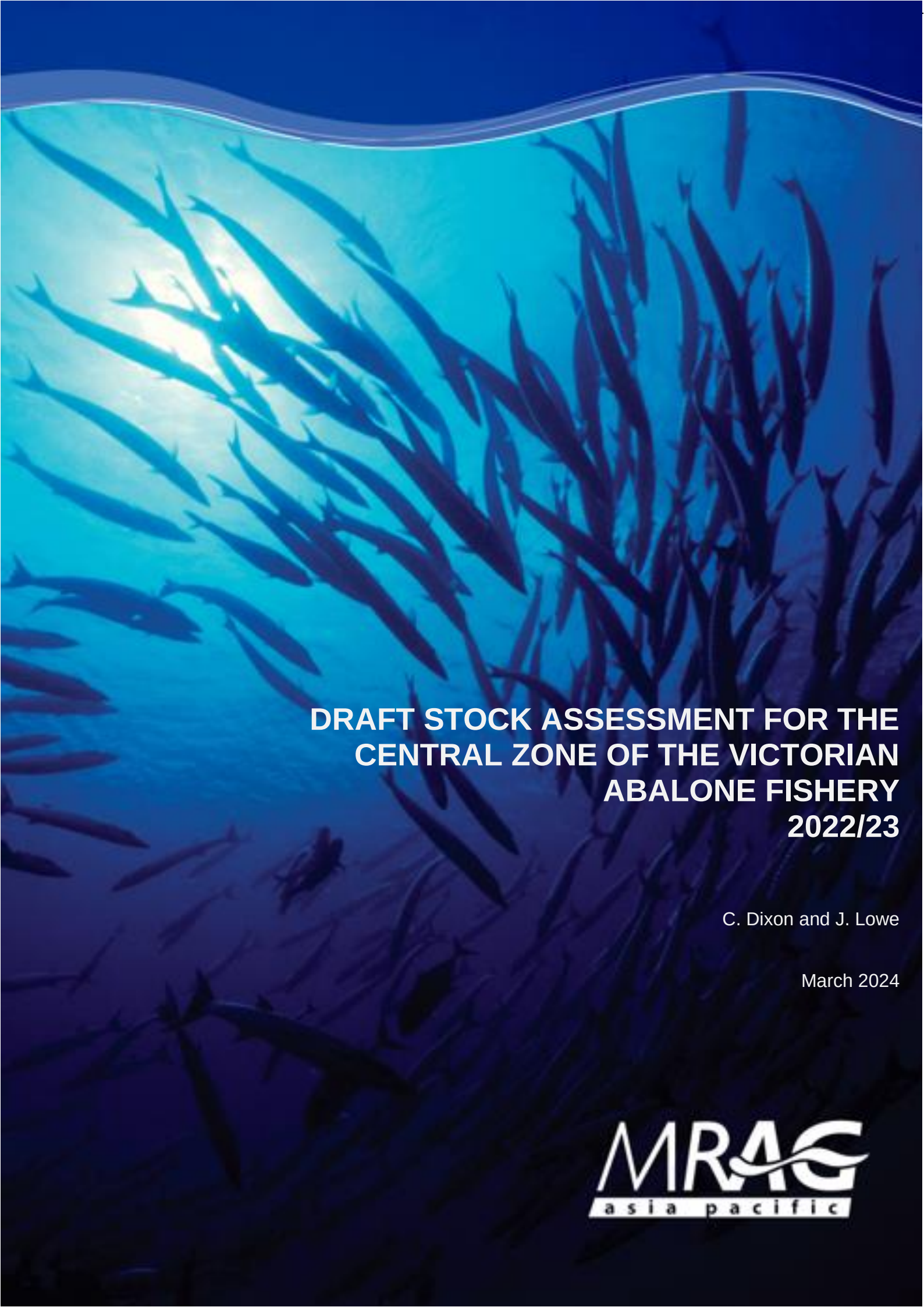

DRAFT STOCK ASSESSMENT FOR THE CENTRAL ZONE OF THE VICTORIAN ABALONE FISHERY 2022/23

C. Dixon and J. Lowe

March 2024

MRAG asia pacific

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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Acronyms

CPUE	Catch per unit effort
FIS	Fishery independent survey
DEDJTR	Department of Economic Development Jobs Transport and Resources
VFA	Victorian Fisheries Authority
SMU	Spatial management unit
OT	Optimal target
TACC	Total allowable commercial catch
AFAL	Abalone Fishery Access Licence
GLMM	Generalised linear mixed model
LML	Legal minimum length

Executive Summary

This Stock Assessment Report builds on previous annual reports for the Central Zone of the Victorian Abalone Fishery. The report analyses fishery-dependent catch and effort data (up to 30 June 2023) and fishery independent survey (FIS) data (up to July 2023) against a framework of performance indicators to assess the status of the blacklip abalone stock. In addition, an analysis of commercial length frequency data was provided independently by industry (attached as an appendix) and is considered in the weight of evidence assessment at the Spatial Management Unit (SMU) scale. The report also provides a summary assessment of greenlip catch and summarises results of the Draft Harvest Strategy.

The commercial catch in the Central Zone for 2022/23 was 252.5 t, which was close to 100% of the TACC including carryover. The current zonal CPUE of 79.5 kg/h is 18% lower than it was in 2003/04, 10% lower than it was in 2009/10 but 10% higher than it was in 2019/20. CPUE was relatively stable between 2013/14 and 2020/21 but has increased substantially in recent years and is currently around 2010/11 levels. Mean daily catch in 2022/23 was 448 kg/day and has increased substantially since 2013/14.

The “Top 15” FIS sites were surveyed in July 2023. Across the Central Zone, recruit abundances at the Top 15 sites declined from 2003 to 2018 but have increased by 25% thereafter. Pre-recruit abundance declined substantially and consistently from 2003 to 2021, however increased by 87% in 2023 and was the highest observed since 2008.

Standardised average length of the commercial catch demonstrated consecutive increases in the mean size of abalone harvested at 7 of 10 SMUs since 2016/17. This included the four most important SMU contributors toward total catch: Cape Otway, Back Beaches, Phillip Island, and Shipwreck Coast. These size increases were over and above LML increases that had been implemented at the SMU level in Apil 2021. Average length at most other SMUs were stable over time. Given the concurrent increase in pre-recruit abundance observed on FIS across the Central zone, increases in the size of abalone caught likely reflect reduced fishing mortality and improving stock status.

In recent years, the assessment of stock status has been based on two primary sources of data, CPUE and FIS abundance, that are positively and negatively biased, respectively. The uncertainty in these data sources has resulted in a necessarily precautionary approach to the assessment of stock status and subsequent recommendations. The inclusion of data on average length of the commercial catch and mean catch per day greatly enhances the assessment this year.

At the zonal scale all four measures - CPUE (kg/h), mean daily catch (kg/day), FIS abundance (recruit and pre-recruit) and average length from the commercial catch - are currently trending positively, which provides much greater confidence in the outcomes of the weight of evidence assessment. While some measures have only recently improved (e.g. FIS pre-recruit abundance), most have been trending positively for several years.

It is unequivocal that the spatial extent of the fishery has contracted substantially in the last two decades, and the fishery now concentrates heavily on shallow water, high catch-rate reefs. Until this report, the status of stocks on these reefs was highly uncertain. Although uncertainty in individual measures remain, the positive trends observed in all indicators over recent years suggests that the decline in zonal biomass has stabilised and is likely increasing. Nevertheless, it's essential to recognise that this is the first year of consistently positive results across all stock status measures, and confidence in the assessment will improve if the upward trends persist. On this basis, a prudent approach to management would be to continue to invest in potential stock recovery by maintaining the TACC at current levels while continuing to monitor and improve biomass indicators, and the stock assessment approach.

1. General Introduction

1.1. Overview

This Stock Assessment Report builds on previous annual reports for the Central Zone of the Victorian Abalone Fishery (e.g. VFA 2018; Dixon and Dichmont 2019, Dixon et al 2021, 2022a, 2023). The report analyses fishery-dependent catch and effort data (up to 30 June 2023) to assess the blacklip abalone stock against long- and short-term performance indicators. Fishery Independent Surveys (FIS) were not completed in 2022, but 15 FIS sites (referred to as 'Top 15') were surveyed in June 2023 and the historic data from these 15 sites are used to assess against the Performance Indicators at the zone scale only. 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 Central Zone Draft Harvest Strategy 2023 are provided and discussed for each SMU. This report also provides advice to improve the stock assessment process going forward.

1.2. Description of the Central Zone

The Central Zone Abalone Fishery extends along the coast of Victoria from just east of the Hopkins River at Warrnambool in the west, to Lakes Entrance in the east of the state (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 34 Abalone Fishery Access Licences (AFALs) and 680 quota units in the Central Zone. 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.

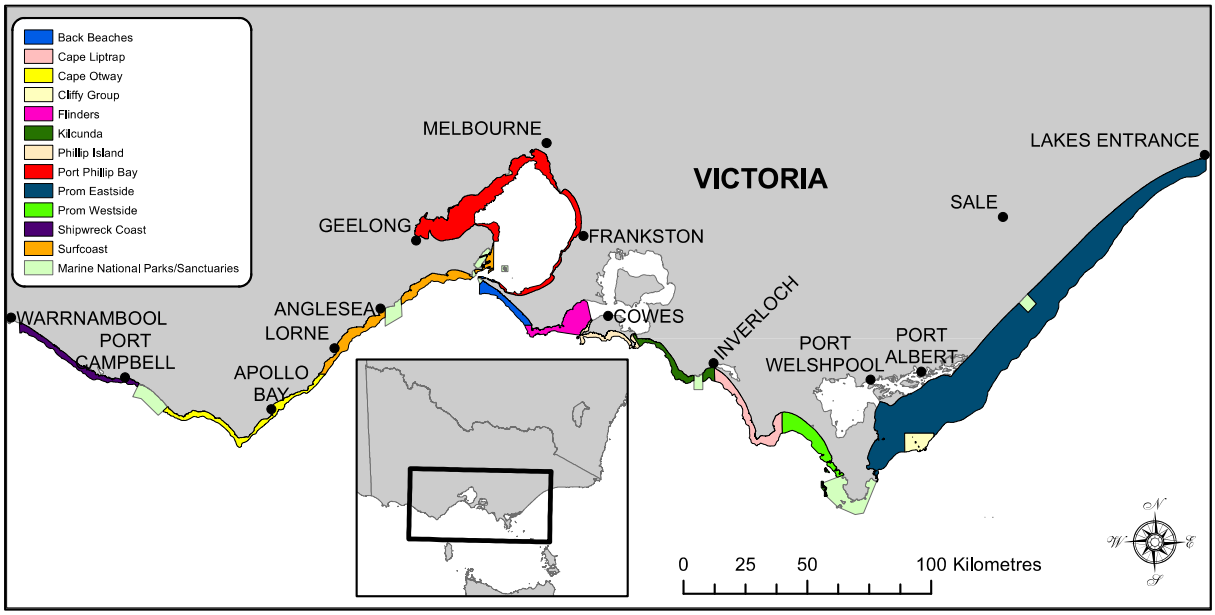

Figure 1: Map of the Central Zone Abalone Fishery showing the Spatial Management Units and Marine Protected Areas.

The TACC for the Central Zone is set at a Zonal scale, but management of the fishery occurs at a finer spatial scale defined by the twelve SMUs (Figure 1). An Optimal target (OT) is set for each SMU based on current quota reference points, catch history and stock assessment outputs. The combined value of all OTs then equate to the TACC. Total catches for each SMU for the following fishing season are intended to meet the OT for that SMU. 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 commercial Victorian abalone fishery commenced about 1962 in the Mallacoota region, with the Central Zone of the fishery created in 1970 by subdivision of the existing Eastern and Western Zones (Gorfine et al 2008). Detailed daily logbooks providing catch, effort and spatial data at the reefcode level were established during 1978 with logbook data presented in this report from 1 April 1979.

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 Central 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, 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. However, 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 current assessment and Draft Harvest Strategy rely heavily on the CPUE that is positively biased due to hyperstability and other factors. 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 years when divers fished five days or more in a single SMU and more than 50 kg of abalone was recorded for the day.

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 2019a), 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 Central 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 Central 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. The loss of these reefs did not impact CPUE in a linear manner, as catch rates were largely maintained during the period when a shift in the distribution of effort moved toward shallower reefs where FIS sites were not located (due to logistic reasons). On this basis, the declines in FIS 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. In summary, historical FIS sites are a negatively biased representation of changes in total biomass.

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 (Appendix 1). 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 Central 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 and slightly deeper than areas of more intense fishing effort. It was considered by the group that these "adjacent sites" may be the first historic FIS sites that would show signs of potential stock recovery. While data from these sites alone are not considered to be representative of trends in biomass for the overall 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 2 and 4 at 6 of the 11 SMUs in the Central Zone. 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 have similar statistical precision 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 2. 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, for the six SMUs with Top 15 sites. Interpretations of the data are included in the summary assessment for each SMU.

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 as a result represent a negatively biased estimate of biomass. And secondly, changes in the approach to collecting length frequency data has biased the size data towards larger abalone, suggesting they are not representative of the abalone population. While comparisons of trends among years for each consistent sampling approach provide some useful information, the interpretation of these data should be given little weight in the overall assessment.

Finally, FIS length frequency data previously enabled abundance measures to be split into pre-recruit indices for the harvest strategy, however this is no longer the case and the Tertiary Indicator needs to be reassessed.

Commercial length frequency

Size structure data from the commercial catch are a very important source of information 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. Conversely, increases in mean size of abalone caught over time under a consistent LML may be a positive indicator of reduced fishing mortality. This latter measure may also reflect lower recruitment to the fishery, so the data need to be interpreted in conjunction with other relevant information.

The Central Zone Stock Assessment from 3 years ago (Dixon et al 2021a) included, as an appendix, data from the commercial catch provided by AVCZ. The same summary data have been updated for this report and are provided in Appendix 4. The assessment is done independently of MRAG and has not been altered. As such, the views expressed in the appended report are those of the author only.

The analyses conducted have not been independently reviewed or audited and therefore their interpretation warrants some caution. In addition, the report itself identifies uncertainties (described as confounding factors) in the assessment that include but are not limited to the temporal and spatial replication influenced by the number of divers from which data were collected, particularly in the last two years. Nevertheless, they provide very useful information in the overall weight of evidence approach, and each SMU section in this report provides a brief overview of the relevant data presented in Appendix 4.

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.

While size limits have been relatively stable in recent years (other than small incremental increases at some SMUs), there had been numerous size limit changes, regulated and voluntary, within the Central Zone during the previous decade. These changes at times applied at the reef code scale; however, more recently some changes were 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 5.

The changes to LML have included both increases and decreases over time. 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). These changes in LML have further complicated the interpretation of historic data within the assessment. A significant benefit of maintaining stable size limits is reduced uncertainty in the assessment. However, the size limits need to be appropriate for each sub-stock.

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 following VFA (2018). 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 2019a) 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 2022, 2023).

In this report, we have added a third temporal scale for assessment, with 4-year trends also presented to provide a more recent assessment of change, in line with the maximum temporal scale of the Harvest Strategy.

Table 1: Performance indicators used in the assessment of the Central 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 Central Zone these data sources include catch, effort, CPUE data (kg/h and catch/day), 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, considering their various uncertainties, to determine stock status as done in previous years. Future assessments need to integrate additional data sources into the weight of evidence approach, in particular data collected from new FIS sites and other data collected through the commercial data logger programs (e.g. 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 2023 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. Central Zone Blacklip Assessment

3.1.1. Catch and effort

The Victorian abalone fishery commenced about 1962 in the Mallacoota region, with the Central Zone of the fishery created in 1970 by subdivision of the existing Eastern and Western Zones (Gorfine et al 2008). Detailed daily logbooks providing catch, effort and spatial data at the reefcode level were established in 1978 and Figure 2 shows the catch and effort history of the Central Zone from the 1979 quota year from daily logbook data.

Catch ranged from a peak of 750 t in 1984 to 535 t in 1988 before the introduction of quota. Catch steadily increased to 693 t in 1992 and remained relatively stable before declining to 663 t in 2002 when Marine Parks were first introduced. Catch slowly declined to 591 t in 2007 when the abalone viral ganglioneuritis (AVG) first hit the Central Zone with catch reducing to 462 t in 2008 and 297 t in 2010. In the last 12 years catch has declined slowly and was 253 t in 2022, which was around one third of the peak catch.

Reported effort peaked around 1,000,000 minutes in 1980 and has generally declined thereafter. Currently, reported effort is only 20% of the historic peak.

The total catch for 2022/23 was 252.5 t, which was close to 100% the TACC of 252.57 t. This represented an increase of 4.6% compared to the previous years' catch.

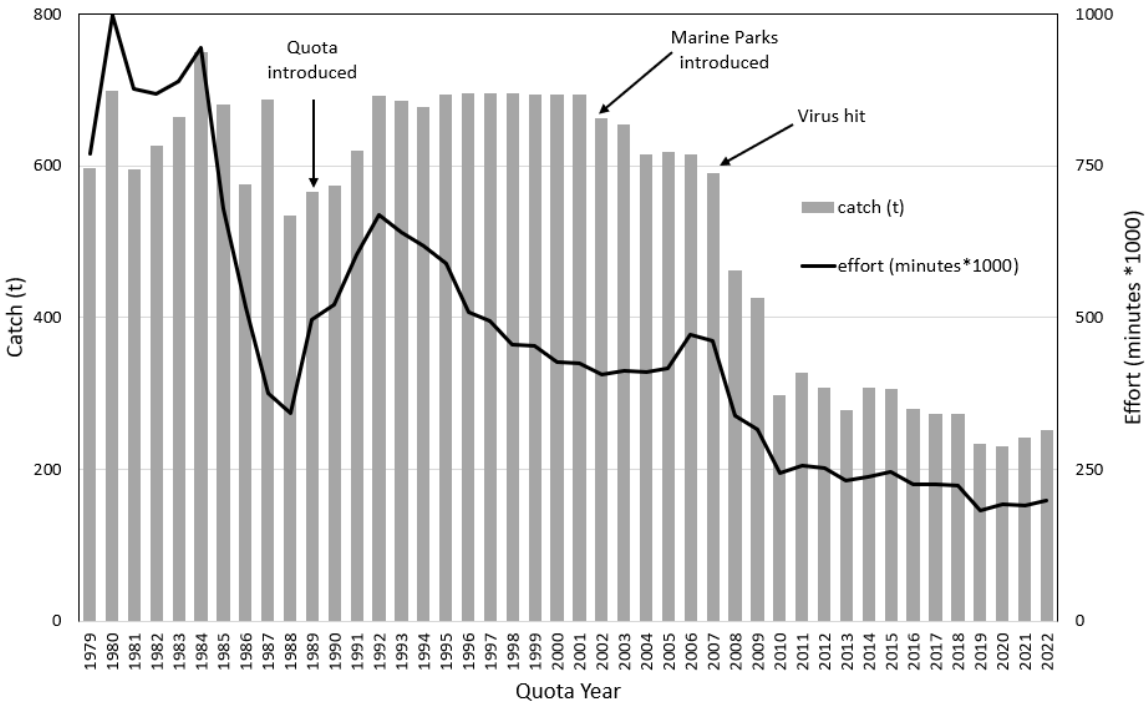

Figure 2: Historic catch (t) and effort (minutes) from 1979 to 2022. Quota was introduced in 1988 with the quota year running from April to March. All data prior to 2020 are from April to March. In 2020, the quota year was changed to the financial year, resulting in the 2020 quota year being 15 months in duration.

Mean daily catch steadily increased from 250 kg per day in 1979 to 531 kg per day in 2000 (Figure 3). Mean daily catch slowly declined to 387 kg per day in 2013 and has slowly but steadily increased thereafter, reaching 448 kg per day in 2022.

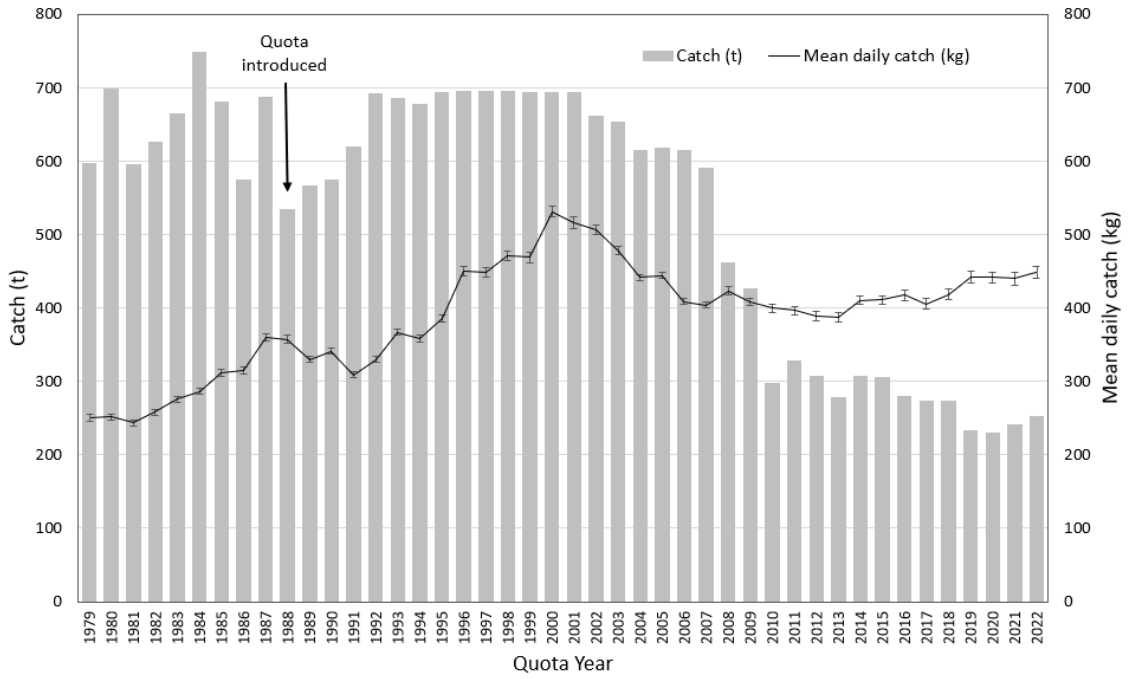

Figure 3: Historic catch (t) and mean daily catch (kg per fishing day +/- SE) from 1979 to 2022. Quota was introduced in 1988 with the quota year running from April to March. All data prior to 2020 are from April to March. In 2020, the quota year was changed to the financial year, resulting in the 2020 quota year being 15 months in duration.

3.1.2. Catch per unit effort (CPUE)

Nominal CPUE generally increased from 1992 to 2001, declined from 2001 to 2010, and has been relatively stable thereafter. Standardised CPUE followed similar trends, increasing from 1992 to 2000, declining from 2000 to 2013, and remaining relatively stable between 2013 and 2020. CPUE has increased in the last two years and is currently the highest it has been since 2010 (Figure 4).

Figure 4: Central 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. Quota was introduced in 1988 with the quota year running from April to March. All data prior to 2020 are from April to March. In 2020, the quota year was changed to the financial year, resulting in the 2020 quota year being 15 months in duration.

3.1.3. FIS abundance

3.1.3.1. 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 2009, then was relatively stable between 2009 and 2016 before declining to historic low levels in 2018. Recruit abundance has increased thereafter and in 2023 was around the 2009 levels.

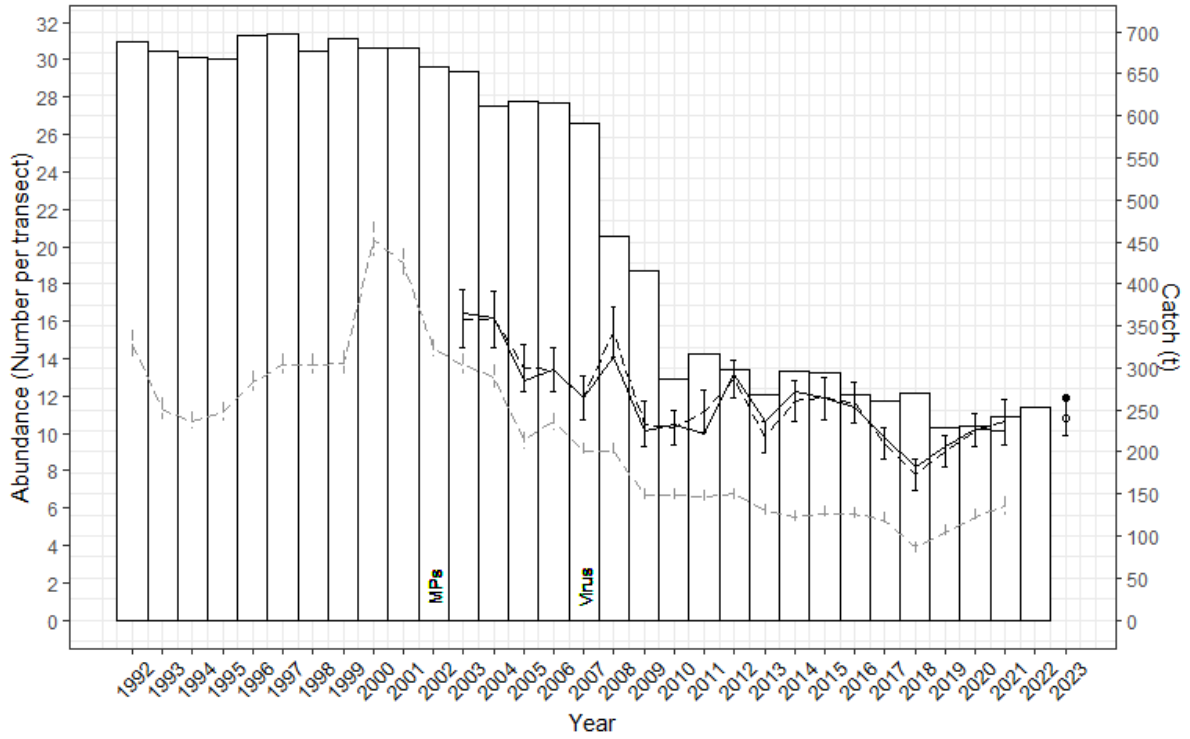

Figure 5: FIS recruit abundance (1992-2023) and catch (1992/93 – 2022/23) for the Central Zone. Catch = bars, grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line, open datapoint in 2023; +/- SE) and standardised (solid line, solid datapoint in 2023)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

3.1.3.1. Pre-recruit abundance

Figure 6 plots 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 2008, was relatively stable from 2008 to 2020 before declining to a historic low in 2021. Surveys were not conducted in 2022 but in 2023 pre-recruit abundance increased by 87% in 2023 and was the highest observed since 2008.

