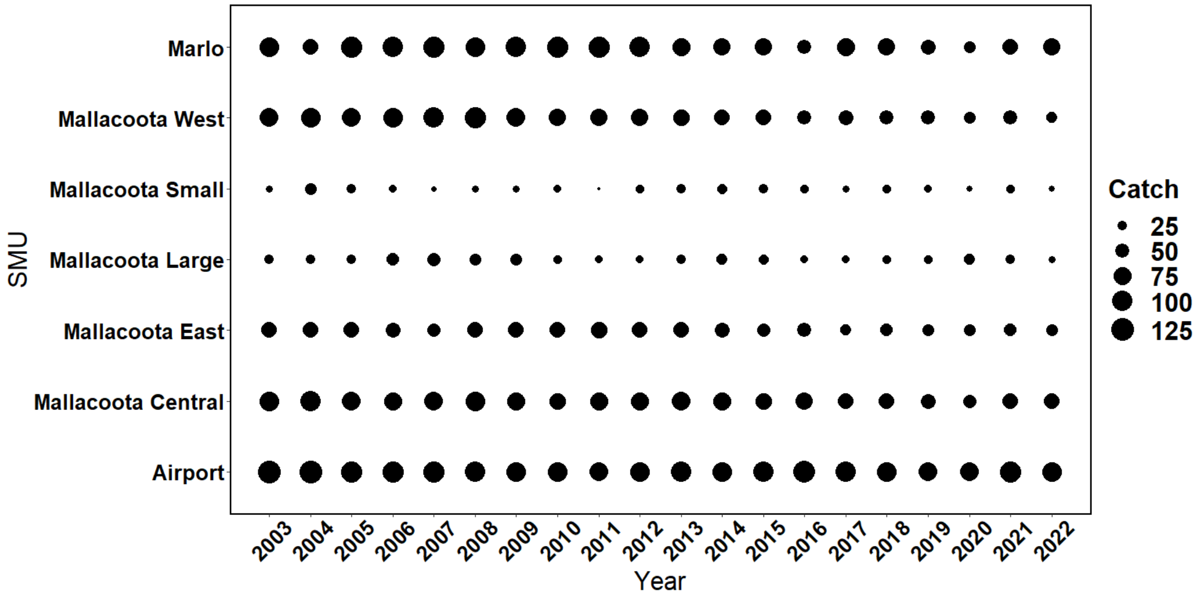

Figure 7: Relative distribution of catch at each SMU in the Eastern Zone by quota year.

3.2.3 Draft Harvest Strategy outputs

The full Draft Harvest Strategy results are published in a separate report for the Eastern Zone fishery. Tables 4 and 5 provide a summary of results to inform the TACC setting process. Current CPUE is above the Target at the Airport SMU, and between the Threshold and Target levels at all other SMUs (Table 4). CPUE has been above the Threshold level at all SMUs for at least 29 years, meaning that following the harvest strategy, an "Increasing" SMU result could allow an increase in catch up to 25%. Catch Control Rule (CCR) 1 applies for all SMUs.

Table 4: Reference points for Eastern Zone SMUs, mean annual CPUE from 2017 - 2022 and applicable catch control rules (CCR).

SMU	Limit RP	Threshold RP	Target RP	2017	2018	2019	2020	2021	2022	Current Status	Years above Threshold	CCR
Airport	50	80	110	108.7	111.7	123.9	116.0	113.7	118.6	Above Target	29	1
Mallacoota Central	50	70	110	100.7	108.3	116.8	104.3	105.7	97.6	Above Threshold	30	1
Mallacoota East	50	70	110	95.3	106.4	113.8	104.1	111.7	104.2	Above Threshold	30	1
Mallacoota Large	50	70	110	85.0	95.4	103.8	96.7	94.9	88.3	Above Threshold	31	1
Mallacoota Small	50	70	100	98.3	110.6	113.8	103.3	109.4	96.1	Above Threshold	30	1
Mallacoota West	50	70	120	107.7	112.7	124.9	112.9	111.4	97.9	Above Threshold	31	1
Marlo	50	70	130	116.4	126.8	124.3	107.0	128.1	117.1	Above Threshold	31	1

The Final Category for the Airport SMU was assessed as Stable, while all other SMUs had a Decreasing Final Category (Table 5). The Decreasing results were primarily the result of a significant change in the ratio between years (i.e. >5% decrease between years). While the 4-year gradient was negative at all SMUs, only the Mallacoota West SMU had a decreasing Primary Indicator. There were no FIS data to inform the Tertiary Indicator. The suggested total catch range for the Eastern Zone was 250.5 t to 278.8 t, which was lower than the 2023/24 TACC of 284.6 t.

Table 5: Harvest Strategy results for Eastern Zone SMUs, with suggested target catch ranges.

SMU	4yr gradient	Primary Indicator	2yr ratio (% change)	Secondary Indicator	Primary Category	Tertiary Indicator	Final Category	2023/24 Target Catch (OT, t)	Total catch, Lower (t)	Total catch, Upper (t)
Airport	-1.51	Stable	4.3	Stable	Stable	NA	Stable	85.0	80.8	89.2
Mallacoota Central	-4.90	Stable	-7.6	Decreasing	Decreasing	NA	Decreasing	46.4	39.4	44.1
Mallacoota East	-1.89	Stable	-6.7	Decreasing	Decreasing	NA	Decreasing	26.2	22.3	24.9
Mallacoota Large	-4.68	Stable	-7.0	Decreasing	Decreasing	NA	Decreasing	18.5	15.7	17.6
Mallacoota Small	-4.17	Stable	-12.2	Decreasing	Decreasing	NA	Decreasing	15.5	13.2	14.7
Mallacoota West	-6.65	Decreasing	-12.1	Decreasing	Decreasing	NA	Decreasing	21.5	18.3	20.4
Marlo	-0.05	Stable	-8.6	Decreasing	Decreasing	NA	Decreasing	71.5	60.8	67.9
Total								284.6	250.5	278.8

3.2.4 Airport SMU (Large SMU)

The Airport SMU continued to be the most important Eastern Zone SMU in terms of total catch with 93.6 t harvested in 2022/23 representing 26.7% of the TACC (Table 3) and 28.3% of the zone catch (Table 6). The total catch for 2022/23 was 10% above the Optimum Target. CPUE in 2022/23 was 23% higher than 2003/04 and 17% higher than 2009/10, with both trends statistically significant.

Table 6: Summary of Catch, Optimum Targets and Performance Indicators for the Airport SMU. The LML, median length and proportion undersize (%<LML) are also shown. Symbols for long-term and short-term indicators identify if trends were significantly increasing (+), significantly decreasing (-), not significant (black).

Catch					Long-term indicators CPUE 2003/04 – 2022/23 Abundance 2003-2023			Short-term indicators CPUE 2009/10 – 2022/23 Abundance 2009-2023		
2022/23		OT + carryover* (t)			CPUE	Pre-recruits	Recruits	CPUE	Pre-recruits	Recruits
(t)	(%)	21/22	22/23	23/24						
93.6	28.3	85.0	85.0	85.0	23	NA	NA	17	NA	NA
LML = 120 mm			Mean daily catch=377 kg			Top15 mean size=114 mm			Top15 >LML=36%	

The Airport is an important contributor to the Eastern Zone TACC, with an average catch of 93 t since 1979 and 95 t since 1988 and a peak catch of 126 t taken during 2003 when Marine Parks were first implemented (Figure 8). Since the introduction of quota, catches have been generally stable from this SMU, with a low catch of 76 t in 1998. The 2022/23 catch of 93.6 t was at the long-term average. This followed a catch of 106.6 t in 2021/22 that was the second highest catch since 2004/05, and was the fourth highest catch for the Airport SMU in the last 30 years.

Mean daily catch generally ranged from 400 to 500 kg/day from 1979 to 2019 (Figure 8). The last three years have been amongst the lowest levels of mean daily catch reported.

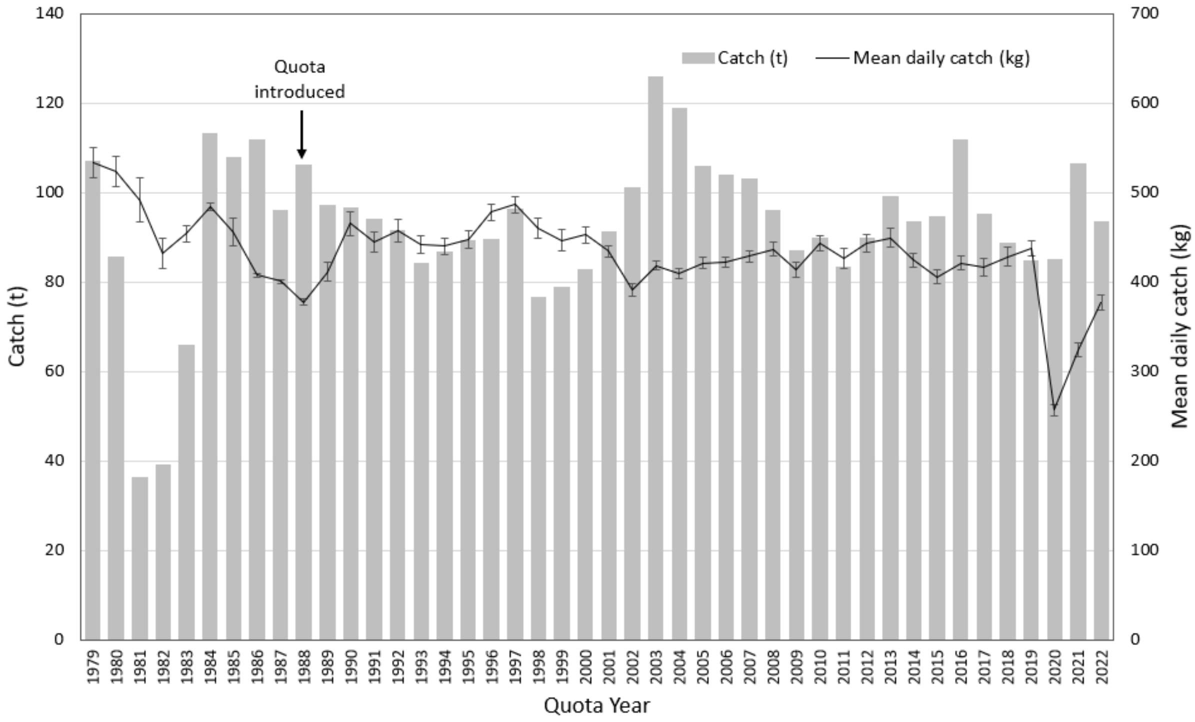

Figure 8: Total catch and mean daily catch for the Airport SMU from 1979 to 2022.

Nominal CPUE generally increased from 1992 to 2004 was generally stable from 2004 to 2018 before reaching a peak of 125 kg/hr in 2019 (Figure 9). Nominal CPUE has ranged from 114 to 123 kg/h in the last three years. Standardised CPUE has closely resembled nominal CPUE since 2003.

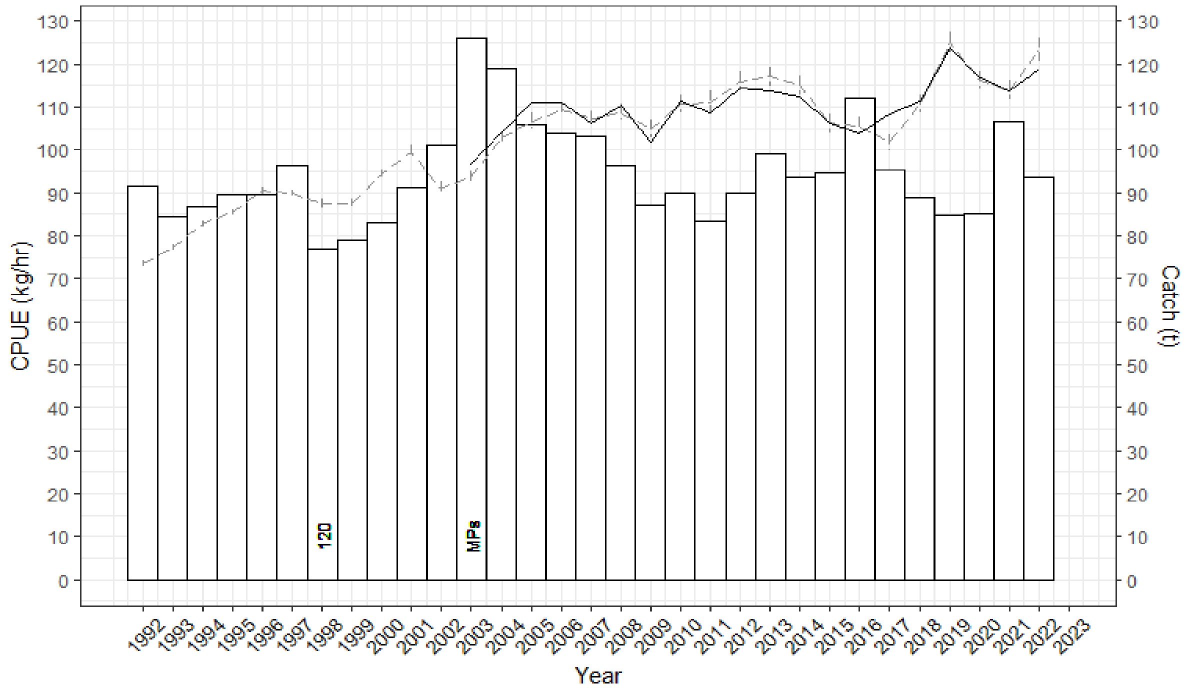

Figure 9: Airport SMU catch, and CPUE (nominal and standardised) from 1992/93 – 2022/23. Catch = bars, nominal CPUE = grey series (+/- SE), standardised series = black. Numbers in bars indicate changes to LMLs. MPs = introduction of Marine Parks.

*Table 7: Catches (kg) by reefcode for the Airport SMU from 2017/18 to 2022/23, the five-year average catch from 2017/18 to 2021/22, and the OT + carryover for 2022/23. * Note the OT is based on the OTs for 2023/24 as there were no OTs for the Airport SMU in 2022/23 and the SMU OT was the same both years (85 t).*

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23	OT*	Difference (kg)
24.21 Quarry Beach / Betka	33335	40319	38550	24373	40805	35476	43676	37000	6676
24.10 Little Rame Lee	24333	21643	25434	19142	22988	22708	18483	23000	-4517
24.16 Gabo Harbour	16947	11087	9343	18415	17235	14605	13629	13000	629
24.15 Tullaberga	11160	9173	4274	11457	13037	9820	11956	6000	5956
24.11 Shipwreck	9633	6557	7184	11797	12540	9542	5809	6000	-191

The Airport SMU comprises five reefcodes each of which have contributed substantially to the Airport SMU catch in the last six years (Table 7). There was no OT by reefcode for the Airport SMU for 2022/23, but there was in 2023/24 so this has been used as a guide here. Catches in 2022/23 were above the previous 5-year average at Quarry Beach / Betka and Tullaberga reefcodes and well below the previous 5-year average at the Shipwreck reefcode. The catch from Tullaberga Island was double the suggested OT, while the catch from Quarry Beach / Betka was 6.6 t above the OT. Catches from Little Rame Lee were below the suggested OT by 4.5 t.

FIS data were not collected during 2022. The trends from the "all sites" data series (grey dashed) are difficult to interpret because of changes in sites over time. The standardised abundance of recruit sized abalone at the two Airport SMU Top 15 sites declined substantially from 2003 to 2007 (Figure 10). Standardised abundance generally increased from 2007 to 2020 but has declined thereafter and is currently at its lowest levels.

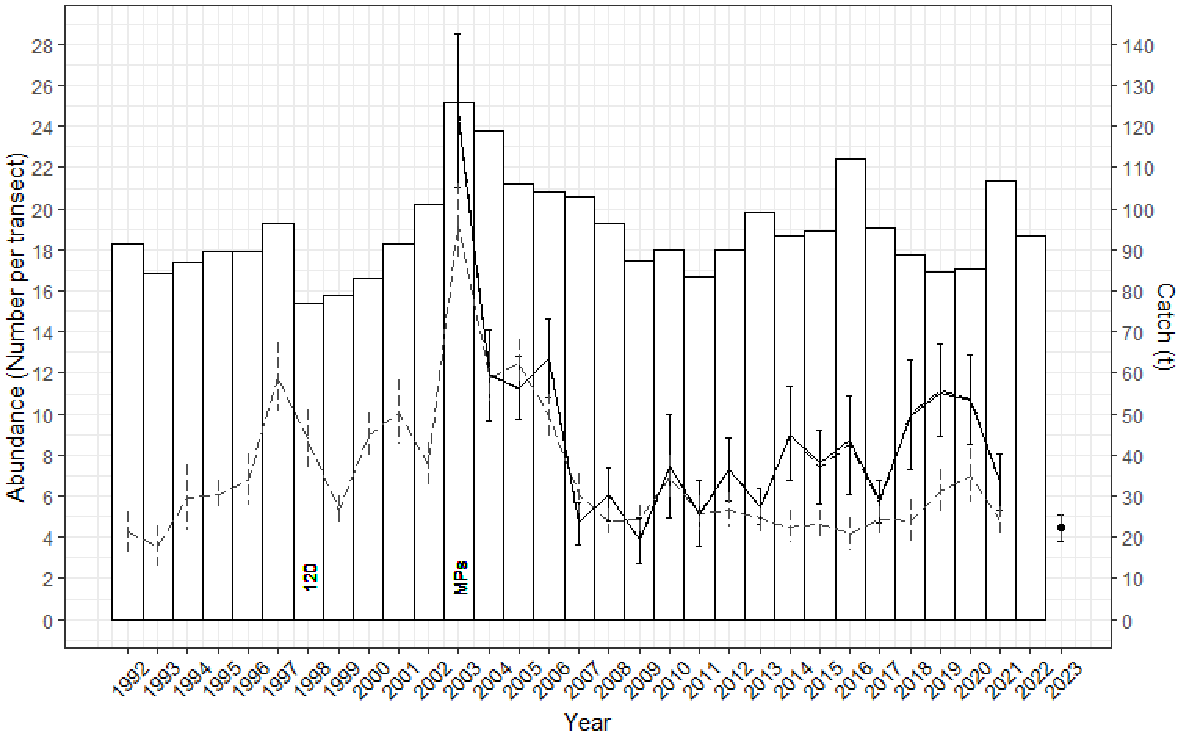

Figure 10: Recruit abundance and catch from 1992/93 – 2022/23 for the Airport SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the two Top 15 sites located within the Airport SMU.

Standardised pre-recruit abundance at the two Top 15 sites declined from 2003 to 2021 before increasing slightly in 2023 to the levels observed in 2011 and 2013 (Figure 11).

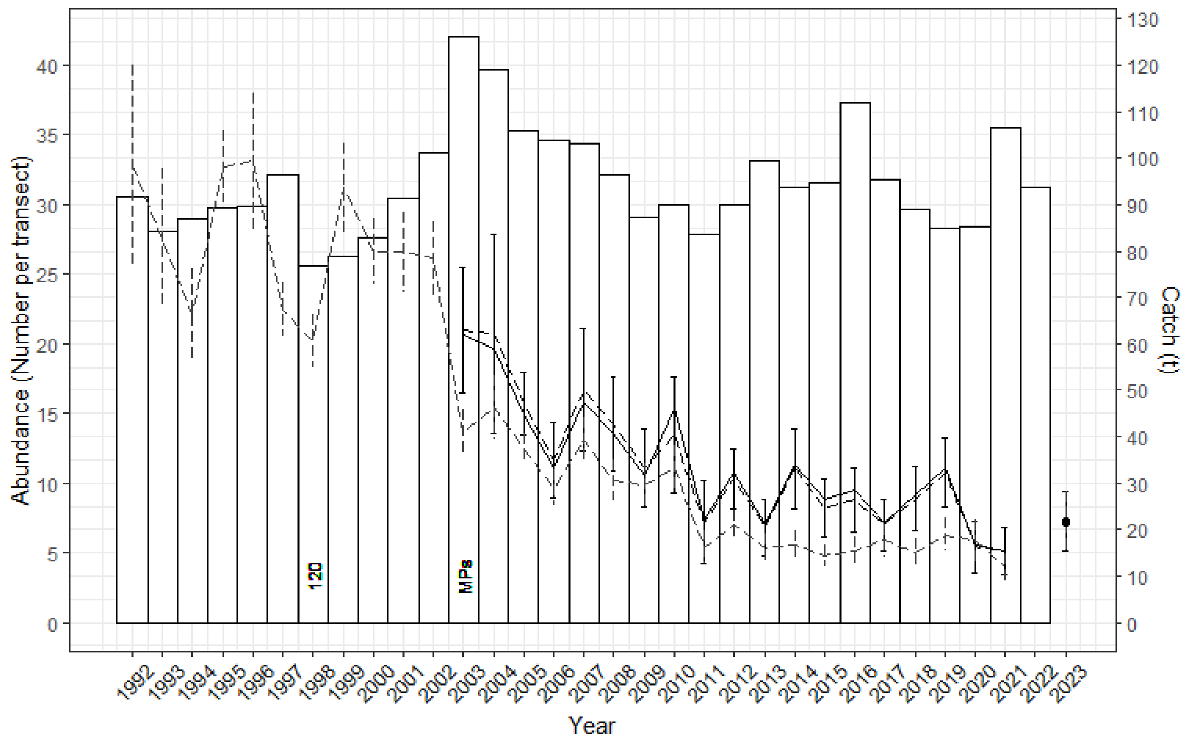

Figure 11: Pre-recruit abundance and catch from 1992/93 – 2022/23 for the Airport SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the two Top 15 sites located within the Airport SMU.

FIS length frequency data

As described in 2.1.3, length-frequency data gathered during FIS from collections at the end of each transect are biased toward the collection of larger abalone relative to the data gathered on transects within pre-recruit and recruit categories. Length frequency distributions and associated statistics are provided in Appendix 4 for (a) all sites and (b) Top 15 sites. The following summary (and for all other SMUs) is based on the “all data” time series.

As FIS abundance has declined at the Airport SMU, the size structure of the surveyed population has remained relatively stable. Modal size was 105-109 or 110-114 in most years, although this has become more variable as FIS abundance has declined. Mean size has ranged from 104 to 110 mm without clear trends. The percentage of abalone above the LML (LML) of 120 mm has ranged from 14% to 28%. This is a low proportion of the population above the 120 mm LML compared to other SMUs however it must be noted that some areas of the Airport are fished at 110 mm LML (but here we have analysed the statistics against the more conservative size limit for comparison with other SMUs).

Commercial length frequency data

Commercial length frequency distributions and associated statistics for the Airport and all other SMUs are provided in Appendix 5.

The size structure of the commercial catch at the Airport SMU has also remained relatively stable since 2010/11. Mean size has been relatively consistent, ranging from 121 – 124 mm. The modal size was 120-124 mm in all years except 2010/11 and 2018/19 where the modal size was 115-119 mm. The interpretation of these data is complicated by a mixture of size limits applicable in this SMU (110 and 120 mm). Samples sizes were above 1000 shells measured in all years except 2015/16 (251 measured). There were no data available from 2019/20.

Summary

The Airport SMU has maintained high catches since 1984 and remains the highest producing SMU in the Eastern Zone. The 2022/23 catch (93.6 t) remains at the historic average (93 t). The catch was above the initial OT agreed to, however additional OT was allocated during the season by VFA at the request of industry to reduce pressure on other reefs. Catches in 2022/23 were above the previous 5-year average at Quarry Beach / Betka and Tullaberga reefcodes and well below the previous 5-year average at the Shipwreck reefcode. OTs were only implemented recently, however the catch from Tullaberga Island was double the suggested OT and has been around those levels in all recent years. The catch from Quarry Beach / Betka was 6.6 t above the OT, while catches from Little Rame Lee were below the suggested OT by 4.5 t. Mean daily catch in the last three years has been at its lowest historical levels. Although daily catches have been lower than average, a high CPUE has been maintained in recent years.

FIS data were not collected in 2022 and only two sites were surveyed in 2023 as part of the Top 15. Recruit abundance from all sites peaked in the early 2000s, while pre-recruit abundance was high in the early 1990s and has declined over time. While both measures are currently low relative to historic levels, both measures were relatively stable between 2011 and 2021. At the two Top 15 sites, recruit and pre-recruit abundance in 2022/23 were low in an historic context.

Size frequency data from FIS and commercial catch sampling indicate stability in the size structure of the population.

Harvest Strategy outcomes in 2023 were driven only by trends in the last four years of commercial CPUE. For the Airport SMU, mean CPUE was above the Target level in the Draft Harvest Strategy and has been above the Threshold level for 29 consecutive years (Table 4). The Primary Indicator (4-year gradient) was Stable and the Secondary Indicator (ratio between years) was Stable, which gave a Stable Primary Category (Table 5). The Tertiary Indicator was not available, resulting in a Stable Final Category for the Airport SMU. The OT for 2023/24 was 85 t, and the results of the Harvest Strategy suggested an OT ranging from 80.8 to 89.2 t.

While catches were maintained at the OT of 85 t in 2019/20 and 2020/21, the cumulative catch in the last two years has been 30 t above the suggested OTs. The catch of 106.6 t in 2021/22 was the fourth highest recorded catch from this SMU in the last three decades. While CPUE has been maintained, it is notable that mean daily catch in the last two years have been the lowest observed since 1979, ignoring 2019/20 that was impacted severely by Covid-19 impacts on the abalone market. The longer-term consequences on the performance of the Airport SMU are unknown.

While CPUE indicators have been maintained within the Stable bounds of the Draft Harvest Strategy, mean daily catch and FIS abundance have declined in recent years similar to other SMUs. While catches at other SMUs have been reduced, the Airport SMU catch in the last two years has exceeded the combined baseline OTs by 30 t. Continuing to maintain high catches at the Airport SMU will highly likely result in declining indicators in the short to medium term. Strong consideration should be given to reducing the OT and not exceeding it to reduce the likelihood of biomass decline and maintain performance measures for the Airport SMU.

3.2.5 Marlo (Large SMU)

The Marlo SMU was second highest contributor to the Eastern Zone total catch with 72.6 t harvested in 2022/23 representing 20.7% of the TACC (Table 3) and 22.0% of the zone catch (Table 8). The catch was 20% below the Optimal Target + carryover of 91.0 t. CPUE is the same as it was in 2003/04, and is 2% lower than 2009/10.

Table 8: Summary of Catch, Optimum Targets and Performance Indicators for the Marlo SMU. The LML, median length and proportion undersize (%<LML) are also shown. Symbols for long-term and short-term indicators identify if trends were significantly increasing (+), significantly decreasing (-), not significant (black).

Catch					Long-term indicators CPUE 2003/04 – 2022/23 Abundance 2003-2023			Short-term indicators CPUE 2009/10 – 2022/23 Abundance 2009-2023		
2022/23		OT + carryover* (t)			CPUE	Pre-recruits	Recruits	CPUE	Pre-recruits	Recruits
(t)	(%)	21/22	22/23	23/24						
72.6	22.0	82.7*	91.0*	71.5	0	NA	NA	-2	NA	NA
LML = 125 mm		Mean daily catch=425 kg				Top15 mean size=116 mm			Top15 >LML=39%	

The Marlo SMU has been a historically important contributor to the Eastern Zone TACC, with an average catch of 69 t since 1979 and 67 t since 1988 (Figure 12). Since the introduction of quota, catches increased from 1990 to 2005 and from 2005 to 2012 catches averaged 102 t per year, with a peak catch of 109 t taken during 2011. Catch declined steadily thereafter, reaching 47 t in 2016. Following a decrease in LML in 2017, catches returned to around 70 t in 2017 and 2018 before reducing again in 2019. The 2020/21 catch of 36 t was the lowest recorded, with catch increasing to 58.7 t in 2021/22 and 72.6 t in 2022/23.

Mean daily catch ranged from 417 to 499 kg/day between 1990 and 2019 before dropping to 269 kg/day in 2020 and recovering to 425 kg/day in 2022.

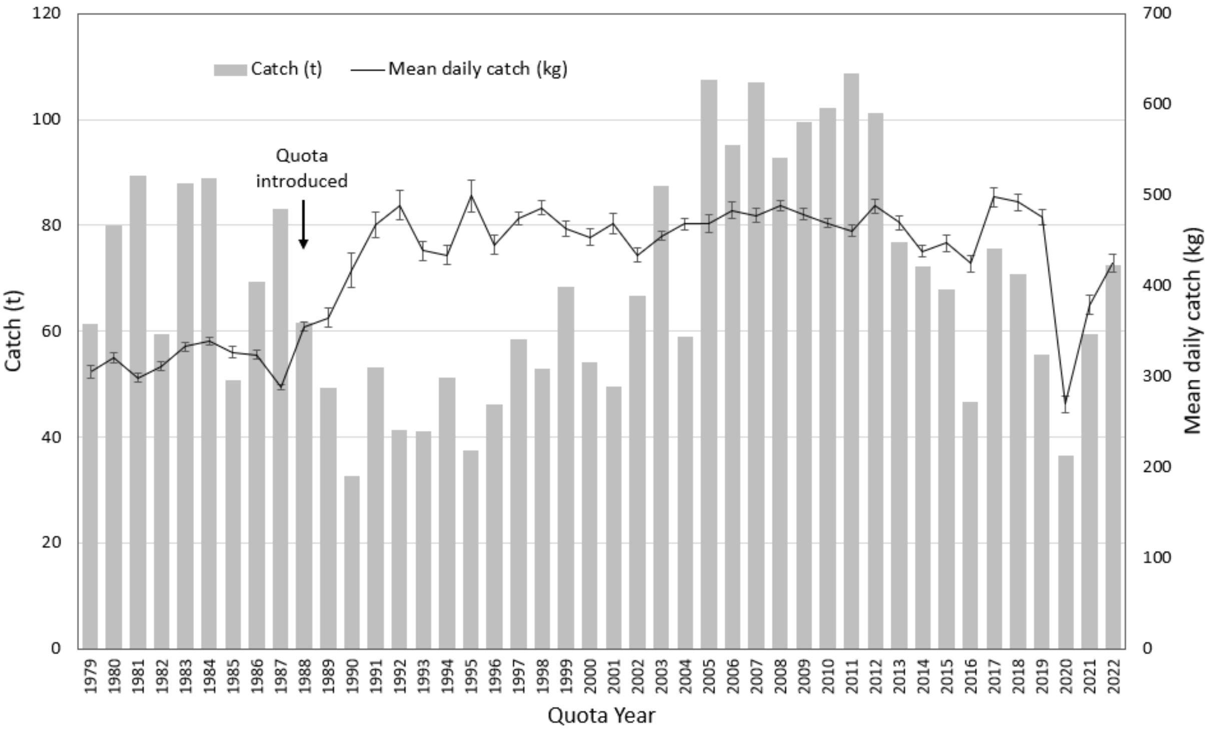

Figure 12: Total catch and mean daily catch for the Marlo SMU from 1979 to 2022.

Nominal CPUE generally increased from 1992 to 2011, reaching a peak of 131 kg/hr before declining to 100 kg/h in 2016 (Figure 13). Nominal CPUE has fluctuated thereafter ranging from 109 to 129 kg/h. Standardised CPUE has generally followed the nominal trends.

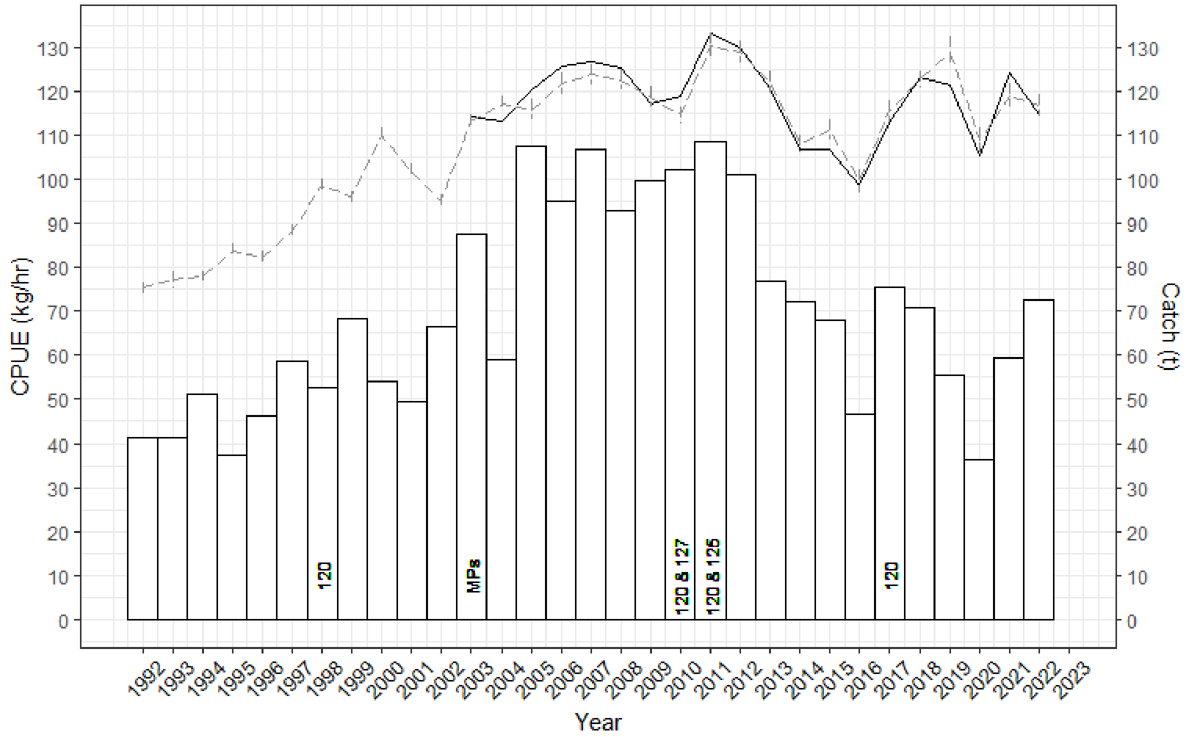

Figure 13: Marlo SMU catch, and CPUE (nominal and standardised) from 1992/93 – 2022/23. Catch = bars, nominal CPUE = grey series (+/- SE), standardised series = black. Numbers in bars indicate changes to LMLs. MPs = introduction of Marine Parks.

Table 9: Catches by reefcode for the Marlo SMU from 2017/18 to 2022/23, the five-year average catch from 2017/18 to 2021/22, and the OT + carryover for 2022/23.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23	OT+carryover	Difference (kg)
22.05 East Cape	14710	13794	11033	11845	13877	13052	23516	22000	1516
22.08 Pearl Point	25150	15580	13072	8453	21288	16709	16607	23200	-6593
22.04 Cape Conran	20017	20501	14859	9312	15116	15961	14906	17500	-2594
22.03 Point Ricardo	4772	5700	5889	1877	3402	4328	6836	7300	-464
22.06 Yeerung Reef	4578	8032	7475	3578	4129	5558	5351	11500	-6149
22.02 Frenches	6400	7285	3329	1316	1687	4004	4761	9500	-4739
22.10 Clinton Rocks	0	0	0	0	0	0	352	0	352
22.09 Tamboon	0	0	0	0	0	0	113	0	113
23.01 Point Hicks	0	0	0	49	0	10	110	0	110
22.01 Marlo	0	0	0	0	0	0	0	0	0

The Marlo SMU comprises ten reefcodes however only six reefcodes contribute meaningful annual catches (Table 9). The Marlo SMU catch was well below the OT +carryover, and this was reflected at the reefcode level with catches below the OT + carryover at all reefcodes except East Cape. The largest differences occurred at Pearl Point, Yeerung Reef and Frenches reefcodes. The catch at East Cape reefcode was 10 t higher than the previous five-year average catch.

FIS data were not collected during 2022. The trends from the “all sites” data series (grey dashed) are difficult to interpret because of changes in sites over time. Standardised abundance from the four Top 15 sites declined substantially from 2003 to 2006 and have been generally stable thereafter.

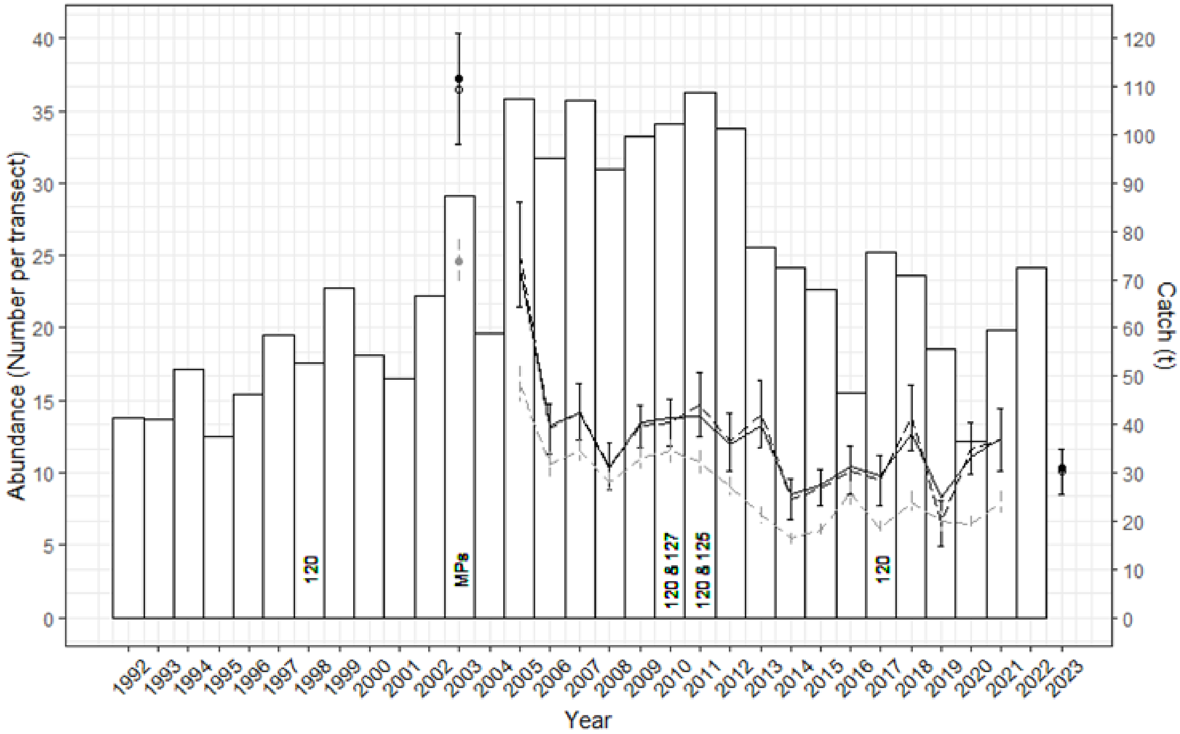

Figure 14: Recruit abundance and catch from 1992/93 – 2022/23 for the Marlo SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the four Top 15 sites located within the Marlo SMU.

The standardised abundance of pre-recruits at the four Top 15 sites has been highly variable since 2003. The standardised abundance in 2023 was around 15 abalone per transect, which was above the long-term average of 12 abalone per transect.

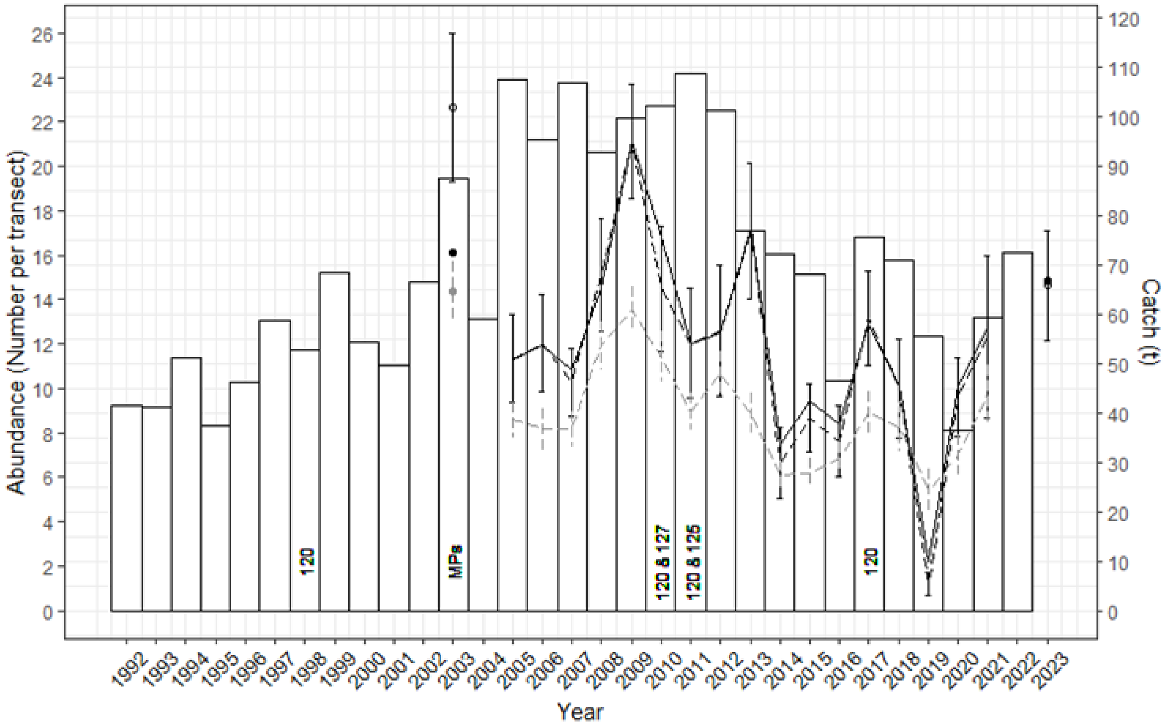

Figure 15: Pre-recruit abundance and catch from 1992/93 – 2022/23 for the Marlo SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the four Top 15 sites located within the Marlo SMU.

FIS length frequency data

From 2005 to 2007, the Marlo SMU surveyed population contained a high proportion of large abalone, with mean size ranging from 120 to 122 mm, modal size of 125-129 mm and a proportion above the LML of 61 to 64% (Appendix 4). While densities remained high until 2012, mean size declined (115 to 119 mm) and the proportion above the LML also decreased (range 50 to 55%). Since 2013 total abundance has declined, mean size has ranged from 115 to 119 mm, modal size has been 120-124 mm or below in all years and the proportion above the LML has ranged from 45 to 57%. While there appeared to be a relatively high proportion of abalone <70 mm in 2019, this did not appear to result in a distinct cohort in 2020 reflective of a strong recruitment pulse nor was there a substantial increase in pre-recruit abundance.

Commercial length frequency data

In 2010/11 and 2011/12, the size structure of the commercial catch primarily comprised abalone in the 125-129 mm and 130-134 mm size classes, well above the size limit of 120 mm (Appendix 5). However, in 2017/18 and 2018/19, a much higher proportion of abalone sampled were in the 120-124 mm size class, immediately above the LML, resulting in a decline in the mean size to 131 and 129 mm, respectively. It is not clear whether these trends were affected by changes in size limits in recent years, or whether this pattern reflects more knife-edge selection. It should be noted that the sample sizes were smaller from these years and higher numbers of shells sampled would increase the certainty in this measure in the future. No data are available from 2018/19.

Summary

The Marlo SMU is an important contributor to the Eastern Zone TACC. The 2022/23 catch of 76.3 t was well below the OT but was similar to catches from 2013/14 to 2018/19. This followed two years of very low catch where anecdotal evidence suggested that conditions for diving were unsuitable for most of the year. At the reefcode level, catches were below the OT + carryover at all reefcodes except East Cape, where the catch (23.5 t) was 10 t higher than the previous five-year average (13.0 t). The largest differences between catch and OT occurred at Pearl Point, Yeerung Reef and Frenches reefcodes. The mean daily catch in the last two years was just below the levels harvested from 1991 to 2019. CPUE has fluctuated without trend in recent years.

Surveys were first implemented in the Marlo SMU in 2003 and were not done in 2022, with four Top 15 sites surveyed in 2023. The abundance of recruits has not varied significantly, and from 2013 to 2021 abundances ranged (without trend) from 5.5 to 8.5 abalone per transect. Pre-recruit abundance has fluctuated without any clear trends since 2003. At the Top 15 sites, recruit abundance was similar to recent years and on a positive note, pre-recruit abundance was the highest observed since 2013.

Size structure from all FIS sites suggested that the mean and modal size of the population, as well as the proportion of abalone above the size limit, has declined since 2010/11. Similarly, commercial catch sampling data up to 2018/19 suggest that the mean size of the catch had also declined to that time, however this was likely affected by changes in LML. Due to uncertainties in both sources information, little weight should be given to the trends from either dataset in this assessment.

Mean CPUE was above the Threshold level in the Draft Harvest Strategy and has been above the Threshold level for 31 consecutive years (Table 4). The Primary Indicator (4-year gradient) was Stable and the Secondary Indicator (ratio between years) was Decreasing, which gave a Decreasing Primary Category. The Tertiary Indicator was not available (Table 5). The base OT (i.e. without carryover) for 2023/24 was 71.5 t. The Decreasing result of the Harvest Strategy suggests that the OT should be reduced, with a range of 60.8 to 67.9 t.

Catches from the Marlo SMU were very low in the two years prior to 2022/23, where catches returned to recent levels. On this basis, logic would suggest that the stocks have been at a reduced fishing mortality rate in recent years relative to what may be considered sustainable levels. The main data source that provides some caution is the lower-than-average mean daily catch in the last two years, however this may be explained in part by the poor diving conditions. Also, it is not clear why catches at most reefcodes were well below OT levels, and it is also not clear whether the very large catch from East Cape (i.e. 10 t over previous 5-year average) is sustainable.

Given the low recent catches relative to OTs and uncertainty regarding diving conditions at Marlo during 2022/23, it is difficult to assess the status of eth Marlo SMU. The Draft Harvest Strategy suggests a reduction in catch is required, though diver observations will be critical in determining the OT for 2024/25.

3.2.6 Mallacoota Central (Large SMU)

The Mallacoota Central SMU was the third highest SMU in terms of total catch with 61.7 t harvested in 2022/23 representing 17.6% of the TACC (Table 3) and 18.7% of the zone catch (Table 10). The 2022/23 catch was just above the Optimum Target of 57.0 t. CPUE in 2022/23 was 3% higher than in 2003/04 and 6% lower than 2009/10.

Table 10: Summary of Catch, Optimum Targets and Performance Indicators for the Mallacoota Central SMU. The LML, median length and proportion undersize (%<LML) are also shown. Symbols for long-term and short-term indicators identify if trends were significantly increasing (+), significantly decreasing (-), not significant (black).

Catch					Long-term indicators CPUE 2003/04 – 2022/23 Abundance 2003-2023			Short-term indicators CPUE 2009/10 – 2022/23 Abundance 2009-2023		
2022/23		OT + carryover* (t)			CPUE	Pre-recruits	Recruits	CPUE	Pre-recruits	Recruits
(t)	(%)	21/22	22/23	23/24						
61.7	18.7	58.7*	57.0	46.4	3	NA	NA	-6	NA	NA
LML = 125 mm			Mean daily catch=381 kg			Top15 mean size=124 mm			Top15 >LML=56%	

The Mallacoota Central SMU is an important contributor to the Eastern Zone TACC with an average catch of 81 t since 1979 and 79 t since 1988, and a peak catch of 104 t taken during 1985 (Figure 16). Catches generally ranged from 60 to 100 t per year from 1979 to 2016 before declining to 44 to 59 t between 2017 and 2021, despite size limit reductions in 2015 and 2017.

Since the introduction of quota mean daily catch has ranged from 267 to 473 kg/day with an average of 417 kg/day. Mean daily catch has been below 400 kg/day for the last three years.

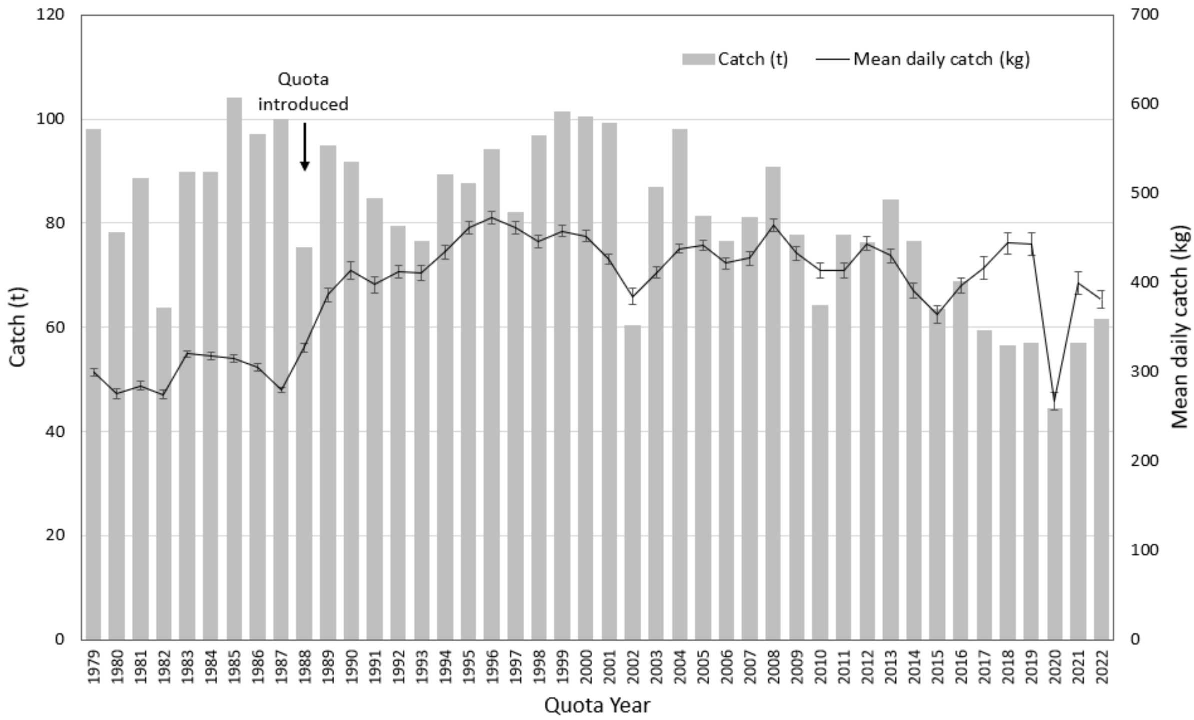

Figure 16: Total catch and mean daily catch for the Mallacoota Central SMU from 1979 to 2022.

Nominal CPUE generally increased from 1992 to reach a peak of 119 kg/hr in 2012 before declining to 90 kg/h in 2016 (Figure 17). Nominal CPUE ranged from 98 to 107 kg/h thereafter. Standardised CPUE has generally followed the nominal trends.

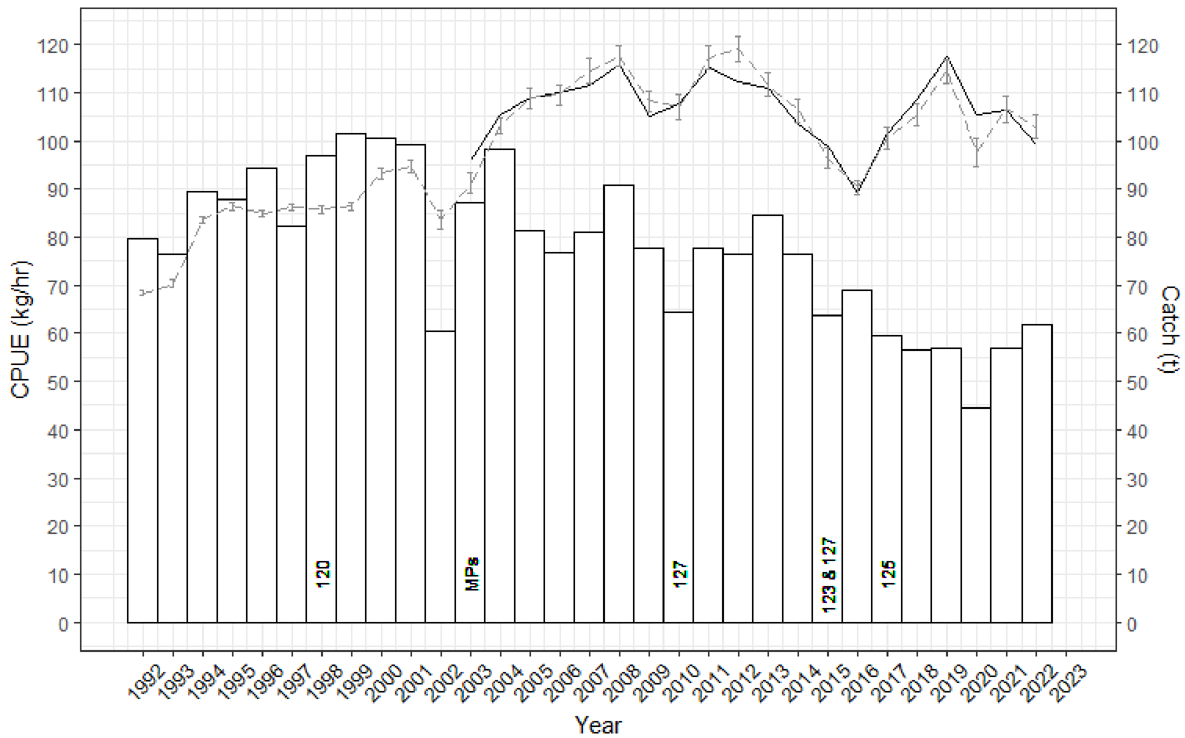

Figure 17: Mallacoota Central SMU catch, and CPUE (nominal and standardised) from 1992/93 – 2022/23. Catch = bars, nominal CPUE = grey series (+/- SE), standardised series = black. Numbers in bars indicate changes to LMLs. MPs = introduction of Marine Parks.

Table 11: Catches by reefcode for the Mallacoota Central SMU from 2017/18 to 2022/23, the five-year average catch from 2017/18 to 2021/22, and the OT + carryover for 2022/23.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23	OT+carryover	Difference (kg)
24.07 Sandpatch Lee	34312	32420	31395	25025	25403	29711	28375	30000	-1625
24.06 Sandpatch Point	19819	16809	15844	10524	20367	16673	22806	18000	4806
24.08 Benedore	4500	6508	8453	8283	10327	7614	9486	7000	2486
24.04 Red River	749	837	1325	616	912	888	1074	2000	-926
24.05 Secret Reef	0	0	0	0	0	0	0	0	0

The Mallacoota Central SMU comprises five reefcodes however only three reefcodes contribute substantially to the annual catch (Table 11). Considering the 5-year average catches, Sandpatch Lee produces the highest catch, with Sandpatch Point around half of that catch and Benedore half of that catch again. In 2022/23, catches were above the OT at Sandpatch Point (4.8 t) and Benedore (2.5 t). The catch at Red River was above the 5-year average yet it was only around half of the OT.

FIS data were not collected during 2022. The trends from the "all sites" data series (grey dashed) are difficult to interpret because of changes in sites over time. The standardised abundance of recruits at the three Top 15 sites has been highly variable since 2003 displaying a general decline (Figure 18). The standardised abundance in 2023 was the lowest recorded.

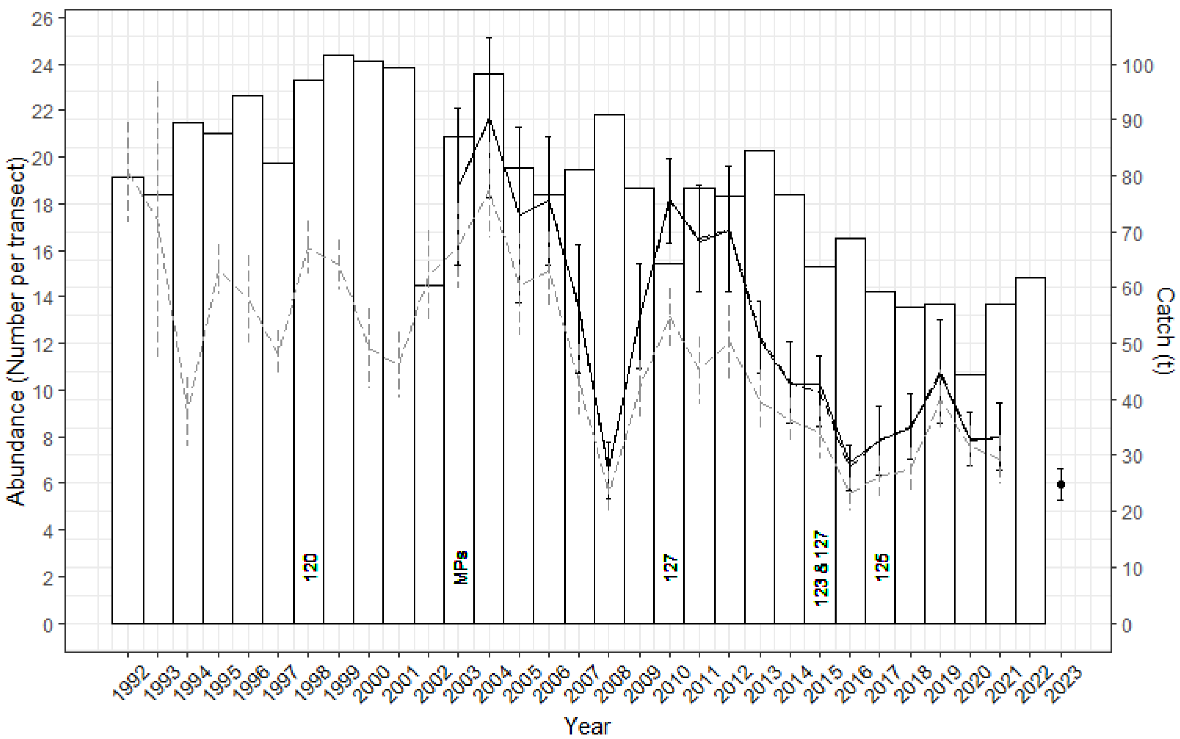

Figure 18: Recruit abundance and catch from 1992/93 – 2022/23 for the Mallacoota Central SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the three Top 15 sites located within the Mallacoota Central SMU.

Standardised pre-recruit abundance at the three Top 15 sites generally declined from 2003 to 2011 and has remained relatively stable thereafter (Figure 19).

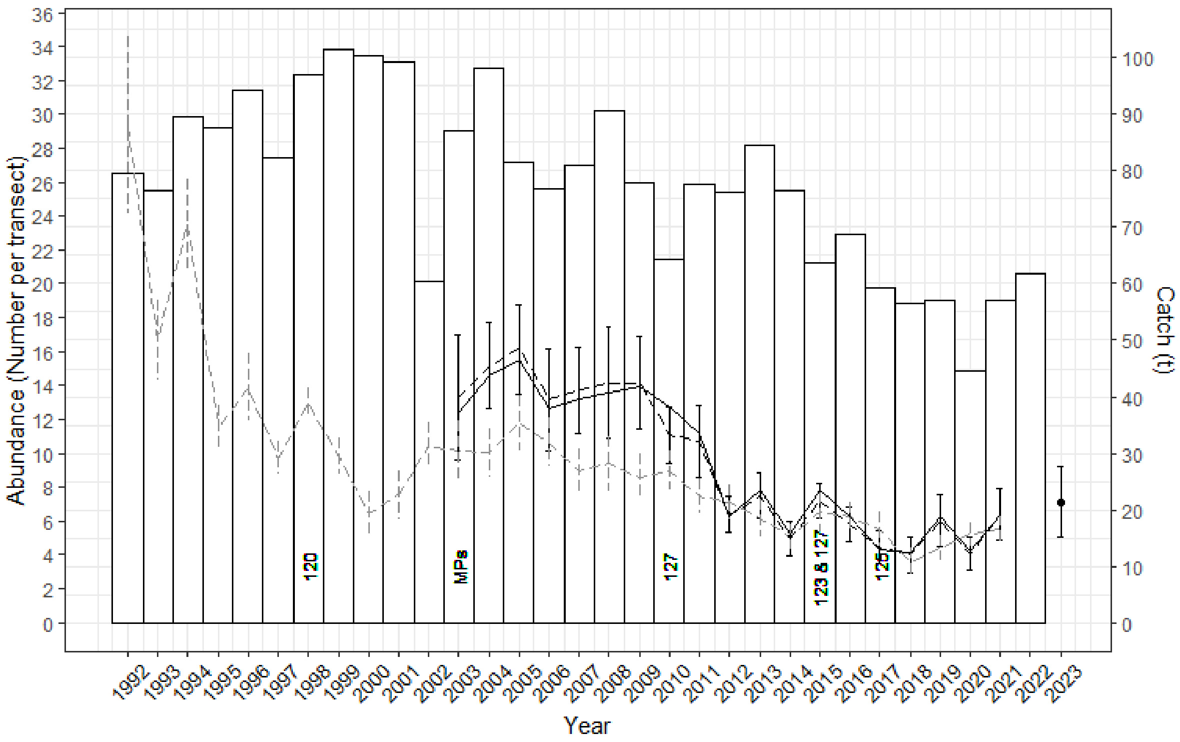

Figure 19: Pre-recruit abundance and catch from 1992/93 – 2022/23 for the Mallacoota Central SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the three Top 15 sites located within the Mallacoota Central SMU.

FIS length frequency data

The size structure of the population at Mallacoota Central has been variable since 2003 (Appendix 4). From 2003 to 2010 the mean size was generally stable from 117 to 118 mm, with the proportion above the LML being 37 to 40%. From 2011 to 2014, mean size increased to 120 to 123 mm and the proportion above LML ranged from 43 to 55%, before declining rapidly to 114 mm and 32% above LML in 2016. In the last five years the mean size (range 119 to 124 mm) and the proportion above LML (range 48 to 59%) have been variable.

Commercial length frequency data

From 2010/11 to 2016/17 a strong modal size class of 130-134 mm was present in the sampled commercial catch in all years (Appendix 5). From 2010/11 to 2013/14, the proportion of abalone just above the size limit (i.e. 125-129 mm size class) was generally around half of the modal size class. However, in 2016/17 22% of the catch was in the 125-129 mm size class compared to 28% in the 130-134 mm size class, and in 2018/19 the proportions in the sampled catch were equal (both 25%). It is unclear how reductions in size limits in 2014/15 and 2016/17 have affected these samples. No data are available from 2019/20. Higher numbers of shells sampled would increase the certainty in this measure in future years.

Summary

The Mallacoota Central SMU has contributed an average of 79 t to the Eastern Zone TACC since the introduction of quota. Following a peak catch of 102 t taken during 1999, catches have generally declined thereafter. Catches in the last 6 years have been among the lowest observed in the last three decades despite size limit reductions in 2015 and 2017. Three of the five reefcodes in the

Mallacoota Central SMU produce most of the SMU catch. In 2022/23, catches were above the OT at Sandpatch Point (4.8 t) and Benedore (2.5 t). Mean daily catch has been below 400 kg/day for the last two years. CPUE remains high in an historic context, however it has declined for the last three years.

FIS data were not collected in 2022, with two Top 15 sites surveyed in 2023. Recruit and pre-recruit abundances from all sites declined substantially from 2003 to 2021. Recruit abundance from the two Top 15 sites was the lowest observed in 2023, while pre-recruit abundance increased slightly at these sites.

Despite declines in abundance, the length frequency distributions from FIS showed no clear trends over time. Commercial catch sampling data up to 2018/19 suggested that a higher proportion of abalone were being harvested close to the LML, however this may have been affected by reductions in size limit.

For the Mallacoota Central SMU, mean CPUE was above the Threshold level in the Draft Harvest Strategy, and it has been above the Threshold level for 30 consecutive years (Table 4). The Primary Indicator (4-year gradient) was Stable (but very close to Decreasing) and the Secondary Indicator (ratio between years) was Decreasing, which gave a Decreasing Primary Category (Table 5). The Tertiary Indicator was not available, resulting in a Decreasing Final Category for the SMU. The OT for 2023/24 was 46.4 t, and the results of the Harvest Strategy suggest reducing this OT to a range of 39.4 to 44.1 t.

While CPUE has declined for the last three years, it remains high in an historic context. Mean daily catch in the last two years has been slightly down on historic levels but remains close to 400 kg/day. While abundance at FIS sites has declined substantially from an historic perspective, recruit and pre-recruit abundance appear to have stabilized in recent years. Higher-than-average catches have been harvested from Sandpatch Point in the last two years. It is noted that the OT was reduced by around 10 t for 2023/24, however there are no data to assess how the stock has responded. **Given the uncertainties in the current assessment and the high catches in recent years at Sandpatch Point, further reductions in OT as suggested by the Draft Harvest Strategy should be considered. Diver observations will be critical in determining the OT for 2024/25.**

3.2.7 Mallacoota East (Medium SMU)

The Mallacoota East SMU contributed 35.8 t in 2022/23 representing 10.2% of the TACC (Table 3) and 10.8% of the zone catch (Table 12). The 2022/23 catch was just over the Optimum Target of 32.5 t. CPUE in 2022/23 was 10% higher than in 2003/04 and 1% lower than 2009/10.

Table 12: Summary of Catch, Optimum Targets and Performance Indicators for the Mallacoota East SMU. The LML, median length and proportion undersize (%<LML) are also shown. Symbols for long-term and short-term indicators identify if trends were significantly increasing (+), significantly decreasing (-), not significant (black).

Catch					Long-term indicators CPUE 2003/04 – 2022/23 Abundance 2003-2023			Short-term indicators CPUE 2009/10 – 2022/23 Abundance 2009-2023		
2022/23		OT + carryover* (t)			CPUE	Pre-recruits	Recruits	CPUE	Pre-recruits	Recruits
(t)	(%)	21/22	22/23	23/24						
35.8	10.8	34.4*	32.5	26.2	10	NA	NA	-1	NA	NA
LML = 120 mm			Mean daily catch=380 kg			Top15 mean size=127 mm			Top15 >LML=65%	

The Mallacoota East SMU has contributed an average catch of 60 t since 1979 and 57 t since 1988 (Figure 20). The peak catch of 83 t was taken the year before quota was introduced. From 2003 to 2014 catches were relatively stable averaging 56 t (range 42-63 t), however in the last eight years catches have declined averaging only 38 t (range 32-47 t).

Since the introduction of quota, mean daily catch has ranged from 258 to 504 kg/day with an average of 407 kg/day. Mean daily catch in the last two years has been similar to those from 2014 to 2019.

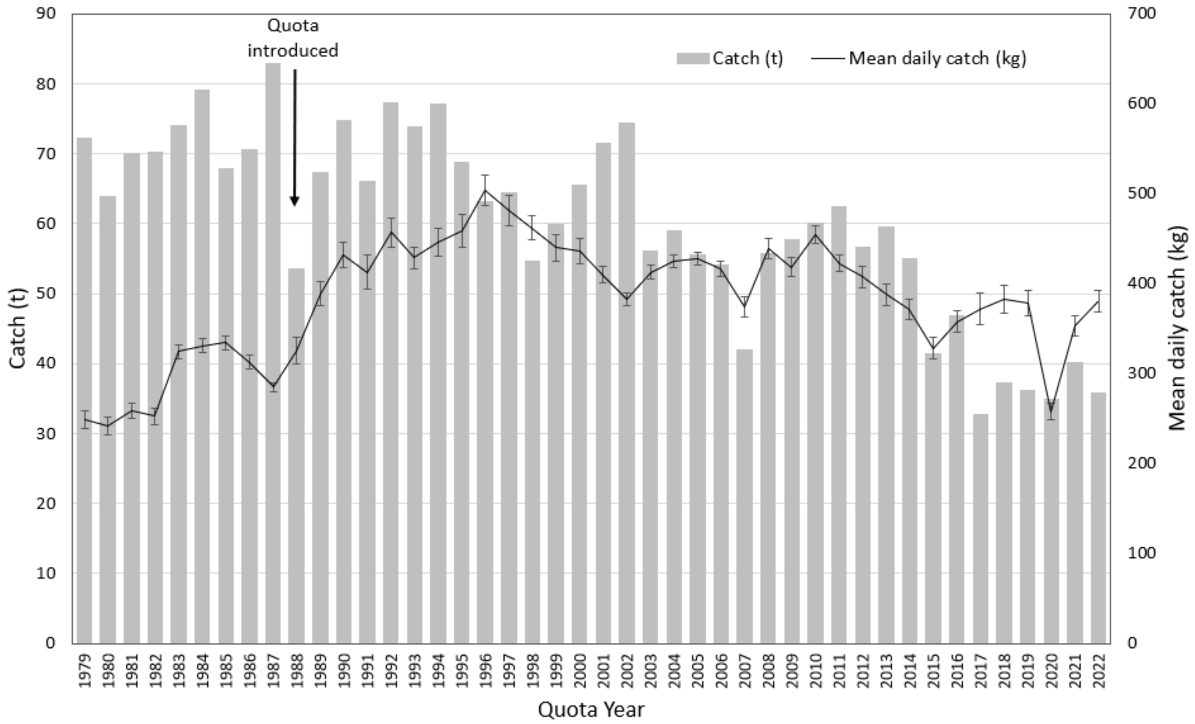

Figure 20: Total catch and mean daily catch for the Mallacoota East SMU from 1979 to 2022.