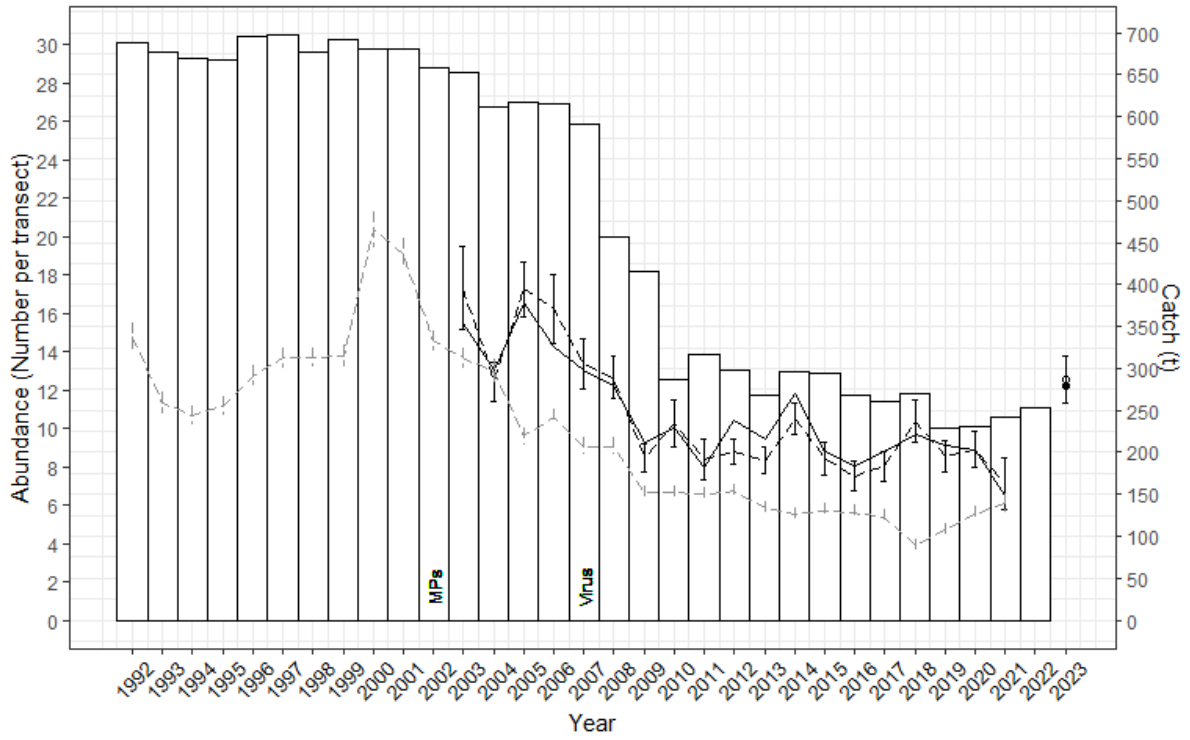

Figure 6: Pre-recruit abundance (1992-2023) and catch (1992/93 – 2022/23) for the Central Zone. Catch = bars, Grey dashed series = nominal abundance across all FIS sites (+/-SE). Black series = nominal (dotted line, open datapoint in 2023; +/- SE) and standardised (solid line, solid datapoint in 2023)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

3.1.4. Central Zone Performance Measures

The catch in 2022/23 totalled 252.5 t, which was 100% of the TACC (Table 2). Catch has declined by 61% in the long term (since 2003/04), 41% in the short-term (since 2009/10) but was 8% higher than it was four years ago (2018/19). CPUE in 2022/23 was 79.5 kg/h, which was 18% lower than the long-term, 10% lower than the short-term, but 10% higher than 4 years ago. Mean daily catch in 2022/23 was 448.2 kg/day, which was 6% lower than the long-term, 10% higher than the short-term, and similar (1% higher) than 4 years ago.

Recruit abundance at the Top 15 sites has declined by 26% in the long-term, but was 13% higher than the short-term and 16% higher than 4 years ago. Pre-recruit abundance has declined by 6% in the long-term but was 10% higher than the short-term and 37% higher than 4 years ago.

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

Measure	2022/23	Long term (since 2003/04)	Short term (since 2009/10)	Last 4 years (since 2018/19)
CPUE (kg/h)	79.5	97.0 (↓18%)	86.5 (↓10%)	72.2 (↑10%)
Mean daily catch (kg/day)	448.2	478.1 (↓6%)	408.4 (↑10%)	445.7 (↑1%)
Recruit abundance (Top 15 n/transect)	11.9	16.1 (↓26%)	10.5 (↑13%)	10.2 (↑16%)
Pre-recruit abundance (Top 15 n/transect)	12.2	13.0 (↓6%)	10.0 (↑22%)	8.9 (↑37%)
Catch (t)	252.5	654.4 (↓61%)	426.2 (↓41%)	233.1 (↑8%)
2022/23 TACC (t, %)	252.5 t, 100.0%			

3.2. Spatial management unit (SMU) blacklip assessment

3.2.1. SMU Performance Measures

In 2022/23, catches were close to the OT at the five highest producing reefs (Table 3). Prom West exceeded its OT by 27% (5.7 t) while Cliffy Group was the only SMU to be substantially under-caught with only 42% of the OT harvested. All others were harvested close to their OT.

Significant long-term declines in CPUE have been observed at almost all spatial scales, however 2003/04 was a highly productive period of the fishery and the declines in abundance of offshore and mid depth reefs since this time have been well documented. The short-term comparisons from 2009/10 are similar, although less severe. In the last four years, trends in CPUE have been more positive, with a 10% increase across the Central Zone as a whole, including increases in CPUE observed at all SMUs except Cape Otway (2% decline).

The sum of agreed OTs was 248.5 t and this was the initial TACC suggested. Shortly thereafter, adjustments were made to the carry-over provisions and the TACC was increased to 252.57 t. This report assesses SMU catches against the initial OTs agreed upon.

Table 3: Performance measures used in the assessment of the Central 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					
Cape Otway	55.8	22.1%	57.9	L	-22	-13	-2
Back Beaches	42.5	16.8%	40	L	-13	-1	19
Phillip Island	35.0	13.9%	34	M	-13	-8	22
Shipwreck Coast	33.9	13.4%	34.3	M	-18	-16	7
Flinders	26.7	10.6%	24.2	M	-22	-7	12
Prom West	26.7	10.6%	21	M	-16	-3	39
Kilcunda	13.3	5.3%	11.8	S	-27	-20	8
Cape Liptrap	10.0	4.0%	12.1	S	-32	-30	4
Prom East	4.7	1.9%	5.7	S	-12	-4	16
Cliffy Group	2.3	0.9%	5.5	S	-25	-20	1
Surfcoast	1.5	0.6%	2	S	-9	19	4
PPB	0.1	0.0%		S			
Central Zone	252.5	100.0%	252.57*		-18	-8	10

** The TACC was 252.57t but this is not the sum of OTs as there was post TACC setting carry-over catch applied.*

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 2022/23 quota year. SMU catch categories (% of zone catch): Large ≥ 15%, Medium 10-15%, Small < 10%.

3.2.2. Distribution of the catch

Since 2002, there have been some substantial changes in catch distribution among the 12 SMUs in the Central Zone (Figure 7). Most notably, catches from the Flinders SMU, which were historically the highest within the zone, are now lower than several other SMUs. The Cape Otway, Back Beaches, Phillip Island and Shipwreck Coast SMUs are now the highest contributors to the Central Zone catch. While catches from the Back Beaches and Phillip Island SMUs have been relatively consistent since 2002, catches from the Cape Otway SMU have declined substantially in the last decade. The decrease in catch in the Shipwreck Coast SMU was largely attributed to closures and reduced TACCs post the abalone virus, although recent increases in catch demonstrate post-virus stock recovery. Catches from most other SMUs are lower and relatively stable except for decreases in the Port Phillip Bay SMU that has been associated with environmental influences (Mayfield et al. 2012).

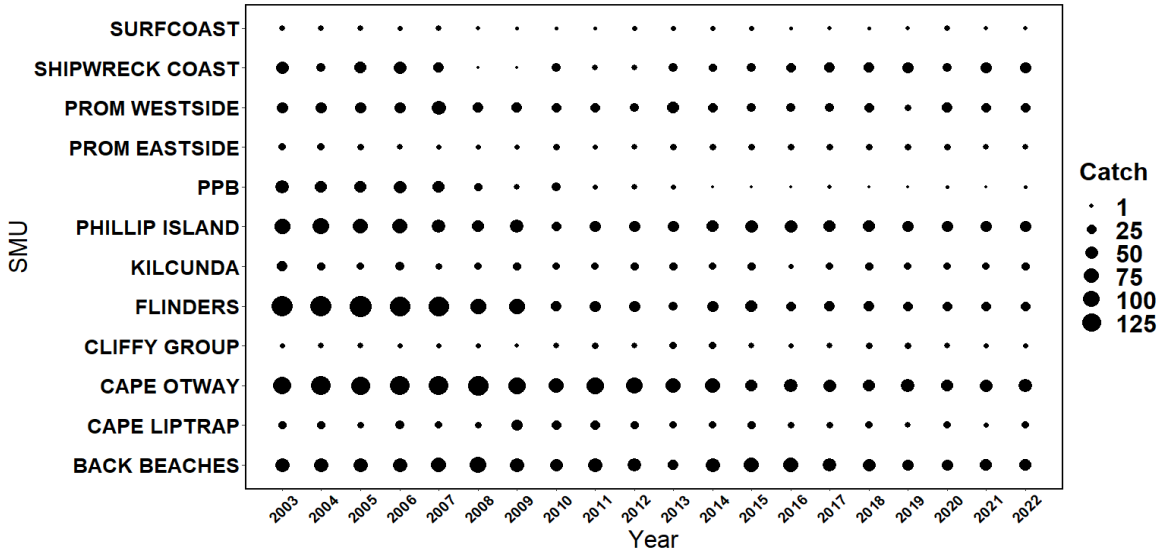

Figure 7: Relative distribution of catch at each SMU in the Central Zone by quota year.

3.2.3. Draft Harvest Strategy outputs

The full Draft Harvest Strategy results are published in a separate report for the Central Zone fishery. Tables 4 and 5 provide a summary of results to inform the stock assessment and TACC setting process. Current CPUE is above the Threshold at all SMUs except for Kilcunda and Prom East, where it is currently between the Threshold and Limit levels (Table 4). CPUE has been below the Threshold but above the Limit at Prom East for five consecutive years. Catch Control Rule (CCR) 1 applies for all SMUs but it is noted that if CPUE remains below the Threshold at Prom East for one more year then CCR 2 would apply. CPUE has been above the Threshold level for more than 2 years at 6 SMUs, meaning that an "Increasing" SMU result allows an increase in catch of up to 25%. This occurred for the Back Beaches, Phillip Island and Prom West SMUs this year (Table 5).

An artefact of the use of standardised rather than nominal CPUE as a measure means that Reference Points can change over time as the standardisation adjusts all values each time the Harvest Strategy is run. As a result, many Refence Points are currently different to those published in the Draft Harvest Strategy (VFA 2019b). Those that differ this year are: Cape Otway Target 110 (kg/h) instead of 100, Phillip Island Target 100 instead of 110, Shipwreck Limit 50 instead of 40 and Threshold 70 instead of 60, Kilcunda Target 110 instead of 100, Prom East Threshold 60 instead of 50, Cape Liptrap Target 100 instead of 120, Cliffy Group Target 100 instead of 110. The Limit, Threshold and Target differ for Surfcoast this year with 50, 70, 80 instead of 40, 60, 70, respectively. These differences do affect Current Status but do not change the outcomes of the Draft Harvest Strategy this year as the Catch Control Rule is not affected. Regardless, this issue requires review.

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

SMU	Limit RP	Threshold RP	Target RP	2017	2018	2019	2020	2021	2022	Current Status	Years at Status	CCR
Cape Otway	50	70	110	77.4	74.5	83.0	79.1	85.1	80.4	Above Threshold	7	1
Back Beaches	50	70	100	69.7	72.0	71.4	75.9	79.3	85.5	Above Threshold	5	1 - 125%
Phillip Island	50	70	100	67.4	69.2	66.8	71.0	73.9	81.4	Above Threshold	3	1 - 125%
Shipwreck Coast	50	70	130	91.3	99.2	93.3	81.1	89.5	99.6	Above Threshold	13	1
Flinders	50	70	100	60.7	66.6	64.6	62.0	73.7	72.6	Above Threshold	2	1
Prom West	50	70	100	63.1	62.1	57.7	77.0	77.4	79.1	Above Threshold	3	1 - 125%
Kilcunda	50	70	100	64.7	67.9	62.0	62.7	75.4	67.8	Limit to Threshold	1	1
Prom East	40	60	80	62.7	57.5	52.8	50.1	49.6	59.1	Limit to Threshold	5	1
Cape Liptrap	40	60	100	68.1	69.3	69.0	72.6	59.9	72.3	Above Threshold	1	1
Cliffy Group	40	60	100	87.8	76.8	72.0	65.6	66.0	69.8	Above Threshold	27	1
Surfcoast	50	70	80	62.4	81.6	69.6	67.3	56.6	72.9	Above Threshold	1	1

The Final Category for the Back Beaches, Phillip Island, Flinders and Prom West SMUs were all assessed as Increasing, with all but Flinders having a maximum OT 25% above the current OT (Table 5). Cape Otway and Kilcunda SMUs had a Decreasing Final Category while all other SMUs were assessed as Stable. The two Decreasing results were the result of a significant change in the ratio between years (i.e. >5% decrease between years) as both were Stable over four years. There were no FIS data to inform the Tertiary Indicator. The suggested total catch range for the Central Zone was 211.6 t up to 248.9 t.

Table 5: Harvest Strategy results for Central 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)
Cape Otway	-0.22	Stable	-5.6	Decreasing	Decreasing	NA	Decreasing	49	41.7	46.6
Back Beaches	6.44	Increasing	7.7	Increasing	Increasing	NA	Increasing	40	40, 42	46, 50
Phillip Island	7.01	Increasing	10.2	Increasing	Increasing	NA	Increasing	32.3	32.3, 33.9	37.1, 40.4
Shipwreck Coast	3.17	Stable	11.3	Increasing	Stable	NA	Stable	29.2	27.7	30.7
Flinders	5.70	Increasing	-1.4	Stable	Increasing	NA	Increasing	20.5	20.5, 21.5	23.6
Prom West	10.23	Increasing	2.1	Stable	Increasing	NA	Increasing	21	21, 22	24.1, 26.2
Kilcunda	4.81	Stable	-10.0	Decreasing	Decreasing	NA	Decreasing	10.3	8.8	9.8
Prom East	3.70	Stable	19.3	Increasing	Stable	NA	Stable	4.8	4.6	5
Cape Liptrap	-0.39	Stable	20.8	Increasing	Stable	NA	Stable	9.4	8.9	9.9
Cliffy Group	-0.90	Stable	5.8	Increasing	Stable	NA	Stable	4.7	4.5	4.9
Surfcoast	-0.08	Stable	28.9	Increasing	Stable	NA	Stable	1.7	1.6	1.8
Total								222.9	211.6, 217.2	239.5, 248.9

3.2.4. Cape Otway (Large SMU)

The Cape Otway SMU was the most important in terms of total catch with 55.8 t harvested in 2022/23 representing 22.1% of the total catch (Table 6) and TACC (Table 3). The 2022/23 catch was just below the OT of 57.9 t which included carry-over. CPUE has significantly declined since 2003 by 22%, with a 13% reduction observed since 2009 and a 2% decline over the last 4 years.

Table 6: Summary of Catch, Optimal targets and CPUE performance indicators for the Cape Otway SMU. The LML and mean daily catch are also shown. Coloured numbers for Performance Indicators identify if trends were significantly increasing (green), significantly decreasing (red), not significant (black).

Catch					CPUE Performance Indicators (%change)		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
55.8	22.1	58.3*	57.9*	49.0*	-22	-13	-2
LML 2022/23 = 125 mm					Mean daily catch 2022/23 = 457 kg		

The Cape Otway SMU has been an important contributor to the TACC since 1992, with an average catch of 85 t during this period and a peak catch of 159 t taken during 2008, the year after the virus became apparent in the west of the Central Zone (Figure 3). Catches have generally declined thereafter, reaching a low catch of 40 t in 2015 and an average catch of 50 t over the past 8 years.

Nominal CPUE generally increased from 1992 to 2002 when it reached a peak of 108 kg/hr (Figure 8). Standardised CPUE has closely resembled nominal CPUE since 2003, with a significant declining trend to 2015. CPUE has increased since the low catch harvested in 2015, however the increase is not statistically significant.

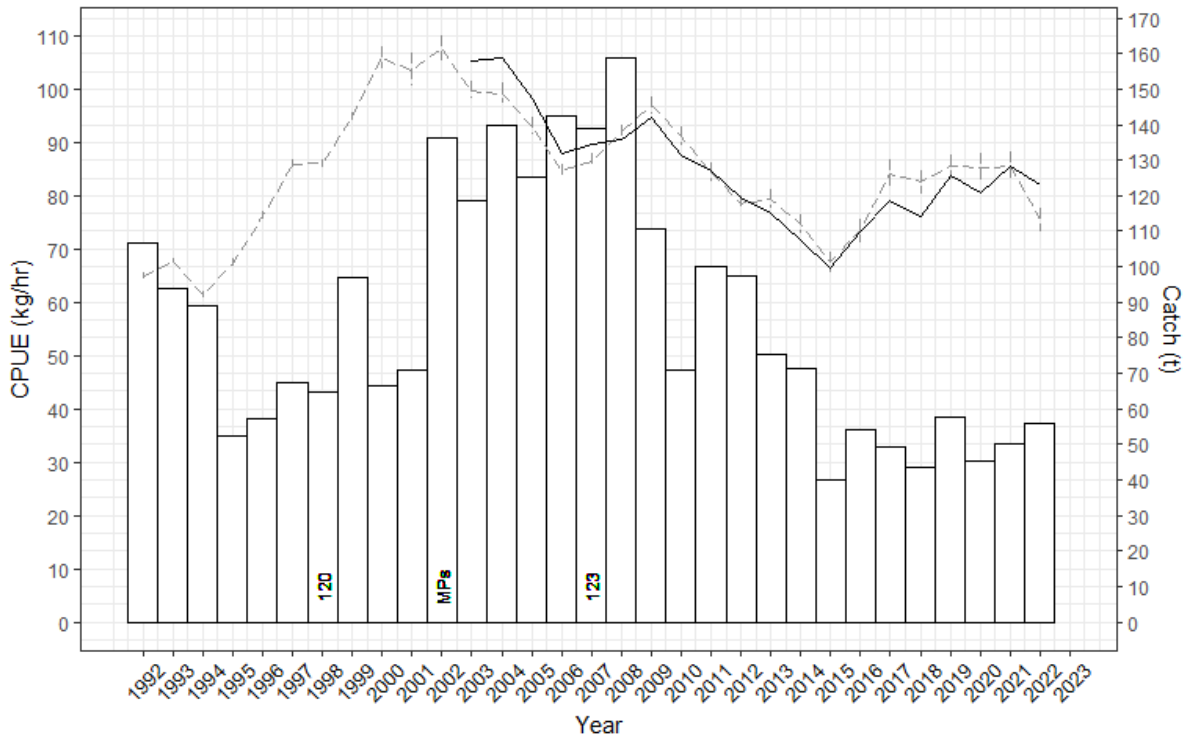

Figure 8: Cape Otway SMU catch, and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE), standardised series = black. Numbers indicate changes to LMLs. MPs = introduction of Marine Parks

Mean daily catch was increased slowly from 1979 to 1995 and was highly variable from 1996 to 2004 (Figure 9). Mean daily catch increased substantially from 389 kg/day in 2015 to 565 kg/day in 2019 but has since declined to 457 kg/day in 2022.

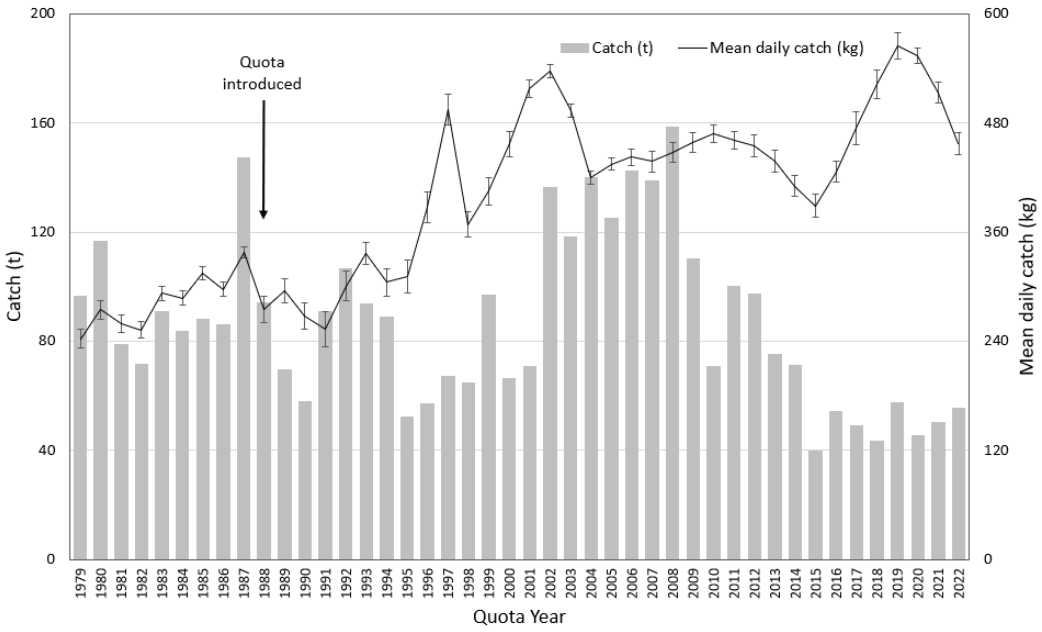

Figure 9: Total catch and mean daily catch for the Cape Otway SMU from 1979 to 2022.

Table 7: Catches (kg) by reefcode for the Cape Otway SMU from 2017/18 to 2022/23 and the five-year average catch from 2016/17 to 2020/21.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23
6.02	6331	8325	15648	20397	11511	12442	11674
6.01	14088	9500	10670	9959	12441	11332	12348
6.03	7783	6742	9951	10111	9765	8870	4978
7.08	7162	10599	14351	1586	6111	7962	11993
7.07	8658	4828	5070	2851	8642	6010	8501
7.05	2729	1891	437	282	1119	1292	1347
7.03	929	286	682	278	274	490	1733
7.06	1096	1000	0	0	331	485	2094
7.04	397	187	828	0	88	300	1103
8.01	66	0	0	0	0	13	0
Totals	49239	43358	57638	45464	50283	49196	55771

The Cape Otway SMU comprises ten reefcodes (Table 7). In 2022/23, the catches at the two highest catch reefcodes were similar to their previous 5-year averages. Catches from 6.03 were well below the 5-year average, while catches from 7.08 were well above the five-year average. Catches at 7.03, 7.04 and 7.06 were the highest observed in the last 6 years.

FIS recruit abundance (Four Top 15 sites)

Nominal trends in pre-recruit abundance across all sites show decline since 2000 (Figure 10). While highly variable, the abundance of recruit sized abalone at Top 15 sites generally decreased from 2003 to a historic low in 2016 and have slowly increased thereafter.

FIS pre-recruit abundance (Four Top 15 sites)

Nominal trends in pre-recruit abundance across all sites show consistent decline since 1992 (Figure 11). The abundance of pre-recruits at Top 15 sites has been highly variable since 2003.

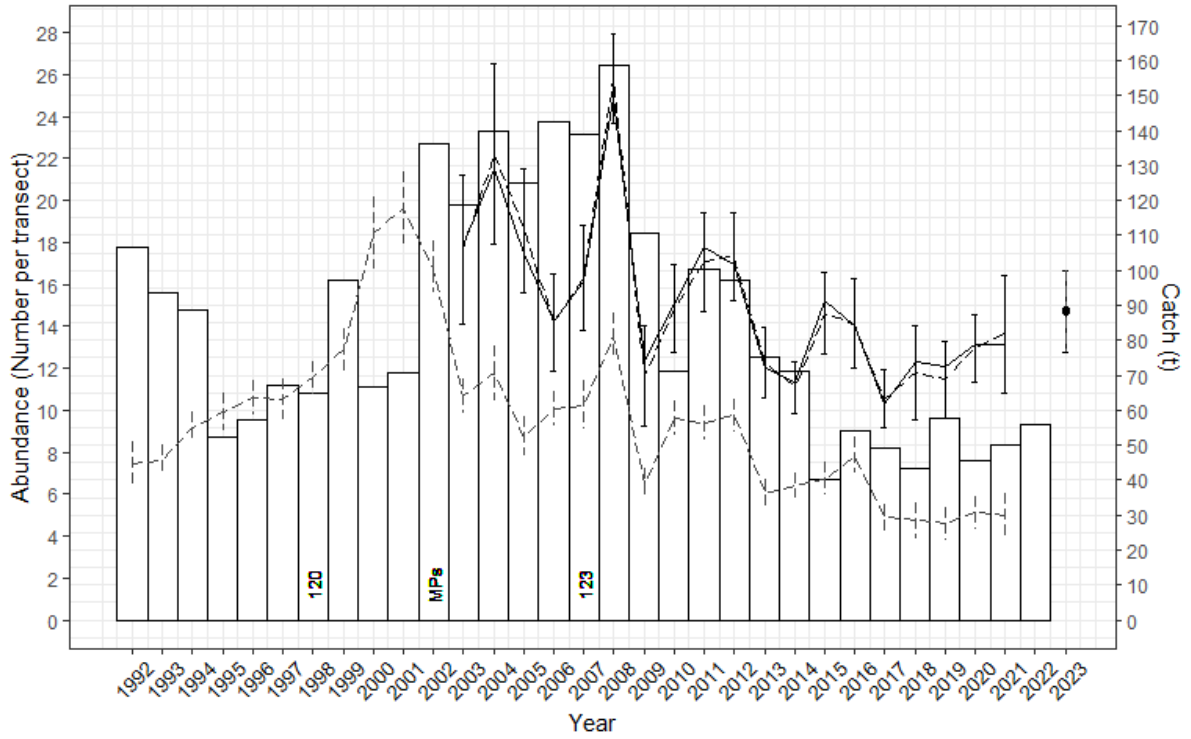

Figure 10: Recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) including catch from 1992/1993 – 2022/23 for the Cape Otway SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

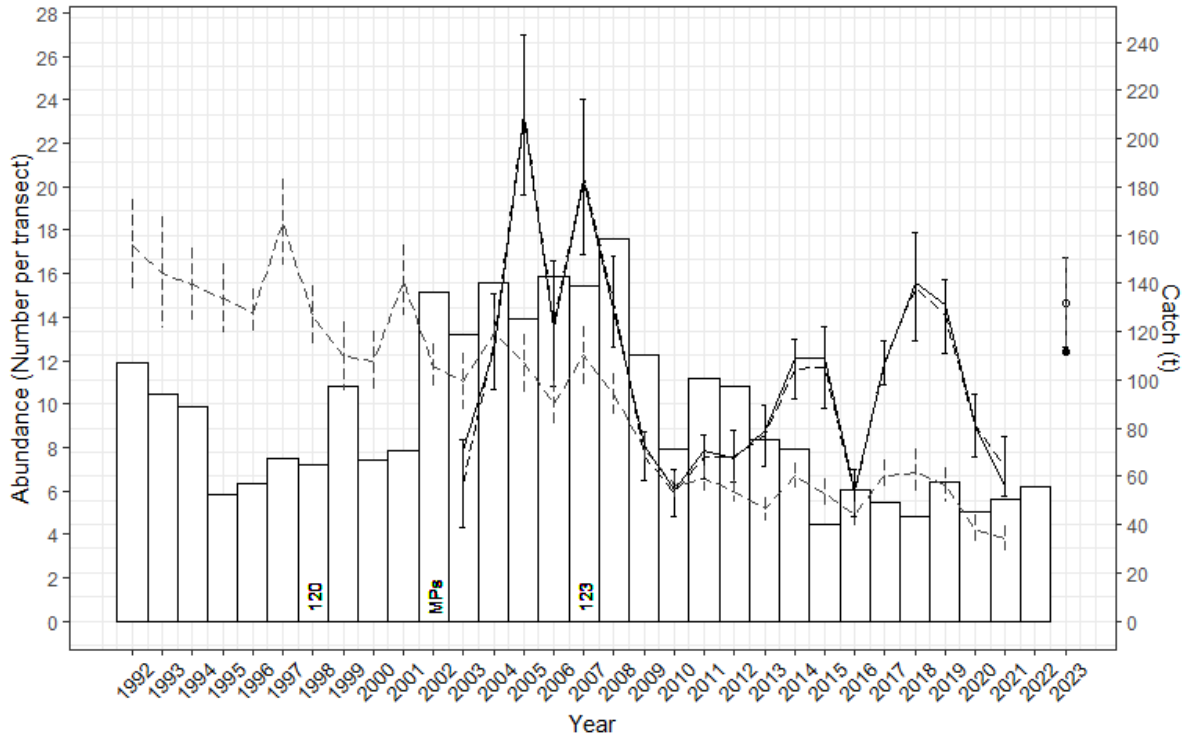

Figure 11: Pre-recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) including catch from 1992/1993 – 2022/23 for the Cape Otway SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

Length frequency data – FIS

The size structure of the surveyed population at the Cape Otway SMU has remained stable over time despite declines in abundance (Appendix 2). The increase in pre-recruit abundance observed in the four Top 15 sites surveyed in the 2023 FIS was primarily abalone within 10 mm of the current size limit.