Nominal CPUE generally increased from 1992 to 2010, reaching a peak of 122 kg/hr before declining to 88 kg/h in 2016 (Figure 21). Nominal CPUE increased to 106 kg/h in 2018 and has been stable thereafter. Standardised CPUE has generally followed the nominal trends.

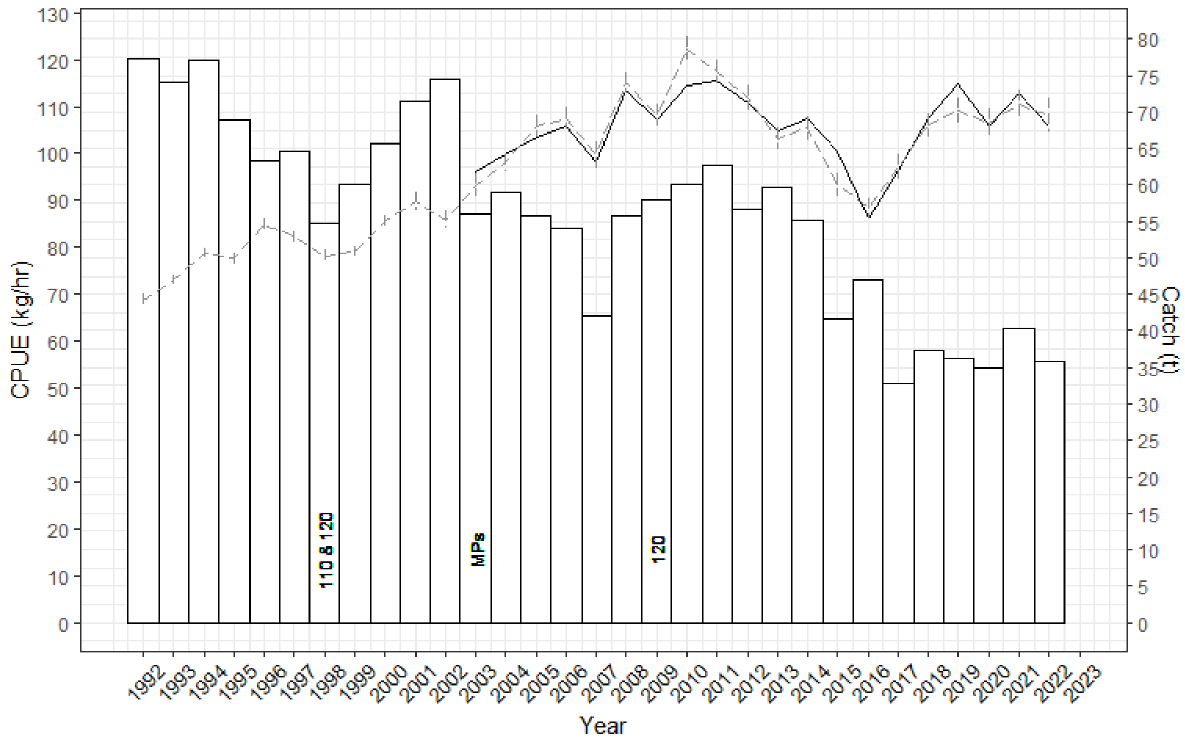

Figure 21: Mallacoota East SMU catch, and CPUE (nominal and standardised) from 1992/93 – 2022/23. Catch = bars, nominal CPUE = grey series (+/- SE), standardised series = black. Numbers in bars indicate changes to LMLs. MPs = introduction of Marine Parks.

Table 13: Catches by reefcode for the Mallacoota East SMU from 2017/18 to 2022/23, the five-year average catch from 2017/18 to 2021/22, and the OT + carryover for 2022/23.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23	OT+carryover	Difference (kg)
24.17 Gabo Island	20330	23236	25897	26047	25613	24225	24891	19000	5891
24.19 Iron Prince	9276	11460	8312	6477	11877	9481	8154	11500	-3346
24.18 Gunshot	3213	2591	2004	2438	2810	2611	2781	2000	781

The Mallacoota East SMU comprises three reefcodes, with Gabo Island the highest contributor in all recent years (Table 13). The catch at Gabo Island in 2022/23 was again well above the Optimum Target + carryover, as it has been for the last six years. The catch at Iron Prince was below the OT by 3.4 t. The catch at Gunshot was again above the OT as it has been in all previous years.

FIS data were not collected during 2022. The trends from the "all sites" data series (grey dashed) are difficult to interpret because of changes in sites over time. The standardised abundance of recruits at the two Top 15 sites declined from 2003 to 2009 and was generally stable up to 2021 (Figure 22). The abundance in 2023 was the lowest recorded.

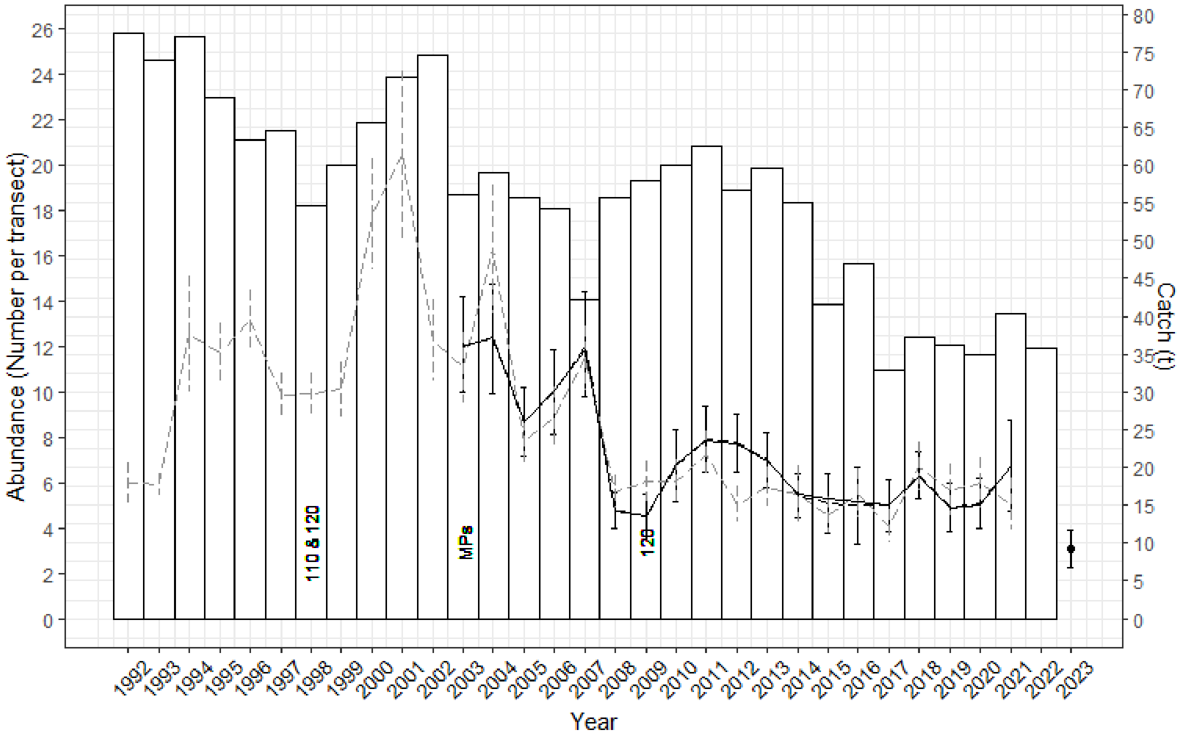

Figure 22: Recruit abundance and catch from 1992/93 – 2022/23 for the Mallacoota East SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the two Top 15 sites located within the Mallacoota East SMU.

Standardised pre-recruit abundance at the two Top 15 sites was variable from 2003 to 2013 but has declined thereafter (Figure 23). Standardised abundance in 2023 was the lowest recorded.

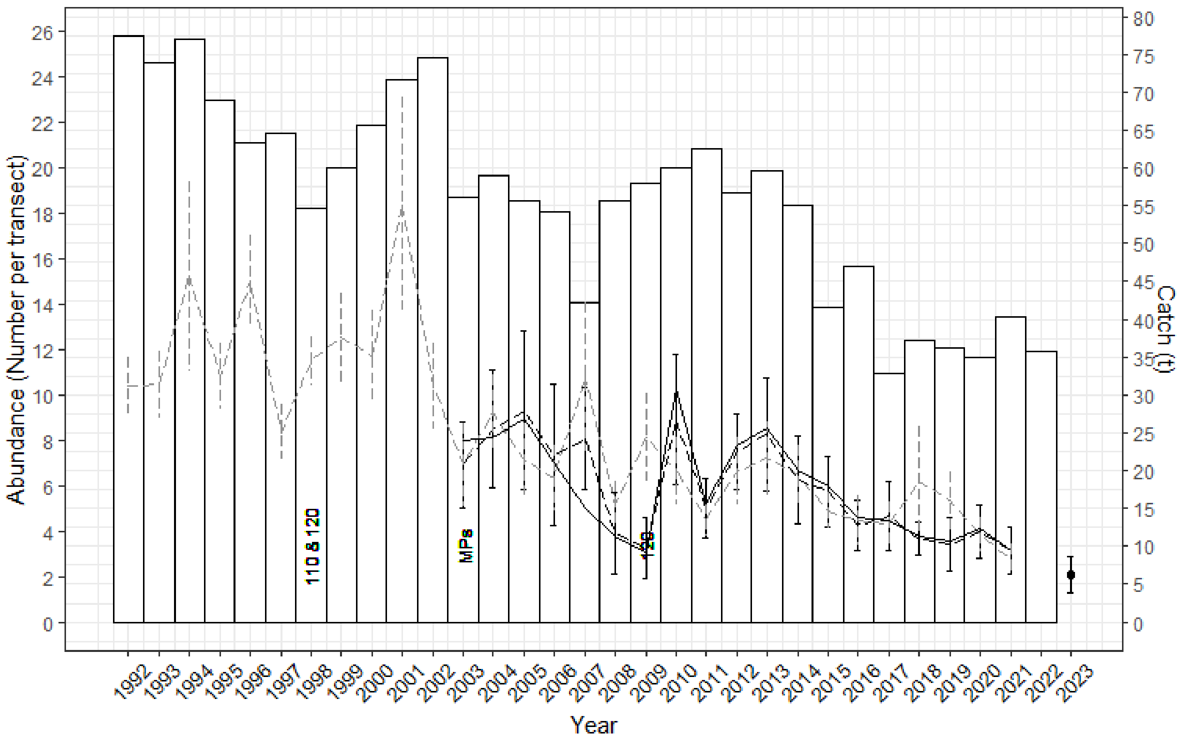

Figure 23: Pre-recruit abundance and catch from 1992/93 – 2022/23 for the Mallacoota East SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the two Top 15 sites located within the Mallacoota East SMU.

FIS length frequency data

There are few clear trends evident in the size structure of the population sampled during the FIS in the Mallacoota East SMU (Appendix 4). Mean size was variable, ranging from 113 to 124 mm and the proportion above the size limit has ranged from 35 to 66%, although notably the highest mean size and % above the size limit occurred in 2021. The modal size class has also varied considerably, from 115-119 mm to 130-134 mm.

Commercial length frequency data

While the size structure of the commercial catch was stable from 2010/11 to 2013/14, the mean and modal size has declined substantially in 2016/17 and 2018/19 with a higher proportion of abalone harvested closer to the size limit (Appendix 5). No data are available from 2018/19. Higher numbers of shells sampled would increase the certainty in this measure in future years.

Summary

The Mallacoota East SMU has contributed an average catch of 57 t since 1988, however in the last six years catches have been lower averaging only 38 t (range 32-47 t). The catch of 35.8 t at Mallacoota East in 2022/23 was 3.3 t above the OT , which continues a recent trend of catches above the OT. The Mallacoota East SMU comprises three reefcodes, with Gabo Island the highest contributor in all recent years. The catch at Gabo Island in 2022/23 was well above the OT (by 6 t), as it has been for the last six years. Mean daily catch in the last two years has been similar to levels from 2014 to 2019. CPUE has fluctuated without trend for the last five years.

FIS data from all sites showed declines in recruit and pre-recruit abundances since the early 2000s. Pre-recruit abundance has continued to decline since 2003 while recruit abundance appears to have been relatively stable since 2008, likely the result of progressively reduced catches from this SMU during this period. However, of some concern abundances of both recruits and pre-recruits at the two Top 15 sites declined to their lowest levels in 2023.

It is difficult to interpret trends in the size structure of the population from either FIS or commercial length frequency data.

For the Mallacoota East SMU, mean CPUE was above the Threshold level in the Draft Harvest Strategy and has been above the Threshold level for 30 consecutive years (Table 4). The Primary Indicator (4-year gradient) was Stable and the Secondary Indicator (ratio between years) was Decreasing, which gave a Decreasing Primary Category (Table 5). The Tertiary Indicator was not available, resulting in a Decreasing Final Category for the SMU. The OT for 2023/24 was 26.4 t, and the results of the Harvest Strategy suggested decreasing this OT within a range of 22.3 to 24.9 t.

While CPUE and mean daily catch have been relatively stable for the last 5 years (other than 2020), there are some concerns for the Mallacoota East SMU. Of greatest concern, catches in the last few years have exceeded the suggested OTs + carryover. Most of the over-catch appears to have come from Gabo Island, which has exceeded its OT by 1-7 t for the last six years. Although only two Top 15 sites were surveyed in 2023, both pre-recruit and recruit measures declined by 50% compared with 2021 levels.

Given the uncertainties in the current assessment and the high catches in recent years relative to OTs particularly at Gabo Island, further reductions in OT as suggested by the Draft Harvest Strategy should be strongly considered. As there is no data yet to inform how stock has responded to the reductions in OT in place for 2023/24, diver observations will be critical in determining the OT for 2024/25.

3.2.8 Mallacoota West (Small SMU)

The Mallacoota West SMU contributed 31.9 t in 2022/23 representing 9.1% of the TACC (Table 3) and 9.7% of the zone catch (Table 14). This catch was 28% below the Optimum Target of 44.0 t. CPUE in 2022/23 was 1% higher than in 2003/04 and 12% lower than 2009/10.

Table 14: Summary of Catch, Optimum Targets and Performance Indicators for the Mallacoota West SMU. The LML, median length and proportion undersize (%<LML) are also shown. Symbols for long-term and short-term indicators identify if trends were significantly increasing (+), significantly decreasing (-), not significant (black).

Catch					Long-term indicators CPUE 2003/04 – 2022/23 Abundance 2003-2023			Short-term indicators CPUE 2009/10 – 2022/23 Abundance 2009-2023		
2022/23		OT + carryover* (t)			CPUE	Pre-recruits	Recruits	CPUE	Pre-recruits	Recruits
(t)	(%)	21/22	22/23	23/24						
31.9	9.7%	50.2*	44.0	21.5	1	NA	NA	-12	NA	NA
LML = 125 mm			Mean daily catch=408 kg			Top15 mean size=122 mm			Top15 >LML=53%	

The Mallacoota West SMU has been an important historical contributor to the Eastern Zone TACC, with an average catch of 72 t since 1979 and 69 t since 1988, with a peak catch of 114 t taken during 1983 (Figure 24). Since the introduction of quota, catches increased from a low of 52 t at that time to a contemporary peak of 101 t in 2008 but have continually declined thereafter. Catches since 2016 have been below the 1988 level despite reductions in size limit during 2011 and 2015. The catch in 2022 was the lowest recorded.

Mean daily catch was consistent between 1989 and 2014, ranging from 397 to 507 kg/day with an average of 450 kg/day but as catches have declined mean daily catch has become more variable.

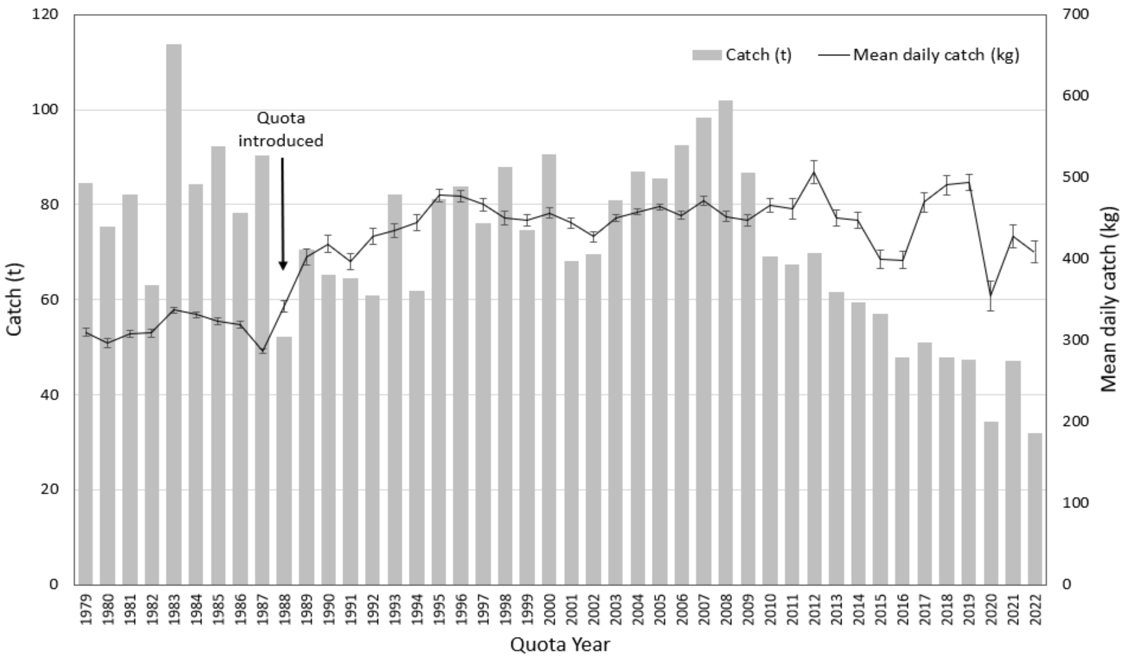

Figure 24: Total catch and mean daily catch for the Mallacoota West SMU from 1979 to 2022.

Nominal CPUE has showed three peaks in 2006, 2012 and 2019 (Figure 25) with substantial fluctuations in between. Nominal CPUE has declined in the last four years and is currently the lowest observed since 2016 and second lowest level since 2003. Standardised CPUE has generally followed the nominal trends.

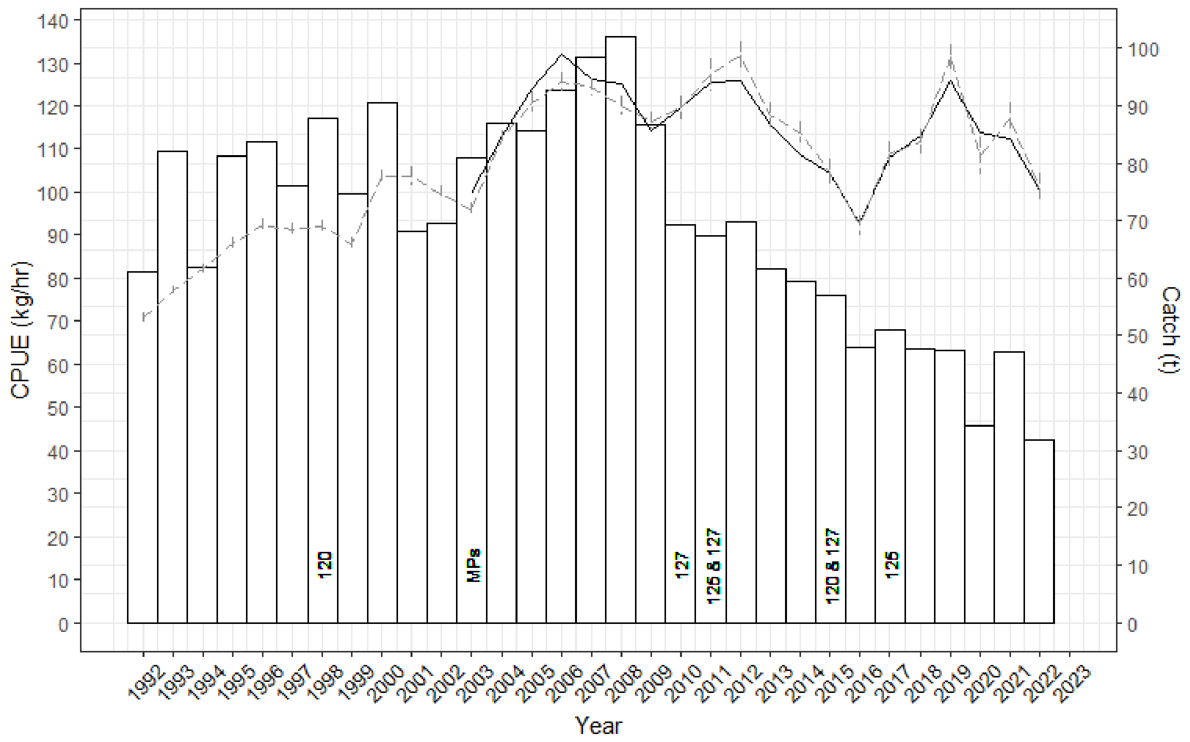

Figure 25: Mallacoota West SMU catch, and CPUE (nominal and standardised) from 1992/93 – 2022/23. Catch = bars, nominal CPUE = grey series (+/- SE), standardised series = black. Numbers in bars indicate changes to LMLs. MPs = introduction of Marine Parks.

Table 15: Catches by reefcode for the Mallacoota West SMU from 2017/18 to 2022/23, the five-year average catch from 2017/18 to 2021/22, and the OT + carryover for 2022/23.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23	OT+carryover	Difference (kg)
23.04 Petrel Point	17505	19015	20634	13239	20964	18272	13708	18000	-4292
23.05 Island Point	20205	15312	15108	13103	15685	15883	8283	13500	-5217
23.02 Whaleback	7998	8343	5853	5708	5519	6684	5580	6500	-920
23.03 Meuller	5290	5075	5729	2334	5058	4697	4282	6000	-1718

The Mallacoota West SMU comprises four reefcodes, with Petrel Point and Island Point the highest contributors (Table 15). The catch in 2022/23 was below the OT at all reefcodes, with the greatest differences at Petrel Point and Island Point. Catches were also well below the previous 5-year averages at Petrel Point and Island Point.

FIS data were not collected during 2022. The trends from the “all sites” data series (grey dashed) are difficult to interpret because of changes in sites over time. Standardised abundance of recruits at the two Top 15 sites declined from 2003 to 2008 and has been highly variable thereafter (Figure 26). Standardised abundance was the lowest recorded in 2023.

Standardised pre-recruit abundance at the two Top 15 sites declined from 2003 to 2021 but increased in 2023 (Figure 27).

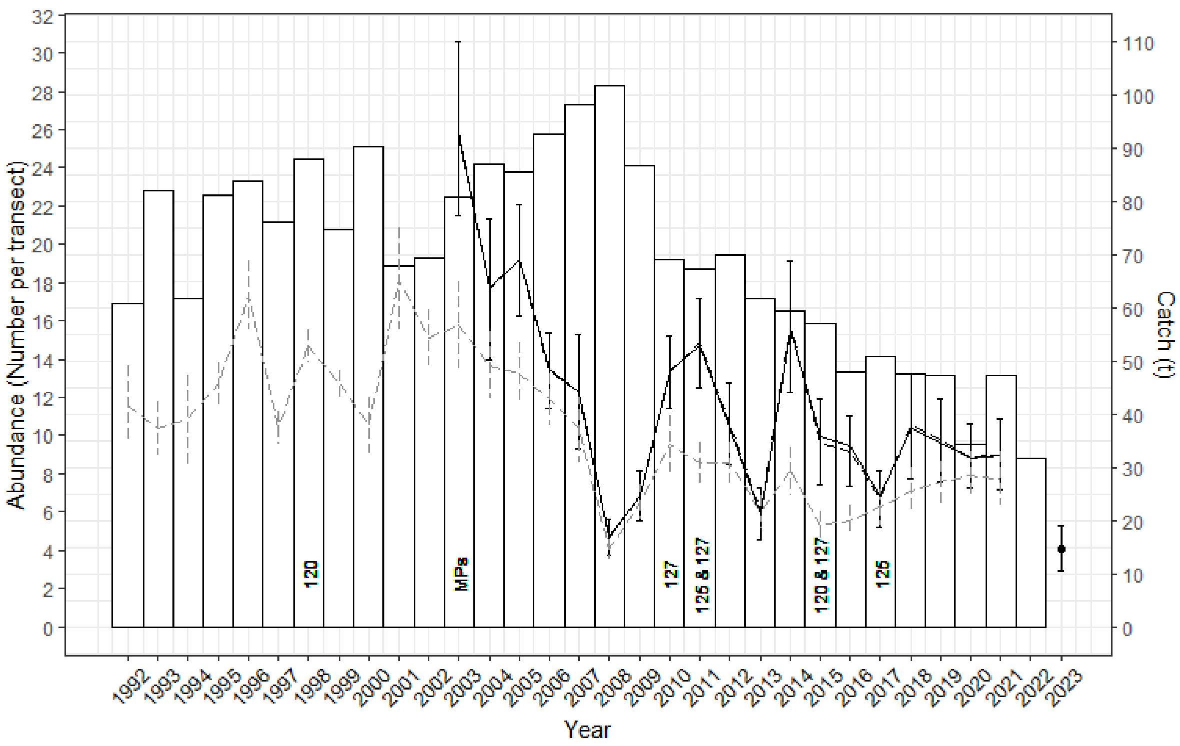

Figure 26: Recruit abundance and catch from 1992/93 – 2022/23 for the Mallacoota West SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the two Top 15 sites located within the Mallacoota West SMU.

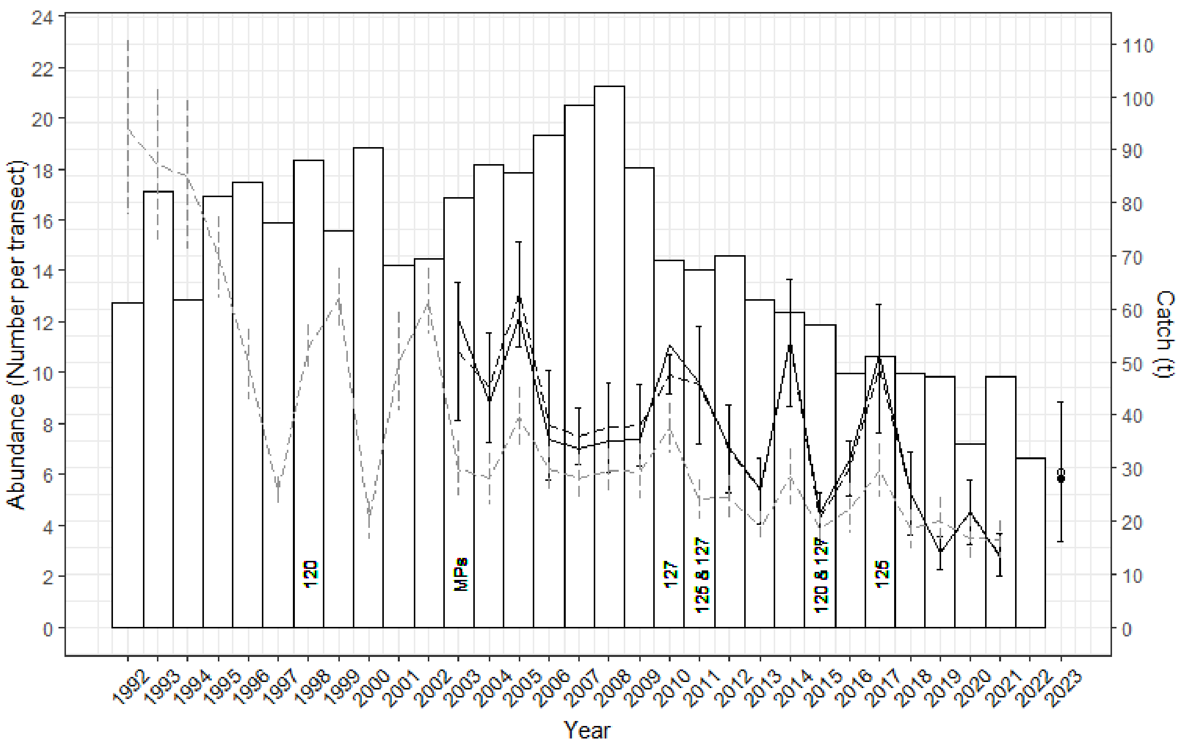

Figure 27: Pre-recruit abundance and catch from 1992/93 – 2022/23 for the Mallacoota West SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the two Top 15 sites located within the Mallacoota West SMU.

FIS length frequency data

There are few clear trends evident in the size structure of the population sampled during FIS in the Mallacoota West SMU (Appendix 4). Mean size has generally ranged from 118 to 124 mm (except for 115 mm in 2009) and the proportion above the size limit has ranged from 37 to 57%. The modal size class has been 125-129 mm or 130-134 mm in all years except 2015 and 2016 where it was 120-124 mm.

Commercial length frequency data

From 2010/11 to 2016/17, most of the sampled catch was in the size classes 130-134 and 135-139 mm (Appendix 5). In 2018/19 only 230 shells were measured, however more than 40% of these were just above the size limit (i.e. 125 – 129 mm size class). No data are available from 2018/19. Higher numbers of shells sampled would increase the certainty in this measure in future years.

Summary

The Mallacoota West SMU has been an important historical contributor to the Eastern Zone TACC, however catches have slowly declined since a contemporary peak catch of 101 t taken during 2008. The catch in 2022 was the lowest recorded. Catches at all SMUs were below the OT, particularly the two most important reefcodes Petrel Point and Island Point. Mean daily catch has been maintained just over 400 kg/day for the last two years, however it is still well below the historic average. CPUE has declined in the last four years and is currently second lowest level since 2003 and the lowest observed since 2016.

Recruit and pre-recruit FIS abundances from all sites are low in historical terms. Recruits fluctuated without trend from 2009 to 2021, whereas pre-recruits have declined slowly from 2003 to 2021. Two Top 15 sites were surveyed in 2023. Notably, recruit abundance declined by more than 50% compared to 2021, however on a more optimistic note pre-recruit abundance more than doubled during this period.

Size structure data from FIS and commercial catch showed few trends up to 2021 and 2016/17, respectively.

For the Mallacoota West SMU, mean CPUE was above the Threshold level in the Draft Harvest Strategy and has been above the Threshold level for 31 consecutive years (Table 4). Both the Primary Indicator (4-year gradient) and Secondary Indicator (ratio between years) were Decreasing, which gave a Decreasing Primary Category (Table 5). The Tertiary Indicator was not available, resulting in a Decreasing Final Category. The OT for 2023/24 was 21.5 t, and the results of the Harvest Strategy suggested an OT range from 18.3 to 20.4 t.

Island Point was closed for 2023/24 due to sustainability concerns, while the OT at Petrel Point was halved. In total, the OT for the SMU was reduced from 44 t to 21.5 t. The Draft Harvest Strategy suggests that further reductions in OT are required due entirely to further declines in CPUE. **Given the severity of the reductions in OT for 2023/24 and lack of information to determine how the stock may have responded in this time, it is unclear whether further cuts are required. In the absence of information to assess the Petrel Point reefcode, a second year of closure is recommended. Diver observations will be critical in determining the OT for 2024/25.**

3.2.9 Mallacoota Large (Small SMU)

The Mallacoota Large SMU contributed 18.6 t in 2022/23 representing 5.3% of the TACC (Table 3) and 5.6% of the zone catch (Table 16). This was just below the Optimum Target (20.0 t). CPUE in 2022/23 was 11% (significantly) lower than in 2003/04 and 18% lower than 2009/10.

Table 16: Summary of Catch, Optimum Targets and Performance Indicators for the Mallacoota Large SMU. The LML, median length and proportion undersize (%<LML) are also shown. Symbols for long-term and short-term indicators identify if trends were significantly increasing (+), significantly decreasing (-), not significant (black)

Catch					Long-term indicators CPUE 2003/04 – 2022/23 Abundance 2003-2023			Short-term indicators CPUE 2009/10 – 2022/23 Abundance 2009-2023		
2022/23		OT + carryover* (t)			CPUE	Pre-recruits	Recruits	CPUE	Pre-recruits	Recruits
(t)	(%)	21/22	22/23	23/24						
18.6	5.6	23.5*	20.0	18.5	-11	NA	NA	-18	NA	NA
LML = 135 mm		Mean daily catch=365 kg				Top15 mean size=NA			Top15 >LML=NA	

The Mallacoota Large SMU has produced an average catch of 37 t since 1979 and 30 t since 1988, with a peak catch of 78 t in 1983. Since the introduction of quota, the peak catch was 58 t caught in both 1992 and 1993 (Figure 28). Catch remained around 45 t in 1994 and 1995 before declining substantially to 19 t in 1996. Thereafter catch has ranged from 7 to 43 t, with an average catch of 25 t. The 2022 catch was the lowest recorded since 2000.

Following the introduction of quota, mean daily catch was relatively stable from 1990 to 2014, ranging from 394 to 489 kg/day, with an average of 434 kg/day. Mean daily catch has been highly variable since then, with the last two years around 365 kg/day which is well below the historic average. Mallacoota Large was the only SMU where mean daily catch did not appear to be affected by the impacts of Covid-19 due likely to market demand for larger abalone, as demonstrated by the larger catch in 2020.

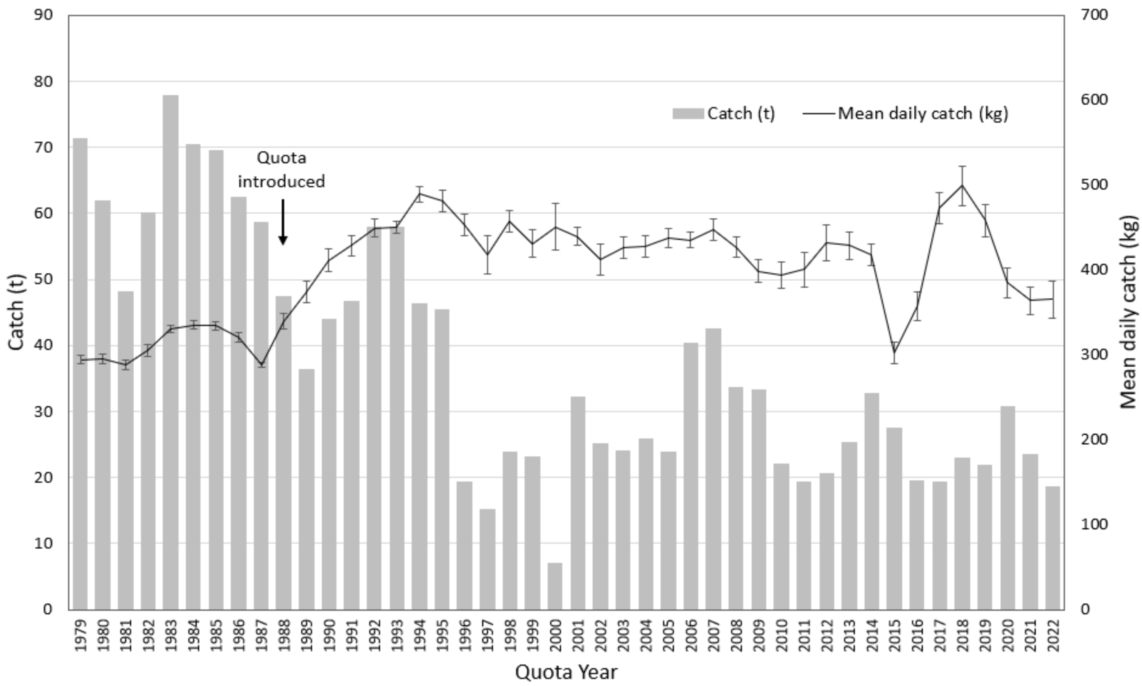

Figure 28: Total catch and mean daily catch for the Mallacoota Large SMU from 1979 to 2022.

Nominal CPUE generally increased from 1992 to 2007, where it peaked at 118 kg/hr and remained stable thereafter until 2014 (Figure 29). Nominal CPUE has fluctuated thereafter but has declined over the last four years and is currently lower than all years 2003 to 2013. Standardised CPUE has generally followed the nominal trends. Mallacoota Large is the only SMU in the Eastern Zone that shows a decline in CPUE performance indicators in both long-term and short-term.

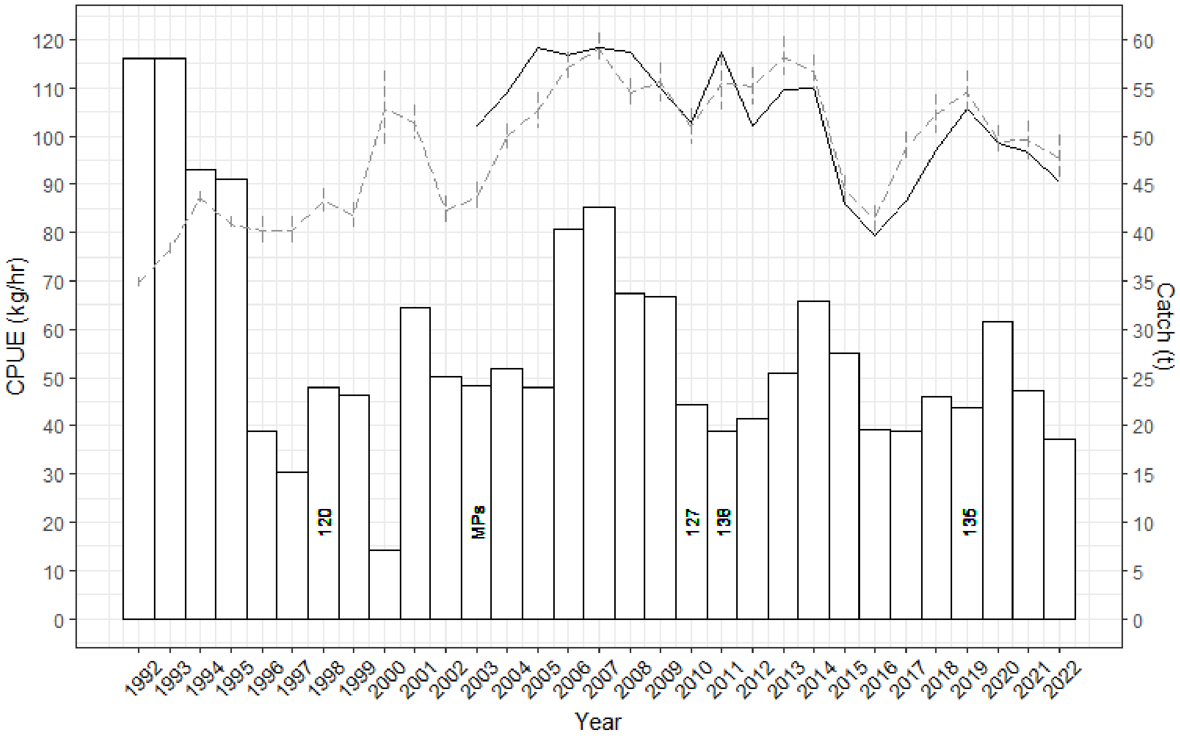

Figure 29: Mallacoota Large SMU catch, and CPUE (nominal and standardised) from 1992/93 – 2022/23. Catch = bars, nominal CPUE = grey series (+/- SE), standardised series = black. Numbers in bars indicate changes to LMLs. MPs = introduction of Marine Parks.

Table 17: Catches by reefcode for the Mallacoota Large SMU from 2017/18 to 2022/23, the five-year average catch from 2017/18 to 2021/22, and the OT + carryover for 2022/23.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23	OT+carryover	Difference (kg)
23.06 Big Rame	12597	15589	15057	22246	14558	16009	12960	14500	-1540
24.0 The Skerries	4206	5212	5472	6645	7197	5746	4353	4000	353
24.03 Easby Creek	2681	2198	1323	1902	1887	1999	1317	1500	-183

The Mallacoota Large SMU comprises three reefcodes, with Big Rame the highest contributor followed by The Skerries (Table 17). Catches were around the OTs at all reefcodes in 2022/23.

FIS data were not collected during 2022 and there were no Top 15 sites for the Mallacoota Large SMU. The trends from the “all sites” data series (grey dashed) are difficult to interpret because of changes in sites over time but in general recruit abundance declined from 1992 to 2015 and increased slightly thereafter (Figure 30).

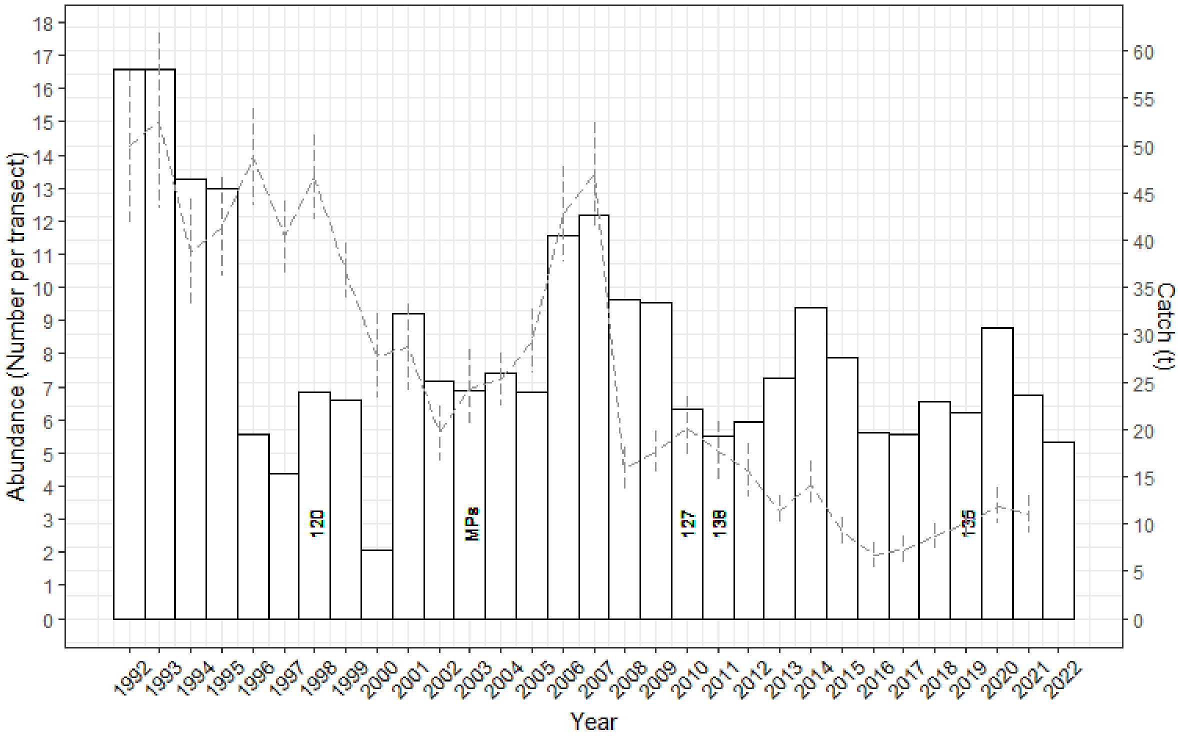

Figure 30: Recruit abundance (nominal grey dashed line) and catch (bars) from 1992/93 – 2022/23 for the Mallacoota Large SMU. There are no Top 15 sites in the Mallacoota Large SMU.

Pre-recruit abundance declined from 1992 to 2009 and remained low thereafter (Figure 31).

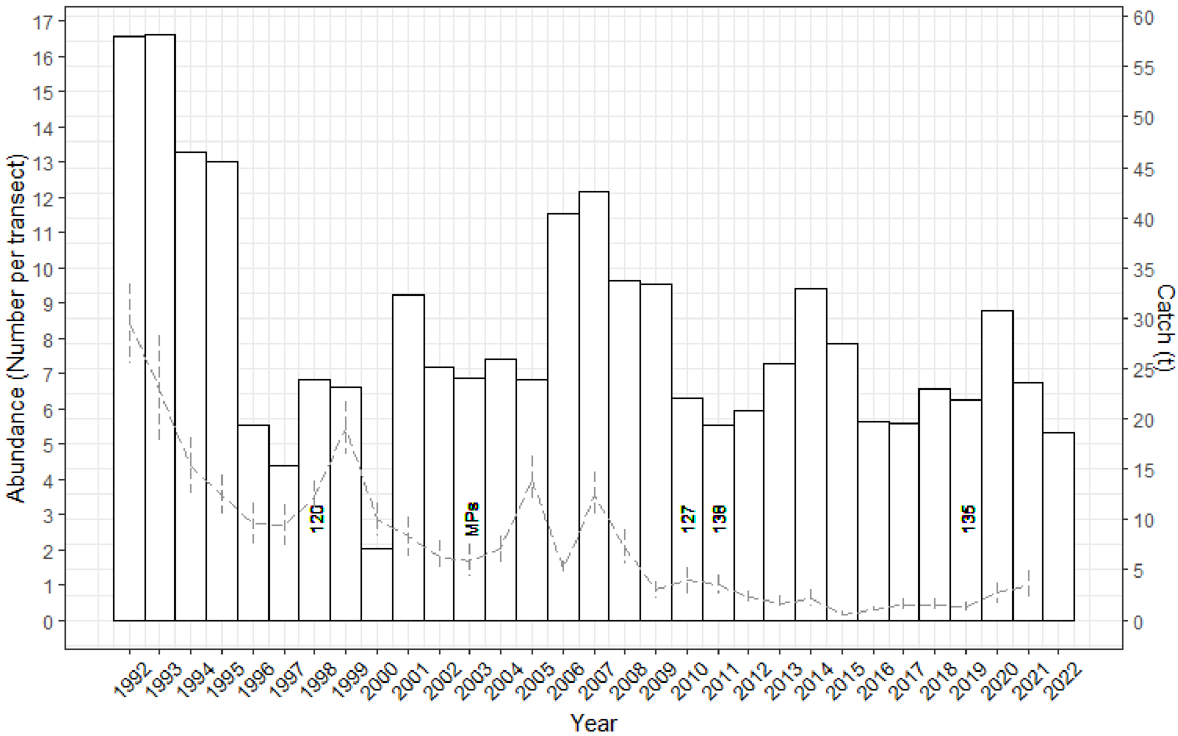

Figure 31: Pre-recruit abundance (nominal grey dashed line) and catch (bars) from 1992/93 – 2022/23 for the Mallacoota Large SMU. There are no Top 15 sites in the Mallacoota Large SMU.

FIS length frequency data

The size structure of the surveyed population in the Mallacoota Large SMU show clear trends associated with the decline in abundance of both recruit and pre-recruit abalone (Appendix 5). From 2003 to 2011, the mean size of the population ranged from 126 to 137 mm, with the proportion above the LML ranging from 33 to 53%. As the abundance of pre-recruits declined substantially thereafter and represent only a small proportion of the population, mean size increased to 135 to 140 mm and the proportion above the LML ranged from 55 to 69% from 2012 to 2020, except for 2019 where a relatively higher abundance of very small abalone (<70 mm) reduced the mean size to 130 mm.

Commercial length frequency data

Sample sizes from the commercial catch have ranged from 93 to 580 shells per year sampled and may not be a very representative sample of the underlying size distribution (Appendix 5).

Summary

The Mallacoota Large SMU has produced an average catch of 37 t since 1979 and 30 t since 1988, with a peak catch of 78 t in 1983. The Mallacoota Large SMU catch exceeded 45 t from 1992 to 1995 before declining substantially to 19 t in 1996. Thereafter catch has ranged from 7 to 43 t, with an average catch of 25 t. The 2022/23 catch of 18.6 t was the lowest recorded since 2000. Reefcode catches in 2022/23 were around their respective OTs, which follows several years of the OTs being exceeded at the Skerries and Big Rame. Mean daily catch has been highly variable since 2014, with the last two years around 365 kg/day which is well below the historic average. CPUE has fluctuated since 2014, declining over the last four years and is currently lower than all years 2003 to 2013 and is currently low in a recent historic context. Mallacoota Large is the only SMU in the Eastern Zone that shows a decline in CPUE performance indicators in both long-term and short-term.

There were no Mallacoota Large FIS sites in the Top 15 and thus FIS data have not been collected since 2021. The data from all historic FIS show substantial declines in both recruit and pre-recruit abundances.

No meaningful changes in size structure were evident from FIS and commercial length-frequency data.

For the Mallacoota Large SMU, mean CPUE was above the Threshold level in the Draft Harvest Strategy and has been above the Threshold level for 31 consecutive years (Table 4) despite this being the only SMU with long-term declines in CPUE. The Primary Indicator (4-year gradient) was Stable and the Secondary Indicator (ratio between years) was Decreasing, which gave a Decreasing Primary Category (Table 5). The Tertiary Indicator was not available, resulting in a Decreasing Final Category for the SMU. The OT for 2023/24 was reduced to 18.5 t, and the results of the Harvest Strategy suggest reducing the OT further, ranging from 15.7 to 17.6 t.

Mallacoota Large is the only SMU where CPUE has declined in the long- and short-term, with CPUE declining further in 2022/23. While catches were close to OTs in 2022/23, this followed two years of catches that exceeded OTs considerably. **As there is no data yet to inform how stock has responded to the reductions in OT in place for 2023/24, further reductions in OT as suggested by the Draft Harvest Strategy should be strongly considered. Diver observations will be critical in determining the OT.**

3.2.10 Mallacoota Small (Small SMU)

The Mallacoota Small SMU catch of 16.4 t in 2022/23 was 22% below the Optimal Target and represented 4.7% of the TACC (Table 3) and 5.0% of the total catch for the Eastern Zone (Table 18). CPUE was 14% (significantly) higher than 2003/04 and 1% higher than 2009/10.

Table 18: Summary of Catch, Optimum Targets and Performance Indicators for the Mallacoota Small SMU. The LML, median length and proportion undersize (%<LML) are also shown. Symbols for long-term and short-term indicators identify if trends were significantly increasing (+), significantly decreasing (-), not significant (black).

Catch					Long-term indicators CPUE 2003/04 – 2022/23 Abundance 2003-2023			Short-term indicators CPUE 2009/10 – 2022/23 Abundance 2009-2023		
2022/23		OT + carryover* (t)			CPUE	Pre-recruits	Recruits	CPUE	Pre-recruits	Recruits
(t)	(%)	21/22	22/23	23/24						
16.4	5.0	22.5*	21.0	15.5	14	NA	NA	1	NA	NA
LML = 115 mm			Mean daily catch=355 kg			Top15 mean size=101 mm			Top15 >LML=21%	

The Mallacoota Small SMU has produced an average catch of 25 t since 1979 and 24 t since 1988 (Figure 32). Following the introduction of quota, catch from the Mallacoota Small SMU increased from 21 t to 1994 to a peak of 44 t in 1998. While catch declined to 20 t in 2001, it has remained stable thereafter with a minimum catch of 13 t and an average of 21 t. The catch in 2022 was among the lowest since 1979 and was 4.6 t below the OT.

Mean daily catch generally increased after quota was introduced from around 300 kg/day to a peak of 453 kg/day in 1998. Mean daily catch remained relatively stable from 1995 to 2019, with a range of 331-453 kg/day and an average of 393 kg/day. While mean daily catch has increased in the last two years following Covid-19 market impacts, it remains below the historic average.

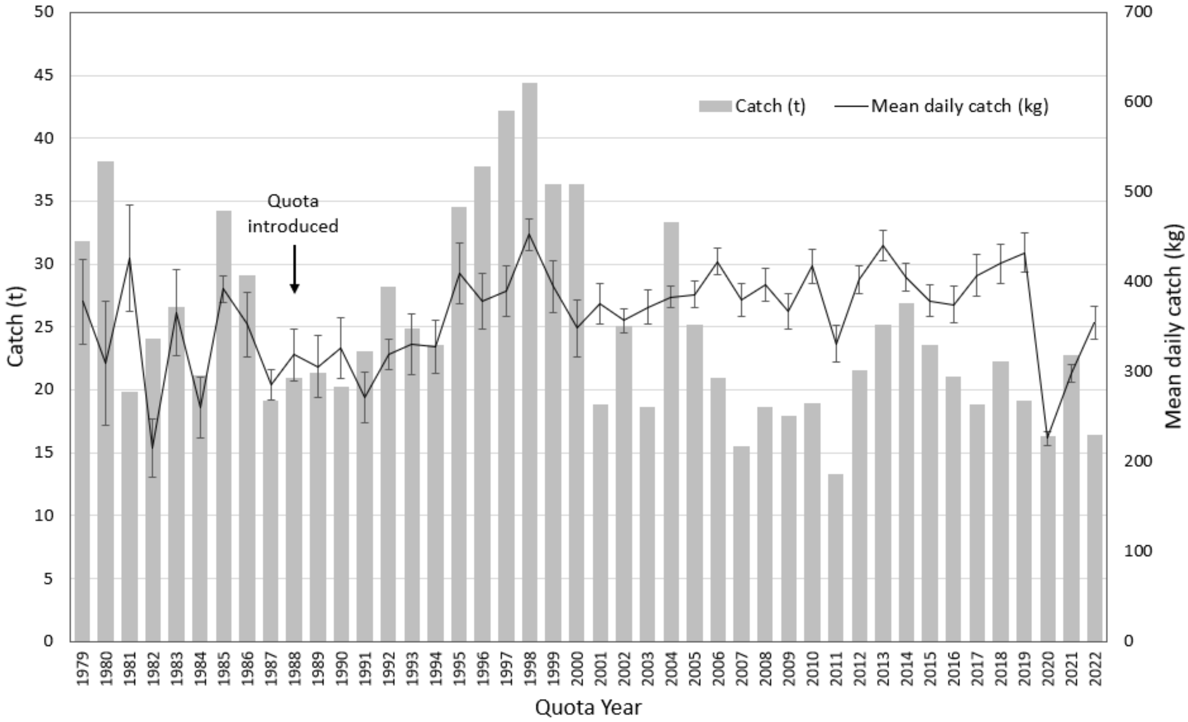

Figure 32: Total catch and mean daily catch for the Mallacoota Small SMU from 1979 to 2022.

Nominal CPUE generally increased from 1992 to 2013, reaching a peak of 116 kg/hr (Figure 33). Nominal CPUE has fluctuated thereafter, with a general decline over the last four years. Standardised CPUE has generally followed the nominal trends.

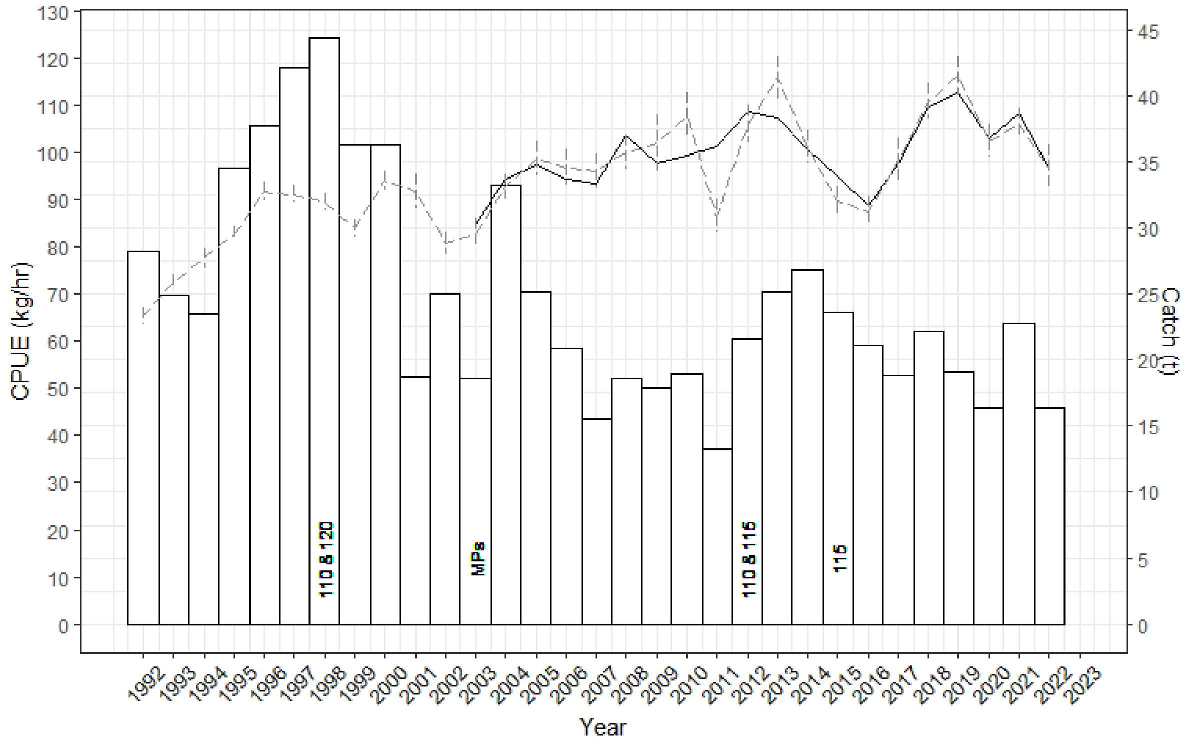

Figure 33: Mallacoota Small SMU catch, and CPUE (nominal and standardised) from 1992/93 – 2022/23. Catch = bars, nominal CPUE = grey series (+/- SE), standardised series = black. Numbers in bars indicate changes to LMLs. MPs = introduction of Marine Parks.

Table 19: Catches by reefcode for the Mallacoota Small SMU from 2017/18 to 2022/23, the five-year average catch from 2017/18 to 2021/22, and the OT + carryover for 2022/23.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23	OT+carryover	Difference (kg)
24.09 Little Rame	13309	16115	12515	11270	14776	13597	10342	15000	-4658
24.14 Bastion Point	5498	6093	6581	5063	7949	6237	6025	6000	25

The Mallacoota Small SMU comprises two reefcodes (Table 19). Catch at Little Rame in 2022/23 was 4.6 t below the OT and was the lowest recorded in the last six years.

FIS data were not collected during 2022 and there was only one Top 15 site for the Mallacoota Small SMU. The trends from the “all sites” data series (grey dashed) are difficult to interpret because of changes in sites over time. Standardised recruit abundance at the one Top 15 site generally declined from 2003 to 2015 and has been variable thereafter (Figure 34).

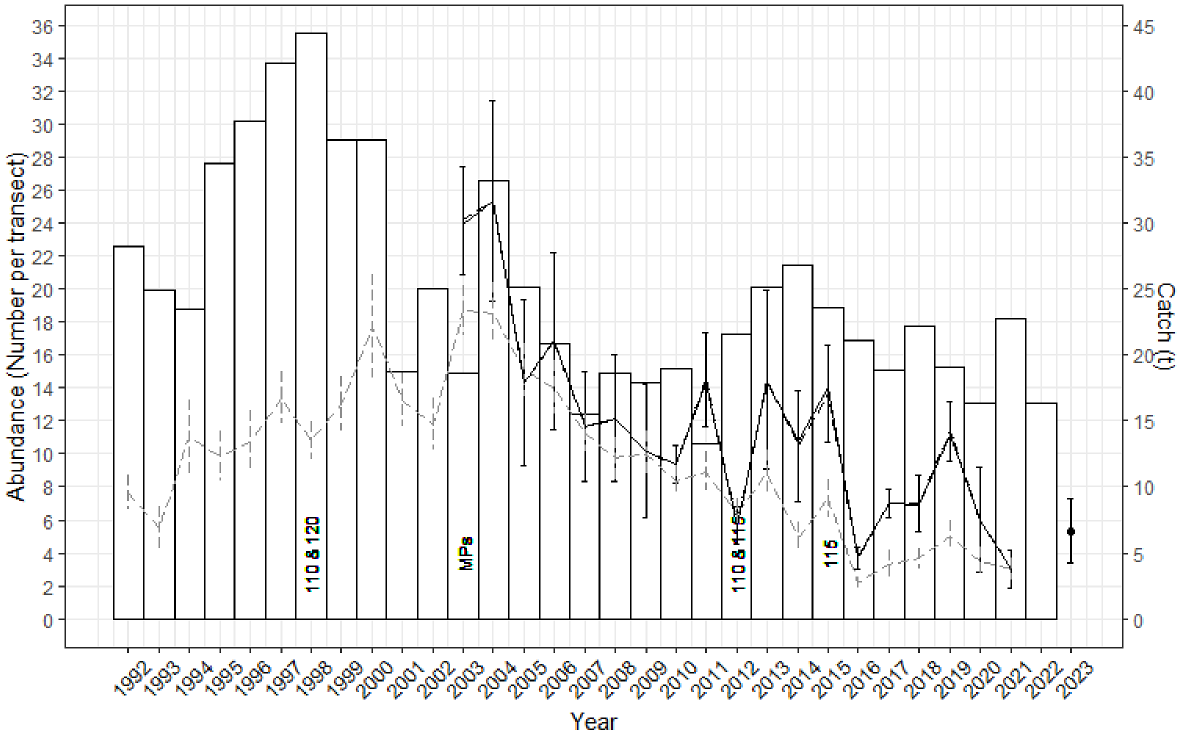

Figure 34: Recruit abundance and catch from 1992/93 – 2022/23 for the Mallacoota Small SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the one Top 15 site located within the Mallacoota Small SMU.

Standardised pre-recruit abundance at the one Top 15 site in the Mallacoota Small SMU has been highly variable since 2003 (Figure 35). The 2023 count was slightly above the long-term average.

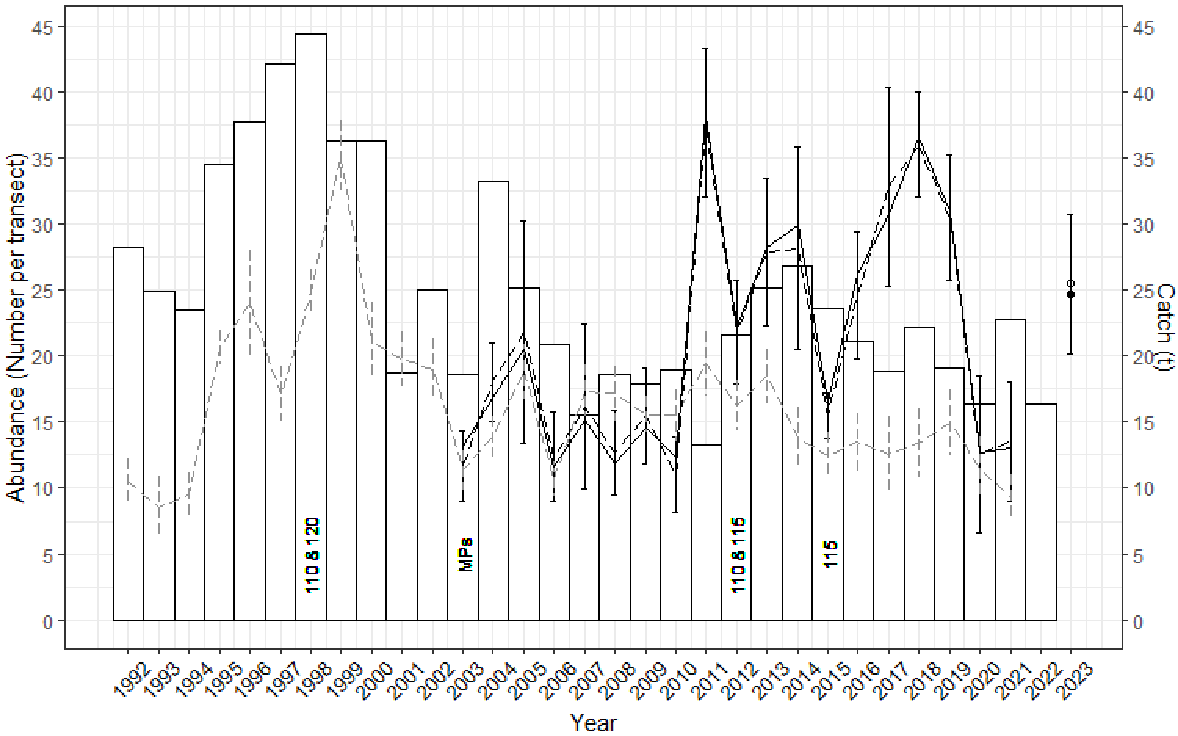

Figure 35: Pre-recruit abundance and catch from 1992/93 – 2022/23 for the Mallacoota Small SMU. Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line) and standardised (solid line and dot point in 2023) abundance at the one Top 15 site located within the Mallacoota Small SMU.

FIS length frequency data

The size structure of the surveyed population in the Mallacoota Small SMU was relatively stable from 2003 to 2015 (Appendix 4). Modal size was 115 – 119 mm in each of those years, while mean size ranged from 107 to 114 mm. A decline in the abundance of recruits in 2016 and 2017 saw a reduction in mean size (105 and 106 mm, respectively) and modal size (105-109 mm and 110-114 mm, respectively). Size structures returned to more normal trends since 2018. Of note, relatively high abundances of juvenile abalone <70 mm were observed in 2019, however they did not appear to translate into increased abundances of pre-recruits in 2020.

Commercial length frequency data

The size structure of the commercial catch in the Mallacoota Small SMU has varied over time (Appendix 5). Of note, a higher proportion of sampled abalone were harvested closer to the size limit (115-119 mm size class) in 2015/16 and 2016/17, however sample sizes were low in these years. There were no data available from 2018/19 to 2022/23.

Summary

The Mallacoota Small SMU has produced an average catch of 24 t since 1988/89. Catch peaked in 1998/99 at 44 t before declining to 20 t in 2001/02. Thereafter catch has remained relatively stable with a minimum of 13 t and an average of 21 t, however the 16.4 t harvested in 2022/23 was among the lowest since 1979 which was 4.6 t below the OT. All of the shortfall in catch occurred at Little Rame reefcode, where the catch was the lowest recorded in the last 6 years. The mean daily catch in 2022/23 of 355 kg was low in an historic context. CPUE has declined since 2019.

Only one FIS site from the Mallacoota Small SMU contributed to the Top 15 sites and the abundances of recruits and pre-recruits from this site have been variable over time. A paucity of data also makes it difficult to interpret length frequency data from FIS and commercial data sources.

For the Mallacoota Small SMU, mean CPUE was above the Threshold level in the Draft Harvest Strategy and has been above the Threshold level for 30 consecutive years (Table 4). The Primary Indicator (4-year gradient) was Stable and the Secondary Indicator (ratio between years) was Decreasing, which gave a Decreasing Primary Category (Table 5). The Tertiary Indicator was not available, resulting in a Decreasing Final Category for the SMU. The OT for 2022/23 was reduced to 15.5 t, and the results of the Harvest Strategy suggest reducing this OT from 13.2 to 14.7 t.

There are some concerning trends for the Mallacoota Small SMU. CPUE has declined since 2019, though remains within historic levels. Mean daily catch is low relative to historic levels. Of most concern, the catch at Little Rame was 4.5 t below the OT in 2022/23 and 2 t below the OT in 2021/22. From the information available it is difficult to determine whether this is due to concerns at the reefcode, but it is noted that the OT at Little Rame was reduced from 15 t to 10.5 t for 2023/24. **As there is no data yet to inform how stock has responded to the reductions in OT in place for 2023/24, further reductions in OT as suggested by the Draft Harvest Strategy should be strongly considered. Diver observations will be important in determining the OT.**

4. Factors affecting the Eastern Zone abalone fishery

As with all fisheries, a number of factors may influence the productivity and sustainability of the Eastern Zone abalone stocks. As discussed in recent Stock Assessment Reports, average recruitment to the Eastern Zone stocks appears to have declined over the last two decades relative to early, more productive periods of the fishery. These trends have been noted throughout southern Australia, across several commercially important abalone species.

In the last three years, diving conditions at the Marlo SMU have been reported to be poor, due to fresh water from the Snowy River. While this has affected the total effort and catch from the Marlo SMU, the impacts of this water on the productivity of the stock are unknown.