Length frequency data – commercial

From 2017/18 to 2023/24, the standardised average length of abalone in the commercial catch has increased near linearly from around 131 mm to over 135 mm, which is 10 mm above the current LML (Appendix 4, Appendix 5). While more variable over time, the same trends are apparent in the raw data. The LML was increased from 123 mm to 125 mm on 1 April 2020, however the increase in size exceeds the increase in LML. Results of an analysis to account for LML increases in Appendix 4 also demonstrates an increase in size over and above the LML increase.

Summary

A peak catch of 159 t was harvested from the Cape Otway SMU during 2008, the year after the virus first affected the west of the Central Zone. Catches have generally declined thereafter, reaching a low of 40 t in 2015. Catch in 2022/23 was 55.8 t. The size limit was increased from 123 to 125 mm on 1 April 2021. Standardised CPUE declined substantially from 2003 to 2015 and has generally increased thereafter. Mean daily catch increased substantially to reach a historic high in 2019. While it has since declined it remains around the average level from the last two decades. Catches from most reefcodes were within their recent historical bounds.

Recruit abundance from the four Top 15 FIS sites has fluctuated without clear trend for the last 15 years. Pre-recruit abundance has been variable over time but more than doubled between 2021 and 2023 and was high in an historic sense.

The standardised average length of abalone in the commercial catch has increased consecutively since 2017/18, and the average size of 135 mm is 10 mm above the current LML.

The total catch in the Cape Otway SMU of 55.8 t was 2.1 t below the OT (57.9 t). Mean CPUE (80.4 kg/h) was above the Threshold level (70 kg/h). While the Primary Indicator is Stable, the Secondary Indicator is Decreasing, resulting in a Decreasing Primary Category and therefore Final Category. For 2023/24 the OT was reduced to 49.0 t, so this suggests an OT of 41.7–46.6 t .

Following reduced catches in 2015, standardised CPUE has been relatively stable for the last six years. Mean daily catch has reduced in recent years but this followed a long period of rapid increase and it remains around average levels for the last two decades. At the four Top 15 FIS sites, recruit abundance is stable and pre-recruit abundance was high in 2023 in historical terms. The standardised average size of the commercial catch has steadily increased for the last six years. The Draft Harvest Strategy suggests a decrease in OT due to a drop in CPUE from 2021/22 to 2022/23. It is noted that in 2023/24 the base OT was reduced to 49.0 t with carry-over. The weight of evidence suggests that the stock appears relatively stable, but a conservative OT as suggested by the Draft Harvest Strategy may promote recovery.

3.2.5. Back Beaches (Large SMU)

The Back Beaches SMU was the second most productive Central Zone SMU with 42.5 t harvested in 2022/23 representing 16.8% of the total catch (Table 8) and TACC (Table 2). The total catch exceeded the OT by 2.5 t. CPUE has significantly declined since 2003 by 13%, was similar in the short-term (1% decline) and 19% higher than 4 years ago.

Table 8: Summary of Catch, Optimal targets and CPUE performance indicators for the Back Beaches SMU. The LML and mean daily catch are also shown. Coloured numbers for Performance Indicators identify if trends were significantly increasing (green), significantly decreasing (red), not significant (black).

Catch					CPUE Performance Indicators		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
42.5	16.8	40	40	40	-13	-1	19
LML 2022/23 = 119 mm					Mean daily catch 2022/23 = 506 kg		

The Back Beaches SMU is an important contributor to the Central Zone TACC, with an average catch of 59 t since 1992 and a peak catch of 95 t taken during 2008 (Figure 12). Catches generally declined in subsequent years reaching a low catch of 32 t in 2013. Catches ranged from 52 to 78 t from 2014 to 2018 and have ranged from 35 to 43 t thereafter.

Nominal CPUE generally increased from 1992 to 2000, reaching a peak of 118 kg/hr (Figure 8). Standardised CPUE has closely resembled nominal CPUE since 2003, generally declining until 2017 and slowly increasing thereafter.

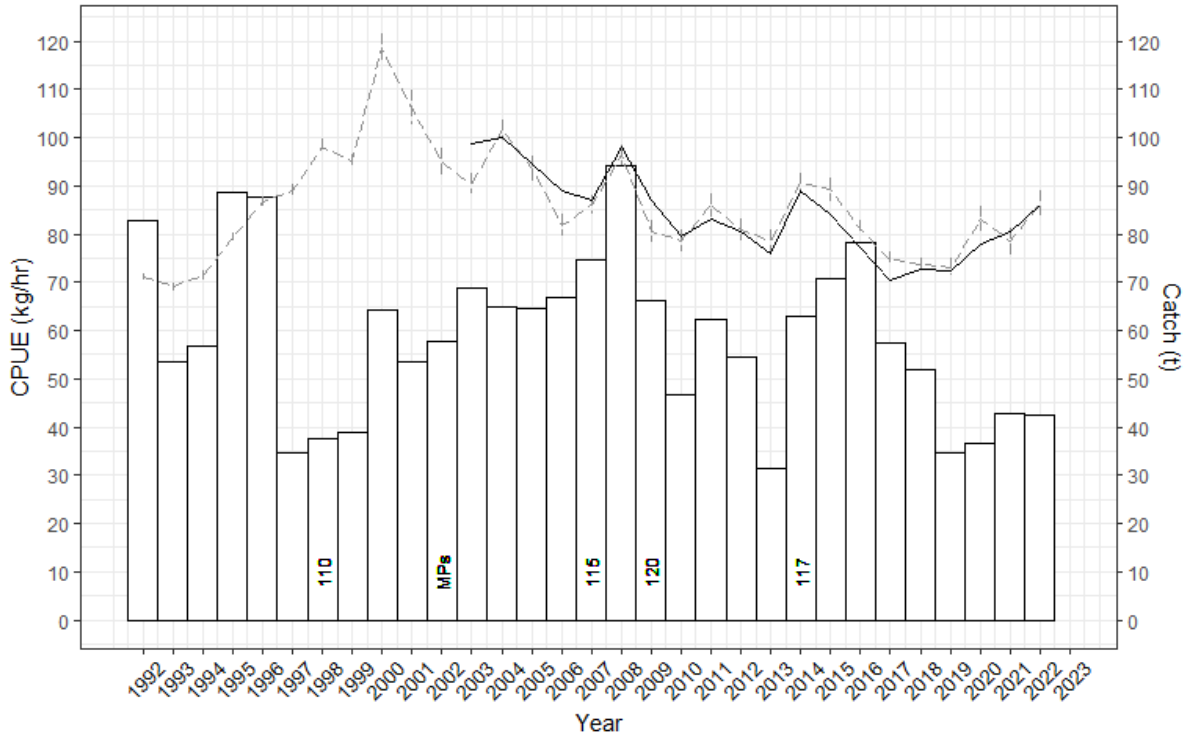

Figure 12: Back Beaches SMU catch, and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE), standardised series = black. Numbers indicate changes to LMLs. MPs = introduction of Marine Parks.

Mean daily catch increased from 264 kg/day in 1979 to 630 kg/day in 2000 (Figure 13). Mean daily catch has ranged from 401 to 510 kg/day since 2002, with an increase observed over the last three years. In 2022, mean daily catch was 506 kg/day.

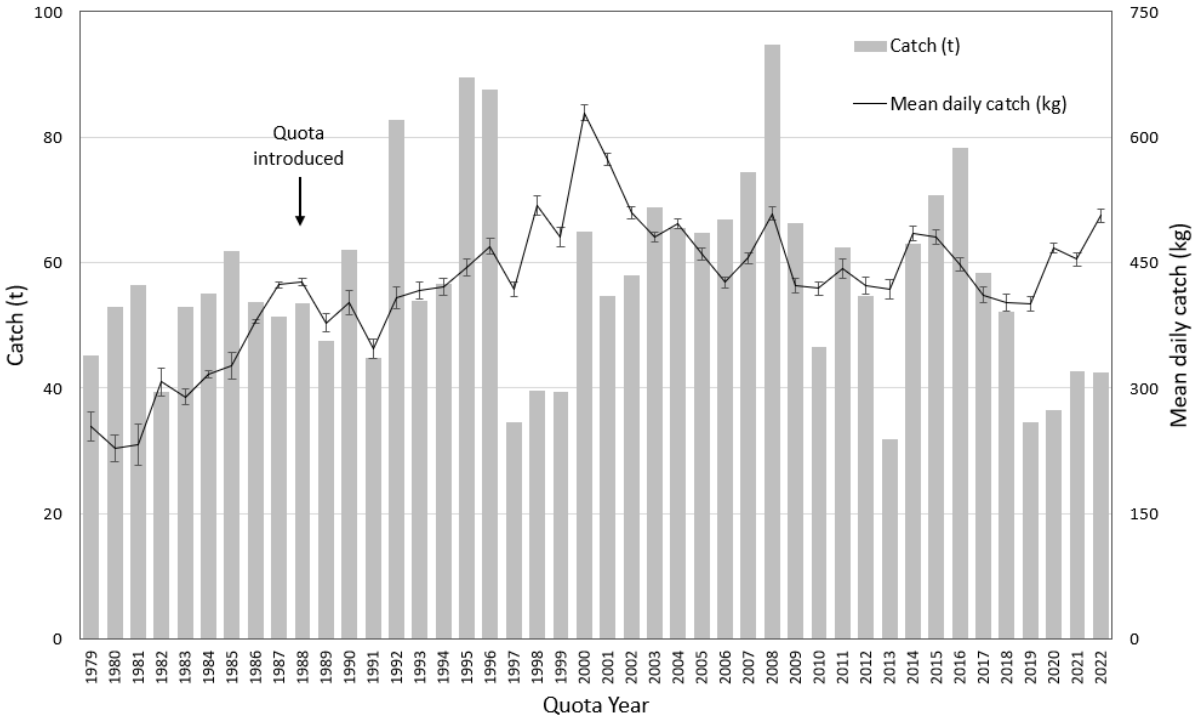

Figure 13: Total catch and mean daily catch for the Back Beaches SMU from 1979 to 2022.

Table 9: Catches (kg) by reefcode for the Back Beaches SMU from 2017/18 to 2022/23 and the five-year average catch from 2017/18 to 2021/22.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23
12.03	24908	26917	12121	14689	20039	19735	19028
12.02	15305	12626	10938	10004	11365	12048	10811
12.05	9655	6262	8218	5494	4993	6924	6883
12.04	8529	6468	3277	6293	6267	6167	5798
12.01	0	0	0	0	0	0	0
Totals	58397	52273	34554	36480	42665	44874	42520

The Back Beaches SMU comprises five reefcodes, four of which regularly produce high catches (Table 9). Catches in 2022/23 were similar to the previous five-year average for all reefcodes.

FIS recruit abundance (Three Top 15 sites)

The abundance of recruit sized abalone on FIS was highly variable from 1992 to 2015 before declining to a historic low in 2017 and 2018 (Figure 14). Abundance has been higher thereafter but remains low in a historic context.

FIS pre-recruit abundance (Three Top 15 sites)

Pre-recruit abundance at the Top 15 sites declined substantially from 2003 to very low levels in 2021, however in 2023 pre-recruit abundance levels increased to be equal with historic high levels (Figure 15).

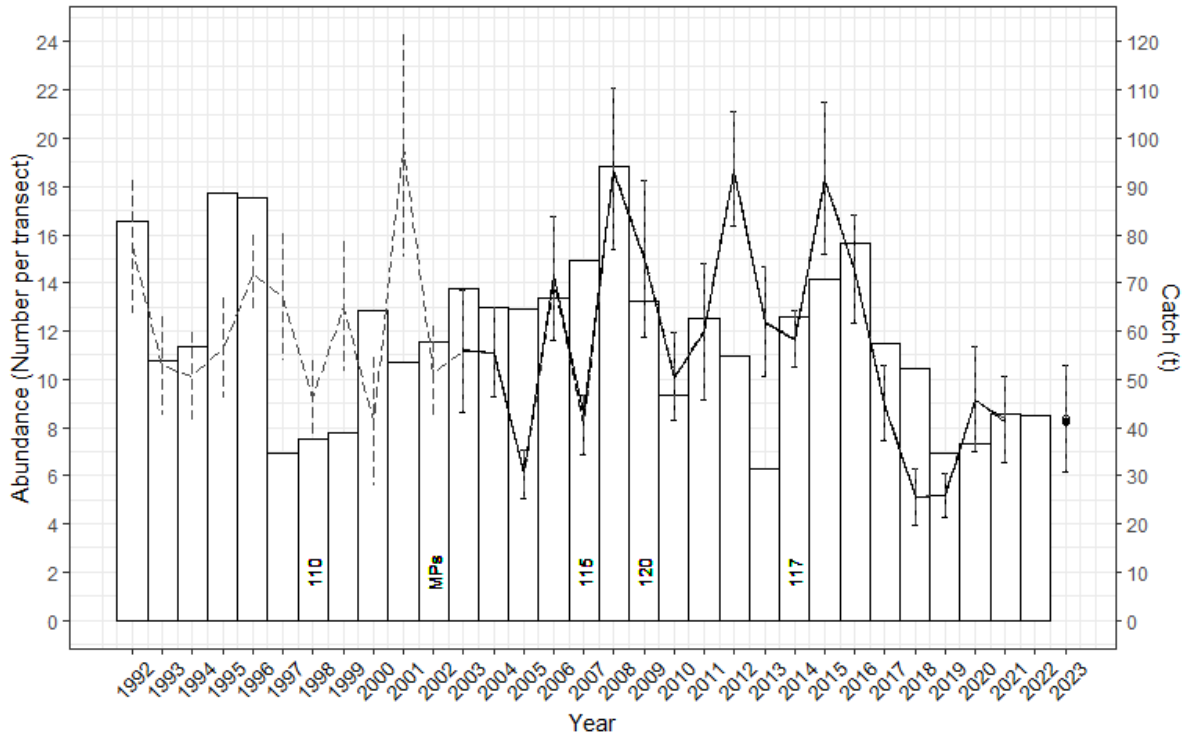

Figure 14: Recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) including catch from 1992/1993 – 2022/23 for the Back Beaches SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

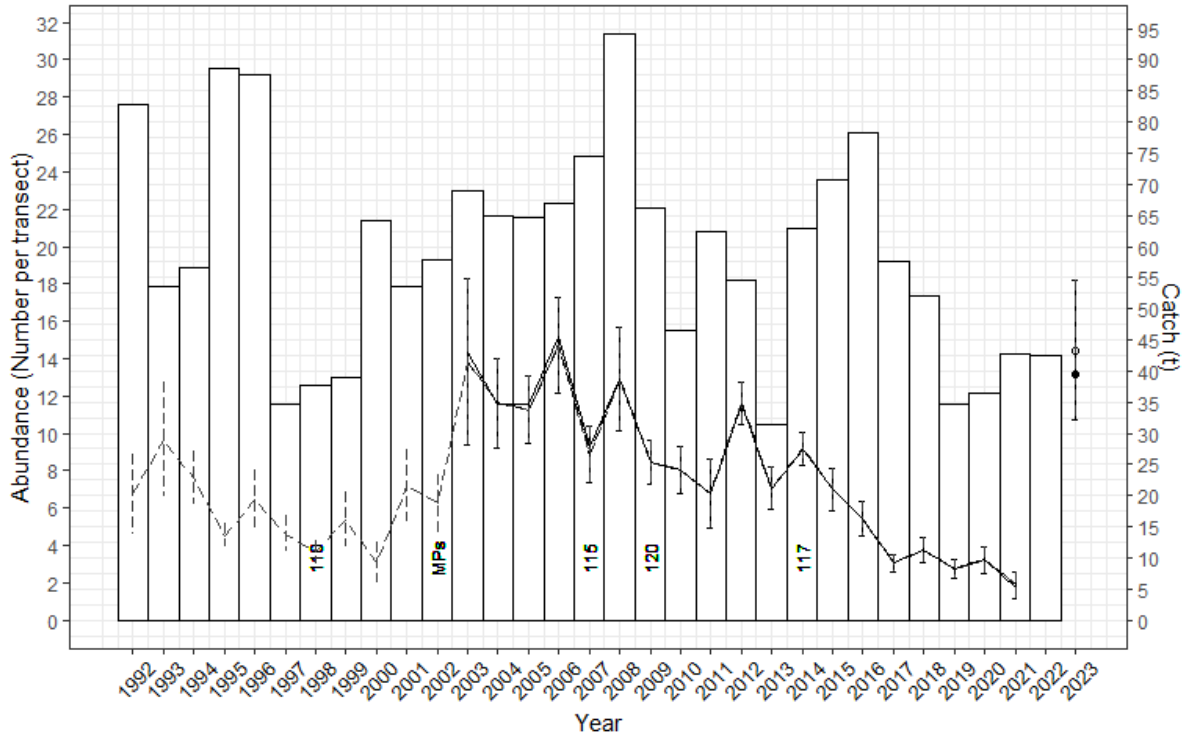

Figure 15: Pre-recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) including catch from 1992/1993 – 2022/23 for the Back Beaches SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

Length frequency data – FIS

The size structure of the surveyed population at the Back Beaches SMU has remained stable over time despite variations in abundance (Appendix 2). The increase in pre-recruit abundance observed in the three Top 15 sites surveyed in the 2023 FIS was across a range of pre-recruit size categories.

Length frequency data – commercial

From 2016/17 to 2019/20, the standardised average length of abalone in the commercial catch was relatively stable around 124 mm, which was around 7 mm above the LML at that time (Appendix 4, Appendix 5). The LML increased to 119 mm on 1 April 2020 and mean size increased by around 2 mm at that time. Thereafter, average size has slowly increased on an annual basis and is currently around 128 mm, which is 9 mm above the LML. Results of an analysis to account for LML increases in Appendix 4 also demonstrates an increase in size over and above the LML increase. It is noted that raw data do not show the same rate of increase as standardised data over time.

Summary

The Back Beaches SMU maintained high catches and catch rates particularly from 2000 to 2009. The peak catch of 95 t in 2008 occurred either side of increases in LML in 2007 and 2009. Catches declined thereafter until 2014 when the LML was decreased and catches again increased to reach almost 80 t in 2016. Catches then declined again, with 36.5 t harvested in the 2020/21 quota year before increasing to 42.7 t in 2021/22 and 2022/23. Standardised CPUE declined from 2003 to 2017 but has increased annually thereafter. Mean catch per day has increased substantially in the last three years. The distribution of catches by reefcode is stable.

At the three Top 15 FIS sites, recruit abundance remains low in a historical context but is almost twice as high as it was in 2017 and 2018. The abundance of pre-recruits increased dramatically in 2023 to be the equal highest observed in 2006.

The standardised average size of the commercial catch has increased substantially since 2019/20. These increases have continued in recent years despite a 2 mm LML increase in 2020.

Total catch in the Back Beaches SMU (42.7 t) was 2.7 t above the OT (40.0 t). Mean CPUE (85.5 kg/h) was above the Threshold level (70 kg/h). The Primary and Secondary Indicators were both Increasing resulting in an Increasing Primary Category and Final Category. This suggests an OT from 40.0 t up to 50.0 t.

Total catches have been lower than average in recent years due to stock concerns. However, all available evidence suggests that stock indicators have responded positively. CPUE and mean daily catch have increased, as has the average size of the commercial catch. FIS recruit abundance is low but stable however pre-recruit abundance in 2023 increased dramatically and was at equal record levels. The Draft Harvest Strategy suggests and increase in OT can be considered, however if this is the case then any increase should be very modest and it should consider that the stock will likely be fished to its upper limit as it has in the last two years.

3.2.6. Phillip Island (Medium SMU)

The Phillip Island SMU was fourth highest contributor to the Central Zone total catch with 35.0 t harvested in 2022/23 representing 13.9% of the total catch (Table 10) and TACC (Table 2). The catch was 1 t above the OT. CPUE has significantly declined by 13% in the long-term, declined by 8% in the short-term but has increased by 22% in the last 4 years.

Table 10: Summary of Catch, Optimal targets and CPUE performance indicators for the Phillip Island SMU. The LML and mean daily catch are also shown. Coloured numbers for Performance Indicators identify if trends were significantly increasing (green), significantly decreasing (red), not significant (black).

Catch					CPUE Performance Indicators		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
35.0	13.9	34.0	34.0	32.3	-13	-8	22
LML 2022/23 = 112 mm					Mean daily catch 2022/23 = 473 kg		

The Phillip Island SMU has had an average catch of 62 t since 1992 and a peak catch of 121 t harvested during 1998 (Figure 16). Following the peak, catches generally declined reaching a low catch of 26 t in 2010. Catches ranged from 33 to 51 t between 2011 and 2018 but have stabilised in the last 4 years under a catch cap.

Nominal CPUE increased from 1992 to 2001, reaching a peak of 116 kg/hr (Figure 16). Standardised CPUE slowly declined from 2003 to 2017 but has increased thereafter and is currently higher than 2006 levels.

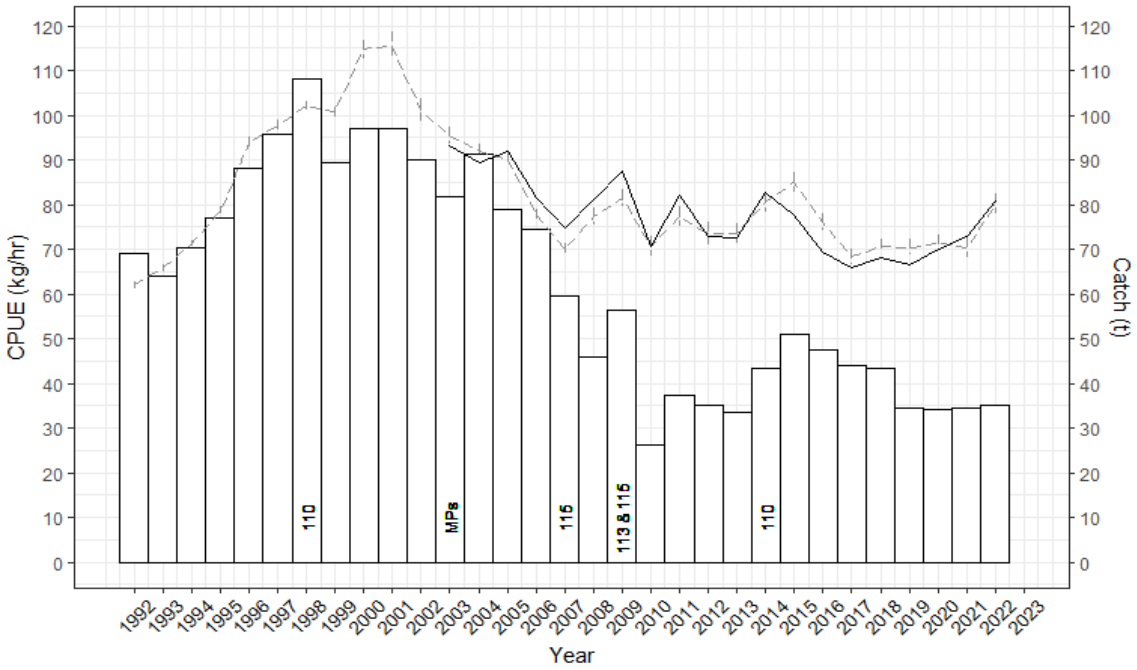

Figure 16: Phillip Island SMU catch, and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE), standardised series = black. Numbers indicate changes to LMLs. MPs = introduction of Marine Parks.

Mean daily catch was increased slowly from 275 kg/day in 1979 to 573 kg/h in 2000 (Figure 17). Mean daily catch has increased from 375 to 473 kg/day in the last four years, with 2022 levels the highest observed since 2003.

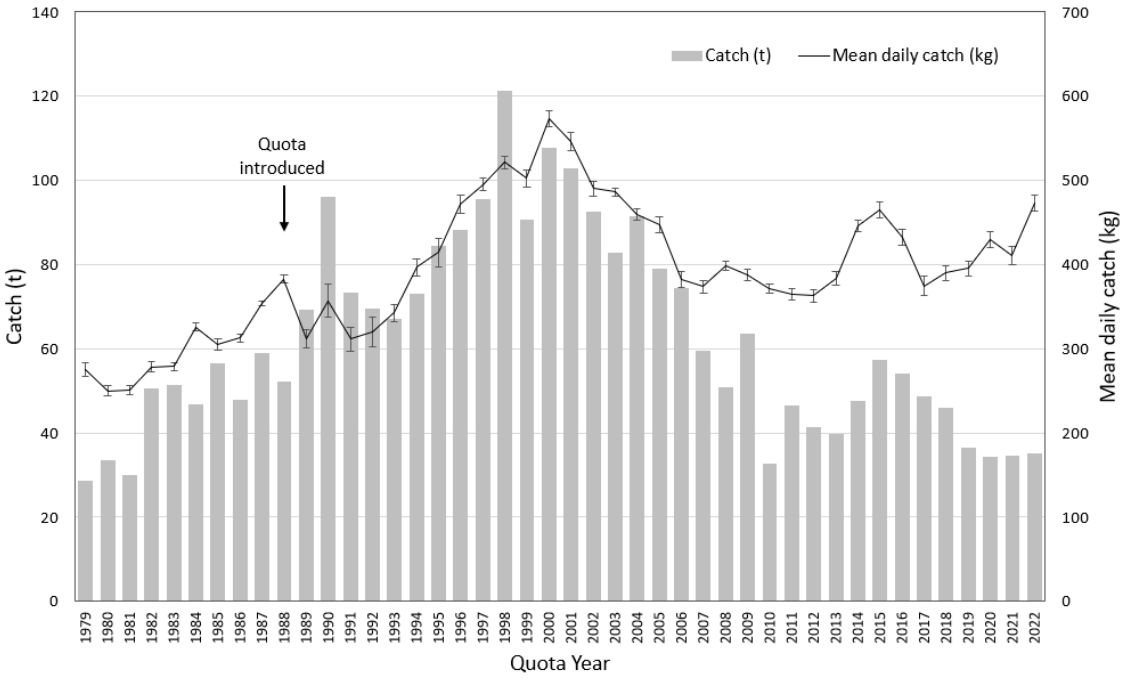

Figure 17: Total catch and mean daily catch for the Phillip Island SMU from 1979 to 2022.

Table 11: Catches (kg) by reefcode for the Phillip Island SMU from 2017/18 to 2022/23 and the five-year average catch from 2017/18 to 2021/22.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23
14.03	15651	13533	9327	10817	12412	12348	8752
14.02	13613	11969	10474	8841	11001	11180	9585
14.04	5838	7009	4584	5567	3777	5355	6310
14.09	6599	6187	4458	4042	3218	4901	3476
14.11	2667	3591	2819	1200	294	2114	2146
14.06	1212	1192	2351	1596	1369	1544	1301
14.05	2047	332	1318	280	1157	1027	680
14.01	632	232	73	810	558	461	259
14.10	420	496	767	419	0	420	700
14.07	30	833	392	542	291	418	1831
14.08	30	672	0	90	489	256	0
Totals	48738	46047	36563	34203	34567	40024	35039

The Phillip Island SMU comprises 11 reefcodes, four of which (14.03, 14.02, 14.04, 14.09) produce most of the catch (Table 11). In 2022/23, the catch from 14.03 was lower than the five-year average. Most other reefcodes were similar to previous years except 14.07 that had an unusually high catch.

FIS recruit abundance (Two Top 15 sites)

Recruit abundance declined sharply at Top 15 sites from 2004 to 2008 and was highly variable until it reached a contemporary low in 2017 (Figure 18). Since then, recruit abundance has linearly increased and in 2023, recruit abundance doubled relative to 2021 and was at the highest levels observed since 2004.

FIS pre-recruit abundance (Two Top 15 sites)

Pre-recruit abundance at Top 15 sites has been highly variable since 2004 (Figure 19). Historic low levels were observed in 2015, increasing slightly thereafter but remaining low in a historic context. In 2023, pre-recruit abundance almost doubled relative to 2021 and was high in a historical context.

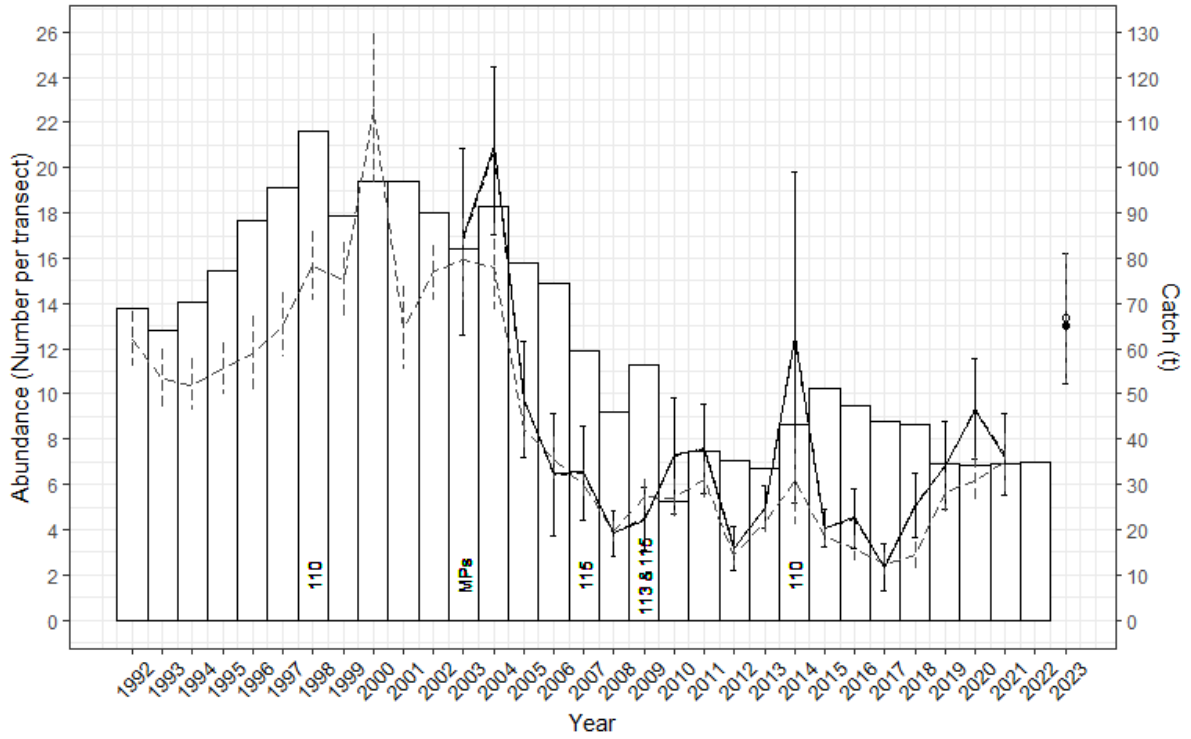

Figure 18: Recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) and catch from 1992/1993 – 2020/21 for the Phillip Island SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

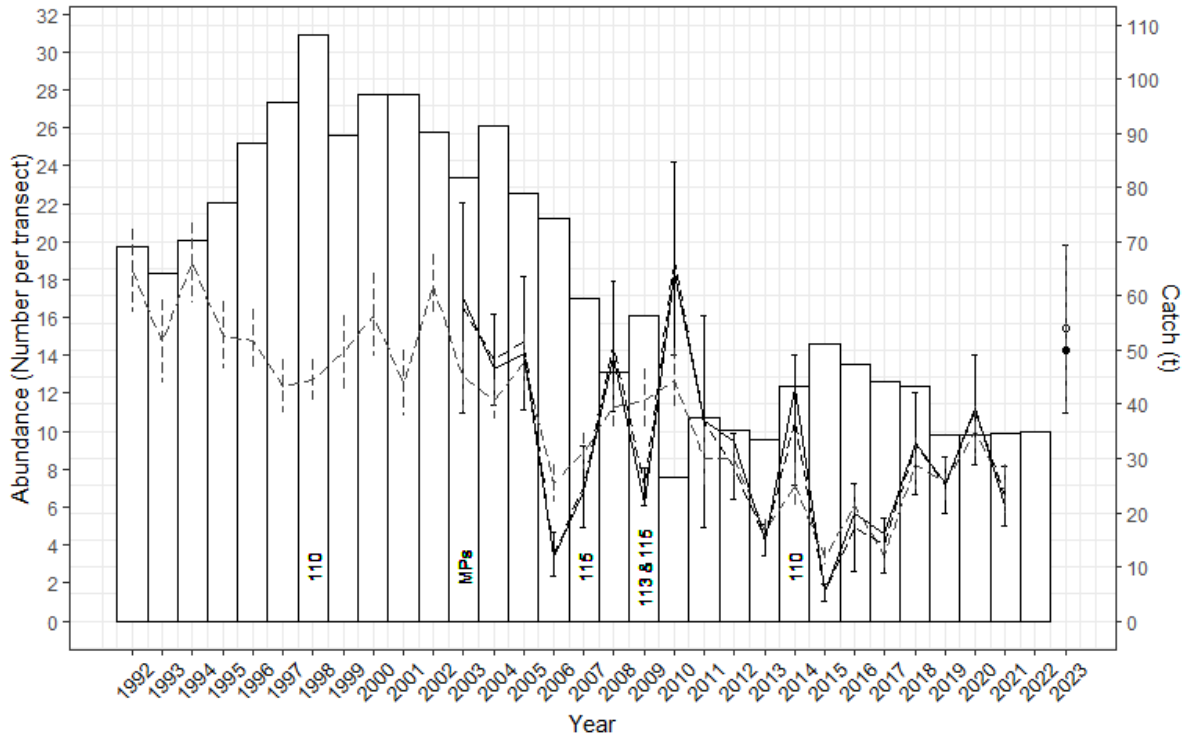

Figure 19: Pre-recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) including catch from 1992/1993 – 2022/23 for the Phillip Island SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

Length frequency data – FIS

The size structure of the surveyed population at the Phillip Island SMU has remained stable over time despite variations in abundance (Appendix 2). The increase in pre-recruit abundance observed in the two Top 15 sites surveyed in the 2023 FIS was across a range of pre-recruit size categories.

Length frequency data – commercial

From 2016/17 to 2019/20, the standardised average length of abalone in the commercial catch increased from around 116 mm to 120 mm, which was 6 to 10 mm above the LML at that time (Appendix 4, Appendix 5). The LML increased to 112 mm on 1 April 2020 and mean size increased by around 2 mm in 2021 to around 122 mm and has increased to around 124 mm in 2023/24, which is around 12 mm above the current LML. Results of an analysis to account for LML increases in Appendix 4 also demonstrates an increase in size over and above the LML increase. Raw data show similar rates of increase as standardised data over time, albeit more variable.

Summary

The Phillip Island SMU has had an average catch of 62 t since 1992 and a peak catch of 121 t harvested during 1998. Following the peak, catches generally declined reaching a low catch of 26 t in 2010. Catches ranged from 33 to 51 t between 2011 and 2018 but have stabilised in the last 4 years under a catch cap. Standardised CPUE generally declined from 2003 to 2019 but has increased substantially in the last four years while catches have been stable. Mean daily catch has also increased, with 2023 levels the highest observed since 2003.

Recruit abundance at the two Top 15 FIS sites had declined substantially between 2003 and 2017 but has increased thereafter, with 2023 levels amongst the highest recorded. Similar trends have occurred for pre-recruit abundance, with 2023 levels close to the historic high.

Since 2016/17, the standardised average length of the commercial catch has increased from 116 mm to 124 mm. The LML increased from 110 mm to 112 mm on 1 April 2020.

Total catch in the Phillip Island SMU of 35.0 t was just above the OT (34.0 t). Mean CPUE (81.4 kg/h) was above the Threshold Reference Point (70 kg/h). The Primary and Secondary Indicators were both Increasing resulting in an Increasing Primary Category and Final Category. The OT was reduced to 32.3 t for 2023/24, which suggests an OT from 32.3 t up to 40.4 t.

After four years of a stable, relatively low catch in historic terms, all available indicators appear positive for the Phillip Island SMU. It is noted that the OT was reduced slightly for 2023/24. Given these positive indicators and the Draft Harvest Strategy outcomes, an OT closer to the previous years (i.e. 34.0 t) would appear sustainable and may continue to promote stock recovery.

3.2.7. Shipwreck Coast (Medium SMU)

The Shipwreck Coast SMU had the fourth highest catch with 33.9 t in 2022/23 representing 13.4% of the total catch (Table 12) and TACC (Table 2). The catch was close to the OT. CPUE has declined in the long-term (18%, significant) and short-term (16%) but was 7% higher than 4 years ago.

Table 12: Summary of Catch, Optimal targets and CPUE performance indicators for the Shipwreck Coast SMU. The LML and mean daily catch are also shown. Coloured numbers for Performance Indicators identify if trends were significantly increasing (green), significantly decreasing (red), not significant (black).

Catch					CPUE Performance Indicators		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
33.9	13.4	36.2*	34.3*	29.2*	-18	-16	7
LML 2022/23 = 130 mm					Mean daily catch 2022/23 = 566 kg		

The Shipwreck Coast SMU has had an average catch of 26 t since 1992 with a peak catch of 49 t harvested during 2002 (Figure 20). This SMU was severely affected by the virus in 2007 (VFA 2018) and there was no fishing in 2008 and 2009. Catches gradually increased post-virus and following a low catch of 17 t in 2022/23, catches were the highest post-virus in 2021/22 (38.4 t).

Nominal CPUE generally increased from 1992 to 2003, reaching a peak of 148 kg/hr (Figure 20). Standardised CPUE has fluctuated without any significant trend post-virus.

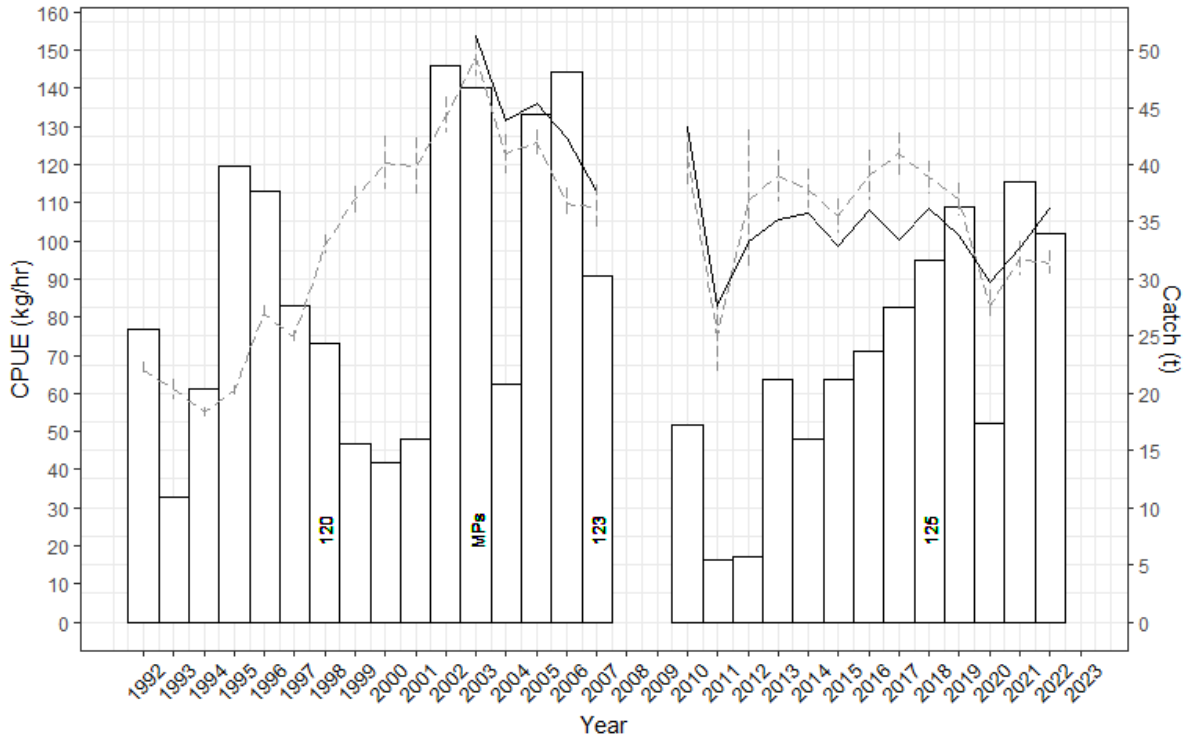

Figure 20: Shipwreck Coast SMU catch, and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE), standardised series = black. Numbers indicate changes to LMLs. MPs = introduction of Marine Parks.

Mean daily catch was increased slowly from 330 kg/day 1979 to 723 kg/day in 2003 (Figure 21). Post-virus, mean daily catch has been highly variable ranging from 451 to 727 kg/day, however it has been more stable in the last three years (range 543 to 583 kg/day).

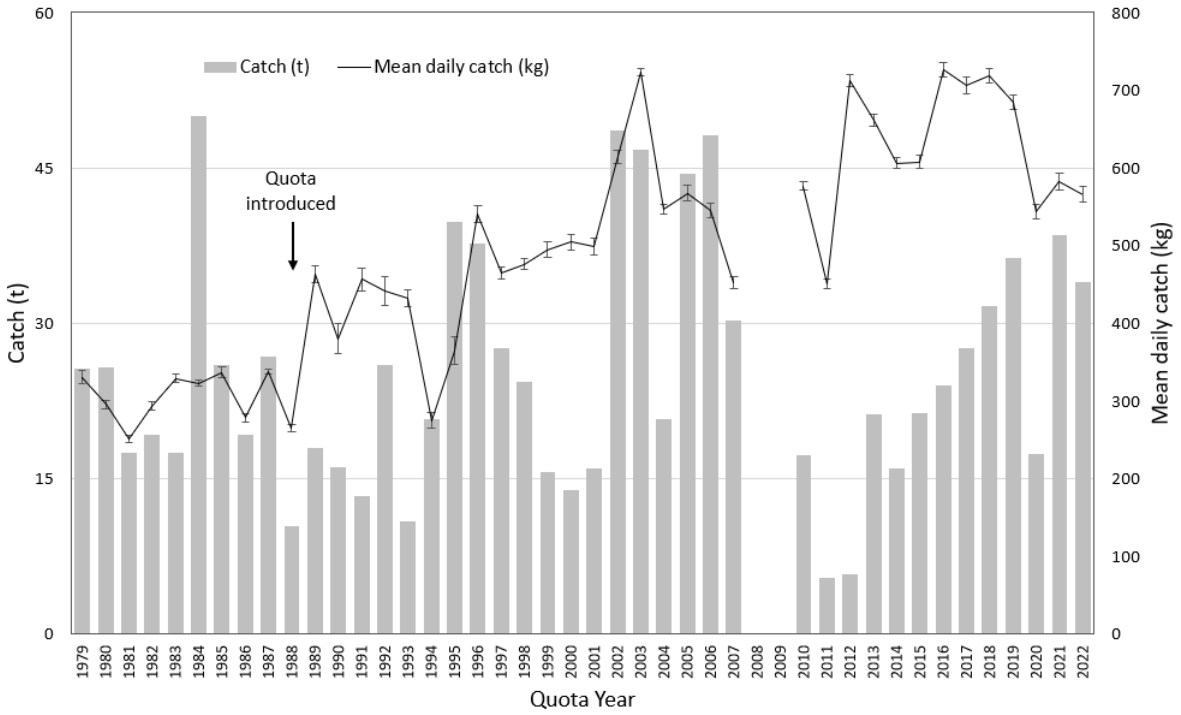

Figure 21: Total catch and mean daily catch for the Shipwreck Coast SMU from 1979 to 2022.

Table 13: Catches (kg) by reefcode for the Shipwreck Coast SMU from 2017/18 to 2022/23 and the five-year average catch from 2017/18 to 2021/22.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23
4.02	12128	16947	15863	8064	11812	12963	13161
4.01	4121	5901	6074	3730	12363	6438	7362
5.02	3947	2883	5682	4010	7766	4858	3959
5.03	4895	4446	5363	1047	5740	4298	4151
5.01	2474	1458	3283	535	768	1703	5311
Totals	27565	31635	36265	17386	38448	30260	33944

All five reefcodes have contributed regularly to the catch from the Shipwreck Coast SMU in the past six years (Table 13). In 2022/23, catches were close to the five-year average at most reefcodes, however a very large catch was harvested from 5.01.

FIS recruit abundance (Two Top 15 sites)

FIS were not implemented in the Shipwreck SMU until 2004. The abundance of recruit sized abalone declined substantially and significantly from 2004 to 2009, seemingly independent of the virus introduction (Figure 22). At Top 15 sites, recruit abundance has generally increased post-virus.

FIS pre-recruit abundance (Two Top 15 sites)

The abundance of pre-recruit abalone has been variable over time (Figure 23). The abundance of pre-recruits generally increased post-virus until 2020 and has been at relatively low levels thereafter.

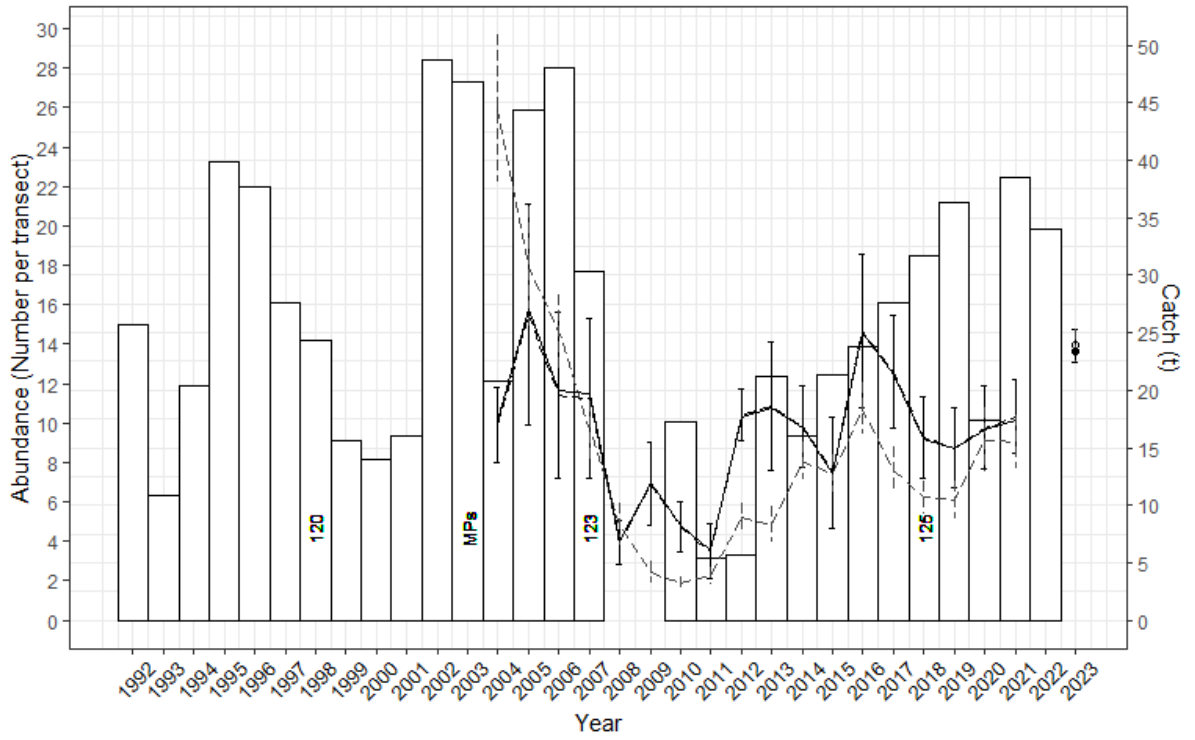

Figure 22: Recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) including catch from 1992/1993 – 2022/23 for the Shipwreck Coast SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

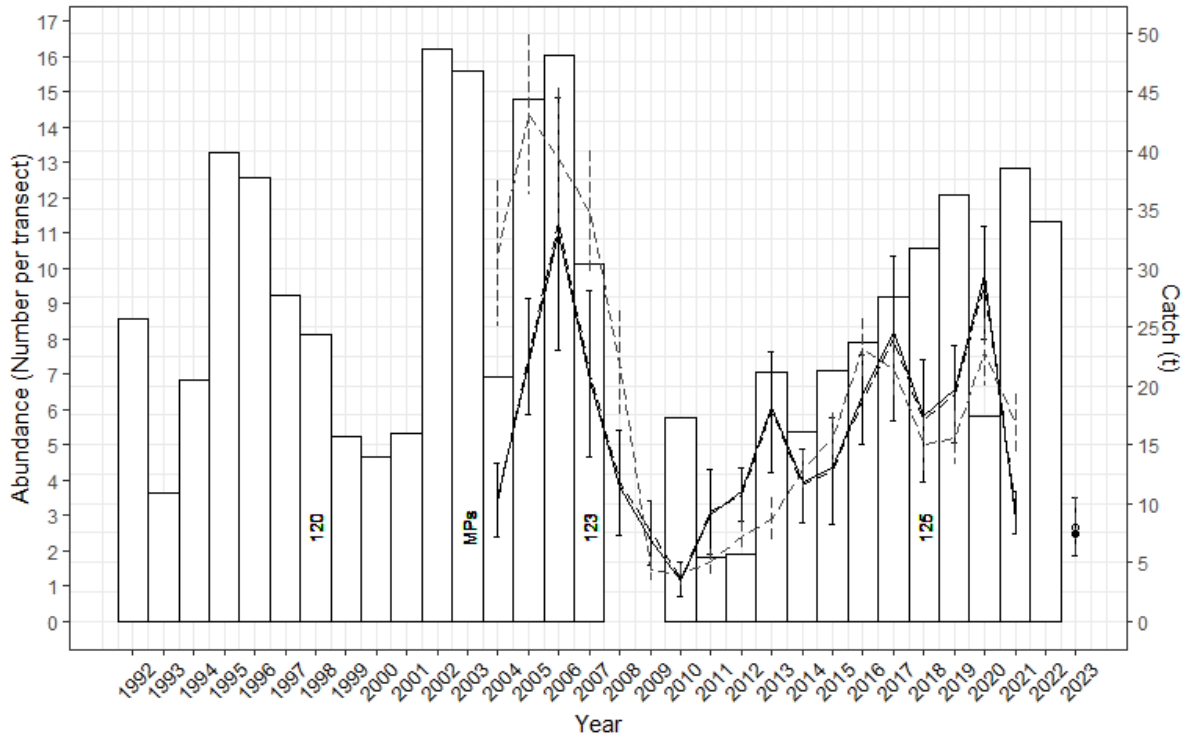

Figure 23: Pre-recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) including catch from 1992/1993 – 2022/23 for the Shipwreck Coast SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

Length frequency data – FIS

The size structure of the surveyed population at the Shipwreck Coast SMU changed prior to the virus, showing declines in mean size (Appendix 2). The size structure has varied post-virus but few clear trends are evident.