Another factor that has substantially impacted the Eastern Zone fishery is the incursion of sea urchins. Long-spined sea urchins (*Centrostephanus rodgersii*) are endemic to New South Wales waters, but in recent decades they have spread further south into eastern Victorian and eastern Tasmanian coastlines. As reported by VFA (2020), "*The long-spined sea urchin, Centrostephanus rodgersii, has the capacity to overgraze temperate reef habitats, creating barrens habitat devoid of macroalgal growth with negative implications for abalone populations and broader ecosystem health*". The following updates information on sea urchin abundance obtained from the abalone FIS.

4.1 Sea urchin abundance

In 2020, VFA produced a report (VFA 2020) that examined all available data on sea urchin abundance in the Eastern Zone. This included an analysis of data from abalone FIS up to 2019. Here, we update the abundance data up to 2021 for all sites, and up to 2023 for the Top 15 FIS sites.

Trends in data from all sites combined are not meaningful, because of spatial variation in sea urchin abundance and changes in the FIS design. On this basis, we have included graphs of the abundance over time for all sites and for the Top 15 sites only (Appendix 7).

For the Top 15 sites at the Zone scale, the abundance of sea urchins declined from 2003 to 2023 (Figure 36). These trends appear counter-intuitive given we know that sea urchins have become an increasing problem for the fishery, however they are not completely unexpected. When sea urchin abundance first begins to increase at an otherwise "healthy" abalone reef, the abundance increases over time while they consume the algae on that reef. But once the sea urchin population has eaten all the algae and have turned the reef into a "barrens" habitat, the abundance of sea urchins declines and stabilises at lower numbers. For example, this may explain the trends seen in Figure 37 for Mallacoota East. On this basis, FIS abalone sites are not a good indicator of changes in the overall abundance of sea urchins.

As identified in VFA (2020), urchin abundance is higher in the far east of the Zone from Little Rame through to the New South Wales border. Fortunately, abundances of urchins are unlikely to increase substantially in shallow waters to the south west of Little Rame because of wave exposure.

FIS sites have been established to monitor abalone abundance, and thus additional data collected such as sea urchin abundance can provide useful information, but the program is not designed to provide sea urchin specific information. Developing a project that examines all data sources, including VMS spatial effort data from the commercial sea urchin and abalone fisheries, would greatly enhance the understanding of the impact of sea urchin incursion on the abalone stocks in the Eastern Zone.

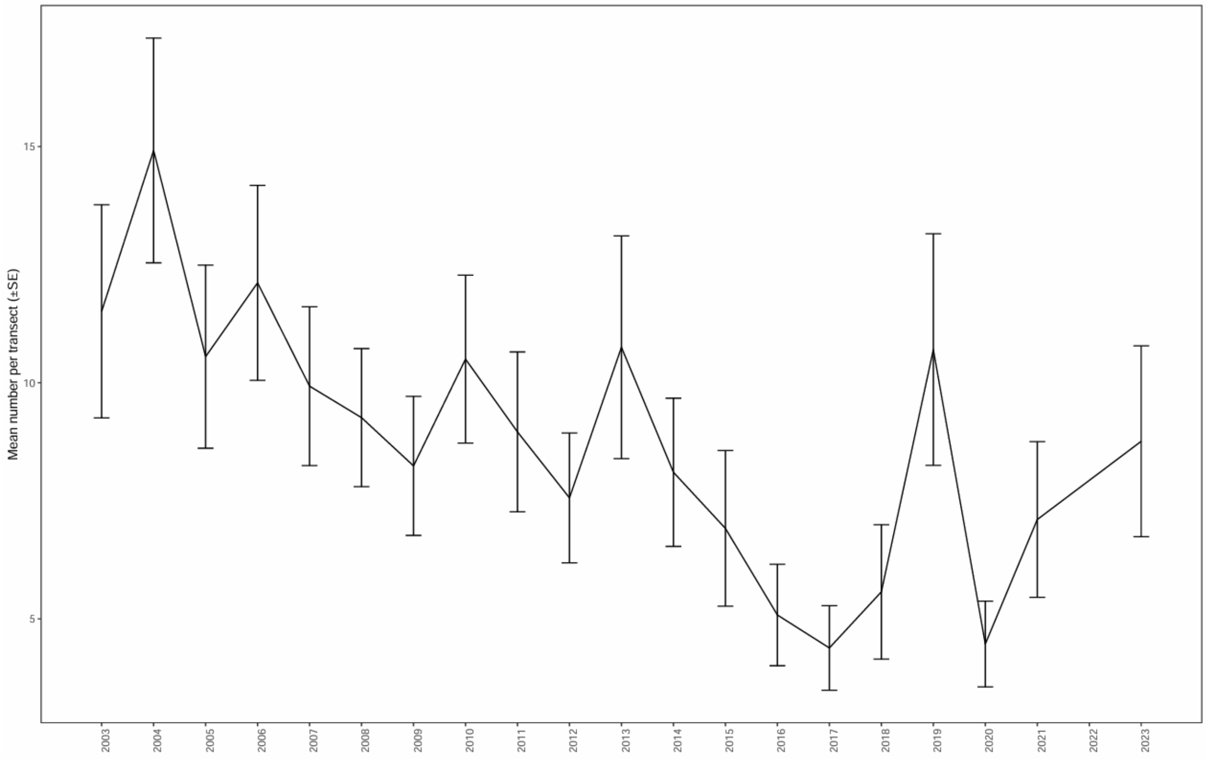

Figure 36: Abundance of sea urchins at the Zone scale for the Top 15 FIS sites.

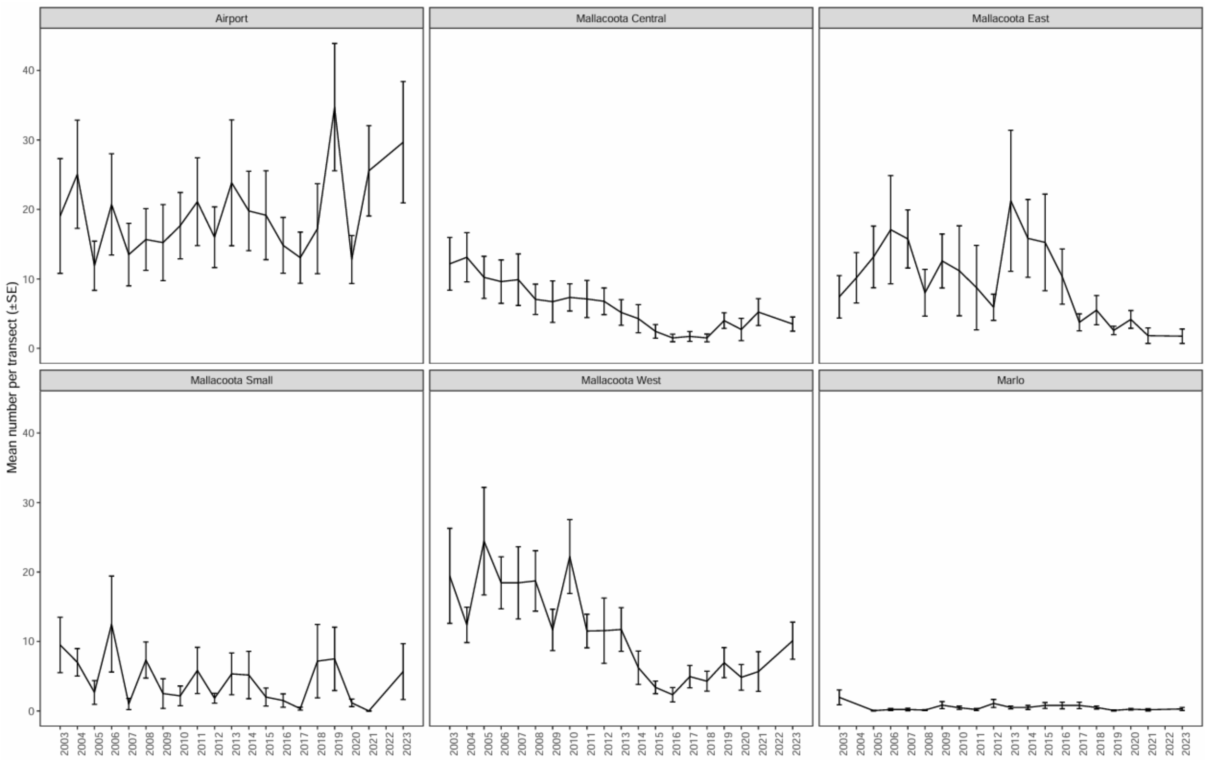

Figure 37: Abundance of sea urchins at the SMU scale for the Top 15 FIS sites.

5. Conclusions and recommendations

5.1 Analytical approaches to stock assessment

There are three primary analytical approaches used in the assessment of stock status to inform TACC decision making. As reported in previous Stock Assessment Reports and associated review documents, there are substantial uncertainties associated with the two primary sources of data for the assessment process. CPUE data are positively biased due to hyperstability, and therefore present an overly optimistic assessment of stock status. FIS data are negatively biased because FIS site locations are not representative of the entire stock, and thus they represent an overly pessimistic assessment of stock status. As a result, in recent years VFA have requested reviews of the current CPUE standardisation approach (Dichmont et al 2022) and the FIS approach (Dixon 2023). Reviews of other components of the management framework are also planned (e.g. Performance Indicators, Harvest Strategy, Management Plan).

The framework for the assessment of stock status has been developed with careful consideration over time and is appropriate for the stock and the available data. However, the uncertainties in the data have resulted in assessment outcomes that have been misleading in recent years. A 2022 report by MRAG (Dixon et al 2022) highlighted how poorly the outcomes from the weight of evidence assessment and Draft Harvest Strategy had translated into TACC outcomes for the Eastern Zone in recent years. This reflected a lack of faith from industry in the assessment outcomes, with most TACC decisions being based on industry views rather than the stock assessment outcomes.

Highlighting this issue, during the 2022 TACC setting process, industry decided to close the Island Point reefcode and halve the OT at the Petrel Point reefcode based on diver observations. At the time, these two reefcodes provided a combined OT of 34.7 t, which was 69% of the OT for the Mallacoota West SMU. Importantly, the data that informed the 2022 assessment for the Mallacoota West SMU showed no signs of the need for these impending OT reductions. The assessment was primarily driven by CPUE trends which had been relatively stable for the previous four years, resulting in a Stable Draft Harvest Strategy outcome. While the decision to reduce catches in response to diver observations is responsible stewardship by industry, the fact that the current assessment process, which is driven almost entirely by CPUE trends, was not able to identify these issues is highly concerning. It should be noted that the Draft Harvest Strategy for the current assessment period has suggested reductions in OTs of up to 15% in 6 of the 7 SMUs including Mallacoota West, however this was one year after industry decided to make reductions at most SMUs with Mallacoota West a much higher magnitude than 15%.

It is important to understand that the clear deficiency in the current assessment process regards the data that underpins it rather than the framework itself. The fishery is currently undergoing a period of critical review and development that will result in an improved assessment process underpinned by more rigorous data sources that aim to minimise bias.

5.1.1 Performance Indicators

Previous reports have identified that the current Performance Indicators require review. The Performance Indicators are assessed for the long-term from 2003 to current and for the short-term from 2009 to current. This was a highly productive period of the fishery and clearly stocks have declined substantially since that time. These reference points would be useful if the objective for the fishery was to recover stocks to 2003 levels, however no such objectives exist. It is recommended that explicit biological objectives regarding stock status (i.e. stock recovery objectives) are determined immediately to help inform an appropriate performance assessment.

In this report, we included an analysis of the current Performance Indicators over the last four years, which aligns with the timelines of the Draft Harvest Strategy. In addition, we included a performance measure of mean daily catch which could be considered in a future review. While CPUE will likely remain a key performance measure in the future, the issues associated with hyperstability need to be accounted for. The current FIS program is being restructured with new sites likely being implemented in current fishing grounds in 2024. However, it will be several years before meaningful data can be included as performance measures. The review of Performance Indicators must include potential measures that can be derived from commercial effort logger data that have been gathered for the last two years.

5.1.2 Draft Harvest Strategy

Like all fishery assessment tools, harvest strategies evolve over time as new information is acquired. The current Draft Harvest Strategy was first implemented in the 2017/18 season. Since 2018/19, results from the Draft Harvest Strategy have been prepared as a separate report and have also been included explicitly in this report and the stock assessment process. The five most recent stock assessments have used an independent weight of evidence assessment for each SMU and compared these directly with the Draft Harvest Strategy outcomes. These two sources of information have then been presented at TACC setting meetings where final recommendations on the OT for an SMU are determined by stakeholders.

The conduct and review of Draft Harvest Strategy outcomes in recent years has highlighted several deficiencies. The Draft Harvest Strategy relies primarily on CPUE data which, as previously described, is a positively biased measure of abundance. While the Tertiary indicator of pre-recruit abundance is useful, its influence on the final outcomes is limited and it cannot be implemented at the SMU scale under the new FIS structure. Until new FIS data are gathered that are representative of the fishery, the Tertiary Indicator will have no data to inform it at the SMU scale.

Of concern, the decision rules to determine limit, threshold and target values are limited in their effectiveness. In this current assessment, each of the seven SMUs has been above the threshold range for between 29 and 31 years which means that all SMUs are assessed under Catch Control Rule 1 (CCR1). Catch Control Rule 2 aims to reduce exploitation as stocks decline, however this is only enacted once the fishery has been below the threshold level for 5 consecutive years. Currently none of the SMUs are close to threshold levels, yet reductions in OT have been required at the SMU scale in recent years, including the industry decision to close the Petrel Point reefcode for 2023/24. Clearly, the Draft Harvest Strategy is not sensitive to the changes at the stock level that led to this closure and recent reductions in OTs at many other reefcodes.

As described above, the 2022 Draft Harvest Strategy suggested a Stable outcome for the Mallacoota West SMU, yet industry recommended the Island Point reefcode be closed and the Petrel Point reefcode halve its OT. While this provides clear evidence of the positive bias in CPUE which drives the assessment as the primary measure, it also reflects the difficulties associated with the timeframes of the Draft Harvest Strategy because data from 2022/23 are being used to establish TACCs for 2024/25. Future Harvest Strategies should consider the inclusion of some data from the current fishing year, even if it is not a full year of data.

As discussed in previous reports, the Draft Harvest Strategy requires review and further development. It has been proposed that MRAG provide a retrospective analysis of Harvest Strategy results in the form of a discussion paper to inform discussions among a Working Group that includes industry representatives. The FRDC Project 2019-118 “Drawing strength from each other: simulation testing of Australia’s abalone harvest strategies” includes an MSE of the current Draft Harvest Strategy for Central and Eastern Zones that is being finalised currently. The results from this study can also be used for the re-evaluation of the Draft Harvest Strategy through the Working Group. Also, Tasmania and South Australia have recently developed approaches to address hyperstability using diver logger data. The applicability of this approach for the Eastern Zone should be investigated.

5.1.3 Weight of evidence

The weight of evidence assessment is impeded by the same data uncertainties as the Harvest Strategy and Performance Indicators, particularly regarding the importance of CPUE as the primary data source. The FIS review has identified that historic FIS site locations are no longer representative of the current fishing grounds. The Top 15 sites provide some data for sites adjacent to the current fishing grounds, however these data need to be augmented with data from shallower sites to provide a reliable index of abundance at the Zone scale, across current fishing grounds. This year's report includes analysis of mean catch per day, which augments the assessment. Length frequency data from the commercial catch were only collected up to 2018/19 and length frequency data gathered during FIS include two sources of bias that mean they should be given little weight in the assessment of stock status.

5.2 TACC setting and Optimal Target catches

The TACC setting process occurs in December of each year for the Eastern Zone, around two thirds of the way through a current quota year. TACC setting is complicated by the lag in time between the assessment of stock status based on data from the previous quota year and the need to establish a TACC for the following quota year (i.e. a full year lag). In the last two years, informal assessments of up-to-date summaries of catch (SMU and reefcode) and CPUE (SMU only) have been provided at the TACC setting meeting, and it anticipated that this will occur again in December 2023. However, future assessment processes should aim to incorporate all available data into the assessment and TACC setting process in a formal manner. The key limitations to this approach will be the availability of data and the time required to assess it.

The 2023/24 closure of the Island Point reefcode and the halving of the OT at Petrel Point have clearly demonstrated deficiencies in the assessment process at identifying declines in localised abalone abundance. The Draft Harvest Strategy outputs this year have recommended a reduction in OT for the Mallacoota West SMU of up to 15%, but this falls well short of the 51% reduction that industry proposed and VFA agreed to during last year's TACC setting process. On this basis, during this period of uncertainty in the assessment, industry diver observations will remain a primary driver of the TACC setting process, at least until a more robust assessment framework is in place. In that context, industry's role as stewards of the resource and VFA's obligation to act precautionarily in the face of uncertainty will be particularly important until a more robust assessment framework is in place.

The 2022 Stock Assessment Report identified large discrepancies in catches and OTs at both the SMU and reefcode levels. These discrepancies continued at both spatial scales in this current assessment. Given the objective of quota setting for the Eastern Zone is to follow a "bottom-up" approach by determining sustainable levels of catch at the reefcode scale, it seems clear that a review of reefcode level catches is required. Appendix 8 provides a table of average catches in the last 4 years relative to the 2022/23 and 2023/24 Optimal Targets for each reefcode and SMU in the Eastern Zone. The analysis does not aim to directly identify SMUs or reefcodes that have been overcaught or under-caught; rather it demonstrates that catch distribution in recent years has not followed the OTs, particularly at the reefcode level. This table could be used by industry and VFA to make informed decisions regarding appropriate OTs at the reefcode scale.

5.3 Eastern Zone trends in available data

The commercial catch in the Eastern Zone for 2022/23 was 330.5 t, which was 94.3% of the TACC. Catches in recent years have been the lowest observed since commercial logbook data were gathered the fishery (from January 1969). The 2022/23 catch was 31% lower than that harvested in 2003/04 and 28% lower than that harvested in 2009/10. In recent years, the TACC has been higher than the agreed OTs due to carry-over provisions that resulted from the impacts of Covid-19 that impacted the 2020/21 catch. The TACC for the current 2023/24 season was 284.6 t, which did not include any carry-over catch.

Mean daily catch in 2022/23 was 388.9 kg/day, which was 9% lower than 2003/04 (426.5 kg/day), 10% lower than the 2009/10 (433.3 kg/day), and 13% lower than 2018/19 (445.7 kg/day). Mean daily catch has increased in the last two years following an historic low in 2020/21 of 277.5 kg/day which was influenced by catch limits resulting from Covid-19 impacts on the abalone market. However, it remains low in an historic context.

CPUE remains high in an historic context at 106.4 kg/h, which was 8% higher than 2003/04, 2% lower than 2009/10, and 11% lower than 2018/19. Effort for the fishery is around one third of the historic high levels, suggesting that divers have become more efficient at harvesting abalone over time. Standardisation of CPUE makes little difference in CPUE trends, implying that the current standardisation approach is unable to detect the changes in diver efficiency and changes in the distribution of effort, among other factors that may influence CPUE. A recent review of the standardisation approach (Dichmont et al 2022) was unable to determine an accepted alternative to the current approach. Inconsistencies in the data collected over time was a significant contributing factor.

FIS data were not collected in 2022. Following the outcomes of the FIS review, the “Top 15” sites were surveyed in 2023. These sites are not representative of the current fishery and therefore remain positively biased, however analysis from the review process identified these as the best of all sites historically surveyed. This was based on the fact that these sites had the highest densities of all sites and were adjacent to areas with high diving effort, albeit generally in slightly deeper water. Statistical analysis of FIS abundance trends suggested that the reduction in the total number of sites did not adversely affect precision of mean abundance trends at the zone scale. Recruit abundance at the Top 15 sites declined substantially from 2003 to 2008 before increasing the following two years. Thereafter recruit abundance has generally declined. Concerningly, recruit abundance in 2023 was the lowest recorded, declining by 20% from 2021 levels. While pre-recruit abundance has declined substantially since 2003, on a more optimistic note, pre-recruit abundance increased by 27% in 2023 and was the highest observed since 2017.

5.4 Eastern Zone Stock Status

The latest Status of Australian Fish Stocks (SAFS) assessment of the Victorian Eastern Zone Abalone Fishery is based on data up to and including 2019 (Mundy et al. 2021). The authors conclude *“For the periods 1995 to 2015 and 2012 to 2017, fishery independent and dependent performance measures respectively indicated that the biomass was declining, but not to the extent that the stock could be considered to have become depleted or recruitment impaired. In the last two years, both CPUE and recruit abundance have increased. Pre-recruit abundance has continued to decline and remains of concern, however it is reasonable to conclude that the status of the resource has stabilised and the likelihood of depletion to a level causing recruitment impairment in the near to medium term is low at the current precautionary TACC of 337.5 t [Dixon and Dichmont 2019b].*

On the basis of the evidence provided above, the Victoria Eastern Zone Fishery management unit is classified as a depleting stock.”.

The above assessment was based on the 2019/20 Stock Assessment Report. At that time, maintaining a relatively stable TACC appeared to be a reasonable conclusion on the basis that ongoing reductions in catch since 2012 (at an average of around 15 t per year over this period) appeared to have stabilised the FIS abundance measures and increased CPUE. However, circumstances in the fishery and its assessment have changed substantially since then.

Recent Stock Assessment Reports have discussed at length the uncertainty with the two biomass measures and their associated biases. Nominal CPUE is a poor measure of abalone abundance due to the impacts of hyperstability and the current standardisation approach makes little difference to CPUE trends. To demonstrate this, the reductions in OTs agreed to for the Eastern Zone at the 2022 TACC setting process were made despite Stable or Increasing Primary and Secondary Indicators (4-year and between year CPUE trends) of the Draft Harvest Strategy at all SMUs (Dixon et al 2022).

The FIS review (Dixon 2023) provided evidence that the historic FIS sites are no longer representative of current fishing grounds. This confirms that the decline in FIS abundance measures from 2003 to around 2010 represents serial depletion of the stocks in the offshore and mid depth reefs. Currently the fishery is reliant primarily on shallow water reefs that are not currently surveyed, although improvements in the survey design are underway. Therefore, at this time FIS trends present a negatively biased assessment of stock status. Until data are gathered from shallow water reefs, there is no reliable way to determine the relative contribution of deep and mid water reefs to shallow water reefs historically, and therefore neither total or relative biomass estimates for the entire stock can be made.

As described in Section 4.3 above, the majority of data that are available for the weight of evidence assessment look pessimistic for the fishery. Total catch for the zone was 20 t below the TACC. CPUE has declined over the last three years at most SMUs, with >5% decreases between 2021/22 and 2022/23 that led to Decreasing Final categories in the Draft Harvest Strategy at 6 of 7 SMUs. Mean daily catches are at low levels from an historic perspective. Trends in FIS data at the Top 15 sites adjacent to the main fishing areas showed substantial reductions in the abundance of recruits across the zone. On a positive note, there was an equally substantial increase in pre-recruit abundance.

The factors affecting the Eastern Zone stock over the last two decades appear to have affected most, if not all, Australian abalone stocks. The reductions in biomass observed in the Eastern Zone have likely resulted from reduced recruitment over a prolonged period. In addition, sea urchins have increased in abundance and have reduced the available habitat for abalone. Nevertheless, while factors outside of the control of the fishery have impacted stocks, the management of catch is the only reliable tool available to the fishery to maintain sustainability.

In summary, the previously positive assessments on stock status from 2020 and 2021, that were based on increasing CPUE and stable FIS abundance measures, appear to have been misleading. In the 2022 report, the assessment was more concerning, concluding that the stable catches in recent years were likely to have further impacted on an already declining biomass. Reductions in the TACC were recommended, and were implemented, for the 2023/24 quota year despite stable Draft Harvest Strategy results. Given this year's assessment is based on data from 2022/23, the impact of the TACC reductions on the biomass are currently unknown. As summarised above, the weight of evidence assessment is pessimistic for the fishery, and the Draft Harvest Strategy results suggest that reductions are required at all SMUs except the Airport, based primarily on >5% declines in CPUE from 2021/22 to 2022/23 at these SMUs. However, the Airport SMU has exceeded its combined base OT by 30 t in the last two years, and this is likely to result in reduced performance in the next few years. The four-year trends in CPUE were declining across all SMUs, however only the Mallacoota West SMU was >5%. Across the weight of available information, further reductions in the TACC appear necessary to prevent further decline in biomass. Individual diver observation reports will be important in informing where reductions are needed and to what magnitude. The status of the Eastern Zone stock remains 'declining'. It is not possible to determine how close the stock is to a point where future recruitment may be impaired, however the risk is not negligible.

5.5 Future Monitoring and Research

The research, assessment and management framework for the fishery is currently undergoing a period of critical review and development. Reviews of CPUE measures and the FIS program have been in progress for two years and one year, respectively. The need for other reviews has been identified, including review of performance measures, Draft Harvest Strategy, and the Management Plan. Indeed, the stock assessment process itself needs to adapt and evolve as the management framework changes. The FIS Review Working Group proved to be an effective process that had industry representation from each of the three zones. A similar Working Group is expected to be continued to address other key issues for the fishery, including the above reviews. Industry participation in the research planning process will be critical in improving the assessment framework, and engendering acceptance of its outcomes.

A key source of data for future assessments will be commercial logger data that can provide spatial assessments of effort and size structure of the catch. In addition, depth and water temperature data could be gathered through a depth logger program. These data have been routinely gathered in the Western and Central Zones for several years, as well as other abalone producing States. Increasingly, commercial logger data are being formally included into the assessment process in other States, and the establishment of these programs must be an urgent priority for the Eastern Zone.

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Appendix 1: Summary of LML changes

Summary of changes in LML for the Eastern Zone. All measurements are in millimetres. Multiple LMLs indicate different LMLs for reefcodes within an SMU. LMLs on 1 April 1998 continue to be the current legislated LMLs. All other changes are voluntary.

Date from	Marlo	Mallacoota West	Mallacoota Large	Mallacoota Central	Mallacoota Small	Airport Undersize	Airport	Mallacoota East
1 Apr 1998	120	120	120	120	110 & 120	110	120	110 & 120
2 Mar 2009	120	120	120	120	110 & 120	110	120	120
1 Apr 2009	120	120	120	120	110 & 120	110 & 112	120	120
1 Apr 2010	120 & 127	127	127	127	110 & 120	110 & 112	120	120
1 Apr 2011	120 & 125	125 & 127	138	127	110 & 120	110	120	120
1 Apr 2012	120 & 125	125 & 127	138	127	110 & 115	110 & 115	120	120
1 Apr 2013	120 & 125	125 & 127	138	127	110 & 115	110	120	120
1 Apr 2015	120 & 125	120 & 127	138	123 & 127	115	110	120	120
1 Apr 2017	120	125	138	125	115	110	120	120
1 Apr 2019	120	125	135	125	115	110	120	120

Appendix 2: Correlation between nominal CPUE and nominal FIS recruit abundance.

6.1.1 Comparison of CPUE and FIS data

The Hart (2017) review examined correlations between CPUE and FIS abundance. Among his conclusions, the author reported "*Close agreement also occurred between the recruit abundance index from the FIS programme and the commercial fishery catch rates….The correlation of these two indices means there is redundancy in the abundance indices available for assessment.*" The Hart (2017) analysis was based on data from all three Zones combined for the period 2003 to 2016.

In recent Stock Assessment Reports for the Eastern Zone, trends in CPUE and FIS abundance measures provide conflicting messages regarding the status of the stock at the Zone and SMU scales. To address this issue, we compared the three nominal measures at the SMU and Zone (bottom right) scales relative to the average of each series for ease of comparison (i.e. the grey dashed line = 1, Figure 52). The standardised trends are essentially the same as the nominal, except the series is shorter. FIS data were not gathered in 2022, so the following results were based on data up to and including 2021.

The two measures that are comparable are commercial CPUE and FIS recruits. If both were representative of the harvestable biomass, these should be highly correlated, as was found by Hart (2017). However, the figures above provide a strongly contrasting view. In all cases, CPUE has continued to increase over time. While CPUE declined from 2013 to 2016 to average levels, the rapid increases in recent years result in CPUE being around its highest contemporary levels. In contrast, recruit abundance is currently at its lowest levels at all spatial scales except for the Airport SMU, where recruit abundance is currently at the average. In general, recruit abundance was highest in the early 2000s then declined rapidly over the next decade. Thereafter, recruit abundance has stabilised at some SMUs and continued to decline slowly at others. Critically, the rapid decline observed in FIS recruit abundance was not reflected in CPUE which continued to increase until 2013, despite catches from 2003 to 2008 being the highest observed during this period (i.e. 1992 to 2021).

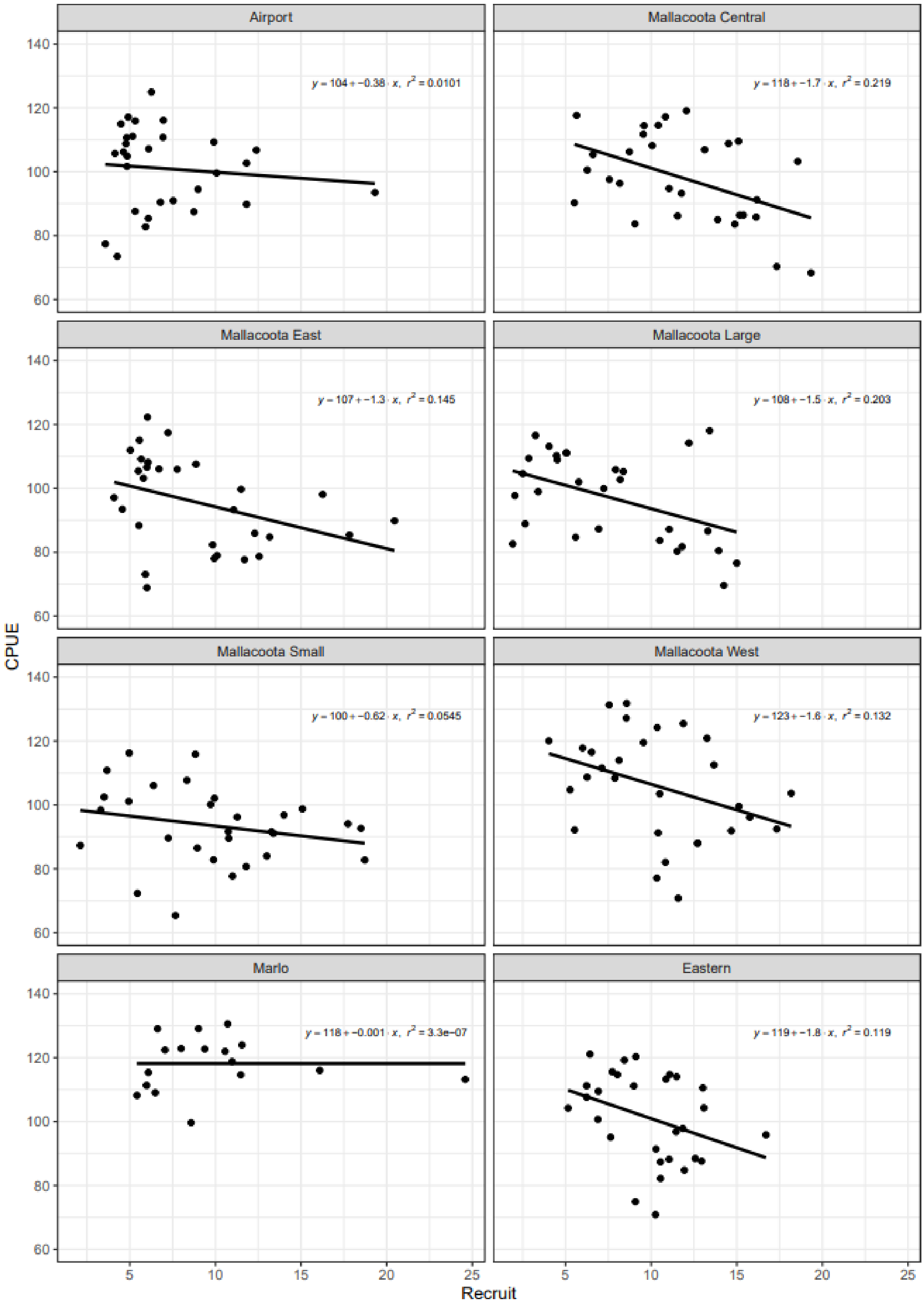
To explore the relationship between CPUE and FIS recruit abundance, we repeated the analysis of Hart (2017) for each SMU and for the Eastern Zone (Appendix 3). In his review, Hart reported a significant positive correlation between higher CPUEs and higher FIS abundance during the period

2003 to 2016 across all three Zones combined. However, using the full period of available data (1992 to 2020) and the same time series as Hart (2003 to 2016) for each SMU and for the Eastern Zone, we found no correlation at any spatial or temporal scale. It should be noted that for both analyses in this report, FIS recruits are measured consistently over time against the LML (i.e. 110 or 120 mm) whereas CPUE has been affected by voluntary size limit increases in some SMUs. This implies that the trends should be even more exaggerated than those observed.