Length frequency data – commercial

From 2016/17 to 2019/20, the standardised average length of abalone in the commercial catch was stable around 134 to 135 mm, which was 9 to 10 mm above the LML at that time (Appendix 4, Appendix 5). The LML increased to 130 mm on 1 April 2020 and mean size increased by around 3 mm to around 138 mm in 2021. Standardised average size has increased slightly thereafter. Results of an analysis to account for LML increases in Appendix 4 demonstrate an increase in size over and above the LML increase. Raw data show almost identical trends to standardised data over time.

Summary

The Shipwreck Coast SMU was severely affected by the abalone virus in 2007 (VFA 2018) and there was no fishing in 2008 and 2009. Catches have recovered substantially since and are currently above the historic average. Post-virus, standardised CPUE has fluctuated without any trend. Mean daily catch in the last three years has been lower than previous, however this is likely the result of an increase in LML from 125 to 130 mm. Catches at the reefcode scale tend to be highly variable and either reflects diver preferences or possibly differing recovery rates of reefs. For example, in 2022/23 the catch from reefcode 5.01 (5.3 t) was more than three times higher than the previous five year's average.

FIS were not implemented in the Shipwreck SMU until 2004. Following the virus outbreak, both recruit and pre-recruit abundance increased substantially at the two Top 15 sites up to 2016 and have fluctuated thereafter. Recruit abundance was high in relative terms while pre-recruit abundance was low.

The standardised average length of the commercial catch has increased from around 134 to 138 mm in the last six years, with an increase in LML from 125 to 130 mm during this time.

The total catch in the Shipwreck Coast SMU of 33.9 t was just below the OT with carry-over (34.3 t). Mean CPUE (99.6 kg/h) was above the Threshold (70 kg/h) Reference Point. The Primary Category was Stable and therefore the Final Category was Stable. The OT with carryover was reduced to 29.2 t in 2023/24, suggesting a target catch of 27.7 to 30.7 t.

Catches in recent years have been above the historic average for the fishery, however given its history of being virus infected it remains difficult to determine whether such catches are sustainable. Further, the large increase in LML from 125 to 130 mm has clearly impacted some of the indicators in recent years. The Draft Harvest Strategy suggests maintaining a stable catch and given the reduction in OT for 2023/24 it seems appropriate to maintain this strategy for 2024/25.

3.2.8. Flinders (Medium SMU)

The Flinders SMU contributed 26.7 t in 2022/23 representing 10.6% of the total catch (Table 14) and TACC (Table 2). CPUE has significantly declined since 2003 by 22%, with a 7% (non-significant) reduction observed since 2009, however CPUE has increased by 12% over the last 4 years.

Table 14: Summary of Catch, Optimal targets and CPUE performance indicators for the Flinders SMU. The LML and mean daily catch are also shown. Coloured numbers for Performance Indicators identify if trends were significantly increasing (green), significantly decreasing (red), not significant (black).

Catch					CPUE Performance Indicators		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
26.7	10.6	24.2*	24.2	20.5	-22	-7	12
LML 2022/23 = 114 mm					Mean daily catch 2022/23 = 405 kg		

The Flinders SMU has been the most important historical contributor to the Central Zone TACC, with an average of 112 t since 1992 and a peak of 231 t taken during 1993 (Figure 24). Catches remained above 150 t up until and including 2008, when a size limit increase was implemented. A catch of 88 t was harvested in both 2008 and 2009 and catches have ranged from 20-44 t per year since.

Nominal CPUE generally increased from 1992 to 2001, reaching a peak of 112 kg/hr (Figure 24). Standardised CPUE has closely resembled nominal CPUE since 2003, with a general decline until 2013. CPUE has slowly increased over the last 5 years.

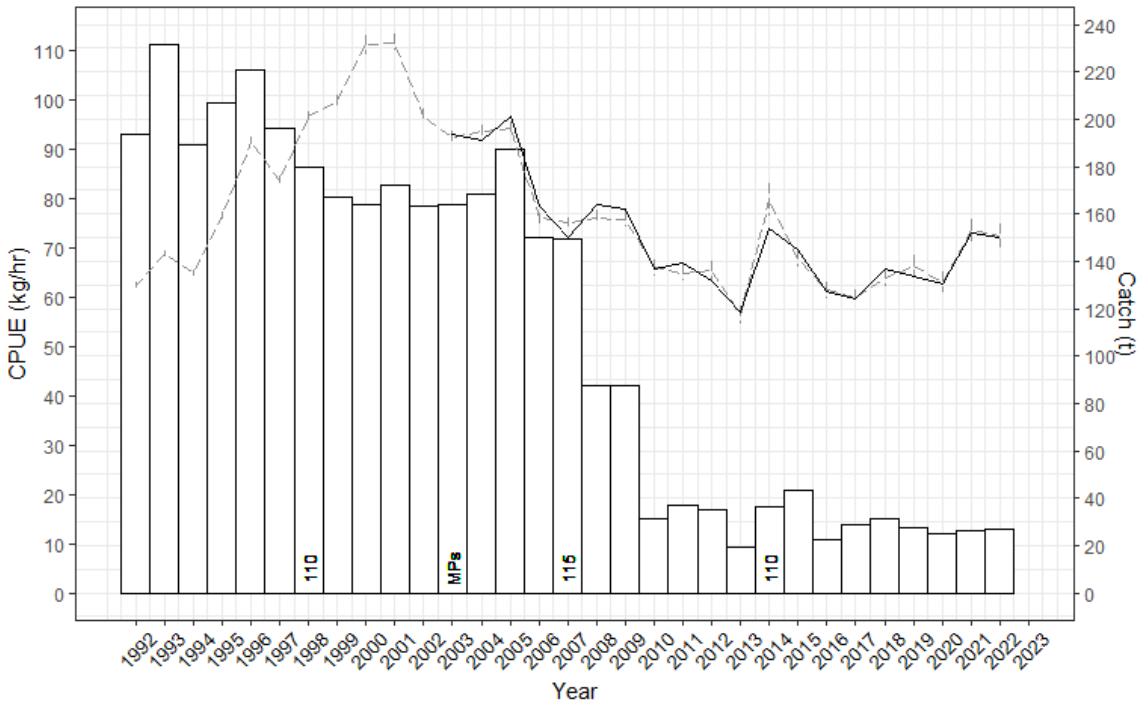

Figure 24: Flinders SMU catch, and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE), standardised series = black. Numbers indicate changes to LMLs. MPs = introduction of Marine Parks.

Mean daily catch increased from 314 kg/day in 1979 to 533 kg/day in 2000 before declining to 270 kg/day in 2013 (Figure 25). Mean daily catch has increased from 302 kg/day to 405 kg/day over the last 5 years.

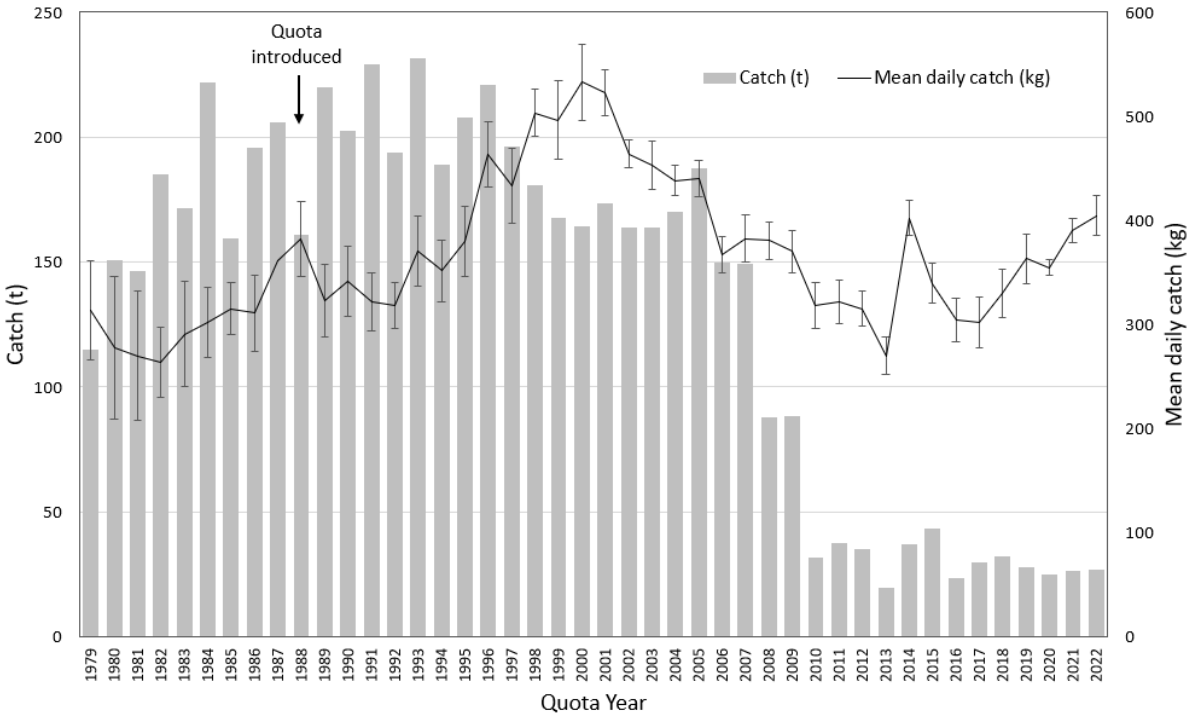

Figure 25: Total catch and mean daily catch for the Flinders SMU from 1979 to 2022.

Table 15: Catches (kg) by reefcode for the Flinders SMU from 2017/18 to 2022/23 and the five-year average catch from 2017/18 to 2021/22.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23
12.06	11669	14953	10120	9604	11554	11587	11970
13.01	5355	5518	4233	4343	3676	4862	3541
13.02	5413	3544	3920	3341	3052	4055	2529
13.03	2582	4247	3203	1717	1211	2937	1655
13.04	882	2338	3633	2798	4181	2413	3129
13.05	933	207	2056	1886	2382	1271	3049
13.07	2203	988	338	0	0	882	651
13.06	887	554	455	1463	233	840	205
Totals	29924	32349	27957	25151	26288	28846	26729

The Flinders SMU comprises eight reefcodes, with 12.06 the key contributor since 2017/18 (Table 15). Catches were generally within the recent historic range at most SMUs except for 13.05 where the highest catch was harvested in the last six years.

FIS recruit abundance (Two Top 15 sites)

The abundance of recruit sized abalone on has declined over time at all sites and Top 15 sites and in 2022/23 remains at low historical levels (Figure 26).

FIS recruit abundance (Two Top 15 sites)

The abundance of pre-recruit sized abalone also declined over time at all sites and Top 15 sites, however there was a large increase in pre-recruit abundance at Top 15 sites in 2023 with abundance levels similar to 2016 (Figure 27).

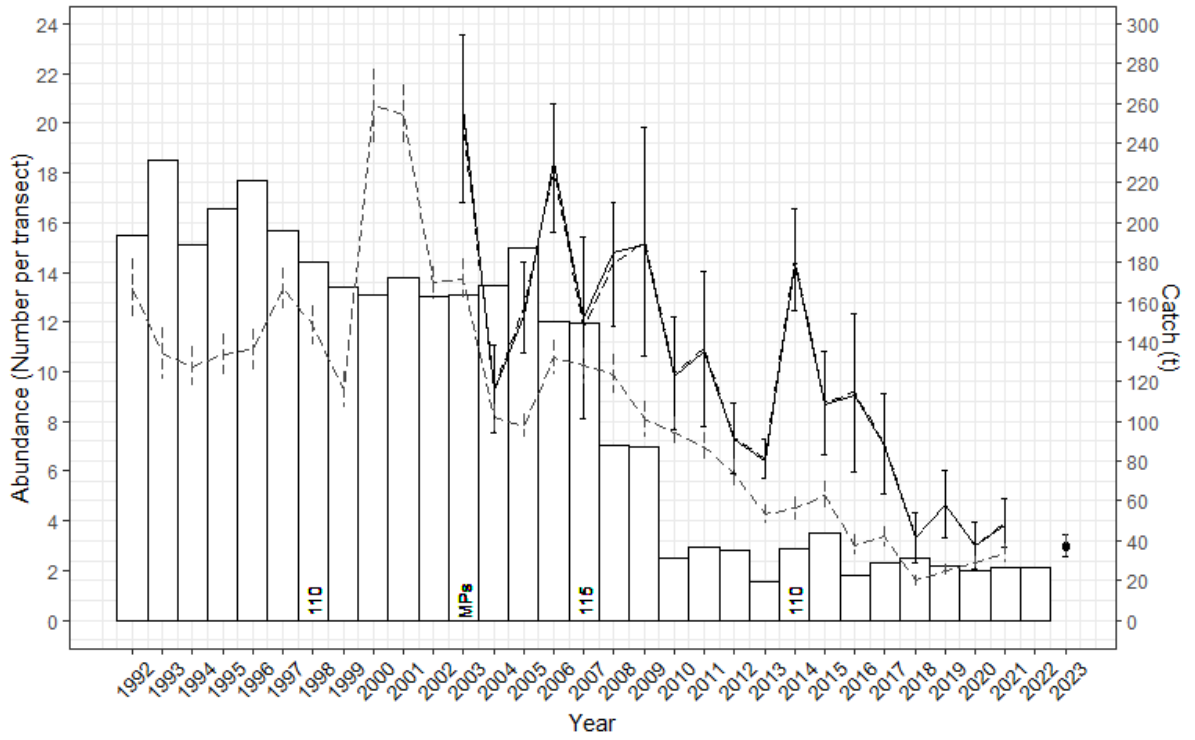

Figure 26: Recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) including catch from 1992/1993 – 2022/23 for the Flinders SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

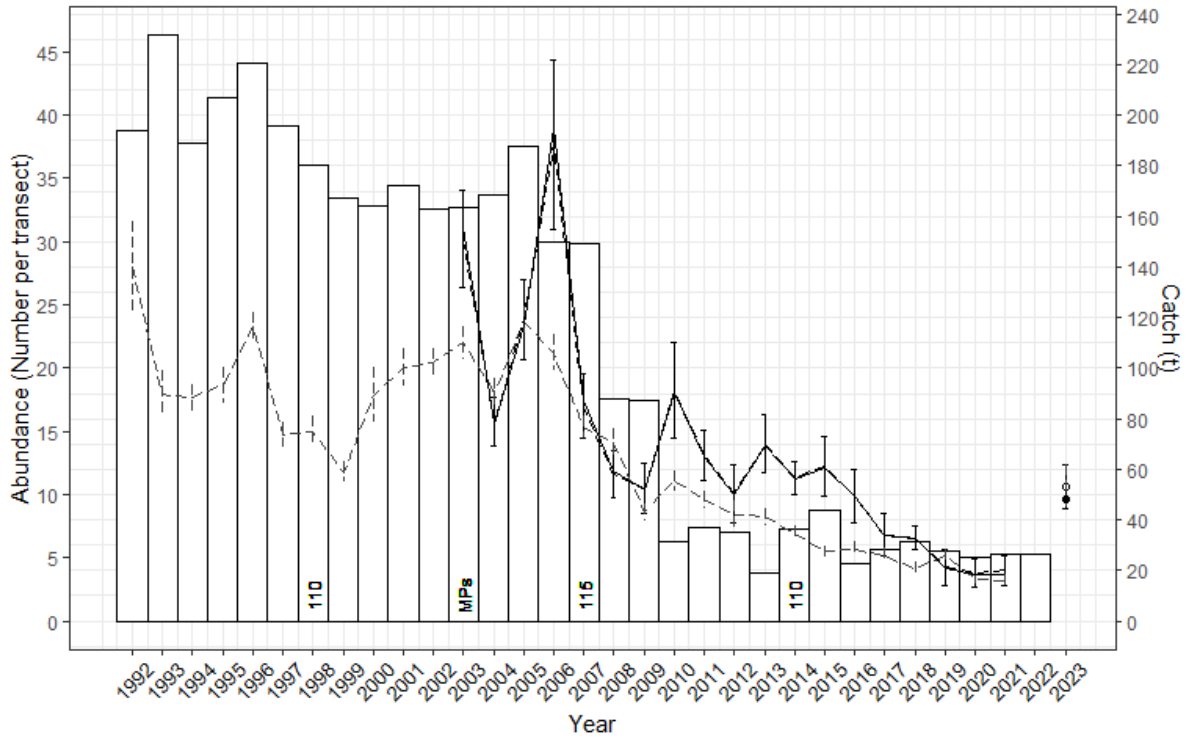

Figure 27: Pre-recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) including catch from 1992/1993 – 2022/23 for the Flinders SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

Length frequency data – FIS

While the abundance of abalone has declined substantially over time, there are few clear trends evident in the size structure data from FIS (Appendix 2). The increase in pre-recruit abundance observed at the two Top 15 sites in 2022/23 occurred across a range of pre-recruit size categories.

Length frequency data – commercial

From 2016/17 to 2019/20, the standardised average length of abalone in the commercial catch increased from around 115 to 118 mm, which was 5 and 8 mm, respectively, above the LML at that time (Appendix 4, Appendix 5). The LML increased to 112 mm on 1 April 2020 and to 114 mm on 1 April 2021, with mean size increasing by around 2 mm in 2020/21 and a further 1 mm in 2021/22. Standardised average size increased again in 2022/23 and while the 2023/24 data suggest a decrease in size, this should be ignored as it comes from only one diver day. Results of an analysis to account for LML increases in Appendix 4 also demonstrate an increase in size over and above the LML increase. Raw data show almost identical trends to standardised data over time.

Summary

The Flinders SMU has been the most important historical contributor to the Central Zone TACC, with an average catch of 115 t (since 1992) and a peak catch of 231 t (1993). Catches remained above 150 t up until 2007 but declined thereafter ranging from 20-44 t per year since 2010. Standardised CPUE declined substantially from 2003 to 2013 but has increased in the last five years. Mean daily catch has also increased during this period. The distribution of catch among reefcodes has generally been stable in recent years.

The abundance of recruit sized abalone at the two Top 15 FIS sites has declined substantially since 2003 and remains low in a historic context. Pre-recruit abundance declined at a similar rate, however in 2023 pre-recruit abundance increased substantially to around the levels observed in 2016.

The standardised average length of the commercial catch has increased from around 115 in 2016/17 to 122 mm in 2022/23, with increases in LML from 110 to 112 then 114 mm in 2021 and 2022, respectively.

The total catch in the Flinders SMU of 26.7 t was 2.5 t above the OT with carryover (24.2 t). Mean CPUE (72.6 kg/h) was above the Threshold (70 kg/h) Reference Point. The Primary Category was Increasing and therefore the Final Category was Increasing. The OT for 2023/24 was reduced to 20.5 t and therefore the suggested OT is between 20.5 t and 23.6 t.

The once productive deeper water reefs of the Flinders SMU have declined substantially, and the fishery currently relies primarily on inshore shallow reefs. While most indicators remain poor relative to the long-term, the short-term outlook is more positive. CPUE and mean catch per day have increased in the last five years, as has the average length of the commercial catch. During this period the LML has increased from 110 to 114 mm. While there are only two Top 15 FIS sites, these have shown large increases in pre-recruit abundance, consistent with the nearby Phillip Island and Back Beaches SMUs. In 2023/24, the OT was reduced to 20.5 t. While the Draft Harvest Strategy suggests that an increase in OT can be considered, given the importance of the Flinders SMU historically, strong consideration should be given to maintaining the lower OT to further build on the positive indicators from recent years.

3.2.9. Prom Westside (Medium SMU)

The Prom Westside SMU contributed 26.7 t in 2022/23 representing 10.6% of the total catch (Table 16) and TACC (Table 2). This was 5.7 t above the OT. CPUE has declined significantly in this SMU in the long-term (16%) and short-term (3%, not significant) but has increased by 39% in the last 4 years.

Table 16: Summary of Catch, Optimal targets and performance indicators for the Prom Westside SMU. The LML and mean daily catch are also shown. Coloured numbers for Performance Indicators identify if trends were significantly increasing (green), significantly decreasing (red), not significant (black).

Catch					CPUE Performance Indicators		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
26.7	10.6	21.0	21.0	21.0	-16	-3	39
LML 2022/23 = 115 / 120 mm					Mean daily catch 2022/23 = 468 kg		

The Prom Westside has a catch average of 31 t since 1992 and a peak catch of 62 t in 2007 that likely reflected catch displacement following the virus first reaching the western end of the Central Zone (Figure 28). In all other years, catches have generally ranged from 20-40 t, except for the low catch (8 t) in 2019 that likely resulted from an increase in size limit to 120 mm across the SMU. The split size limit (115/120 mm) was re-instated in 2020 and catches have increased.

Standardised CPUE has closely resembled nominal CPUE since 2003, showing a general decline from 2003 to 2019 (Figure 28). CPUE has increased substantially in the last 3 years and is currently similar to 2010 levels.

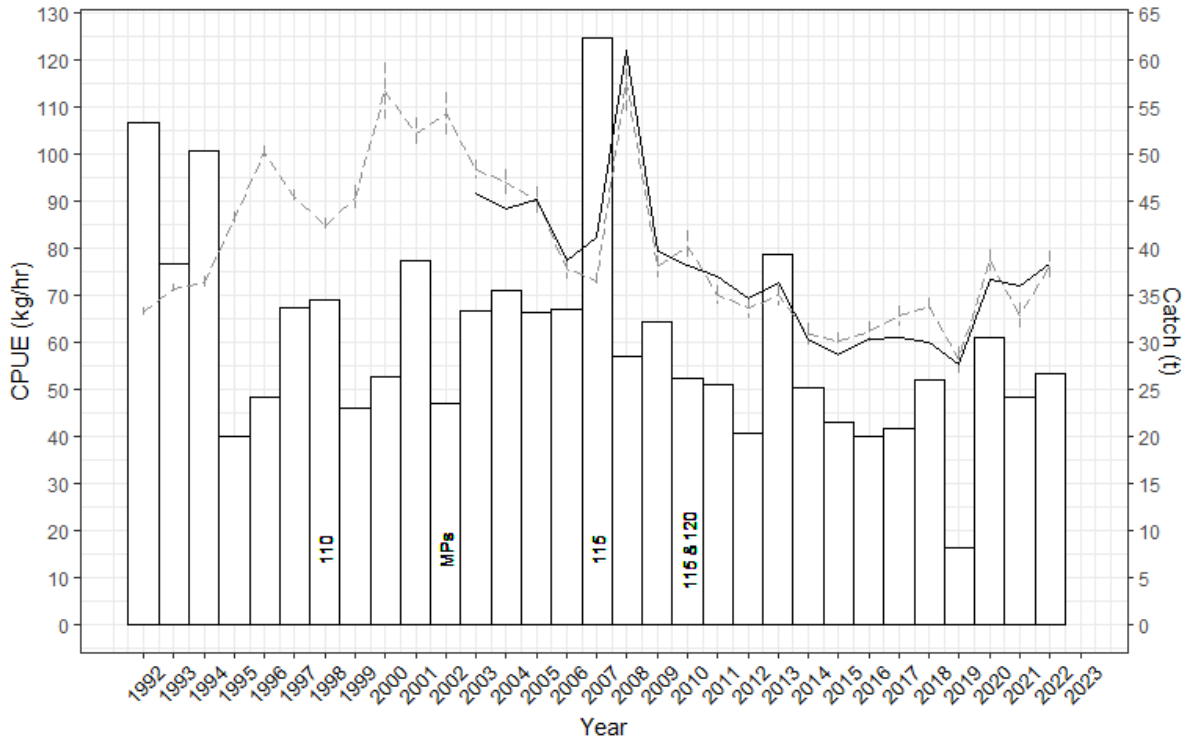

Figure 28: Prom Westside SMU catch, and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE), standardised series = black. Numbers indicate changes to LMLs. MPs = introduction of Marine Parks.

Mean daily catch peaked at 582 kg/day in 1996 and slowly declined to a contemporary low of 319 kg/day in 2015 (Figure 29). While mean daily catch remains variable, it has generally increased in recent years and is currently at similar levels to 2002-2004.

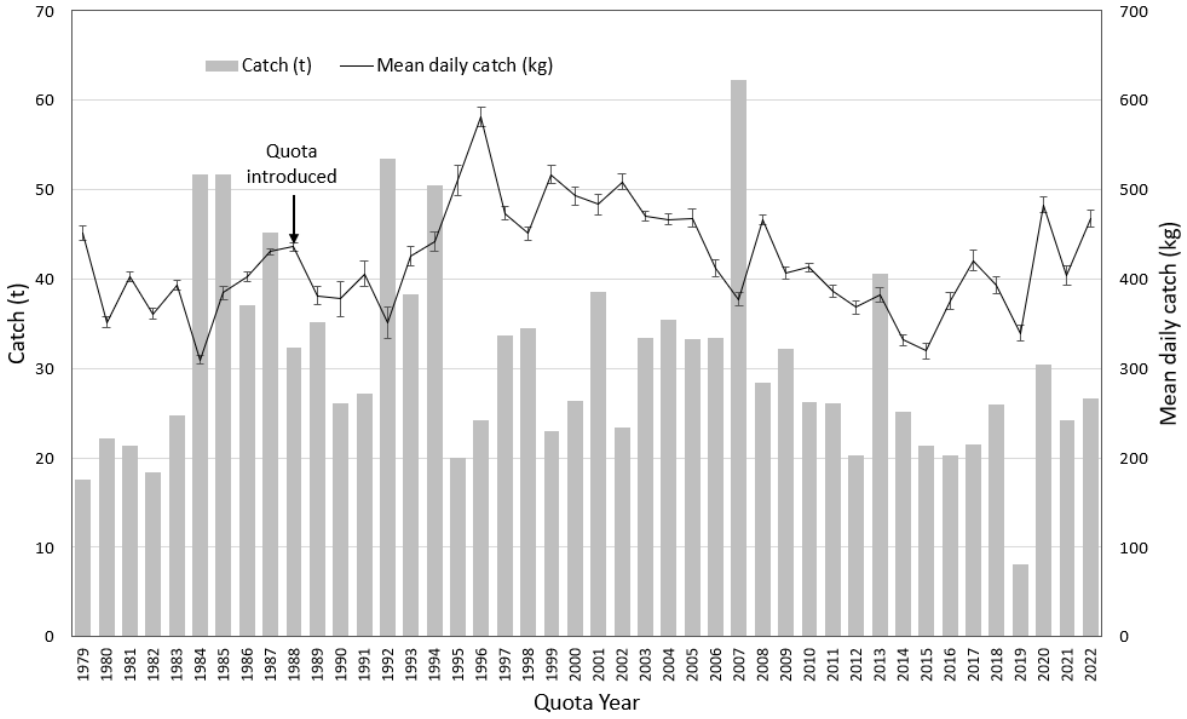

Figure 29: Total catch and mean daily catch for the Prom Westside SMU from 1979 to 2022.