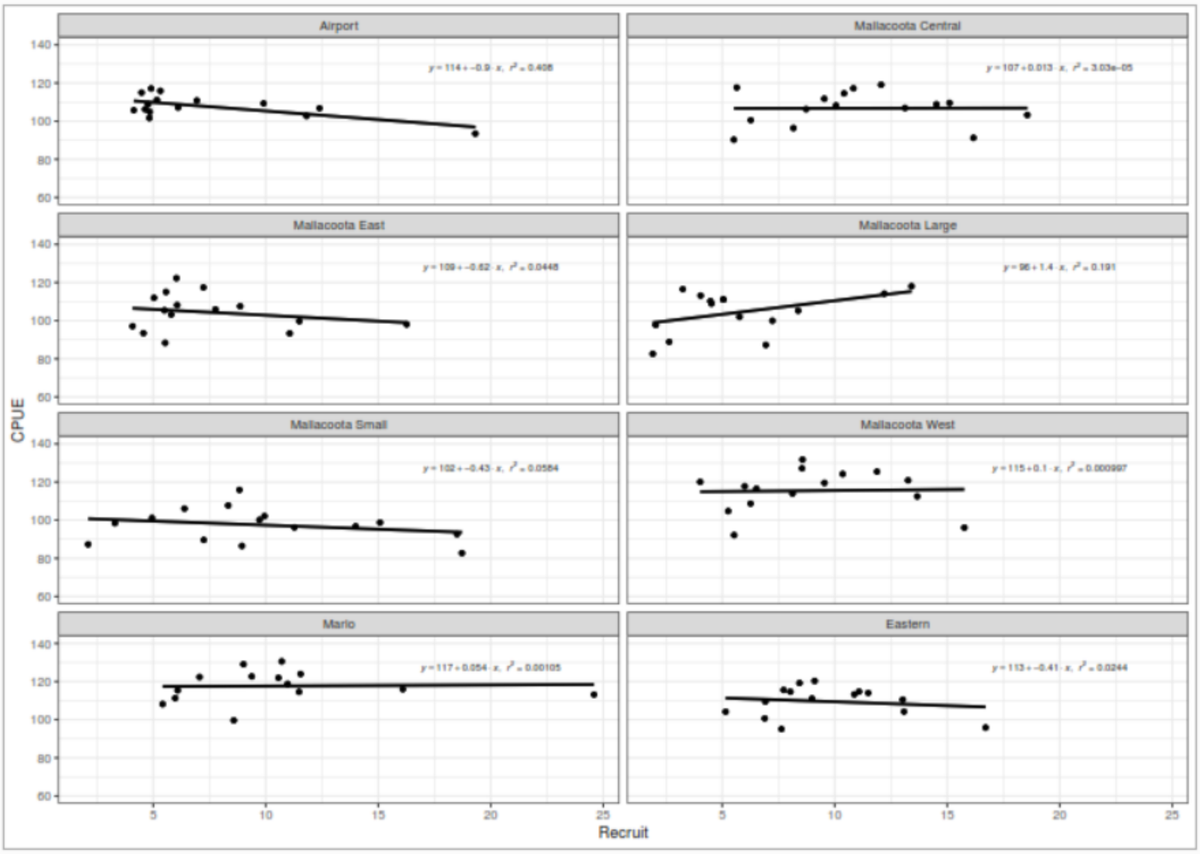
FIS pre-recruit abundance has declined at all SMUs except Mallacoota Small and is more pronounced at SMUs with higher LMLs that are assumed to be reflective of faster average growth rates (Figure 52). The magnitude of the overall decline in pre-recruits has generally been more severe than for recruit sized abalone across the time series. At the Zone scale, the steepest decline in pre-recruit abundance occurred from 1999 to 2006 and appears to be a precursor to the sharp decline in recruit abundance from 2003 to 2008 observed at these sites. While the decline in pre-recruit abundance appears to have slowed in the last 7 years, concerningly it remains a significant declining trend.

These opposing trends in the two primary data sources (rising commercial CPUEs despite substantial declines in abundance at survey sites) together with the possibility that survey sites are not representative of the main contemporary fishing grounds, severely compromises the current assessment of stock status.

Relative trends in nominal commercial CPUE, nominal FIS recruits and nominal FIS pre-recruits from 1992 to 2020 for each SMU and for the Eastern Zone as a whole. Grey dashed line represents the average for each series.



Comparison of nominal commercial CPUE (kg/h) and FIS recruit abundance (no. per site) from 1992 to 2020 for all SMUs and the Eastern Zone (bottom right).



Comparison of nominal commercial CPUE (kg/h) and FIS recruit abundance (no. per site) from 2003 to 2016 for all SMUs and the Eastern Zone.

Appendix 3: Comparison of size structure data gathered in FIS since 2003.

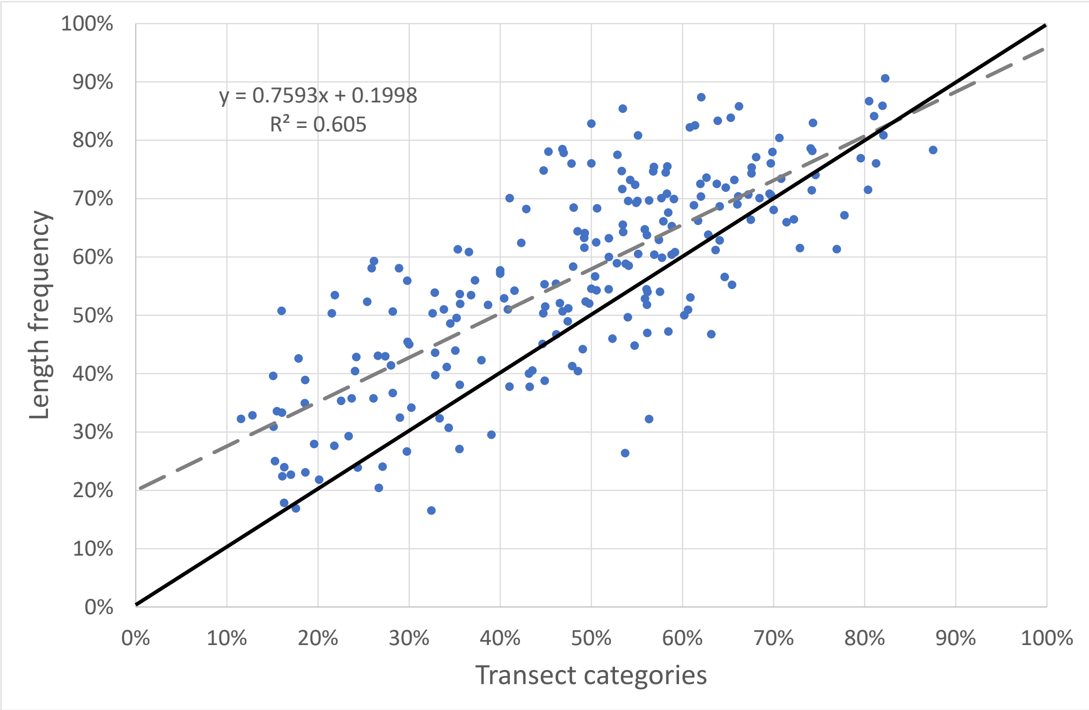
The manner in which length frequency data were gathered from historic FIS changed considerably over time. Originally, all abalone encountered on a transect were collected and brought to the surface to be measured before being returned to the bottom at the same site. This approach was modified when concerns were raised that collecting abalone from within the site may affect the abundance within the site the following year. On this basis, from 2000/01 all abalone encountered on transects were instead counted *in situ* in size categories (VFA 2019). At the end of each transect, divers were then instructed to collect the first 25 abalone randomly encountered. VFA (2019) state "*At the end of each transect 25 abalone are collected as far as possible without bias".* On this basis, it appears the objective of the random collection was to gather an independent length-frequency sample that was representative of the surveyed population within transects.

To examine how well the length frequency samples reflected the abundance on transects by size category, we converted the length-frequency data into recruit and pre-recruit abundances and compared the proportion of recruits versus pre-recruits (juvenile counts were excluded) for each data source from data gathered for the Eastern and Central Zones between 2017 and 2020. To reduce the variation in these results, sites were excluded if the total abundance encountered on transects was less than 50 abalone, which approximately halved the number of data points available for the analysis to 222 total. As a result of this reduction, the total counts from length frequency samples ranged between 95 and 158 per site.

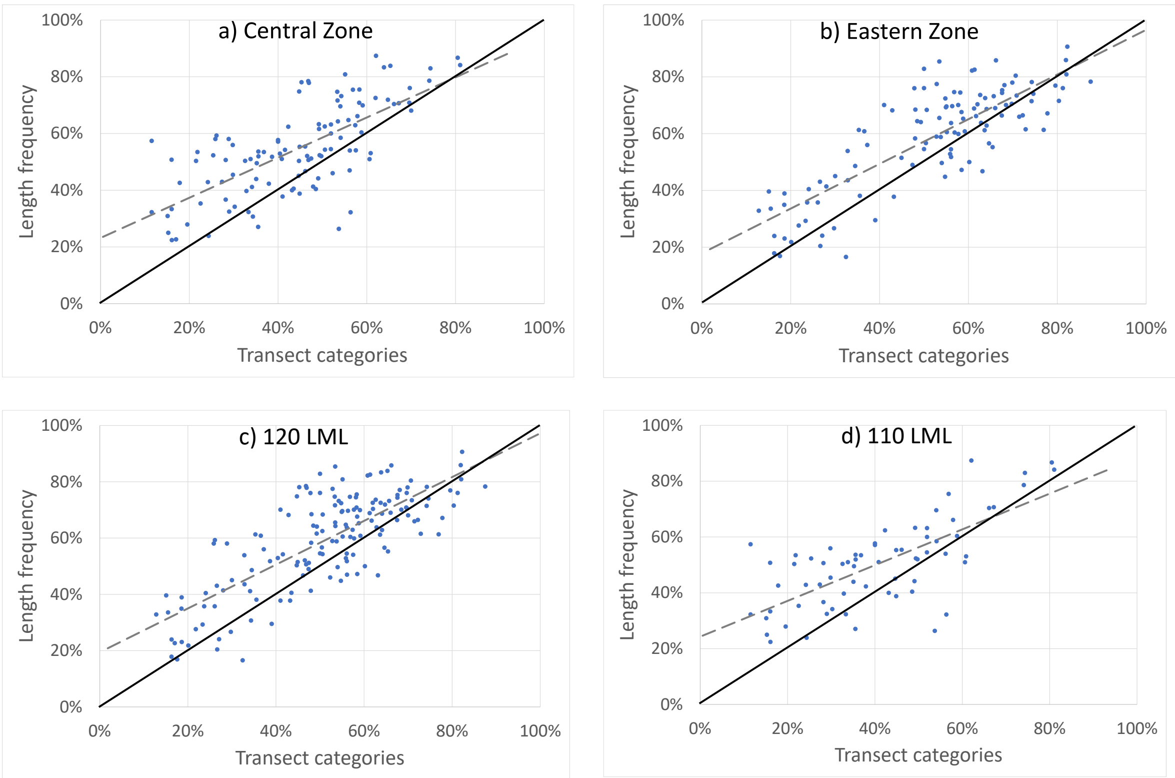
Figure 2 shows the proportion of recruits versus pre-recruits expressed as percentage of recruits for all data combined. The dashed grey line represents the line of best fit for these data. The solid black line that runs from the origin of the axis should be the theoretical line of best fit if there was no bias in these data collection methods. Clearly, there is a strong bias towards collecting larger abalone (i.e. recruits) when gathering length frequency samples at the end of each transect. This bias is strongest when the proportion of recruits observed during transects is low. Figure 3 breaks the dataset into Central and Eastern Zones, and the size limits 110 and 120 mm. The same bias exists at all spatial scales. Interestingly, data gathered from the Central and Eastern Zones were gathered by two different groups of research divers during this period, yet both showed the same trends suggesting this is more to do with the methods of data collection than the individuals involved.

It is considered unlikely that bias in size structure would result from the in situ transect counts as abalone are encountered in a systematic manner. This is supported by Gorfine (1998) who states "*Because the application of radial transacts avoids targeting some emergent abalone to the exclusion of others, there is less potential for divers to bias their sample towards larger abalone as may occur with time searches…. Time searches do not necessarily permit this separation of pre recruits from post recruits because of the potential for divers to collect larger, more accessible abalone at the expense of smaller abalone".* It seems logical to conclude that the bias in length frequency counts has resulted from divers collecting in the manner of a timed-swim and not "*as far as possible without bias*".

The bias suggests that caution should be applied in the analysis of trends in length frequency data gathered from historic surveys, including the pre-recruit measure in the Harvest Strategy. Further, if independent length frequency samples are to be gathered away from fixed transects in any future surveys, strict methods for collection must be applied to ensure a systematic, unbiased, representative size structure is attained.



The proportion of recruits versus pre-recruits, expressed as percentage of recruits. The dashed grey line, equation and R squared represents the line of best fit for these data. The solid black line that runs from the origin of the axis should be the theoretical line of best fit if there was no bias in these data collection methods.

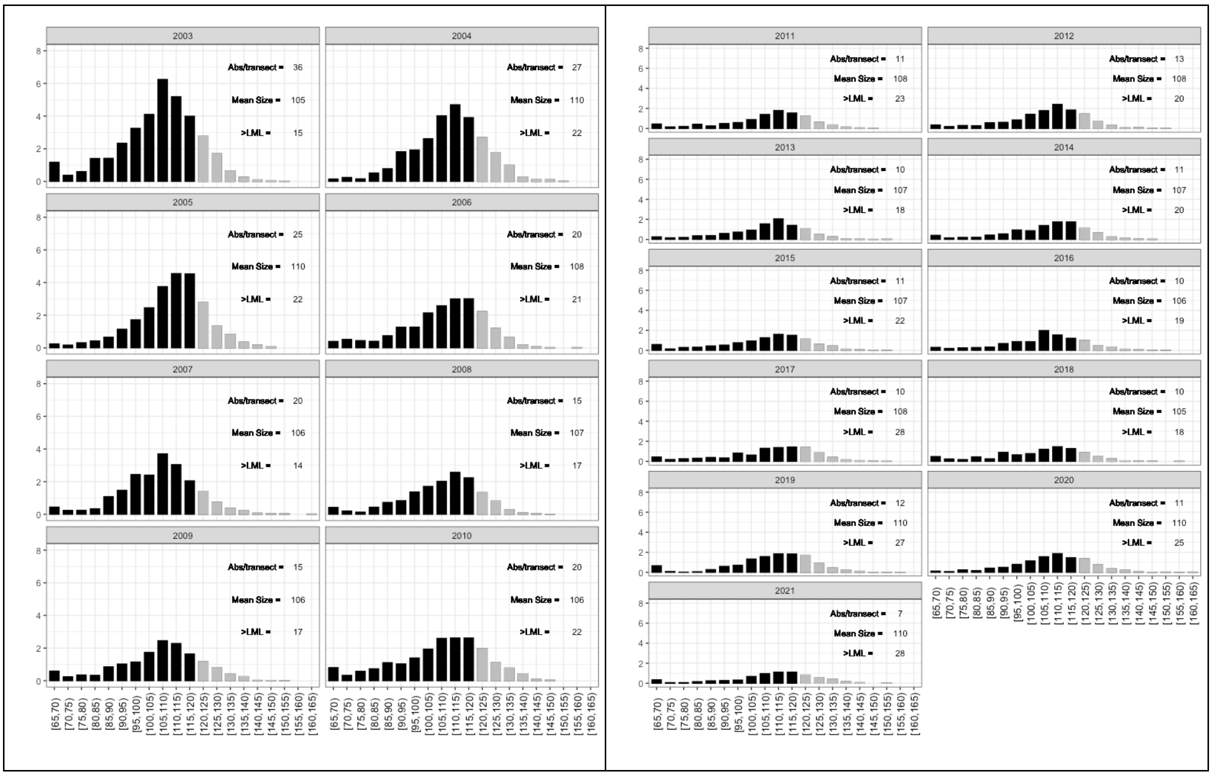


The proportion of recruits versus pre-recruits, expressed as percentage of recruits for a) Central Zone, b) Eastern Zone, c) 120 mm LML and d) 110 mm LML. The dashed grey line represents the line of best fit for these data. The solid black line that runs from the origin of the axis should be the theoretical line of best fit if there was no bias in these data collection methods.

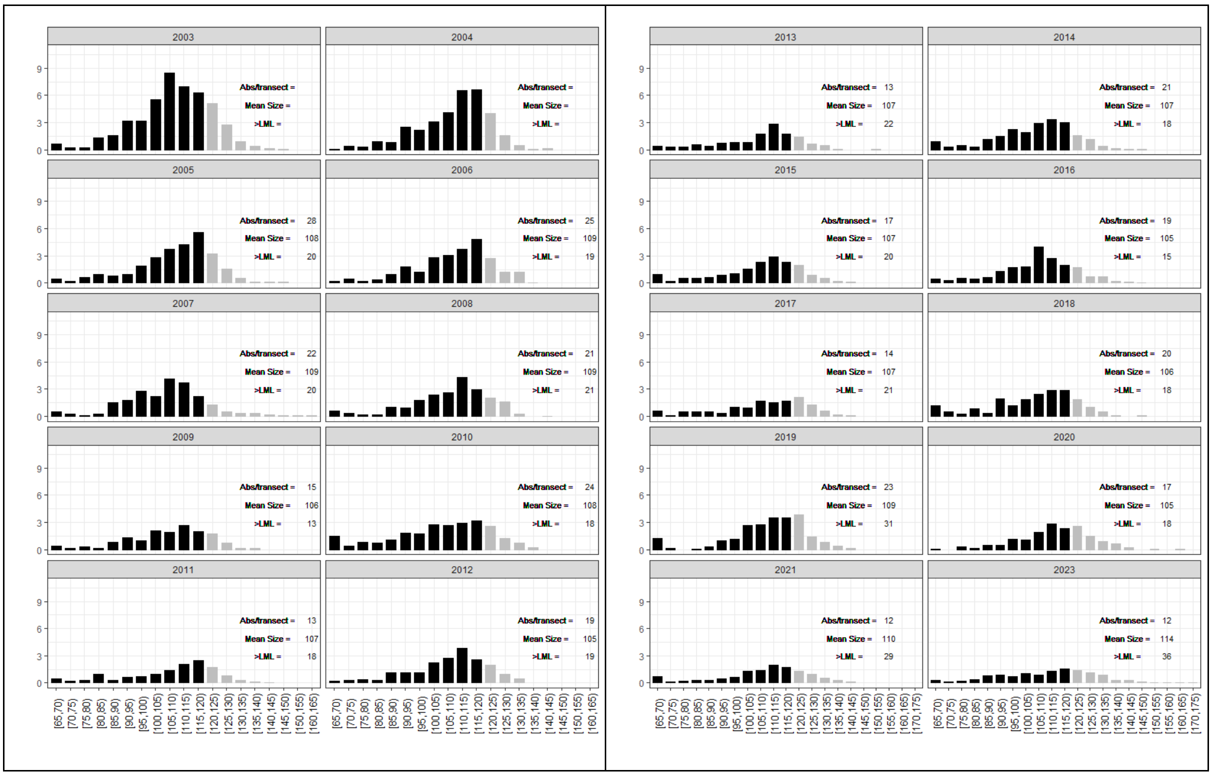
Appendix 4: FIS length frequency data for (a) all sites and (b) Top 15 sites at each SMU

Size frequency distributions for the Airport SMU from (A) 2003 to 2021 for all sites and (B) from 2003 to 2023 for the three Top 15 sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022. Note scales differ slightly.

(A)

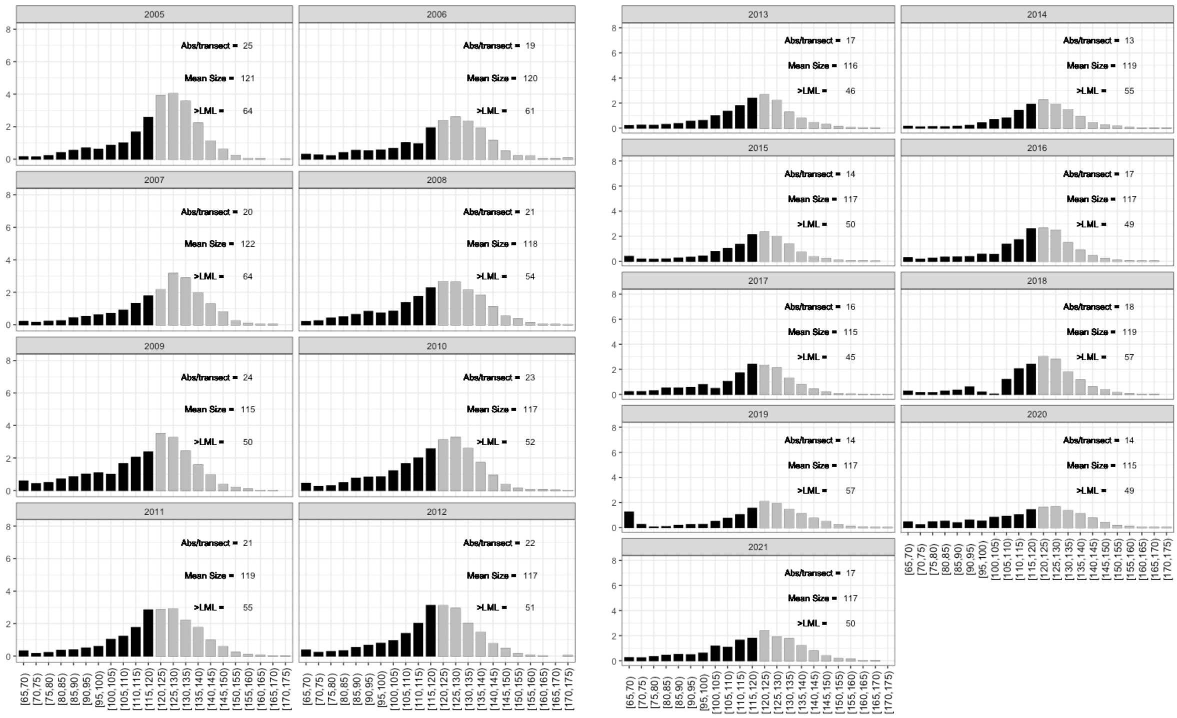


(B)

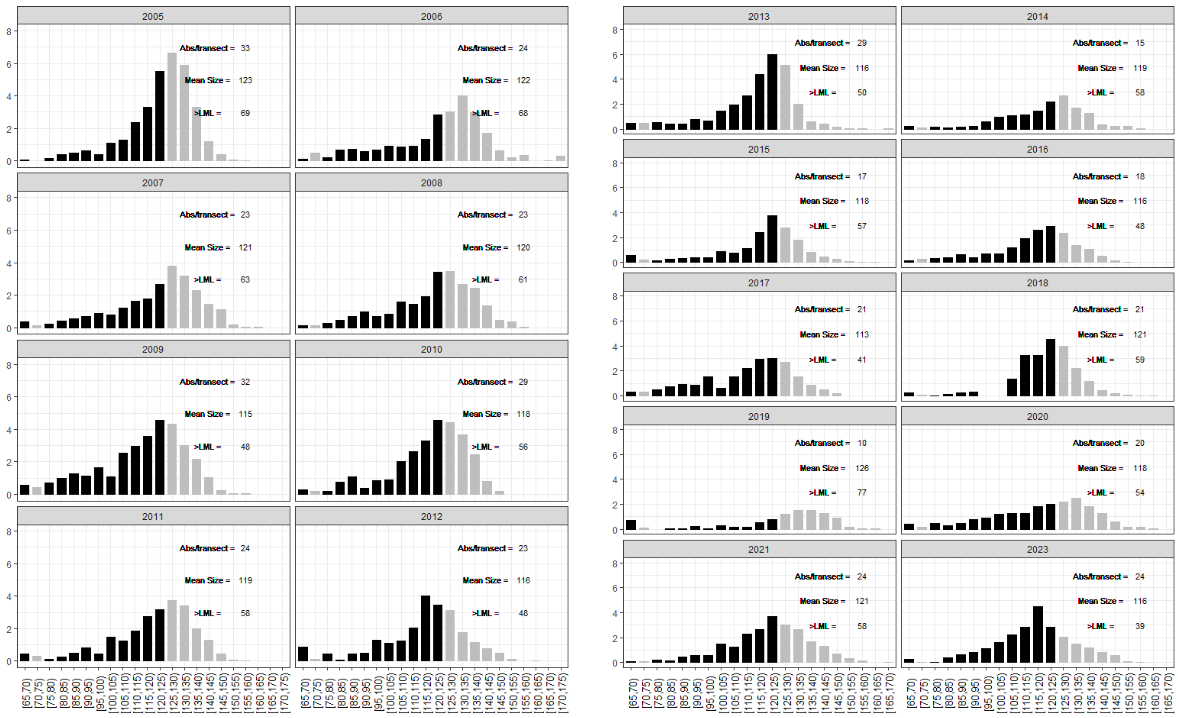


Size frequency distributions for the Marlo SMU from (A) 2003 to 2021 for all sites and (B) from 2003 to 2023 for the four Top 15 sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022.

(A)

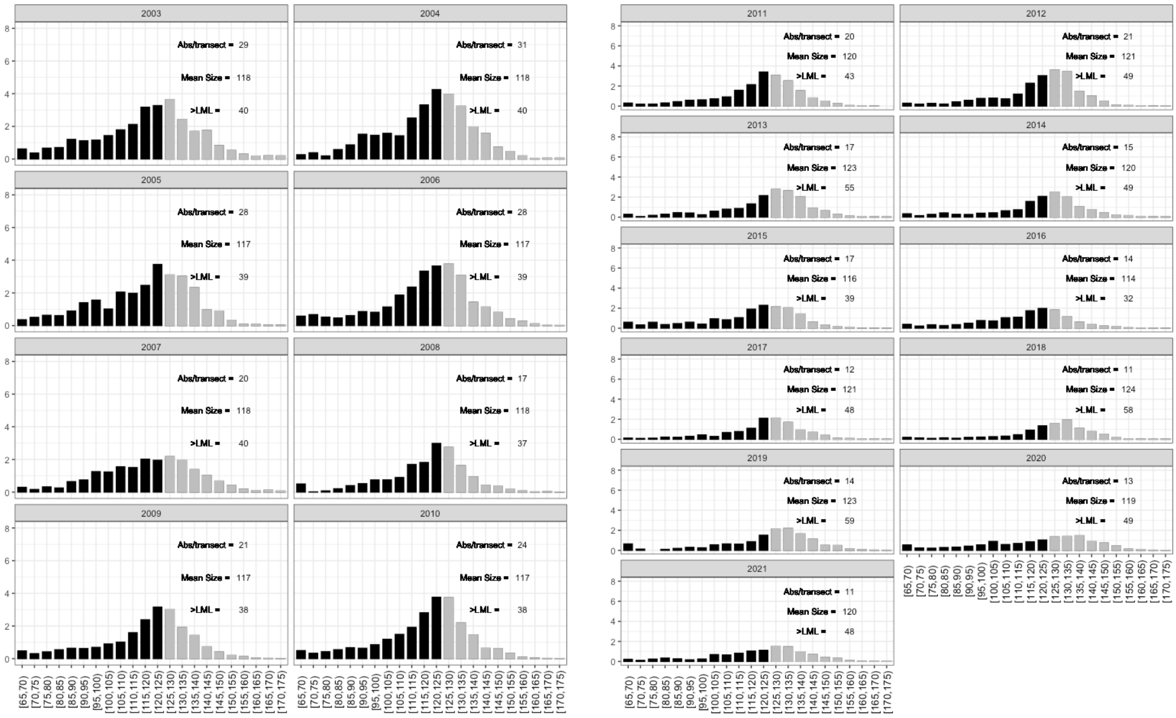


(B)

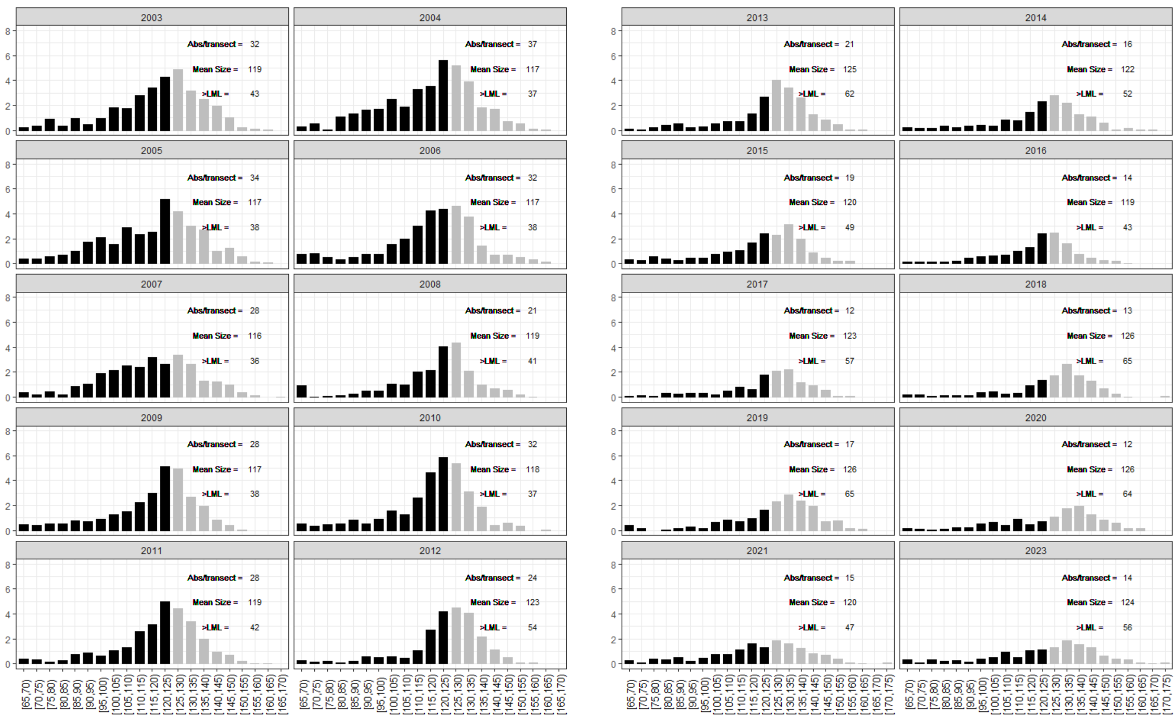


Size frequency distributions for the Mallacoota Central SMU from (A) 2003 to 2021 for all sites and (B) from 2003 to 2023 for the three Top 15 sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022.

(A)

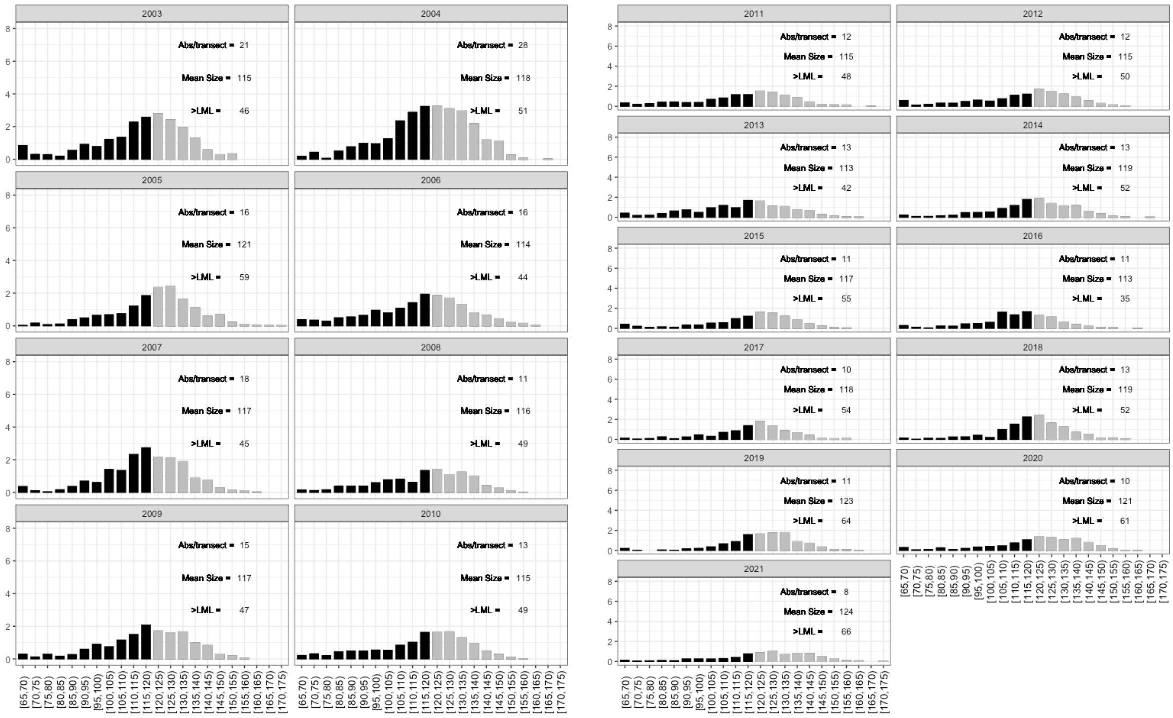


(B)

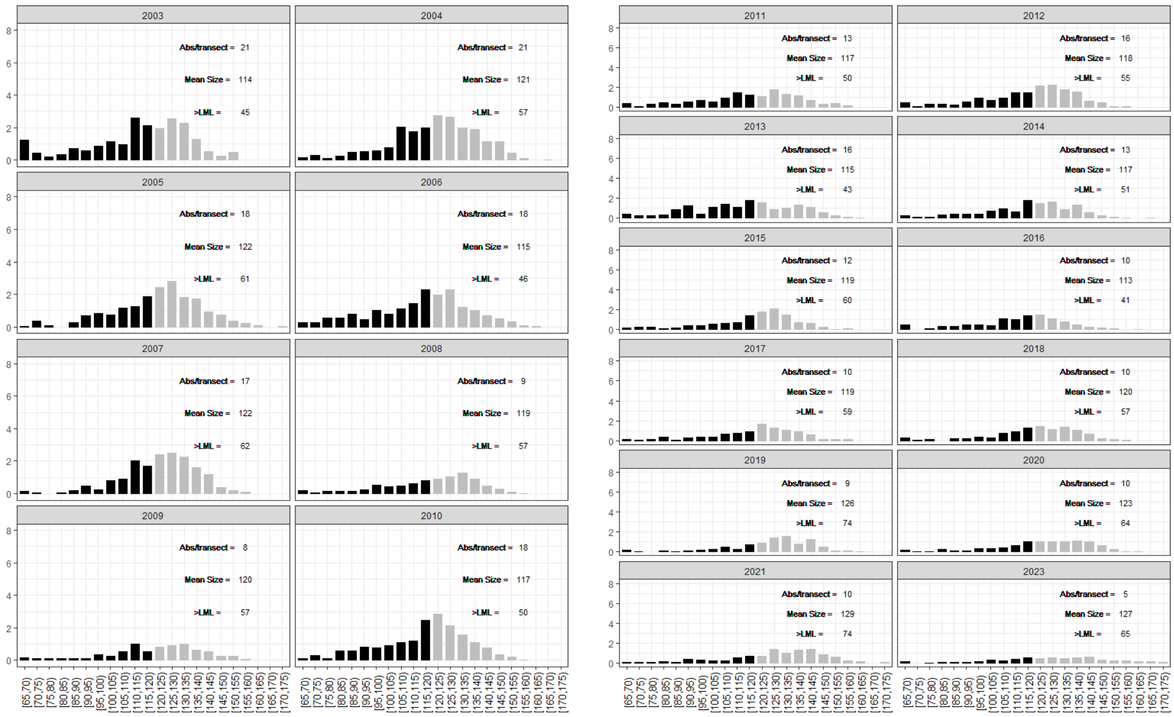


Size frequency distributions for the Mallacoota East SMU from (A) 2003 to 2021 for all sites and (B) from 2003 to 2023 for the two Top 15 sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022.