Table 17: Catches (kg) by reefcode for the Prom Westside SMU from 2017/18 to 2022/23 and the five-year average catch from 2017/18 to 2021/22.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23
17.02	9248	7700	1808	13950	7049	7951	8269
17.10	4067	5885	2542	4462	7683	4928	6109
17.04	2288	3035	413	3856	3359	2590	1645
17.03	1415	2557	1436	2531	3328	2253	2661
17.05	2368	3257	142	2429	570	1753	4551
17.11	550	1414	220	1102	793	816	1643
17.01	504	810	973	636	901	765	685
17.12	666	846	387	678	114	538	735
17.13	447	450	224	378	49	310	151
16.07	0	0	0	405	368	155	207
Totals	21552	25954	8146	30426	24216	22059	26655

The Prom Westside SMU comprises ten reefcodes, with two reefcodes (17.02, 17.10) producing more than half of the SMU catch (Table 17). In 2022/23 most reefcode catches were within the historical range, except for a very large catch from 17.05.

FIS recruit abundance (Two Top 15 sites)

Trends between all sites and Top 15 sites were similar for recruit abundance (Figure 30). Abundance generally declined from 2003 to 2009 and increased thereafter, however it was low in a historical context in 2023.

FIS recruit abundance (Two Top 15 sites)

Pre-recruit abundance has been relatively stable over time but was also low in a historical context in 2023 (Figure 31).

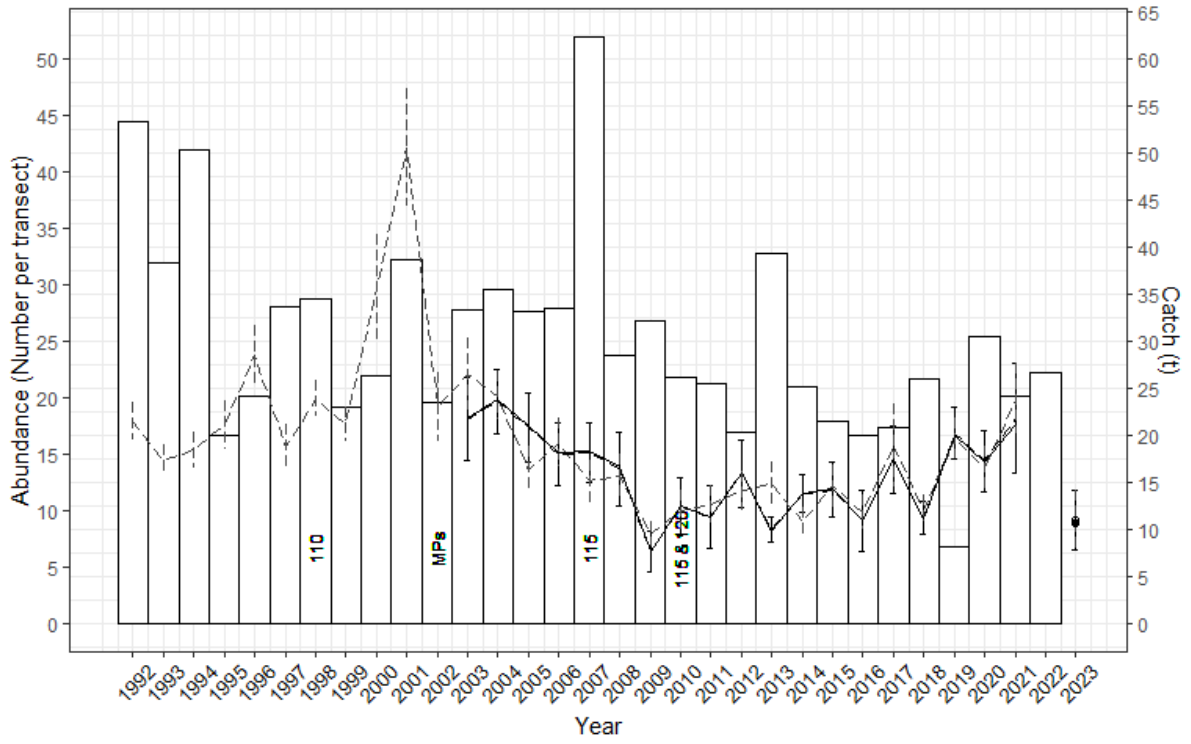

Figure 30: Recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) including catch from 1992/1993 – 2022/23 for the Prom Westside SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

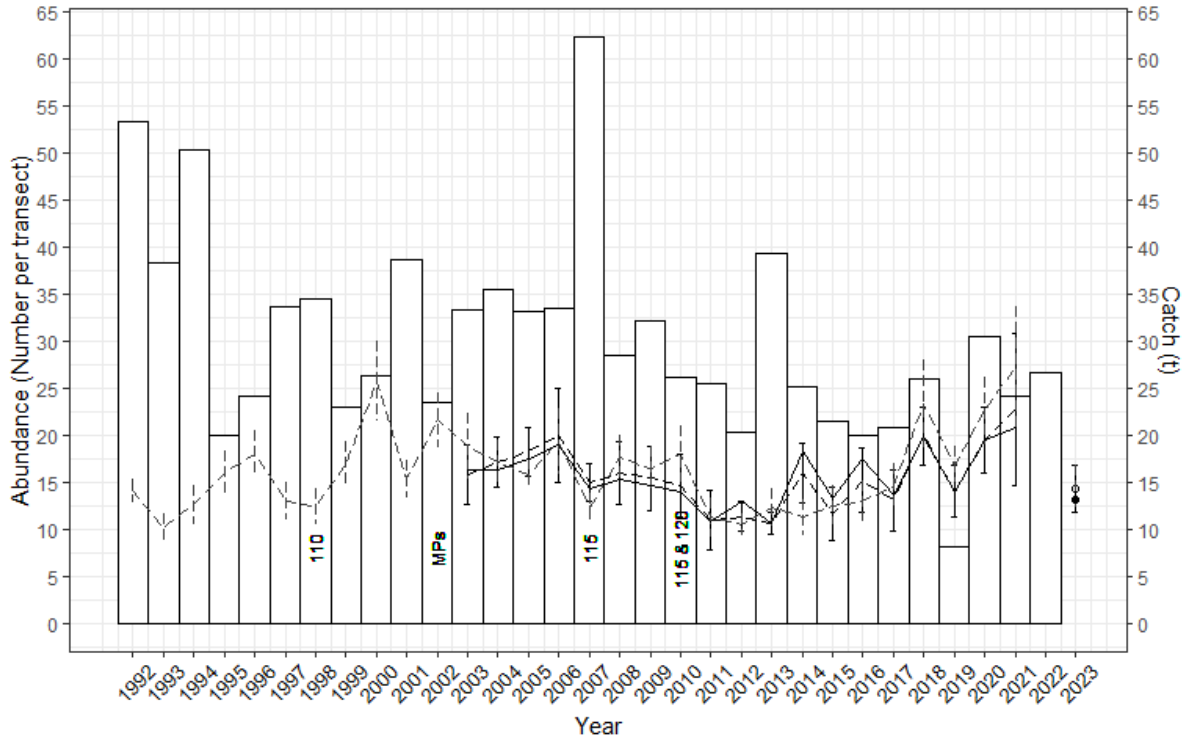

Figure 31: Pre-recruit abundance (grey dashed, nominal all sites 1992 – 2021; black, Top 15 standardised (solid) 2003 – 2023) including catch from 1992/1993 – 2022/23 for the Prom Westside SMU. MPs = introduction of Marine Parks; numbers reflect size limit changes.

Length frequency data – FIS

The size structure at Prom Westside FIS sites has been relatively stable over time, with few trends evident (Appendix 2).

Length frequency data – commercial

The standardised average length of abalone in the commercial catch at Prom Westside has been relatively stable over time, ranging from around 125 to 128 mm (Appendix 4). Average size across the SMU is confounded by multiple size limits (115 and 120 mm), with an increase in size observed for one year when the LML was temporarily increased to 120 mm across the SMU. Raw data show similar trends to standardised data over time.

Summary

A peak catch of 62 t was harvested from the Prom Westside SMU in 2007, likely the result of catch displacement following the virus first reaching the western end of the Central Zone. In all other years, catches generally ranged from 20-40 t per quota year between 1995 and 2018 until 2019 when the 8.1 t caught was the lowest recorded, likely influenced by the increase in LML. Catches have subsequently returned to prior levels. Standardised CPUE has declined from 2003 to 2019 but has increased in the last three years. Mean daily catch has also increased during this time.

The abundance of recruit and pre-recruit sized abalone at the two Top 15 FIS sites had shown increasing trends since around 2010, however both measures declined substantially in 2023.

The standardised average length of the commercial catch has been relatively stable over time, but interpretation is complicated by multiple size limits in this SMU.

The total catch in the Prom Westside SMU of 26.7 t was 5.7 t above the OT (21.0 t). Mean CPUE (79.1 kg/h) was above the Threshold (70 kg/h) Reference Point. The Primary Category was Increasing, resulting in an Increasing Final Category. The OT in 2023/24 was maintained at 21.0 t, suggesting an OT between 21.0 and 26.2 t.

Acknowledging that there was a low catch in 2019, the three subsequent years catches have averaged 27 t which is well above the OT. While CPUE indicators are positive, which has driven an Increasing Draft Harvest Strategy outcome, mean size of the commercial catch has not increased at Prom Westside as it has at most other SMUs. Also, recruit and pre-recruit abundance at Top 15 FIS sites declined substantially in 2023. Given catches at the Prom Westside SMU have been historically variable, stabilising catches at the OT may improve the stock indicators as it has for other important SMUs. On this basis, maintaining and not exceeding the current OT appears to be an appropriate strategy.

3.2.10. Kilcunda (Small SMU)

The Kilcunda SMU contributed 13.3 t in 2022/23 representing 5.3% of the total catch (Table 18) and TACC (Table 2). CPUE has declined (significantly) since 2003 by 27% and by 20% since 2009, however it has increased by 8% in the last 4 years. There is no FIS in the Kilcunda SMU.

Table 18: Summary of Catch, Optimal targets and CPUE performance indicators for the Kilcunda SMU. The LML and mean daily catch are also shown. Coloured numbers for Performance Indicators identify if trends were significantly increasing (green), significantly decreasing (red), not significant (black).

Catch					CPUE Performance Indicators		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
13.3	5.3	13.7*	11.8*	10.3*	-27	-20	8
LML 2022/23 = 110/115 mm					Mean daily catch 2022/23 = 368 kg		

The Kilcunda SMU has an average catch of 19 t since 1992 with a peak catch of 46 t taken during 2001 (Figure 32). Catch history appears to have two distinct periods, with catches ranging from 20-46 t from 1992 to 2003 (average 30 t), then from 2004 to 2022 catches ranged from 4-19 t (average 12 t). Current catches are around the average level harvested since 2003.

Nominal CPUE generally increased from 1992 to 2000, reaching a peak of 119 kg/hr (Figure 32). Whilst standardised CPUE declined slowly from 2003 to 2016, it has stabilised since albeit with annual variation.

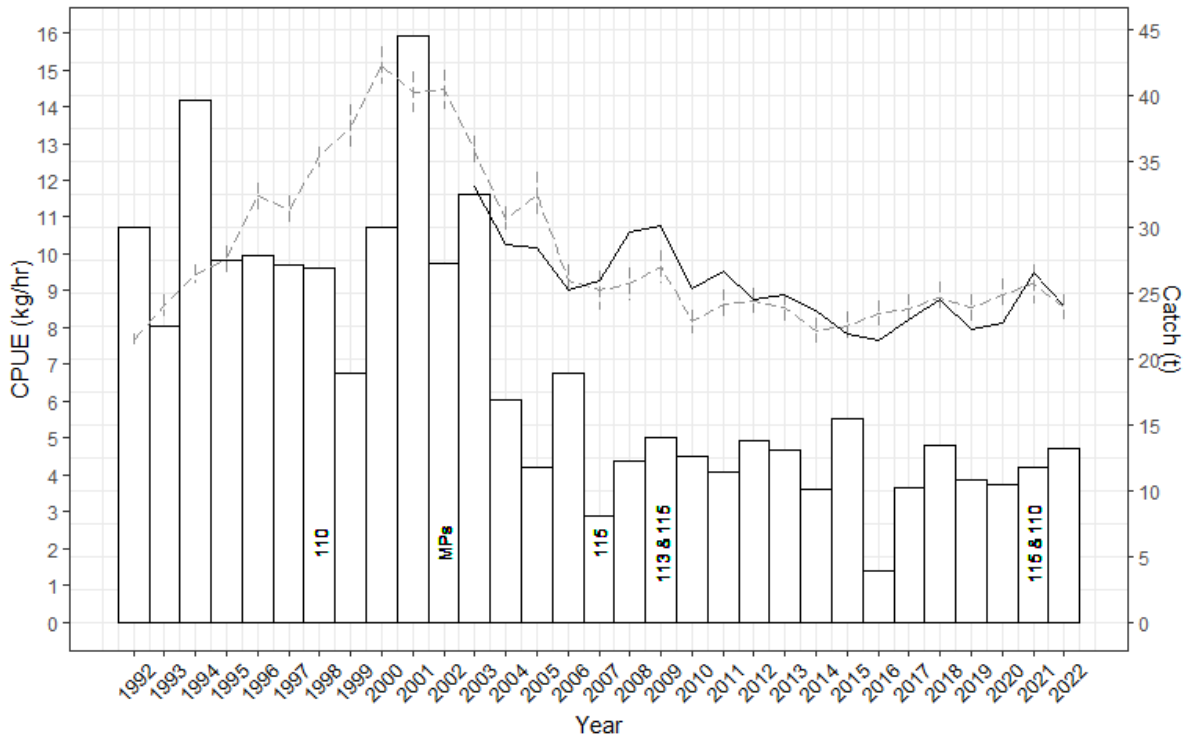

Figure 32: Kilcunda SMU catch, and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE), standardised series = black. Numbers indicate changes to LMLs. MPs = introduction of Marine Parks.

Historic estimates of mean daily catch are incomplete because many days were reported as fishing both the Kilcunda and Phillip Island SMUs (Figure 33). Mean daily catch generally declined from 1999 to 2005 but has been relatively stable thereafter.

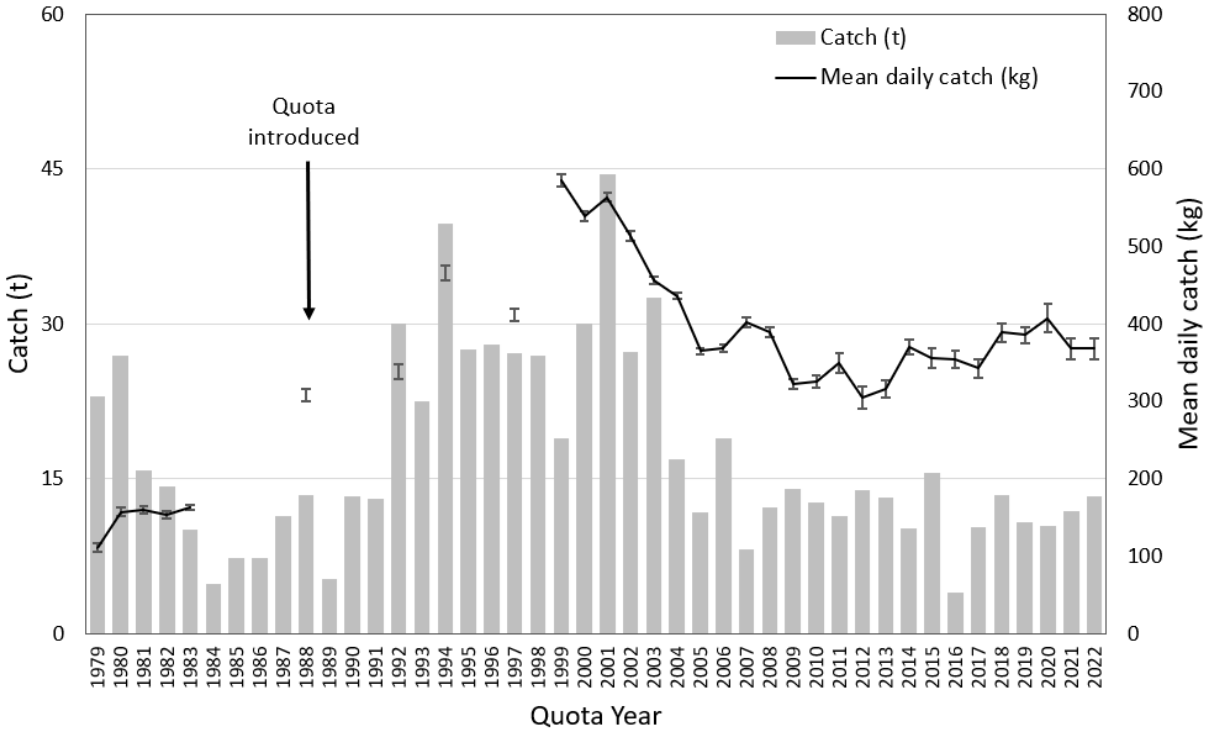

Figure 33: Total catch and mean daily catch for the Kilcunda SMU from 1979 to 2022. Missing years occur because two SMUs (Phillip Island) were reported as fished on the same day.

Table 19: Catches (kg) by reefcode for the Kilcunda SMU from 2017/18 to 2022/23 and the five-year average catch from 2017/18 to 2021/22.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23
15.01	9283	10906	8135	9652	9612	9518	10726
15.05	3555	1783	1585	0	1764	1737	1339
15.03	1536	852	1384	0	367	828	443
15.02	364	509	0	744	62	336	743
15.04	129	0	157	0	0	57	0
Totals	14866	14050	11261	10396	11805	12476	13252

Of the five reefcodes in the Kilcunda SMU, the majority of catch has come from 15.01 (Table 19). In 2022/23, all reefcode catches were within their historical range.

Length frequency data – commercial

The standardised average length of abalone in the commercial catch at Kilcunda has been relatively stable over time, ranging from around 122 to 123 mm (Appendix 4). Average size across the SMU is confounded by multiple size limits (110 and 115 mm). There was no difference in the average size when the LML was temporarily increased to 115 mm across the SMU on 1 April 2021. Raw data show similar trends to standardised data over time.

Summary

The Kilcunda SMU had a period of high catches from 1992 to 2003 where an average of 30 t per year was maintained, however since 2004 average catches have been less than half of this level (12 t). Whilst standardised CPUE declined from 2003 to 2016, it has stabilised since albeit with annual

variation. Mean daily catch has also been stable in recent years. There is no FIS data for the Kilcunda SMU.

The standardised average length of the commercial catch has been relatively stable since 2016/17.

The total catch of 13.3 t was 1.5 t above the OT with carryover (11.8 t). Mean CPUE (67.8 kg/h) was between the Threshold (70 kg/h) and Limit (50 kg/h) Reference Points. The Primary Indicator was Stable, however the Secondary Indicator was Decreasing, resulting in a Decreasing Primary Category and Final Category. The 2023/24 OT with carry-over was reduced to 10.3 t, with a resulting suggested OT of 7.9 to 8.8 t.

The indicators for CPUE, mean daily catch and average commercial length have all been relatively stable in recent years. The Draft Harvest Strategy suggests a further reduction in OT based on a decline in CPUE between years. The Kilcunda SMU has not shown the positive increases in stock indicators that other SMUs have in this assessment, and therefore continuing with more conservative OTs appears to be an appropriate strategy if the objective is to improve stock performance.

3.2.11. Cape Liptrap (Small SMU)

The Cape Liptrap SMU catch was 10.0 t in 2022/23 and represented 4.0% of the total catch (Table 22) and TACC (Table 2). CPUE has significantly declined since 2003 by 32% and by 30% since 2009, however it has increased by 4% in the last 4 years. There are no Top 15 FIS sites at Cape Liptrap.

Table 20: Summary of Catch, Optimal targets and CPUE performance indicators for the Cape Liptrap SMU. The LML and mean daily catch are also shown. Coloured numbers for Performance Indicators identify if trends were significantly increasing (green), significantly decreasing (red), not significant (black).

Catch					CPUE Performance Indicators		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
10.0	4.0	11.8*	12.1*	9.4*	-32	-30	4
LML 2022/23 = 110 mm					Mean daily catch 2022/23 = 354 kg		

The Cape Liptrap SMU contributed <20 t of catch prior to 2009 when a peak catch of 41 t was harvested (Figure 34). The 2009 catch coincided with a decrease in size limit, which followed an increase in size limit in 2007 that reduced catches to around 5 t in 2008. Catch in the last 4 years has averaged 7.5 t which is well below recent historical levels (average catch 13 t from 2012 to 2018).

Nominal CPUE generally increased from 1992 to 1999, reaching a peak of 128 kg/hr (Figure 35). Standardised CPUE declined from 2003 to 2013 but has been relatively stable since.

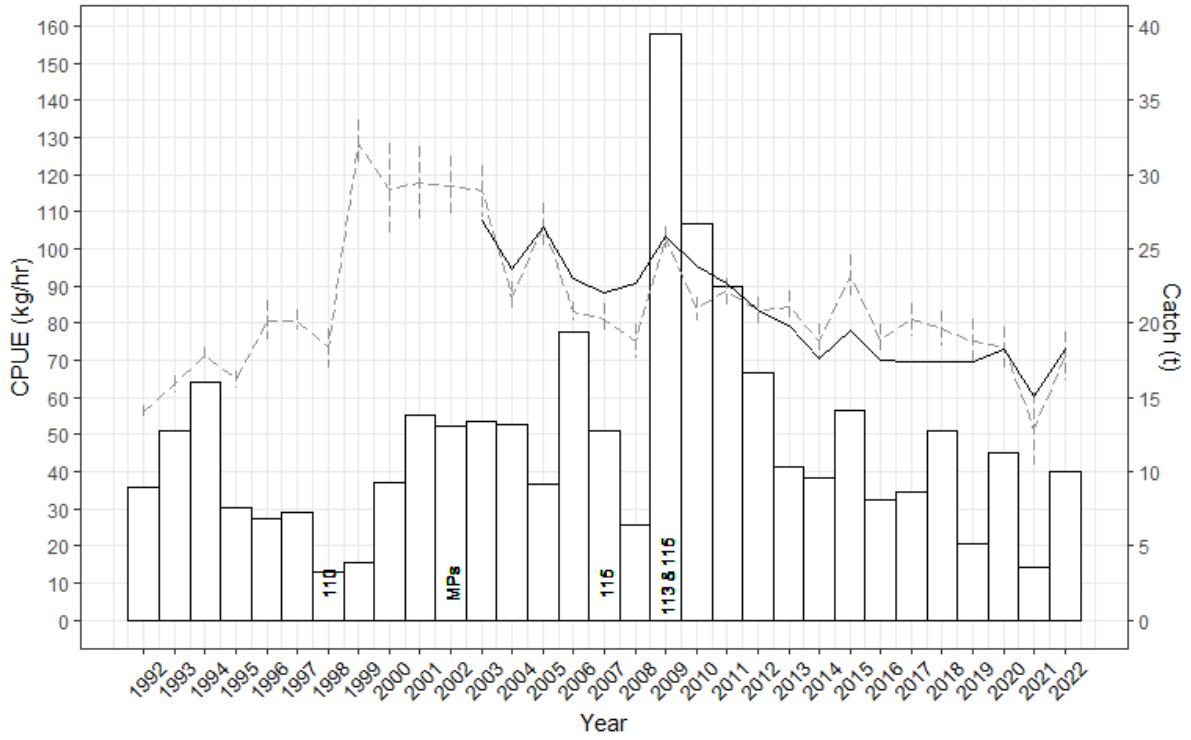

Figure 34: Cape Liptrap SMU catch, and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE), standardised series = black. Numbers indicate changes to LMLs. MPs = introduction of Marine Parks.

Mean daily catch was increased slowly from 201 kg/day in 1979 to 772 kg/day in 2000 (Figure 35). From 2004 to 2019, mean daily catch ranged from 390 to 506 kg/day, but has reduced to 318 to 353 kg/day in the last three years, which are the lowest levels since 1992.

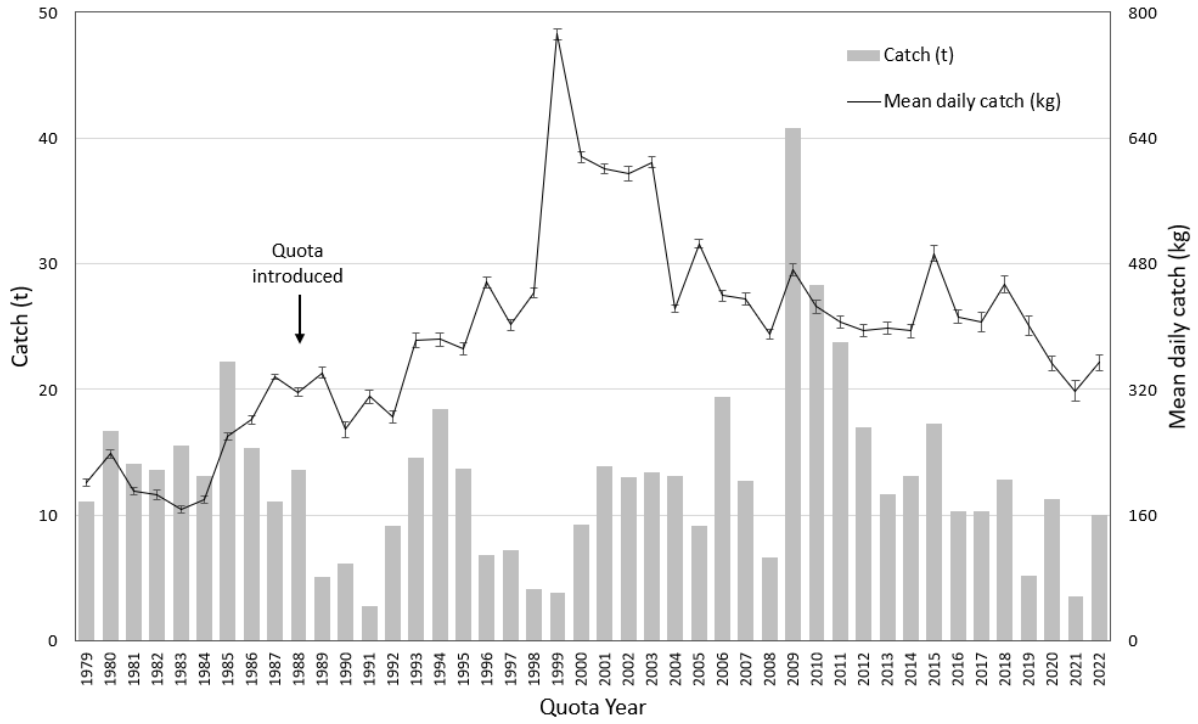

Figure 35: Total catch and mean daily catch for the Cape Liptrap SMU from 1979 to 2022.