(A)

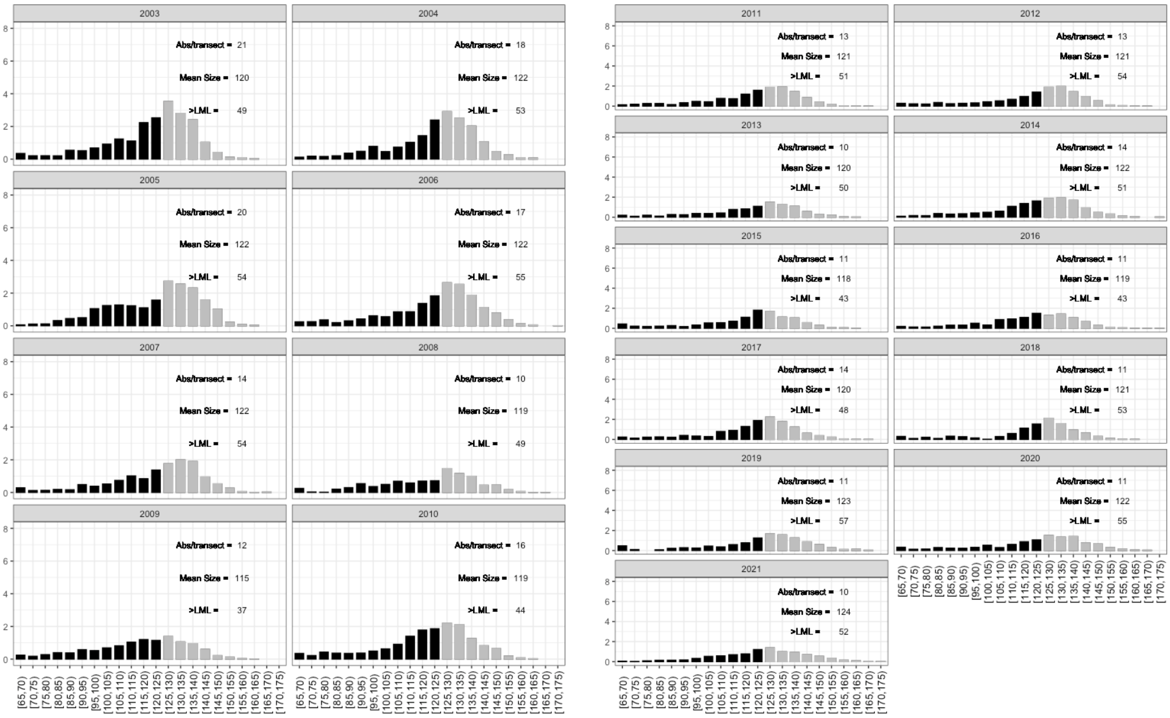


(B)

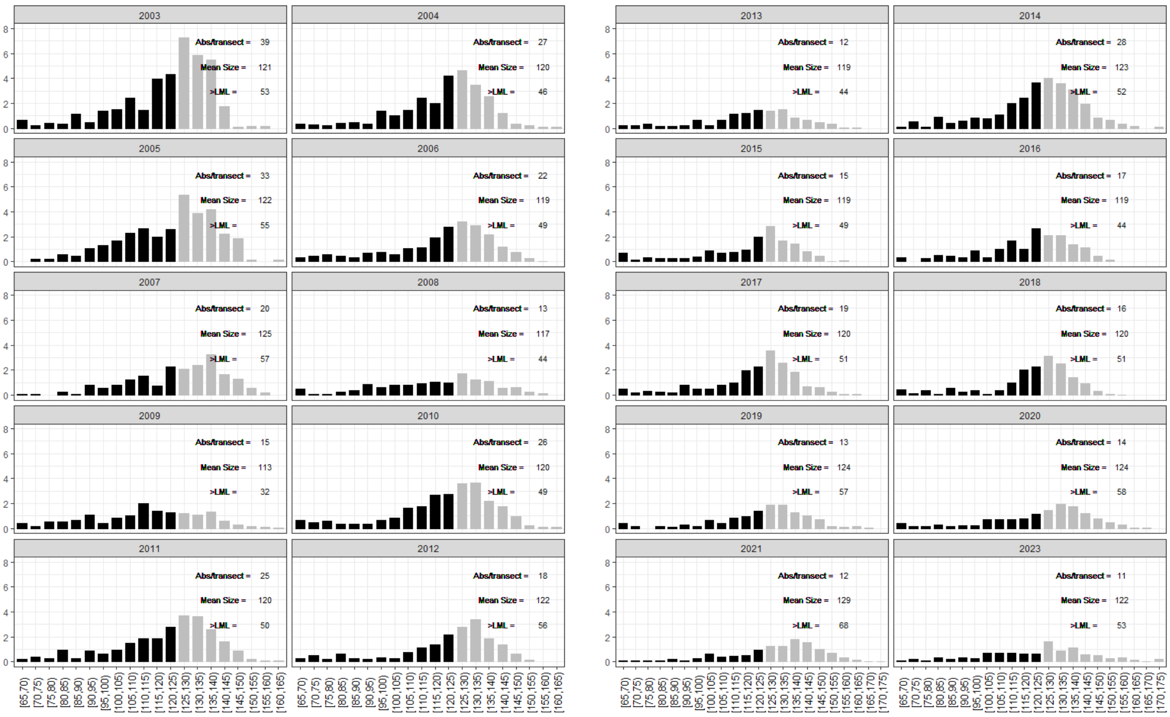


Size frequency distributions for the Mallacoota West SMU from (A) 2003 to 2021 for all sites and (B) from 2003 to 2023 for the two Top 15 sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022.

(A)

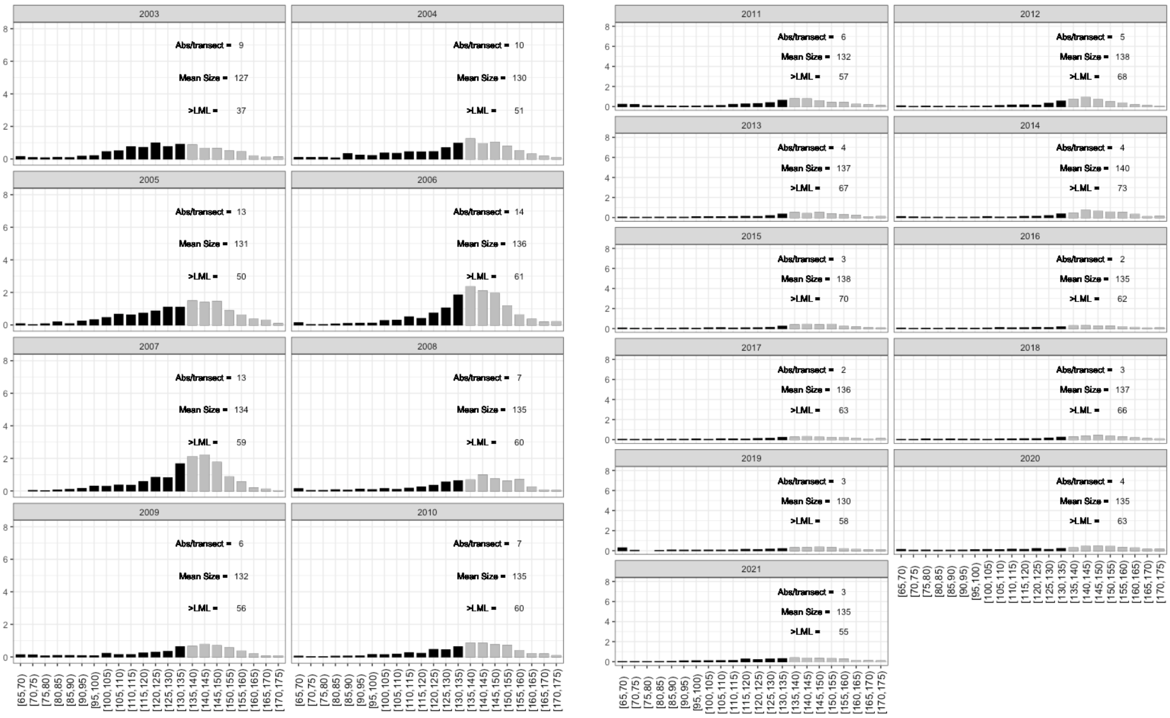


(B)



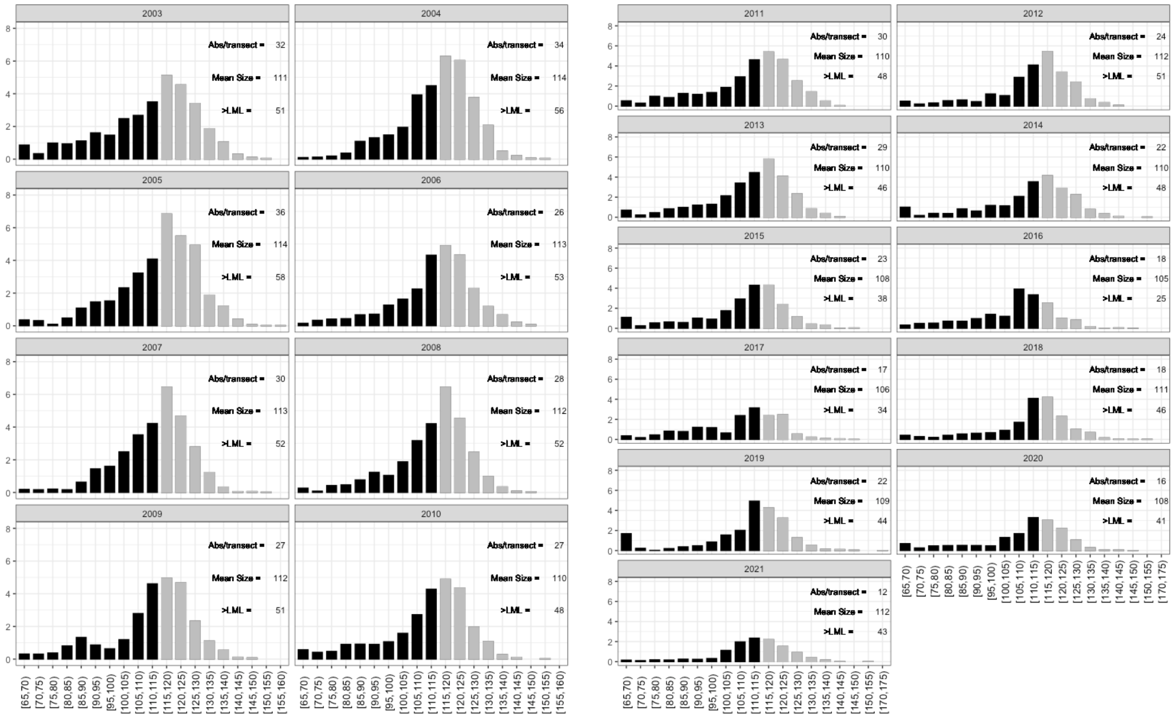
Size frequency distributions for the Mallacoota Large SMU from 2003 to 2021 for all sites There were no Top 15 sites done in the Mallacoota Large SMU in 2023. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022.

(A)

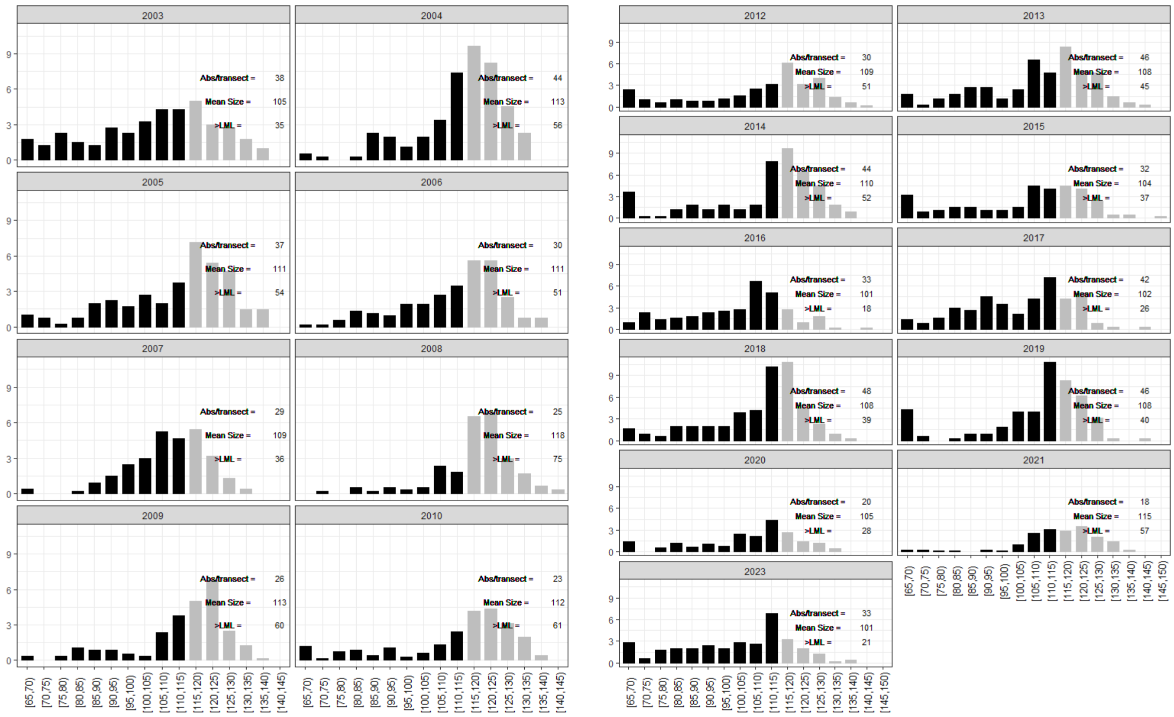


Size frequency distributions for the Mallacoota Small SMU from (A) 2003 to 2021 for all sites and (B) from 2003 to 2023 for the two Top 15 sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022. Note the scales differ slightly.

(A)



(B)



Appendix 5: Commercial length frequency data for each SMU

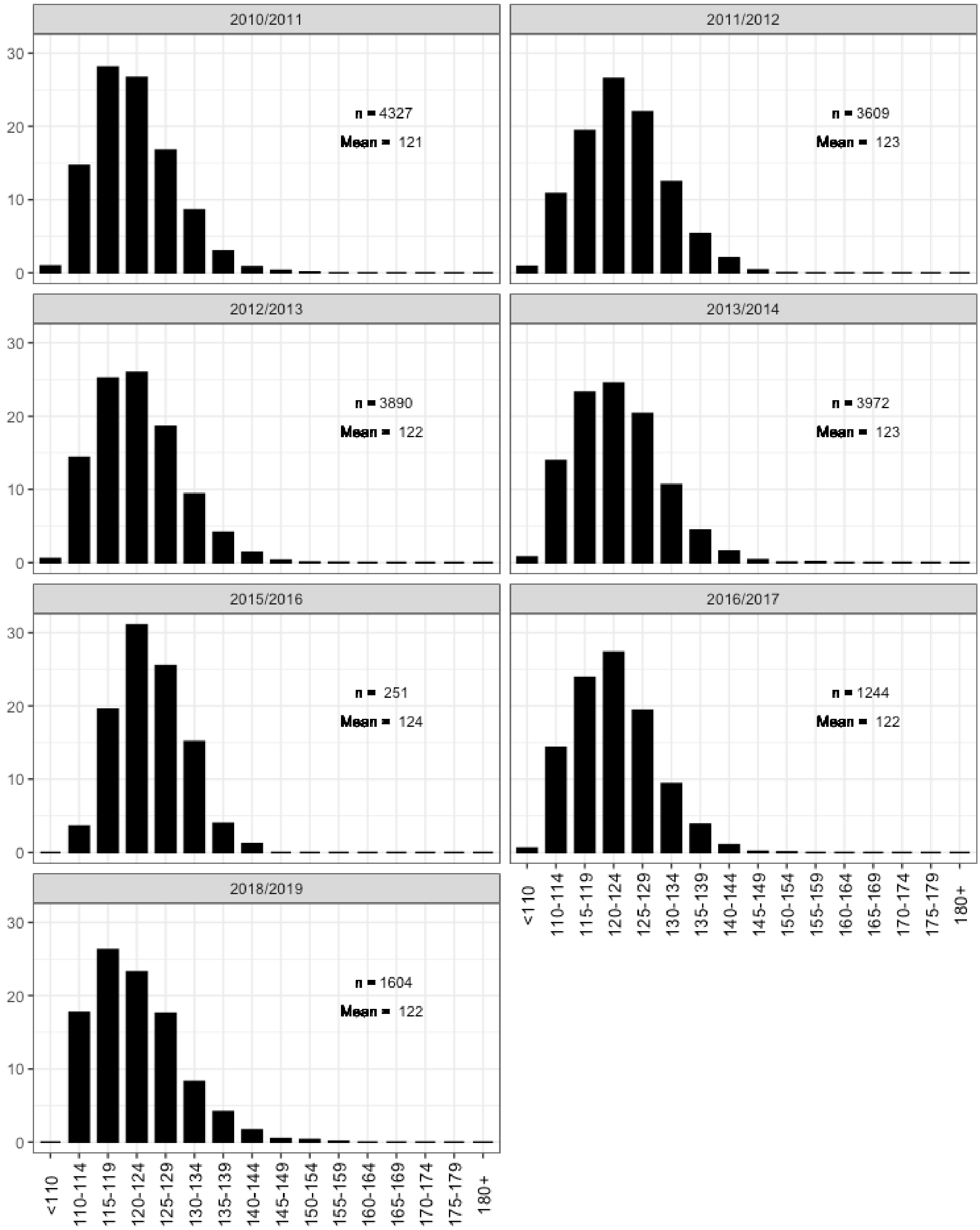
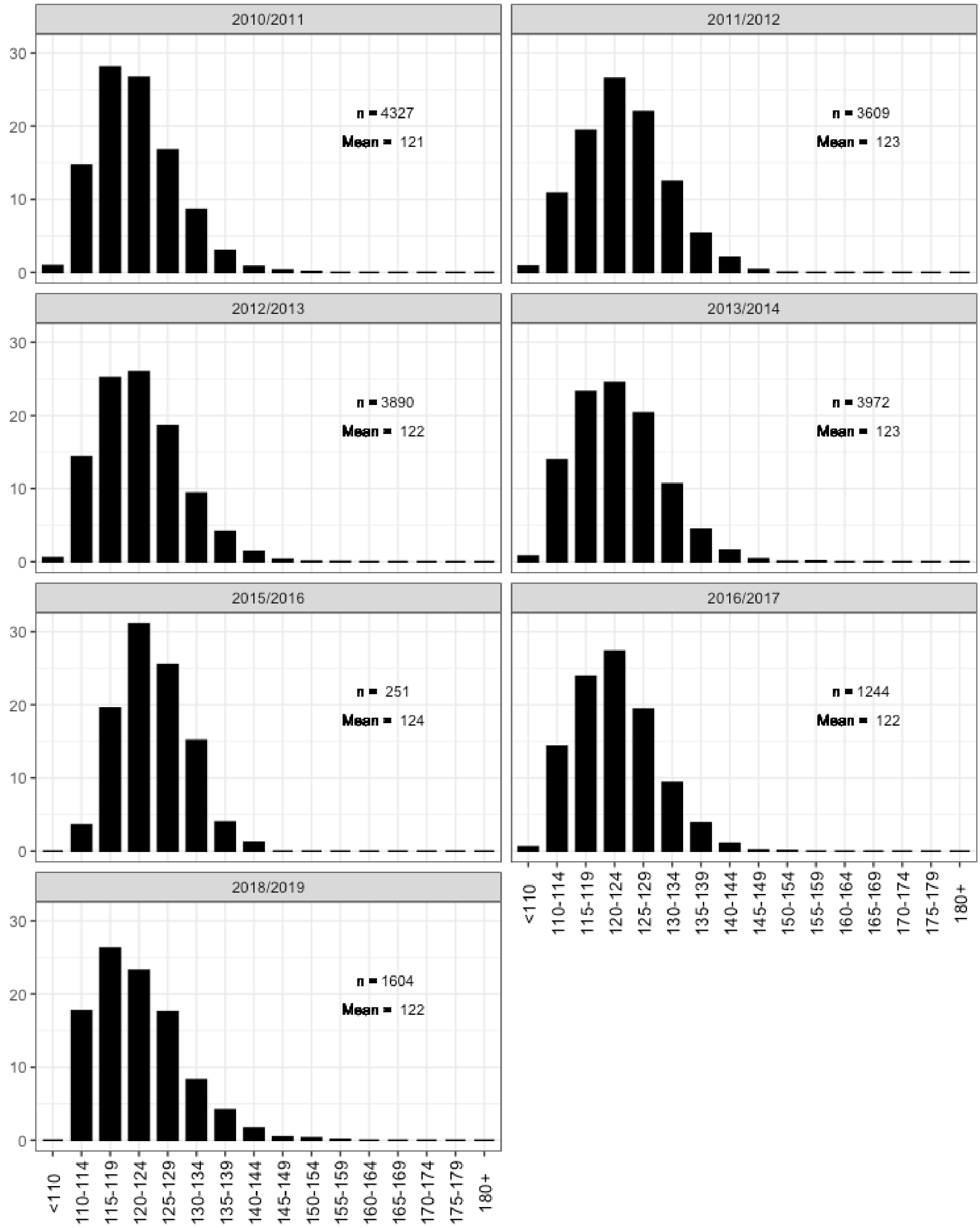
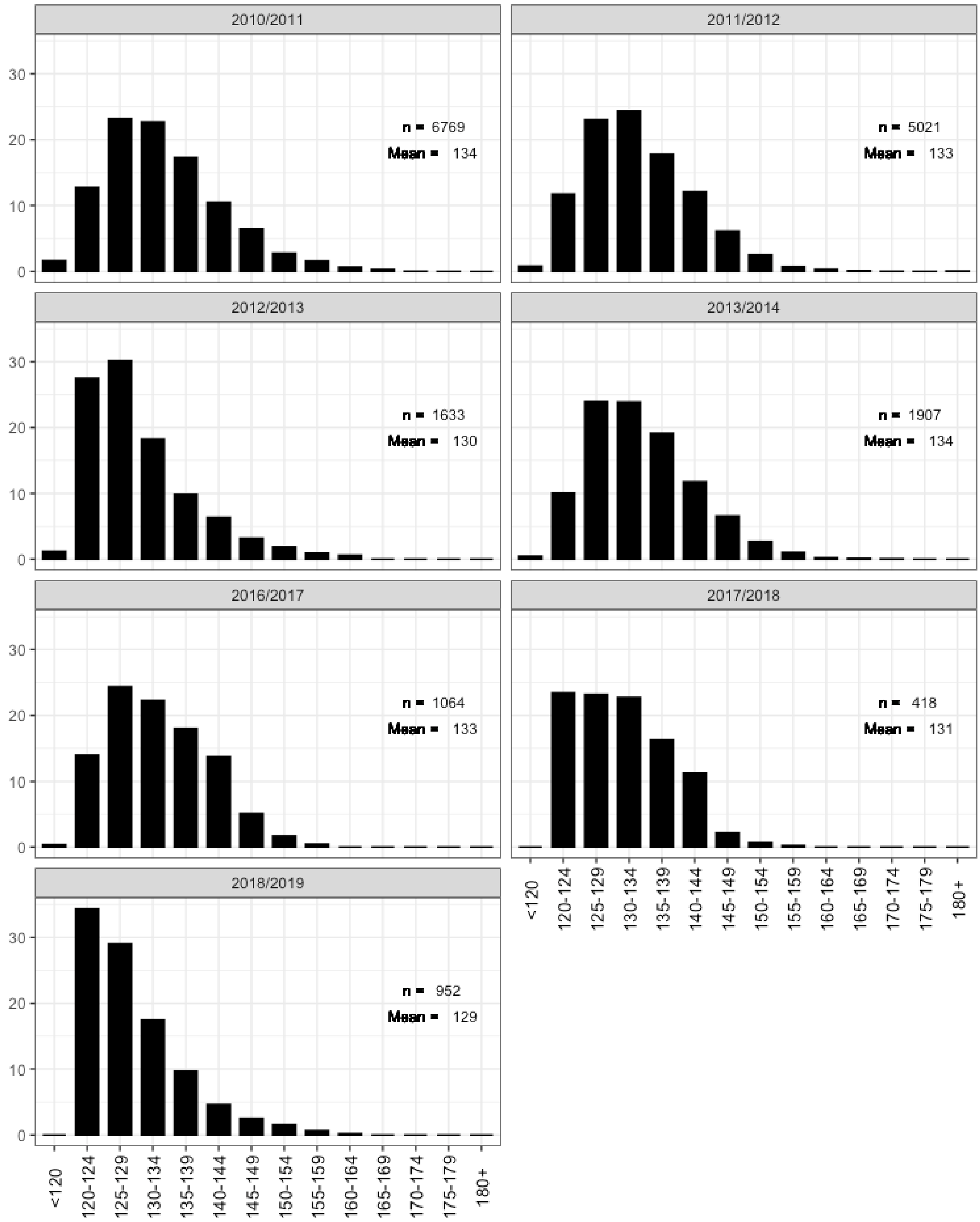


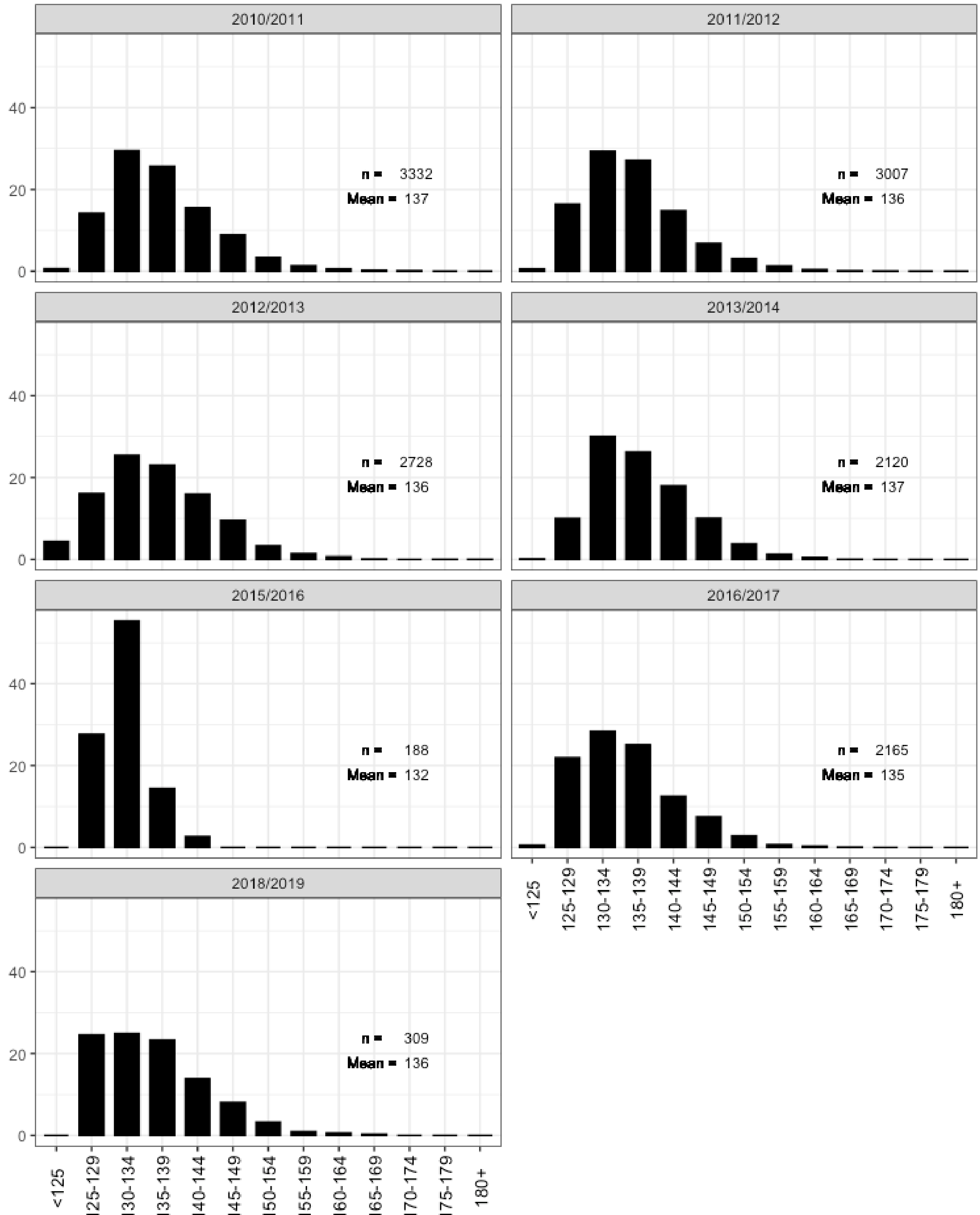
Figure 9: Size frequency distributions for the Airport SMU from commercial catch sampling from 2011 to 2022. 'n' is the number of abalone measured, 'Mean' is the mean size of the samples.



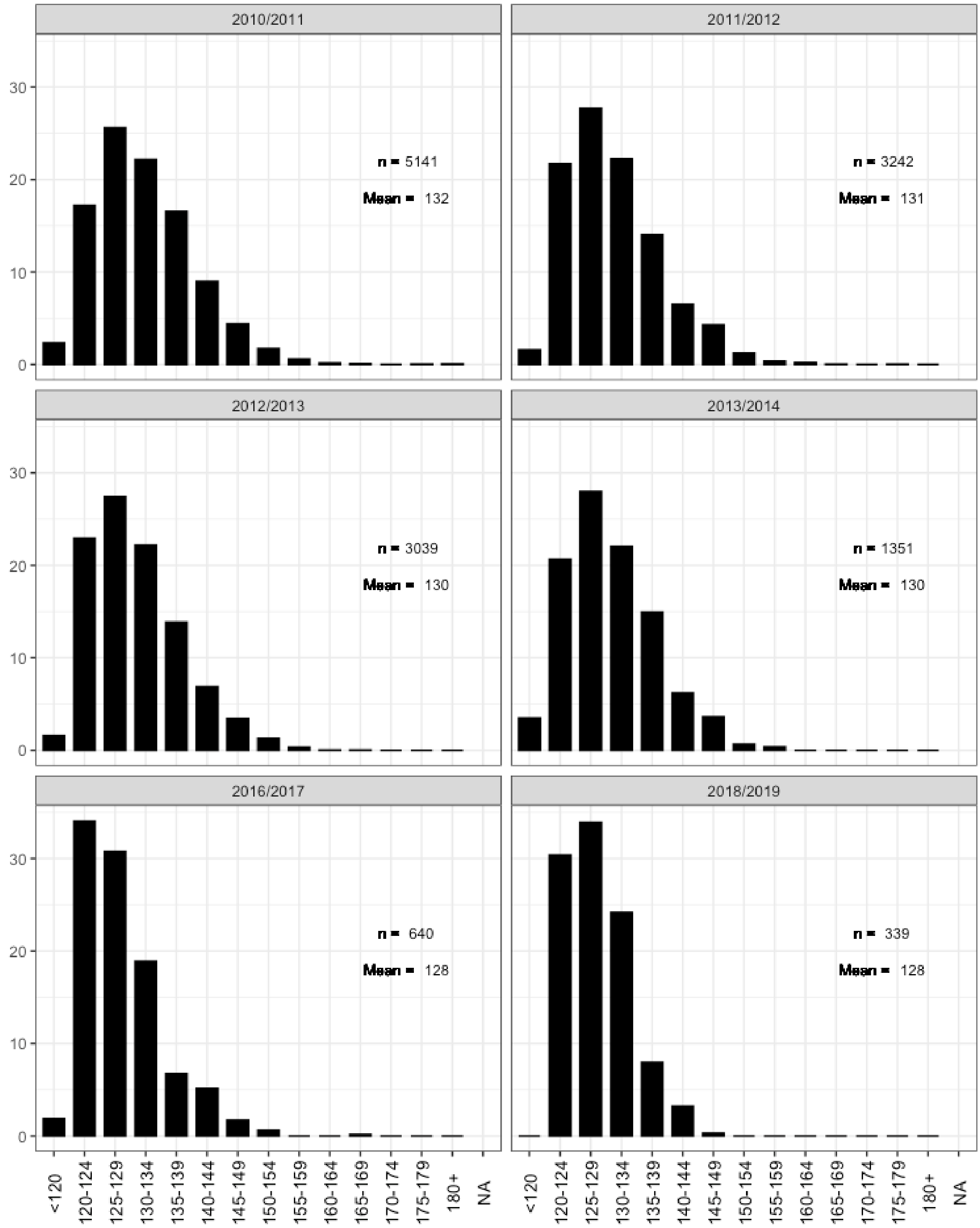
Size frequency distributions for the Airport SMU from commercial catch sampling from 2011 to 2022. 'n' is the number of abalone measured, 'Mean' is the mean size of the samples.



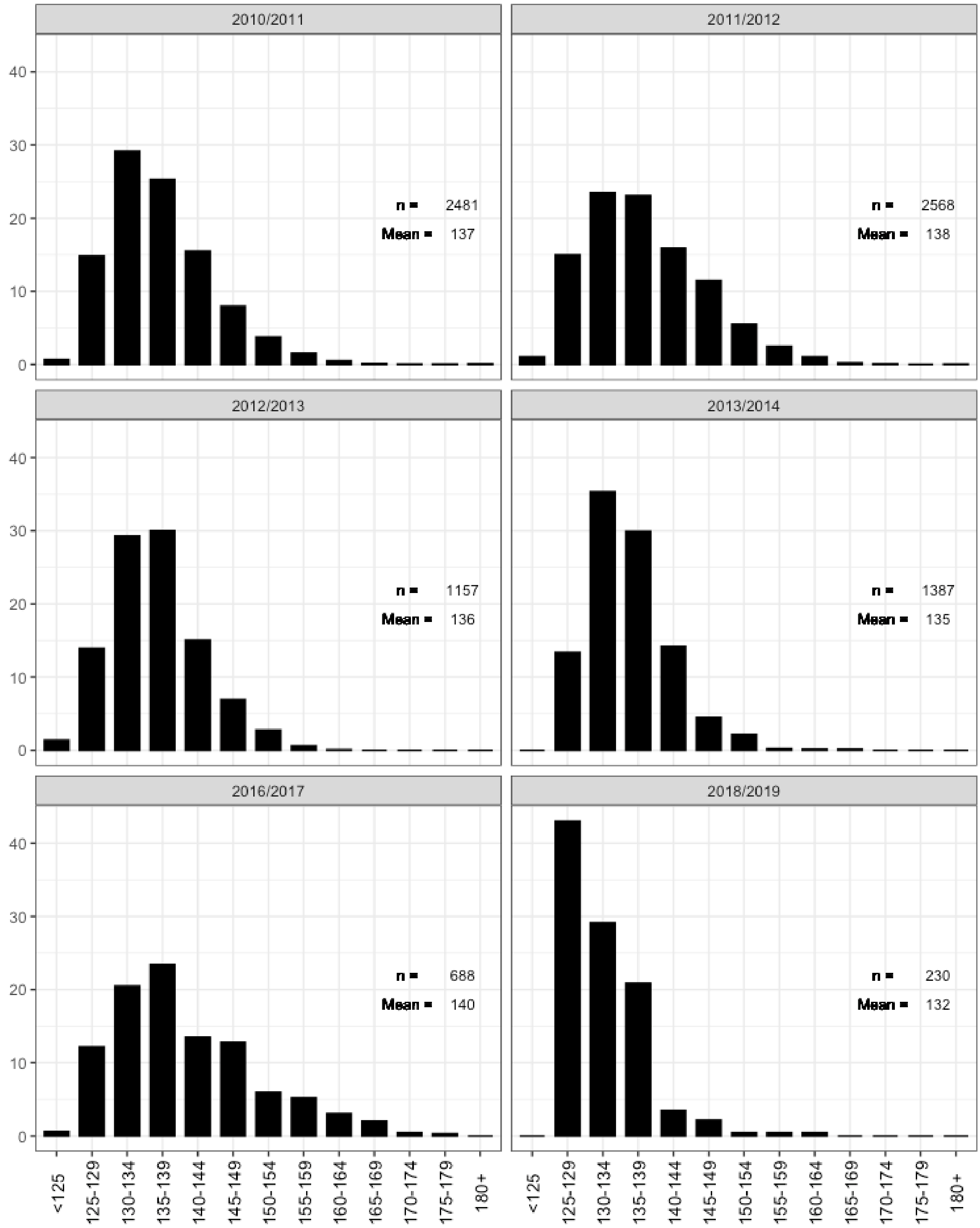
Size frequency distributions for the Marlo SMU from commercial catch sampling from 2011 to 2022. 'n' is the number of abalone measured, 'Mean' is the mean size of the samples.



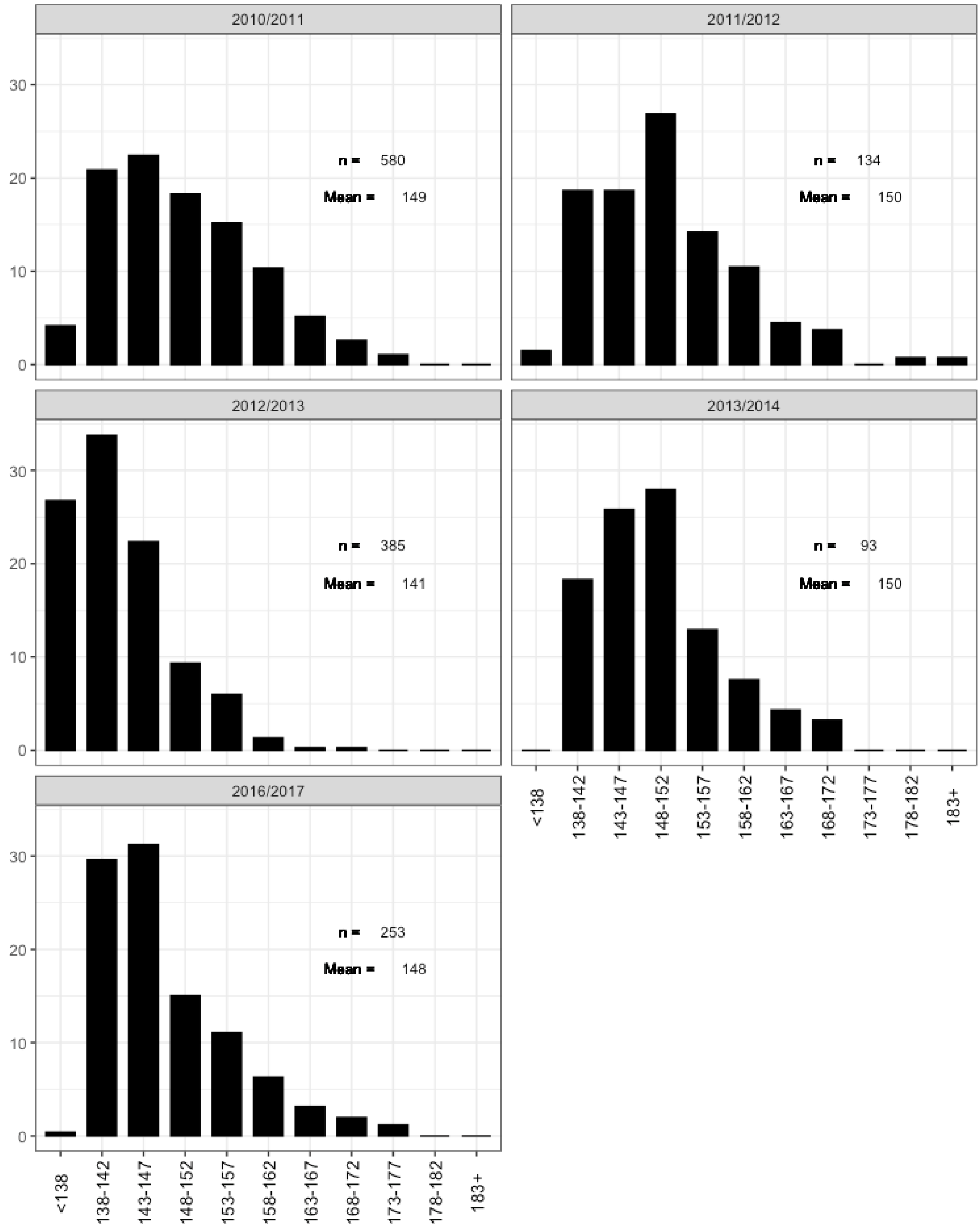
Size frequency distributions for the Mallacoota Central SMU from commercial catch sampling from 2011 to 2022. 'n' is the number of abalone measured, 'Mean' is the mean size of the samples.



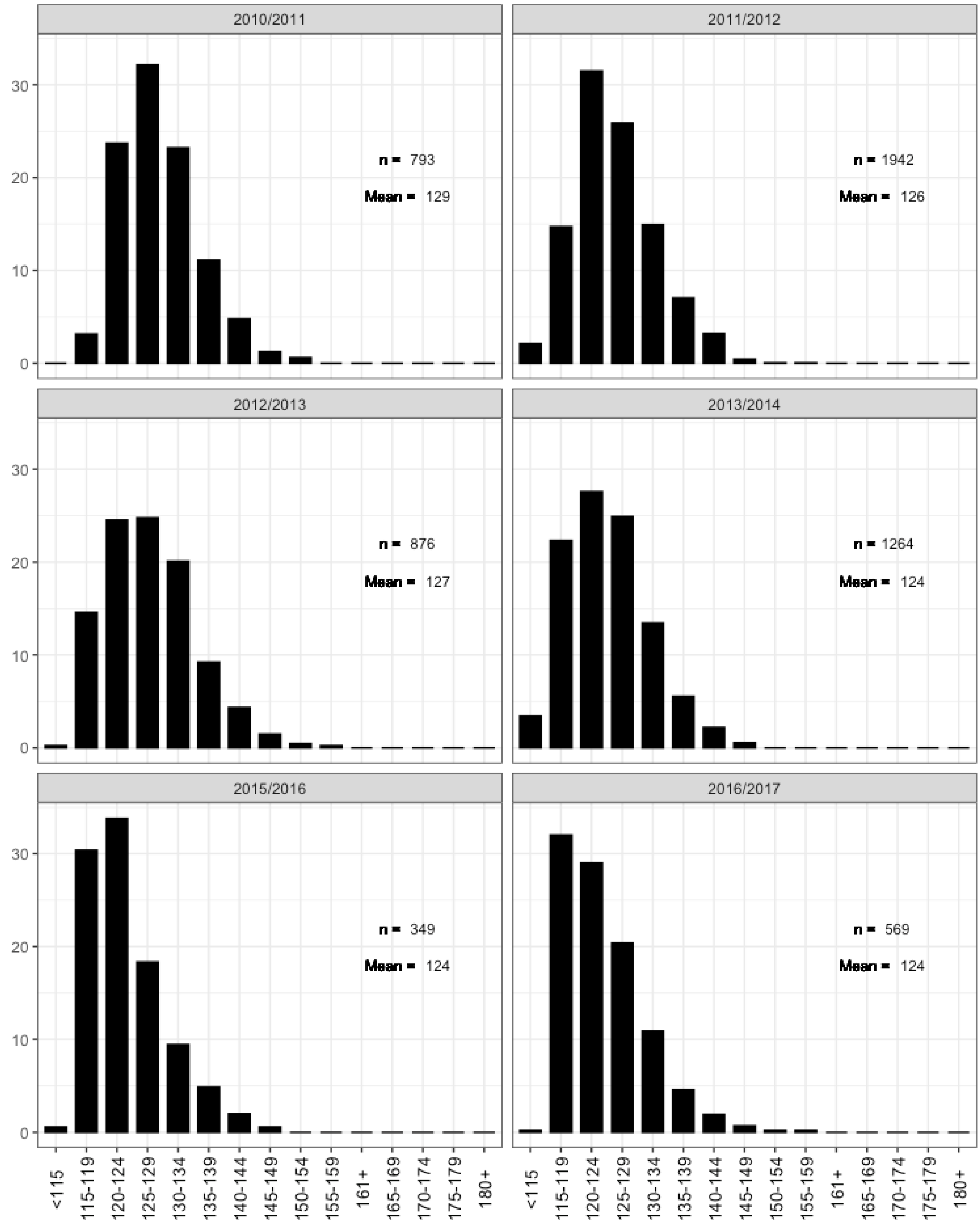
Size frequency distributions for the Mallacoota East SMU from commercial catch sampling from 2011 to 2022. 'n' is the number of abalone measured, 'Mean' is the mean size of the sampled catch.



Size frequency distributions for the Mallacoota West SMU from commercial catch sampling from 2011 to 2022. 'n' is the number of abalone measured, 'Mean' is the mean size of the samples.

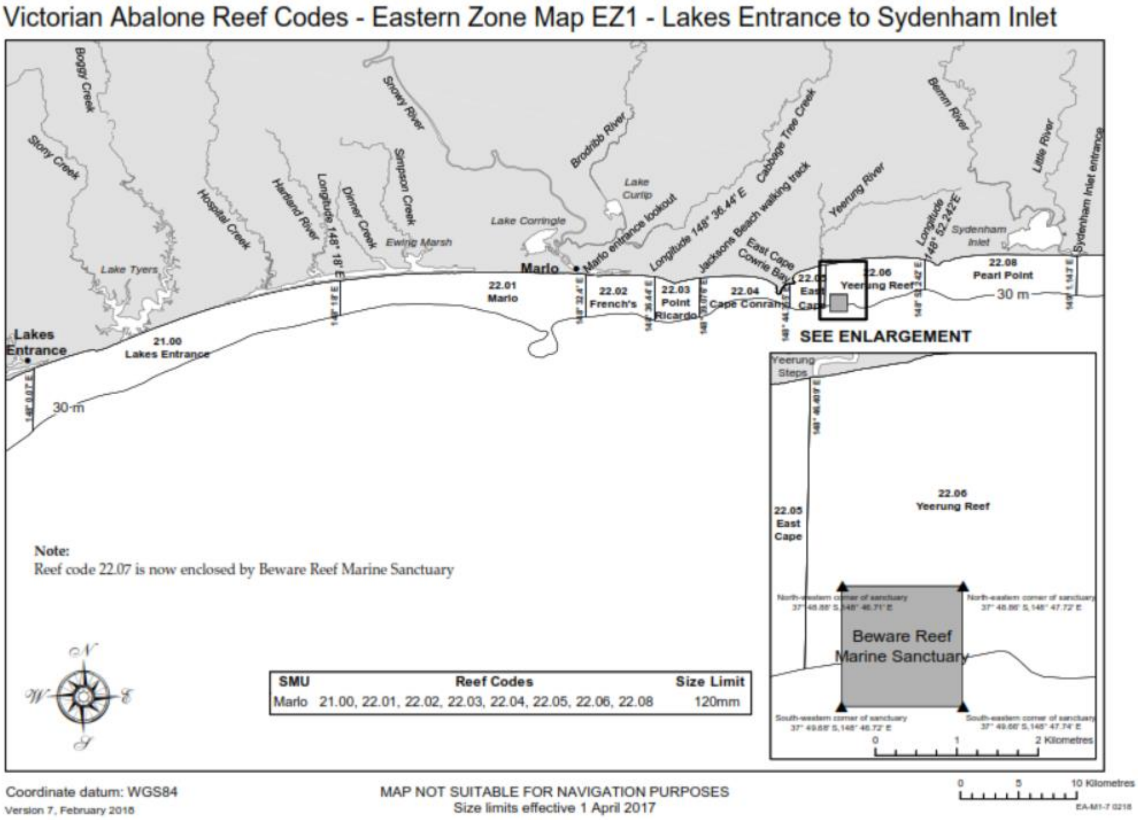


Size frequency distributions for the Mallacoota Large SMU from commercial catch sampling from 2011 to 2022. 'n' is the number of abalone measured.

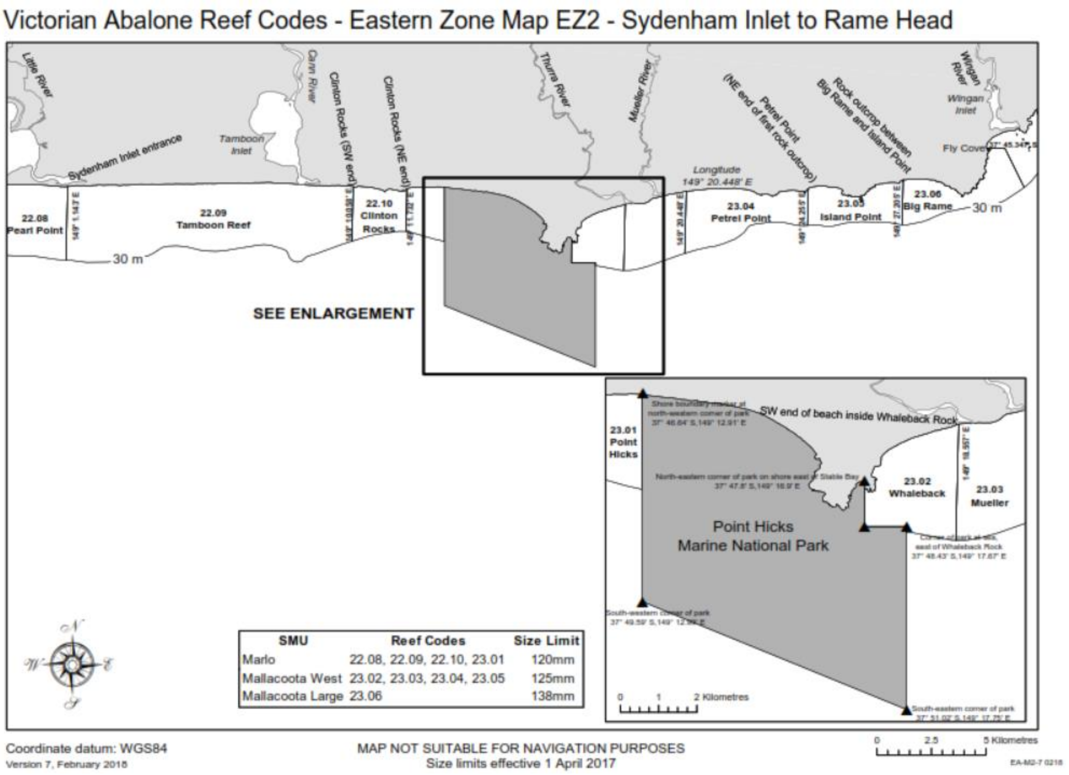


Size frequency distributions for the Mallacoota Small SMU from commercial catch sampling from 2011 to 2022. 'n' is the number of abalone measured.

Appendix 6: Eastern Zone SMU and reefcode maps

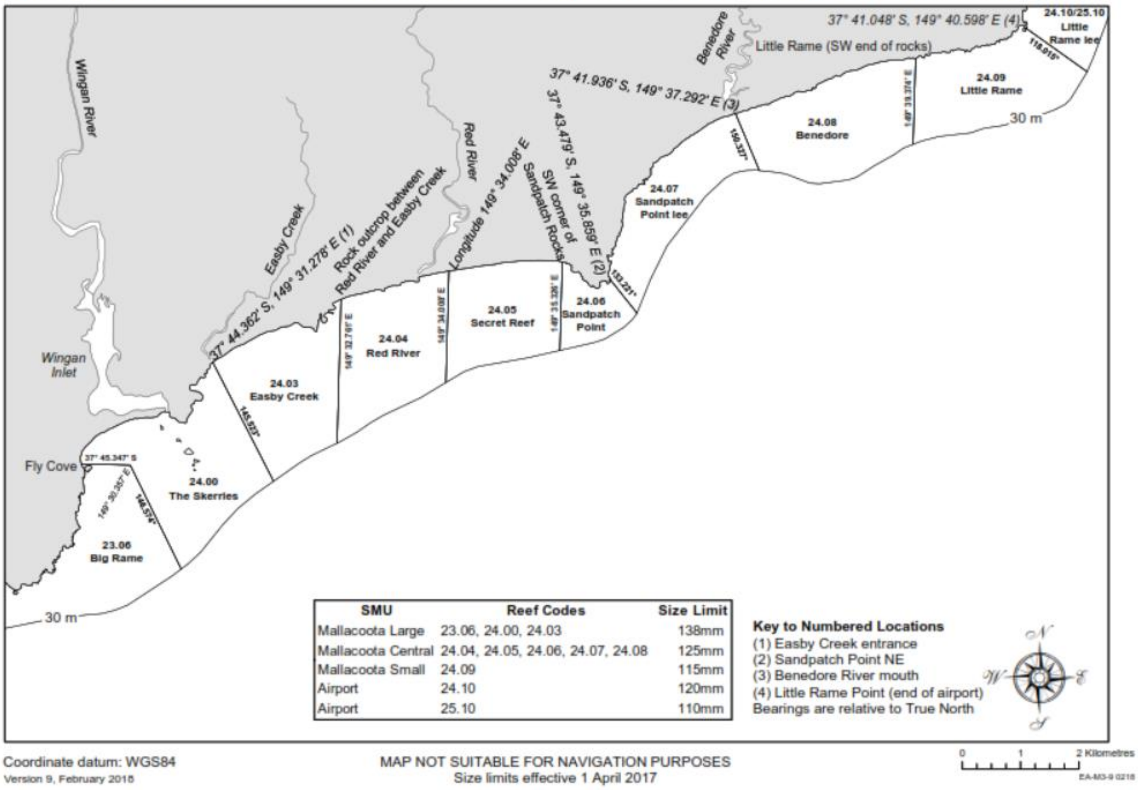


The location of the Marlo SMU and the reef codes within it.



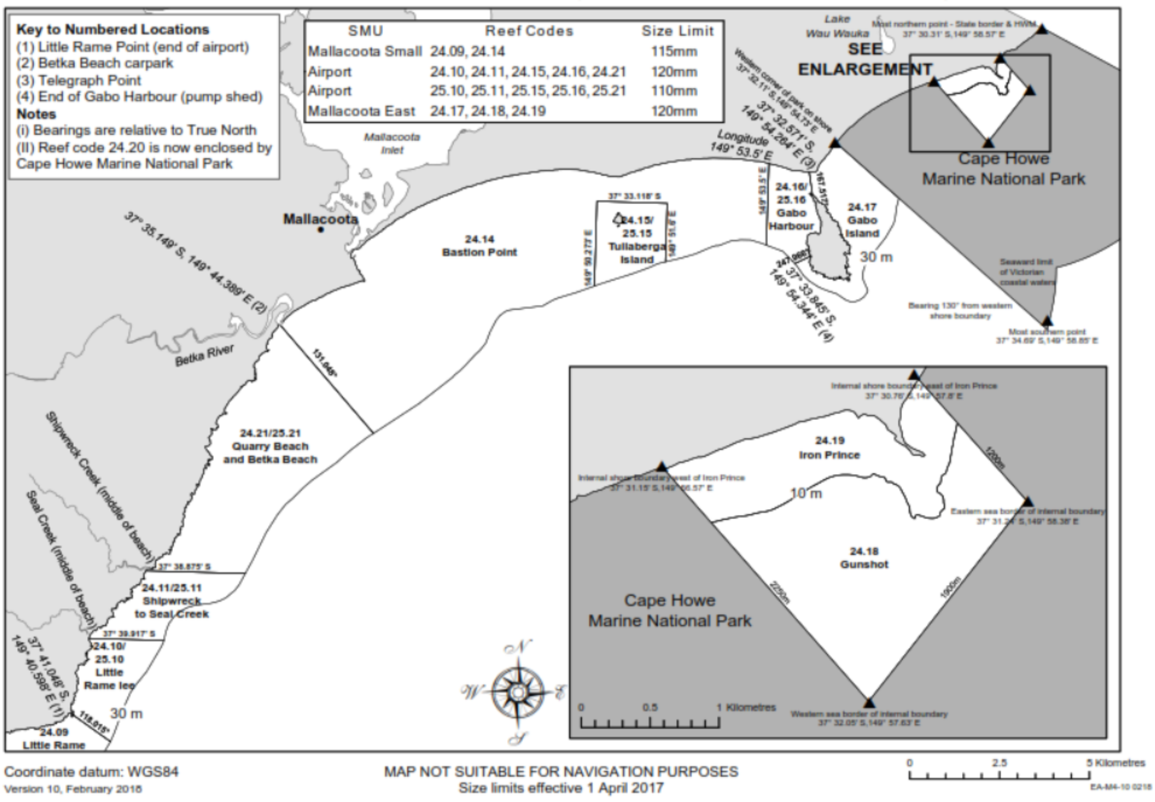
The location of the Mallacoota West and Large SMUs and the reef codes within them.

Victorian Abalone Reef Codes - Eastern Zone Map EZ3 - Rame Head to Little Rame Head



The Mallacoota Central and Small SMUs and the reef codes within them.

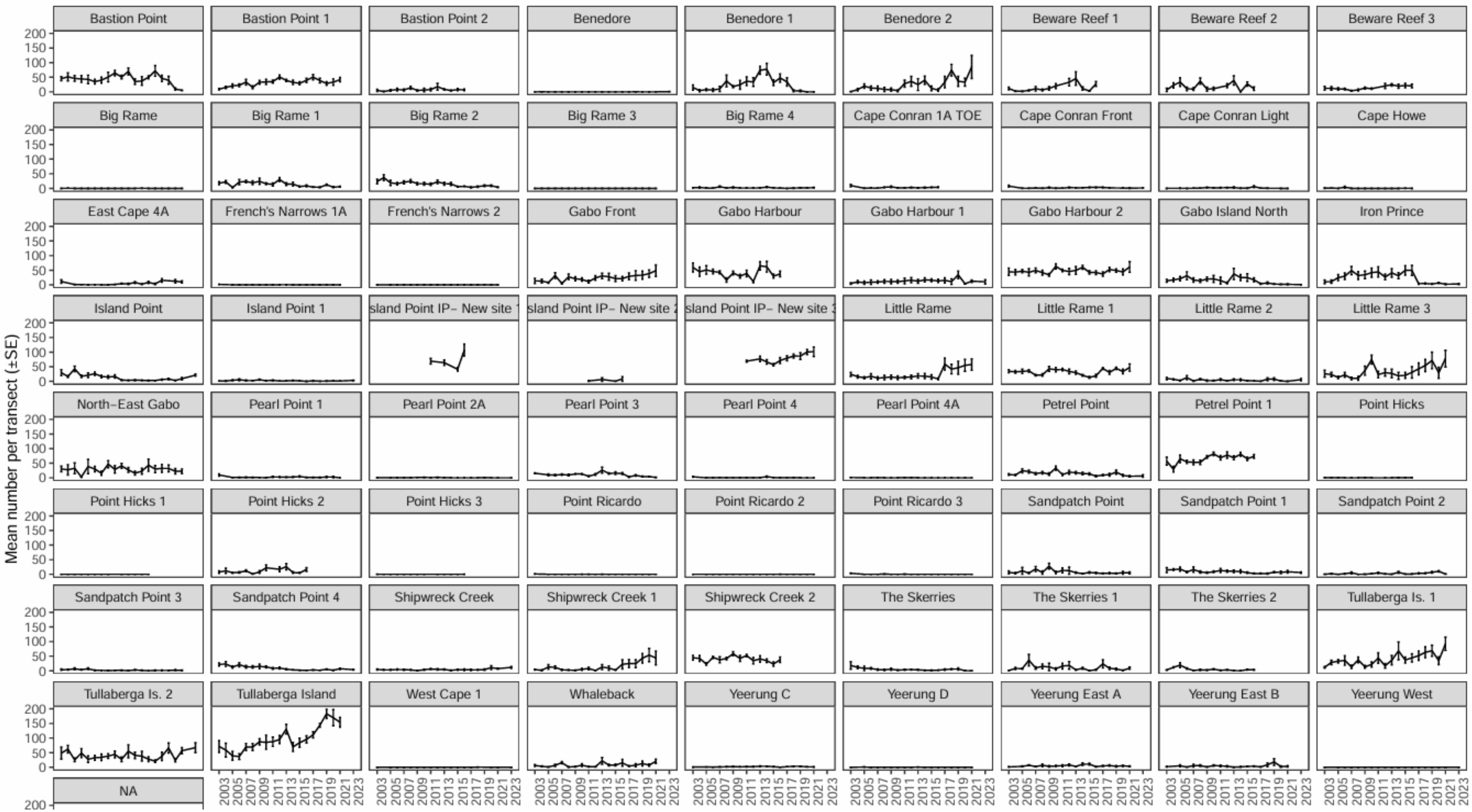
Victorian Abalone Reef Codes - Eastern Zone Map EZ4 - Little Rame Head to Cape Howe



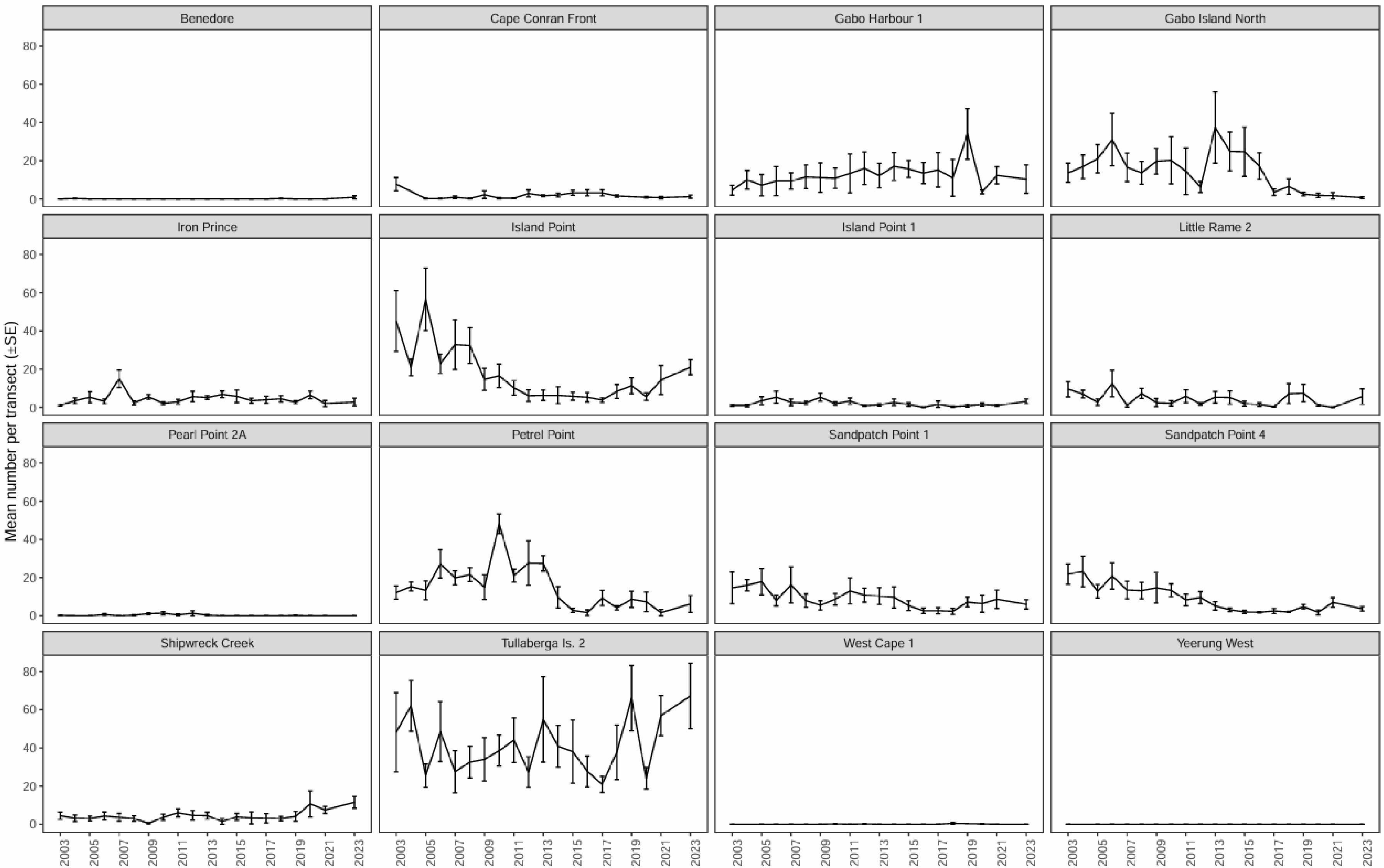
The location of the Airport SMU, part of Mallacoota Small SMU and Mallacoota East SMU and their reef codes.

Appendix 7: Long-spined sea urchin abundance from abalone FIS.

Sea urchin abundance for each site in the Eastern Zone from 2003 to 2023.



Sea urchin abundance for each Top 15 site in the Eastern Zone from 2003 to 2023.



Appendix 8: Catches relative to Optimal Targets

The table below provides average catches in the last 4 years relative to the 2022/23 and 2023/24 Optimal Targets for each reefcode and SMU in the Eastern Zone. Where average catches are either more or less than 15% different than the OT, the magnitude of difference is shown as a percentage.

This analysis does not aim to directly identify SMUs or reefcodes that have been overcaught or under-caught, rather it demonstrates that catch distribution in recent years has not followed the OTs, particularly at the reefcode level. Given the objective of quota setting for the Eastern Zone is to follow a “bottom-up” approach by determining sustainable levels of catch at the reefcode scale, it seems clear that a review of reefcode level catches is required.

Table 3: Average catches in the last 4 years relative to Optimal targets for each reefcode and SMU in the Eastern Zone.

	Average catch (kg)	Optimal Target (kg)	Optimal Target (kg)
Reefcode	**last 4 years**	**2023/24**	**2022/23**
24.21 Quarry Beach / Betka	36851	37000	37000
24.10 Little Rame Lee	21512	23000	23000
24.16 Gabo Harbour	14655	13000	13000
24.15 Tullaberga	10180	6000 (↑70%)	6000 (↑70%)
24.11 Shipwreck	9332	6000 (↑56%)	6000 (↑56%)
Airport SMU	**92532**	**85000**	**85000**
24.07 Sandpatch Lee	27550	24000 (↑15%)	30000
24.06 Sandpatch Point	17385	14400 (↑21%)	18000
24.08 Benedore	9137	7000 (↑31%)	7000 (↑31%)
24.04 Red River	982	1000	2000 (↓51%)
24.05 Secret Reef	0	0	0
Mallacoota Central SMU	**55054**	**46400 (↑19%)**	**57000**
24.17 Gabo Island	25612	15200 (↑69%)	19000 (↑35%)
24.19 Iron Prince	8705	9000	11500 (↓24%)
24.18 Gunshot	2508	2000 (↑25%)	2000 (↑25%)
Mallacoota East SMU	**36826**	**26200 (↑41%)**	**32500**
23.06 Big Rame	16205	12000 (↑35%)	14500
24.0 The Skerries	5917	5000 (↑18%)	4000 (↑48%)
24.03 Easby Creek	1608	1500	1500
Mallacoota Large SMU	**23730**	**18500 (↑28%)**	**20000 (↑19%)**
24.09 Little Rame	12226	10500 (↑16%)	15000 (↓27%)
24.14 Bastion Point	6404	5000 (↑28%)	6000
Mallacoota Small SMU	**18630**	**15500 (↑20%)**	**21000**
23.04 Petrel Point	17137	9000 (↑90%)	18000
23.05 Island Point	13045	0	13500
23.02 Whaleback	5665	6500	6500
23.03 Meuller	4351	6000 (↓27%)	6000 (↓27%)
Mallacoota West SMU	**40197**	**21500 (↑87%)**	**44000**
22.05 East Cape	15068	22000 (↓32%)	22000 (↓32%)
22.08 Pearl Point	14855	20000 (↓26%)	23200 (↓36%)
22.04 Cape Conran	13548	15000	17500 (↓23%)
22.03 Point Ricardo	4501	5000	7300 (↓38%)
22.06 Yeerung Reef	5133	8000 (↓36%)	11500 (↓55%)
22.02 Frenches	2773	6500 (↓57%)	9500 (↓71%)
22.10 Clinton Rocks	88	0	0
22.09 Tamboon	28	0	0
23.01 Point Hicks	40	0	0
22.01 Marlo	0	0	0
Marlo SMU	**56034**	**76500 (↓27%)**	**91000 (↓38%)**