Table 21: Catches (kg) by reefcode for the Cape Liptrap SMU from 2017/18 to 2022/23 and the five-year average catch from 2017/18 to 2021/22.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23
16.04	2594	4402	0	4413	804	2443	2832
16.03	3563	2678	2513	2369	821	2389	2586
16.06	2532	2989	1385	3513	1086	2301	2903
16.05	43	2170	449	999	108	754	621
16.02	1448	609	874	0	755	737	1072
Totals	10180	12849	5221	11295	3574	8624	10013

The Cape Liptrap SMU comprises five reefcodes, with three reefcodes contributing most of the catch (16.04, 16.03, 16.06) (Table 23). In 2022/23, catches from most reefcodes were around the 5-year average.

Length frequency data – commercial

From 2016/17 to 2019/20, the standardised average length of abalone in the commercial catch was stable around 116 to 117 mm, with multiple LMLs (110 and 115 mm) at that time (Appendix 4, Appendix 5). The LML increased to 115 mm across the SMU on 1 April 2020, resulting in an increase in average size of around 2 mm. Average size increased slightly in the following two years. Raw data show almost identical trends to standardised data over time.

Summary

The Cape Liptrap SMU produced consistent, low catches from 1992 to 2008. While the increase in size limit appeared to reduce catch in 2007, the decrease in size limit in 2009 likely increased the available biomass and a catch 3.5 times the long-term average was harvested. Catch in the last 4 years has averaged 7.5 t which is well below historical levels. Standardised CPUE declined from 2003 to 2013 but has been relatively stable since. Mean daily catch in the last three years has been at its

lowest levels since 1992. Interpretation of all indicators is complicated by an increase in size limit during 2020. There were no Top 15 FIS sites at Cape Liptrap.

The total catch in the Cape Liptrap SMU of 10.0 t was 2.1 t below the OT with carryover (12.1 t). Mean CPUE (72.3 kg/h) was above the Threshold (60 kg/h) Reference Point. The Primary Category was Stable, resulting in a Stable Final Category. In 2023/24, the OT was reduced to 9.4 t with carry-over, with a suggested OT of 8.9 to 9.9 t.

Indicators of stock status provide varying signals for the Cape Liptrap SMU. While CPUE has been relatively stable for a number of years, mean daily catch has been very low in the last three years. On a positive note, the average length of the commercial catch has increased over time despite an increase in LML. Also, the average catch in the last four years has been low relative to historic levels. The OT was reduced in 2023/24, and it seems that maintaining this lower OT is an appropriate strategy if the objective is to achieve an increase in the performance of stock indicators.

3.2.12. Prom Eastside (Small SMU)

The Prom Eastside SMU contributed 4.7 t in 2022/23 representing 1.9% of the total catch (Table 20) and TACC (Table 2). CPUE has declined (significantly) since 2003 by 12% and since 2009 by 4%, however in the last 4 years it has increased by 16%. There are no FIS sites at Prom Eastside.

Table 22: Summary of Catch, Optimal targets and CPUE performance indicators for the Prom Eastside 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					CPUE Performance Indicators		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
4.7	1.9	5.7	5.7	4.8	-12	-4	16
LML 2022/23 = 110 mm					Mean daily catch 2022/23 = 304 kg		

The Prom Eastside SMU was inconsistently fished from 1992 to 2012 (Figure 36). Annual catch has averaged just over 5 t, with a peak catch of 11 t in 2003. A consistent catch of 7-8 t was harvested between 2013 and 2020 before catches of around 5 t in 2021 and 2022.

Nominal CPUE generally increased from 1992 to 1998, reaching a peak of 89 kg/hr before declining to 66 kg/hr in 2003 (Figure 36). Since 2003, CPUE has ranged without trend from 43 to 65 kg/h.

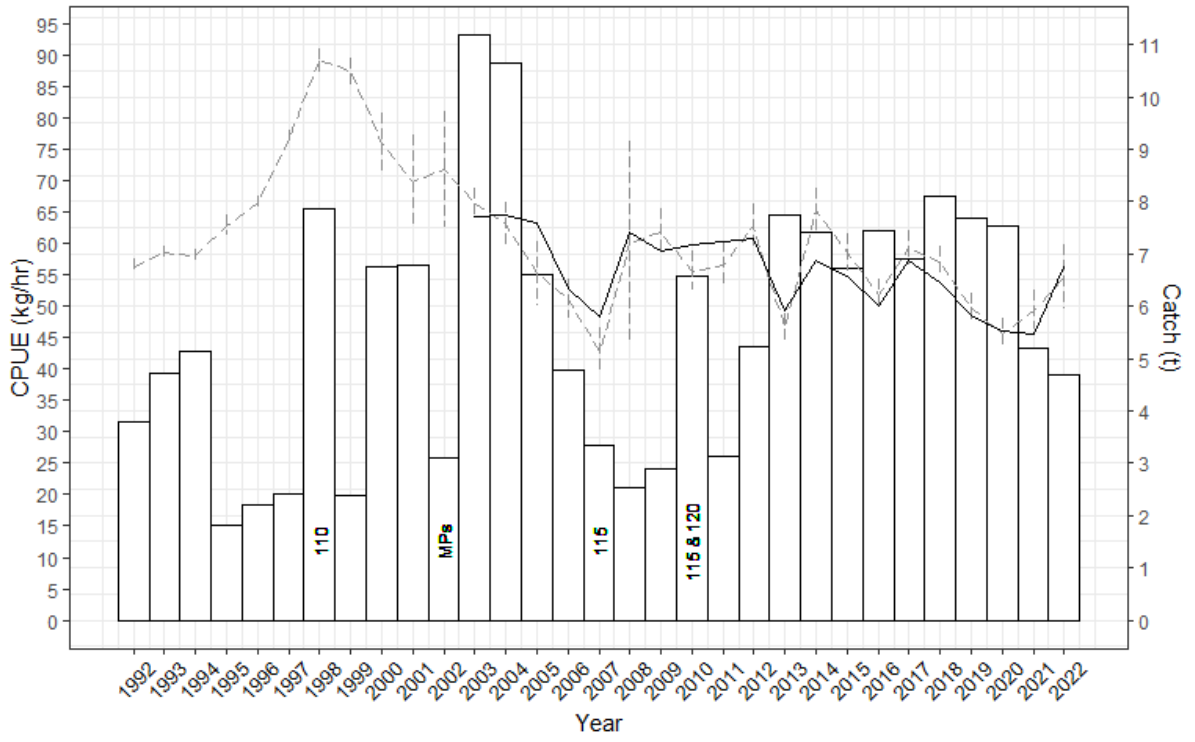

Figure 36: Prom Eastside SMU catch, and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE), standardised series = black. Numbers indicate changes to LMLs. MPs = introduction of Marine Parks.

Mean daily catch has ranged without trend from 1979 to 2022 between 217 and 438 kg/day (Figure 37).

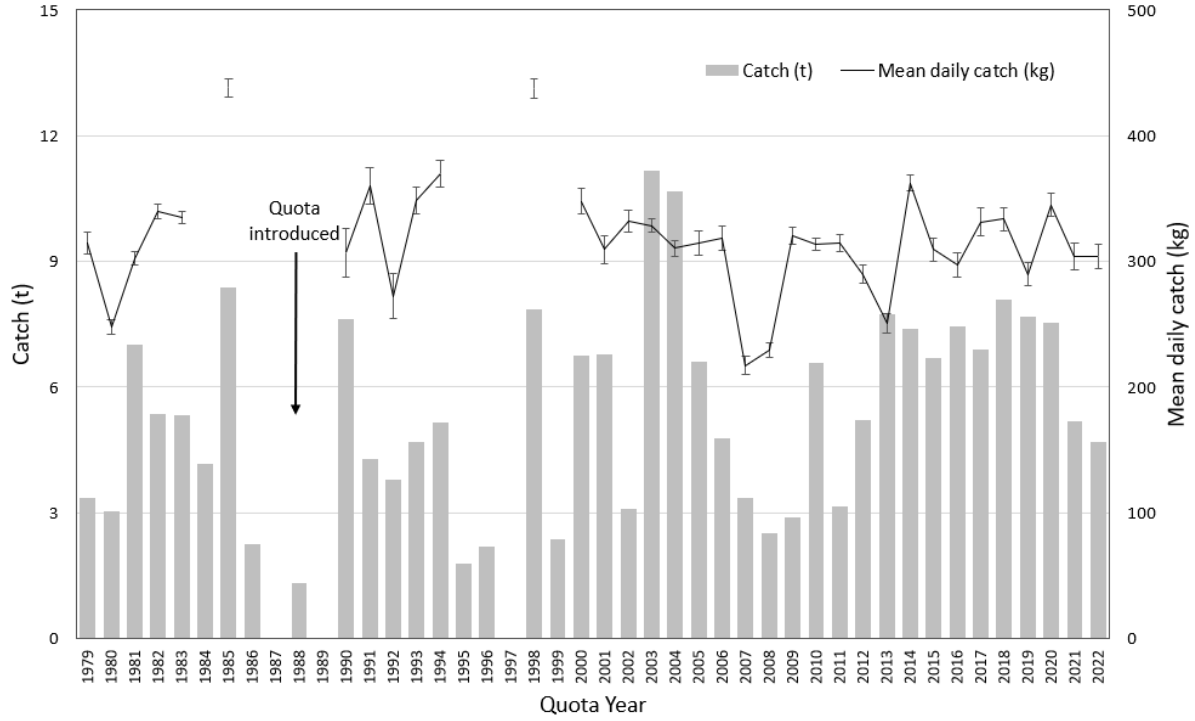

Figure 37: Total catch and mean daily catch for the Prom Eastside SMU from 1979 to 2022.

Table 23: Catches (kg) by reefcode for the Prom Eastside SMU from 2017/18 to 2022/23 and the five-year average catch from 2017/18 to 2021/22.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23
18.04	3386	2635	3162	3115	2250	2910	1660
18.03	2076	3992	3310	3002	2052	2886	2265
18.06	1080	479	578	1107	555	760	220
18.05	369	991	625	299	326	522	540
18.07	0	0	0	0	0	0	0
Totals	6911	8097	7675	7522	5182	7077	4685

The Prom Eastside SMU comprises five reefcodes, two of which (18.04, 18.03) contribute most of the total SMU catch (Table 21). In 2022/23, catches at 18.04 were the lowest in the last 6 years.

Length frequency data – commercial

The standardised average length of abalone in the commercial catch at Prom Eastside has generally increased over time, with the exception of two decreases in 2020/21 and 2021/22 (Appendix 4). The LML has been stable over this time at 110 mm (Appendix 5) with the current average size harvested around 123 mm, which is well above the 118 mm in 2016/17. Raw data are more variable but show similar increasing trends over time.

Summary

The Prom Eastside SMU had produced only variable catches until comsistent catches were harvested from 2013 to 2020. In the last two years catches have been considerably lower. Standardised CPUE had been in recent decline but wit the two low catches CPUE returned to recent levels in 2022/23. Mean daily catch has been stable. The standardised average length of the commercial catch has increased since 2016/17 and is currently 13 mm above the LML.

The total catch in the Prom Eastside SMU of 4.7 t was 1.0 t below the OT (5.7 t). Mean CPUE (59.1 kg/h) was just below the Threshold (60 kg/h) and well above the Limit Reference Point (40 kg/h). The Primary Category was Stable, resulting in a Stable Final Category. The OT was reduced to 4.8 t in 2023/24 which provides a suggested OT of 4.6 to 5.0 t.

The OT was reduced for 2023/24 on the back of declining CPUE over a four-year period. CPUE increased considerably in 2022/23 to return to recent average levels. Mean daily catch has been stable in recent years, while commercial length data suggest that the average size harvested has been increasing. Current catches are well below recent historical levels, so maintaining the current OT as suggested by the Draft Harvest Strategy may result in improved stock indicators in the next few years.

3.2.13. Cliffy Group (Small SMU)

The Cliffy Group SMU contributed 2.3 t in 2022/23 representing 0.9% of the total catch (Table 24) and TACC (Table 2). The catch was less than half of the OT (5.5 t). CPUE has significantly declined since 2003 and 2009 by 25 and 20%, respectively. CPUE was stable over the last 4 years (1% increase). There are no FIS sites at Cliffy Group.

Table 24: Summary of Catch, Optimal targets and CPUE performance indicators for the Cliffy Group SMU. The LML and mean daily catch are also shown. Coloured numbers for Performance Indicators identify if trends were significantly increasing (green), significantly decreasing (red), not significant (black).

Catch					CPUE Performance Indicators		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
2.3	0.9	5.5	5.5	4.7	-25	-20	1
LML 2022/23 = 110 mm					Mean daily catch 2022/23 = 385 kg		

The Cliffy Group SMU was fished consistently at low levels of 2-5 t per year from 1992 to 2010 (Figure 38). Since 2010 annual catch has averaged over 6 t, although it has been quite variable ranging from 2 to 10 t. Catches in the last 2 years have been below 3 t.

Nominal CPUE generally increased from 1992 to 2000, reaching a peak of 127 kg/hr (Figure 38). Since 2003, standardised CPUE has been variable ranging from 60 to 121 kg/h, and has been low but stable ranging from 61 to 66 kg/h in the last 4 years.

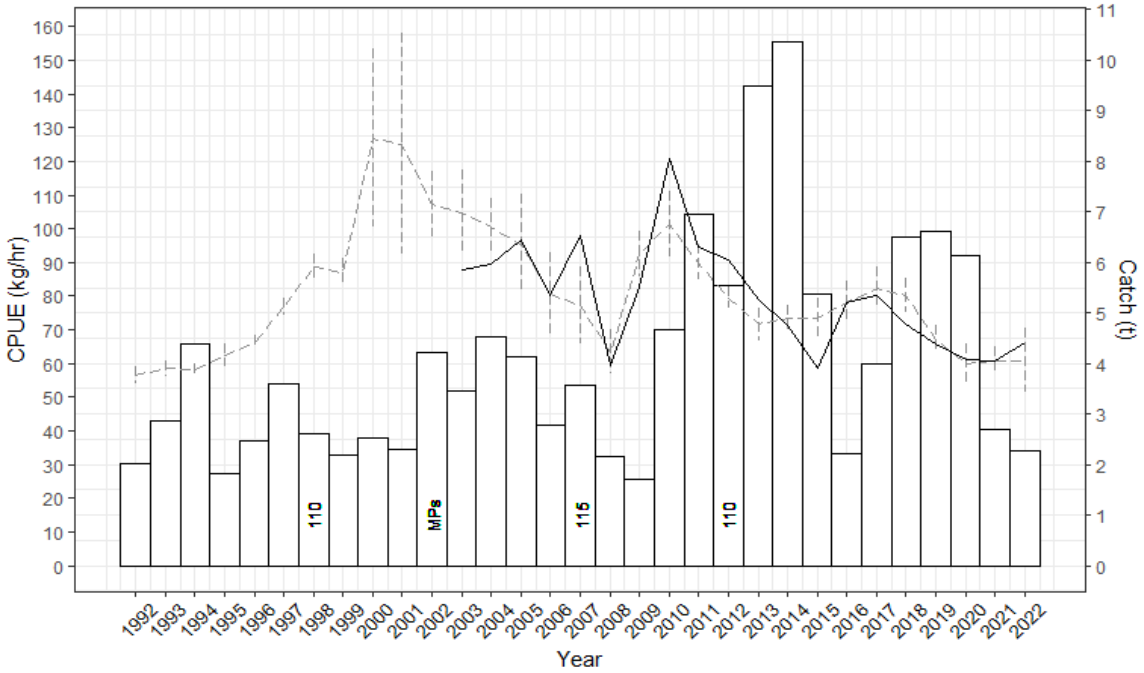

Figure 38: Cliffy Group SMU catch, and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE), standardised series = black. Numbers indicate changes to LMLs. MPs = introduction of Marine Parks.

Historically, the Cliffy Group was often reported as fished on the same day as Prom Eastside and thus mean daily catch data are incomplete (Figure 39). Mean daily catch has ranged without trend from 308 to 503 kg/day.

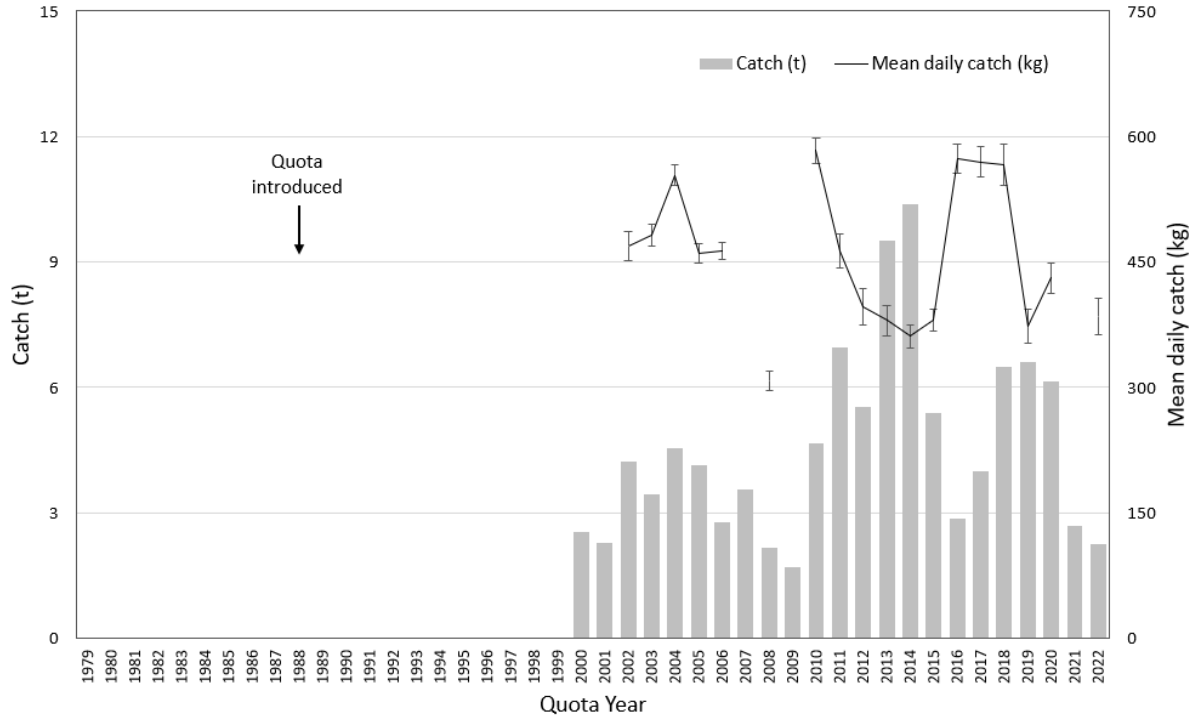

Figure 39: Total catch and mean daily catch for the Cliffy Group SMU from 1979 to 2022.

Length frequency data – commercial

From 2016/17 to 2019/20, the standardised average length of abalone in the commercial catch at Cliffy Group was stable around 122 to 123 mm but declined to around 119 mm in 2020/21 (Appendix 4). No data have been collected in the last two years. The LML has been stable over this time at 110 mm (Appendix 5). Raw data show similar trends over time.

Summary

The Cliffy Group SMU produced much higher than long-term average catches from 2010 to 2020. Standardised CPUE declined from 2017 to 2021 but showed a slight increase in 2022 following two years of lower catch. Mean daily catch data are limited and variable. The standardised average size of the commercial catch was stable from 2017/18 to 2019/20 before declining in 2020/21 and again in 2021/22. No data were available from the last two years.

The total catch in the Cliffy Group SMU of 2.3 t was less than half of the OT (5.5 t). Mean CPUE (69.8 kg/h) was above the Threshold (60 kg/h) Reference Point. The Primary Category was Stable, resulting in a Stable Final Category. The 2023/24 OT was reduced to 4.7 t, suggesting an OT of 4.5 to 4.9 t.

Given less than 50% of the OT was caught in the last two years, the declines in CPUE and mean average length of the commercial catch likely reflect poor performance of the stock. On this basis, further reductions in OT could be considered to aid improvement in the stock indicators.

3.2.14. Surf Coast (Small SMU)

The Surf Coast SMU contributed 1.5 t in 2022/23 representing 0.6% of the total catch (Table 25) and TACC (Table 2). CPUE declined by 9% in the long-term, however the short-term showed a 19% increase. CPUE has increased by 4% in the last 4 years. There are no FIS sites at Surfcoast.

Table 25: Summary of Catch, Optimal targets and CPUE performance indicators for the Surf Coast SMU. The LML and mean daily catch are also shown. Coloured numbers for Performance Indicators identify if trends were significantly increasing (green), significantly decreasing (red), not significant (black).

.Catch					CPUE Performance Indicators		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
1.5	0.6	3	2	1.7	-9	19	4
LML 2022/23 = 110 mm					Mean daily catch 2022/23 = 295 kg		

The Surf Coast SMU produced catches from 20-40 t (average 26 t) between 1992 and 1997 (Figure 40). However, catches have ranged from 0.7 to 9 t (average 4.5 t) thereafter. The catch in 2020/21 was the highest recorded since the size limit was reduced in 2012 but it declined to 1.5 t in the last two years.

Nominal and standardised CPUE have generally fluctuated over time without a clear trend.

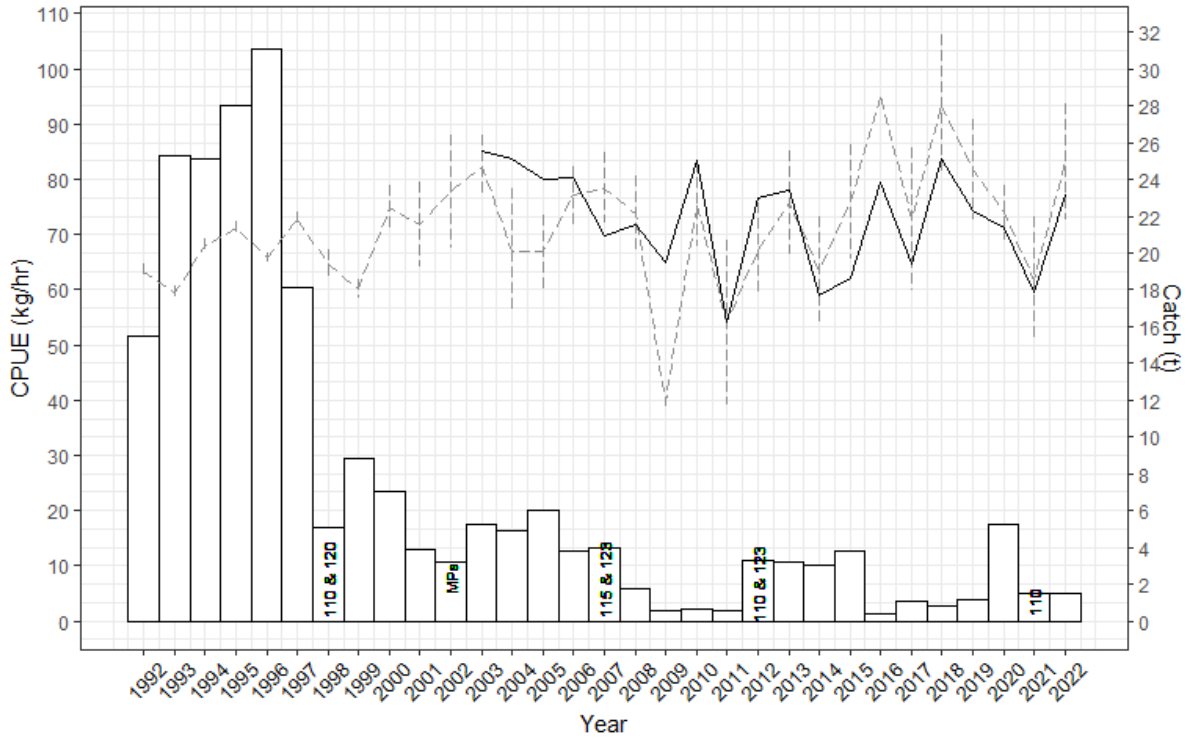

Figure 40: Surf Coast SMU catch, and CPUE (nominal and standardised) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE), standardised series = black. Numbers indicate changes to LMLs. MPs = introduction of Marine Parks.

Mean daily catch increased from 172 kg/day in 1979 to 417 kg/day in 2003 and has generally fluctuated between 200 and 400 kg/day thereafter (Figure 41).

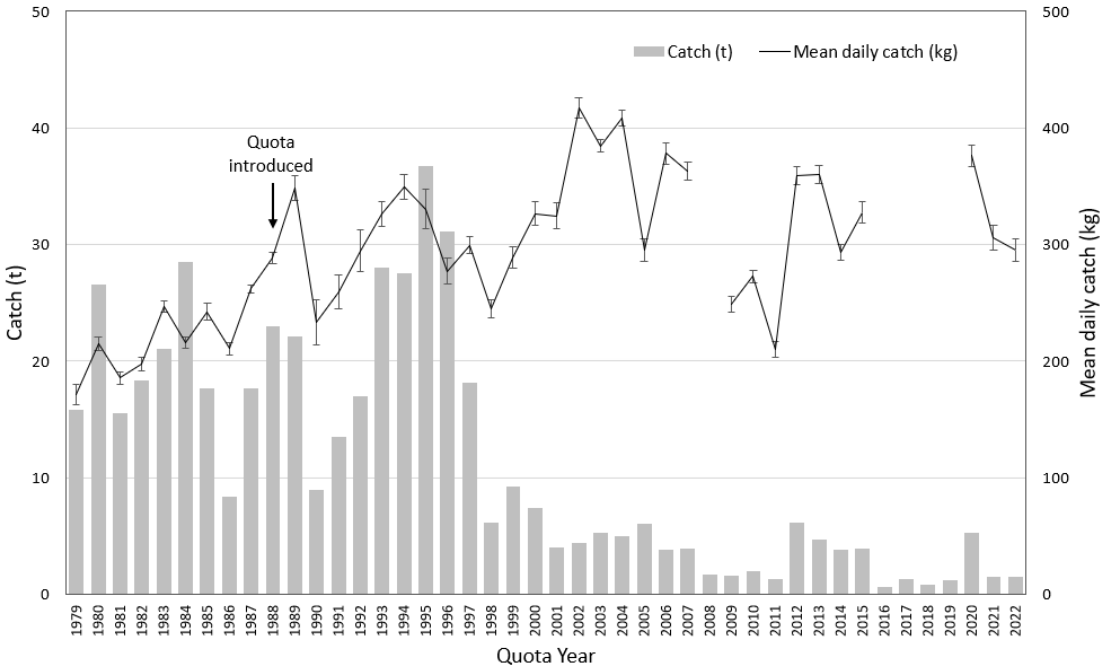

Figure 41: Total catch and mean daily catch for the Surf Coast SMU from 1979 to 2022.

Table 26: Catches (kg) by reefcode for the Surf Coast SMU from 2017/18 to 2022/23 and the five-year average catch from 2017/18 to 2021/22.

Reefcode	2017/18	2018/19	2019/20	2020/21	2021/22	5-yr average	2022/23
10.02	0	684	1183	4143	1152	1432	1475
10.01	689	143	0	614	35	296	0
8.02	510	0	0	0	0	102	0
10.03	0	0	0	509	0	102	0
10.04	85	0	0	0	341	85	0
10.05	53	0	0	0	0	11	0
9.01	0	0	0	0	0	0	0
Totals	1337	827	1183	5266	1528	2028	1475

The Surf Coast SMU comprises five reefcodes, with most of the catch coming from 10.02, which was the only reefcode fished in 2022/23 (Table 26).

Length frequency data – commercial

No commercial length frequency data are presented for the Surfcoast in Appendix 4.

Summary

The Surf Coast SMU averaged catches in excess of 25 t from 1992 to 1997, however catches declined rapidly thereafter. While trends in CPUE have been stable throughout the history of the fishery, catches from 2016/17 to 2019/20 were the lowest recorded. The catch in 2020/21 increased to 5.2 t, most of which was harvested from reefcode 10.02 (Thirteenth Beach) but reduced to 1.5 t in 2021/22 and 2022/23 with most of the catch again coming from 10.02.

The total catch in the Surf Coast SMU (1.5 t) was 0.5 t below the OT (2.0 t). Mean CPUE (72.9 kg/h) was above the Threshold (70 kg/h) Reference Point. The Primary Category was Stable, resulting in a Stable Final Category. The 2023/24 OT was reduced to 1.7 t, suggesting an OT of 1.6 to 1.8 t.

Recent catches from the Surf Coast SMU have been well below historic levels. Annual catches generally come from the one reefcode, with small catches from others in some years. Maintaining the current OT seems an appropriate strategy.

3.2.15. PPB

The Port Phillip Bay SMU contributed 0.1 t of catch to the Central Zone TACC in 2022/23. Short- and long-term indicators for CPUE could not be assessed (Table 27). There are no Top 15 FIS sites in Port Phillip Bay.

Table 27: Summary of Catch and Optimal targets for the Port Phillip Bay SMU. The LML is also shown. There are insufficient data for assessment against CPUE performance indicators.

Catch					CPUE Performance Indicators		
2022/23		OT + carryover* (t)			Long-term	Short-term	Last 4 years
(t)	(%)	21/22	22/23	23/24	2003/04 – 2022/23	2009/10 – 2022/23	2018/19 – 2022/23
0.1	0	0	0	0			
LML 2022/23 = 105 mm							

The Port Phillip Bay SMU was a very important contributor to the Central Zone TACC from 1992 to 2007, with an average catch of 56 t during this period and a peak catch of 102 t taken during 2000 (Figure 42). However, catches declined dramatically thereafter and have not exceeded 6 t since 2010. In 2022/23, 0.1 t was harvested from this SMU.

Nominal CPUE generally increased from 1992 to 1998, reaching a peak of 82 kg/hr (Figure 42). Both nominal and standardised CPUE declined significantly thereafter.

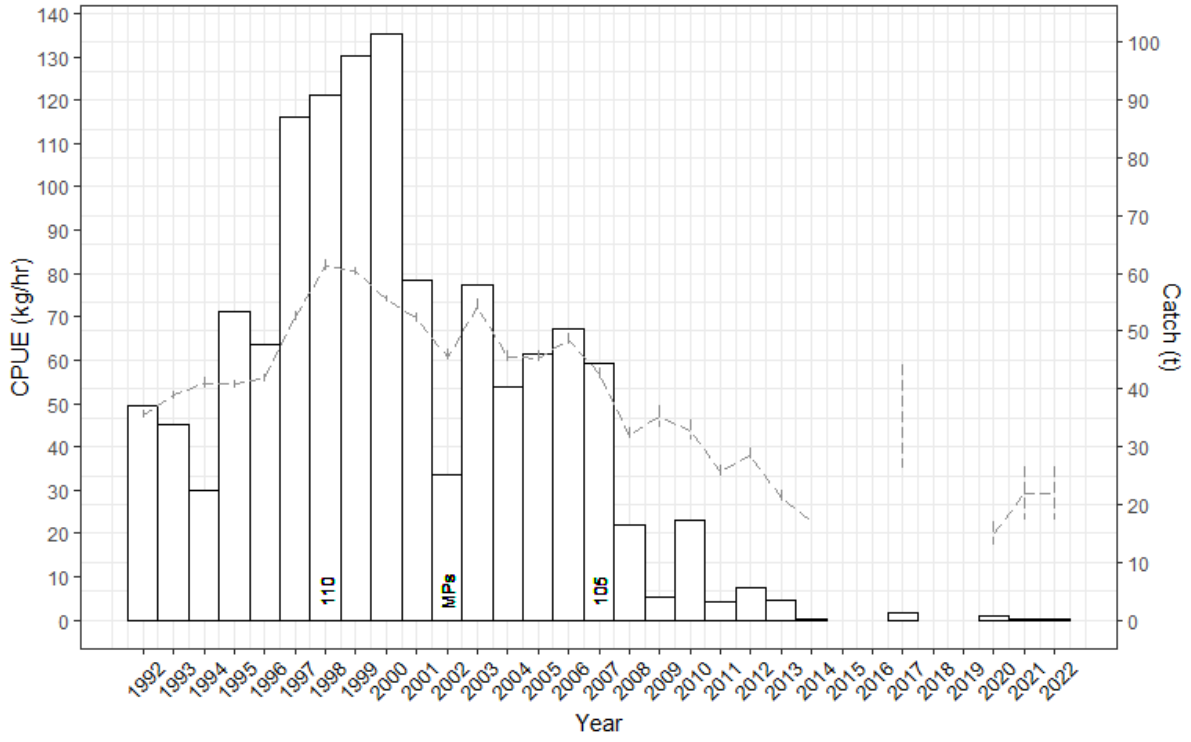

Figure 42: Port Phillip Bay SMU catch, and CPUE (nominal only) from 1992/1993 – 2022/23. Nominal CPUE = grey series (+/- SE). Numbers indicate changes to LMLs. MPs = introduction of Marine Parks.

Mean daily catch increased from 190 kg/day in 1979 to 414 kg/day in 1998, before declining to 187 kg/day in 2013 (Figure 43).

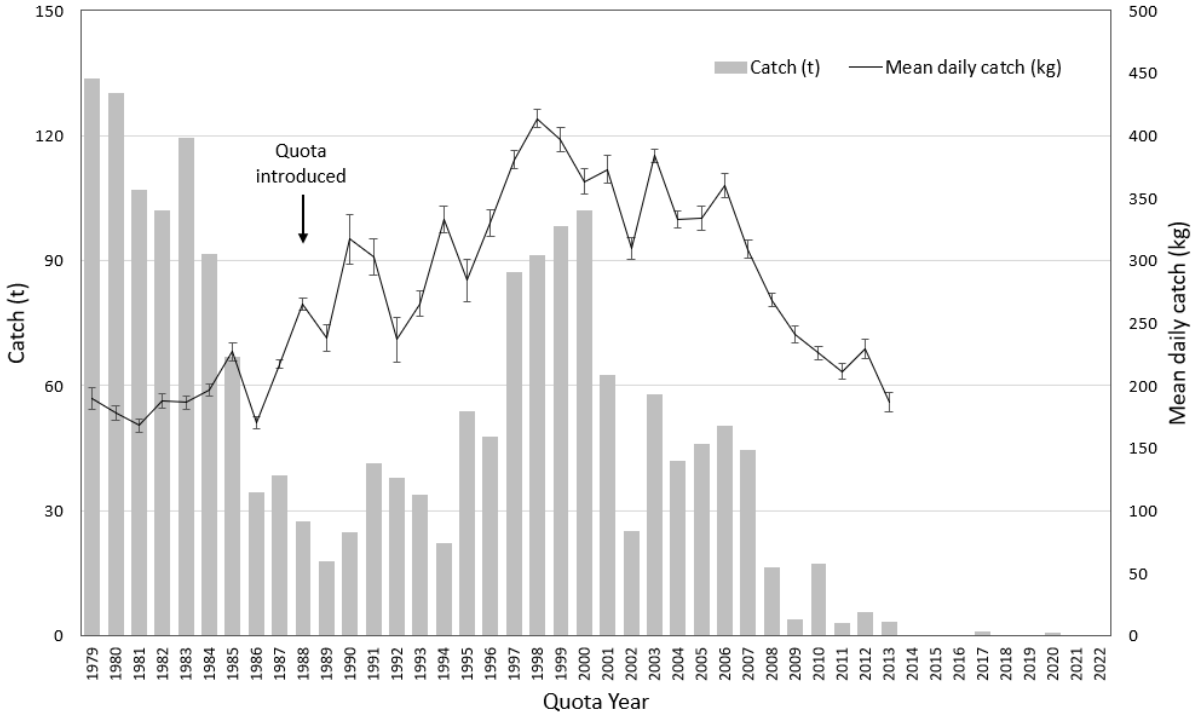

Figure 43: Total catch and mean daily catch for the Port Phillip Bay SMU from 1979 to 2022.

Summary

Prior to 2008, the Port Phillip Bay SMU was a very important contributor to the Central Zone TACC. Catch and CPUE data suggest that the decline in abundance of legal-size abalone from 2008 was substantial and occurred rapidly. FIS data indicate that significant declines in pre-recruit abundance began occurring in 2004, well before the declines in recruit abundance. It is likely that the primary driver for this decline in abundance was environmental effects, including changes to nutrient levels with a consequent reduction in algal productivity and an increase in urchin density (Mayfield et al. 2012).

There is no OT for the Port Phillip Bay SMU and thus it was not assessed under the Draft Harvest Strategy. Maintaining a zero catch is appropriate.

4. Greenlip Abalone

Greenlip abalone are a small but important contributor to the Central Zone abalone catch. Catches of greenlip abalone have been recorded in commercial logbooks since 1979. Total catches greater than 1,000 kg have been recorded in nine of the 12 SMUs, as well as in a number of reefcodes that are now part of the Marine Park network (Figure 44). In the past decade, greenlip catches have been harvested from seven of the nine SMUs (Figure 45). Total catches since 2008 have been very consistent, with an average annual catch of 3,063 kg and a range of 2,507 to 3,546 kg, with the highest catch being harvested in 2022 (Figure 49).

Cape Liptrap has been the highest producing SMU in the Central Zone, with a total catch of 34,356 kg since 1979. More than half of this catch (19,359 kg) has been harvested in the last 15 years, with an average annual catch of 1,291 kg and a range of 933 to 2,002 kg.

The Surf Coast SMU has produced 21,416 kg of greenlip abalone since 1979. Since 2008, the Surf Coast SMU has had an average annual catch of 568 kg and a maximum catch of 1,472 kg in 2008, although only 62 kg was caught in 2022.

With a total catch of 21,396 kg since 1979, the largest annual catches came from the Flinders SMU in the 1980s. From 1980 to 1986, 13 t of greenlip was harvested with a maximum annual catch of approximately 3,500 kg in 1985. In the last decade, an average of 617 kg has been harvested from the Flinders SMU with a peak annual catch of 1,003 kg in 2020.

The Phillip Island SMU has produced 16,228 kg of greenlip since 1979. The stock has produced very consistent catches since 2008, with an annual catch of 577 kg and a range of 272 to 1,017 kg, with the highest catch harvested in 2020.

Smaller contributions have come from the five other SMUs, while 2,961 kg in total was harvested from reefcodes that have subsequently been declared as Marine Parks. In the past decade, the Kilcunda, Prom West and Back Beaches SMUs have produced 1,994 kg of greenlip abalone in total.

Catches appear to be sustainable at current levels.

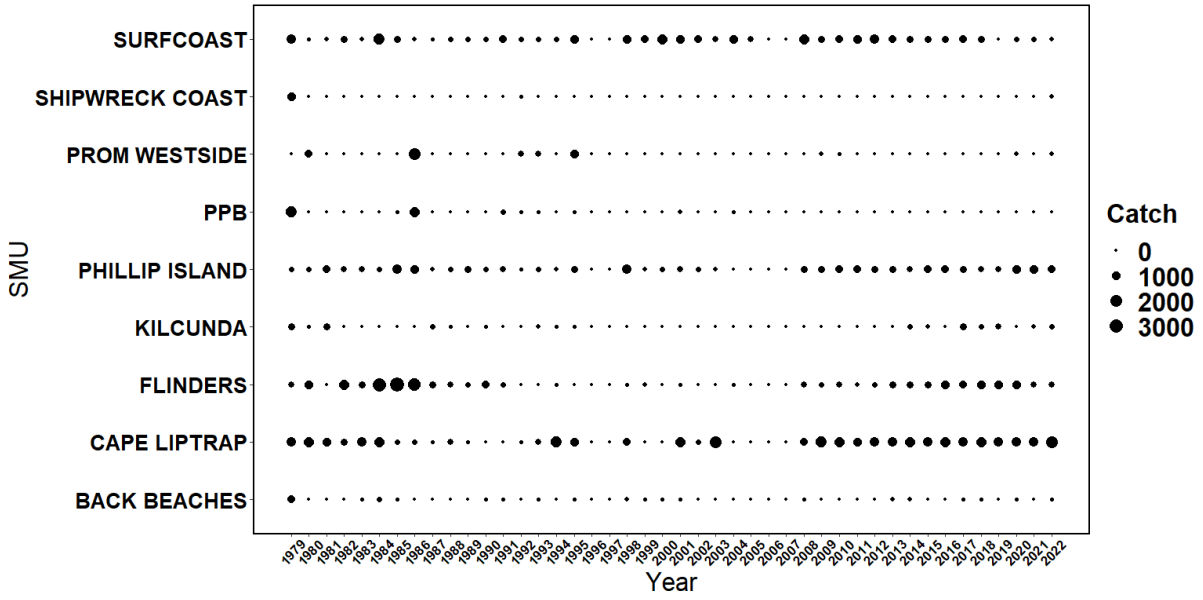

Figure 44: Bubble plot of catch distribution for greenlip abalone in the Central Zone from 1979 to 2022 quota years. Only SMUs where >1 t of greenlip have been caught in total are shown.

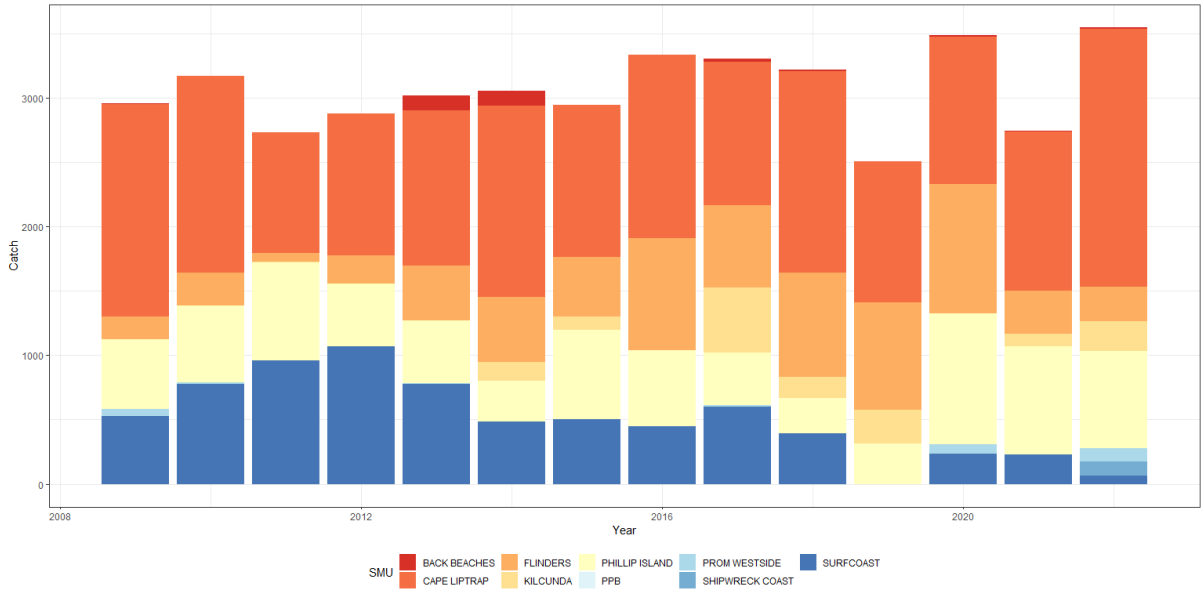

Figure 45: Catch distribution for greenlip abalone in the Central Zone from 2009 to 2021 quota years.

5. Conclusions and recommendations

5.1. Analytical approaches to stock assessment

Three main analytical approaches are employed when evaluating stock status to guide TACC decision-making: assessment based on Performance Indicators, an overall weight of evidence assessment, and outcomes from the Draft Harvest Strategy. As reported in previous Stock Assessment Reports and associated review documents, there are substantial uncertainties associated with the two primary sources of data that underpin the assessment of stock status. 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 improved understanding of the uncertainties and biases in these two key data sources measures has indicated a need for a comprehensive overhaul of the assessment framework. Some of these changes have already begun. Recent changes to the FIS design meant that only the “Top 15” FIS sites were surveyed in 2023, following a year where no survey was conducted. This report is the first to examine mean daily catch as an additional measure of CPUE. In addition, length frequency data from the commercial catch have been provided by industry for the first time since 2021. Finally, assessment of the Performance Indicators includes a shorter temporal scale (4 years) that provides a better understanding of the how the stock has performed in recent history which is more likely to reflect the direction of stock status (i.e. recovering, stable, declining).

It is important to understand that the uncertainties in recent assessments have been driven by the primary data supporting the evaluation (FIS and CPUE), rather than the assessment framework itself. CPUE and FIS data remain critical data sources for the assessment, however they need to be assessed and interpreted differently to the current approaches (i.e. performance indicators) and the overall weight of evidence in this report benefits from the inclusion of other measures. 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 suite of Performance Indicators require updating. 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 the deeper water abalone stocks have declined substantially since that time (Dixon 2023). 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 as soon as practical 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 maximum 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 is expected to remain a key performance measure, addressing issues associated with hyperstability is essential. The current FIS program is being restructured, with new sites likely being implemented in current fishing grounds in 2024. However, it will take several years before meaningful data from these sites can be incorporated as performance measures. The review of

Performance Indicators must include potential additional measures that can be derived from commercial effort logger data collected over the last three 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 (see Dichmont et al 2022), 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.

The suitability of current decision rules for establishing limit, threshold and target reference points is questionable. Notably, the reliance on standardized CPUE data means that reference points inevitably fluctuate over time when new data is added, impacting direct comparisons with historical data. Dichmont et al (2022) identified several issues with the current standardized CPUE measure, primarily associated with unreliable historic data, but the review also identified a need to change the current standardisation approach. Agreeing a new standardisation approach is a high priority for the fishery.

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 currently being finalised. The results from this study can also be used for the re-evaluation of the Draft Harvest Strategy through the Working Group. Finally, Tasmania and South Australia have recently developed approaches to address hyperstability using diver logger data. The applicability of this approach for the Central 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 gathered during FIS include two sources of bias that mean they should be given little weight in the assessment of stock status. Importantly, this year commercial length frequency data were provided by industry for the first time since 2021. These data provide critical information to augment the assessment and add greatly to the weight of evidence. MRAG has not reviewed or audited the analyses of these data, but support prioritising approaches to better integrate these data into the assessment.

5.2. TACC setting and Optimal Target catches

The TACC setting process occurs in April each year for the Central Zone, around three quarters of the way through a current quota year. TACC setting is complicated by the lag 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. more than a year lag). Last year, informal assessments of up-to-date summaries of catch (SMU and reefcode) and CPUE (SMU only) were provided at the TACC setting meeting, and we expect this will occur again in April 2024. However, future assessment processes should aim to incorporate all available data into the assessment and TACC setting process in a more formal manner. The key limitations to this approach will be the availability of data and the time required to assess it.

In recent years, the VFA commitment to "carry-over" uncaught TACC from previous years has complicated the assessment and TACC setting process. Given the stock assessment process examines total catches inclusive of carry-over, we have used these OTs for the Draft Harvest Strategy outcomes.

5.3. Central Zone trends in available data

The commercial catch in the Central Zone for 2022/23 totalled 252.5 t, which was close to 100.0% of the TACC with carry-over. In the last four quota years, catches have ranged from around 230 to 250 t, with one year extended to 15 months meaning the annual catch was lower than the 230 t harvested. The current quota period has a TACC just over 220 t, inclusive of carry-over.

The current zonal CPUE of 79.5 kg/h is 18% lower than it was in 2003/04, 10% lower than it was in 2009/10 but 10% higher than it was in 2019/20. CPUE was relatively stable between 2013/14 and 2020/21 but has increased substantially in recent years and is currently around 2010/11 levels. 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.

Mean daily catch in 2022/23 was 448 kg/day. While mean daily catch is 10% lower than it was in 2003/04, it is currently 10% higher than it was in 2009/10 and similar (1% increase) to what it was in 2019/20. Mean daily catch has increased substantially since 2013/14. An agreed approach to standardising mean daily catch is required.

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 and they were adjacent to areas with high diving effort, albeit generally in slightly deeper water. On this basis, it was considered that the Top 15 sites would be the most likely to demonstrate the first signs of stock recovery. Across the Central Zone, recruit abundance across the Top 15 sites declined from 2003 to 2018 but increased by 25% thereafter. Pre-recruit abundance declined substantially and consistently from 2003 to 2021but increased by 87% in 2023, reaching the highest level observed since 2008.

Standardised average length of the commercial catch has increased consistently at most SMUs since 2016/17. This included the four most important SMU contributors toward total catch: Cape Otway, Back Beaches, Phillip Island, and Shipwreck Coast. These size increases were over and above size limit increases that had been implemented at the SMU level. Most other SMUs demonstrated stable average lengths over time.

5.4. Stock Status

5.4.1. Zone scale

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. 2020). The authors conclude *"The stable, but relatively low, abundances observed in FIS indices indicate that the decline in biomass observed over two decades may have stabilised, but there is no evidence of recovery and commercial CPUE has decreased by 14 per cent during the past decade [VFA 2017a]. However, pre-recruit abundance levels are similar to those for recruits, implying that reasonable recruitment has been occurring at recent stock levels. The current challenge facing the fishery is ensuring that the spatial distribution of catch is aligned with catch targets that reflect the biological productivity of the resource and enable stocks to rebuild. The most recent assessment concluded that maintaining the TACC at current levels was likely to meet objectives for stabilising the biomass at its current level but unlikely to recover stocks to previous levels. The above evidence indicates that the biomass of this stock is unlikely to be depleted and that recruitment is unlikely to be impaired. For the period 2009–2019 the biomass declined, but the stock is not yet considered to be recruitment impaired. Evidence based on the pre-recruit abundance index indicates that reasonable recruitment has been occurring at recent stock levels. [Dixon and Dichmont 2019a]. On the basis of the evidence provided above, the Victoria Central Zone Fishery management unit is classified as a depleting stock.".*

In recent years, the Central Zone assessment of stock status has been based on two primary sources of data, CPUE and FIS abundance, that are positively and negatively biased, respectively. This uncertainty in these data sources which underpin the assessment has resulted in a necessarily precautionary approach to the stock status assessment and subsequent advice including recommendations on Optimal Target catches. While the issues regarding CPUE and FIS abundance remain, the uncertainties in these measures are now better understood, and the first steps have been made toward improving the relevance of FIS data. Importantly, this year's assessment also includes data on the size structure of the commercial catch, derived from logger data gathered and analysed by industry representatives. Combined with analysis of mean catch per day and the refined FIS survey into a single zone-wide measure, the resulting "weight of evidence" is a stronger basis to infer likely stock status and trends than previous assessments.

At the zonal scale CPUE (kg/h), mean daily catch (kg/day), FIS abundance (recruit and pre-recruit) and average length from the commercial catch are all trending positively. Compared to 2018/19, CPUE has increased by 10%, mean daily catch is stable (1% increase), recruit and pre-recruit abundance across the Top 15 sites has increased by 16% and 37% respectively, and average length from the commercial catch has increased substantially at 7 of the 10 SMUs for which data are available (representing 83% of the 2022/23 total catch). For several of these indicators, the increases have occurred over longer time scales than just the last four years.

For fisheries where fishing mortality can be estimated, stock recovery strategies are typically underpinned by reducing fishing mortality (i.e. the proportion of the total stock harvested in any period) to levels that will result in an increase in biomass. For many Australian abalone fisheries, where biomass and fishing mortality are very difficult to estimate, declines in biomass have been addressed by reductions in TACC that do aim to reduce fishing mortality and promote stock recovery. However, TACC reductions have tended to be incremental and often consecutive, and for many fisheries it appears that fishing mortality has not been reduced sufficiently to recover stocks.

While the reasons for the likely increase in biomass indicators for the Central Zone in recent years are undoubtedly complex, the report on commercial length frequency data (Appendix 4), prepared by Dr Duncan Worthington, raises a hypothesis that the impact of Covid-19 resulted in a very low catch (108.8 t) in the 2020 calendar year, which gave much of the fishery an opportunity to "rest". This was, in effect, a full year with a very low total fishing mortality compared to recent history. In

addition, the quota year was extended by 3 months and only 230 t was harvested in that 15-month period. Concurrently, in April 2021, LML increases were implemented across several SMUs and it is plausible that the low catch in 2020 allowed for most abalone to “grow through” the LML increase. This has likely resulted in the observed increases in the average size of abalone caught in most SMUs over and above the LML increase in the last two years. An increase in average length and thus average weight of harvested abalone results in fewer abalone caught for a given TACC.

As stated in the Appendix 4 report, increases in mean size on their own do not necessarily reflect positively on stock status because this can also result from reduced recruitment. Importantly, the 2022/23 FIS data indicate that pre-recruit abundance has increased dramatically in the last two years in four important SMUs: Phillip Island, Flinders, Back Beaches and Cape Otway. While the number of sites was reduced, these four reefcodes comprise 11 of the 15 sites and the increases were consistent across all 11 sites. While interpreting a single year’s data from 11 sites requires considerable precaution, it does offer some optimism that stock recovery might be underway in these intermediate sites adjacent to the current shallow water reefs that are the primary fishing areas. Therefore, the observed increases in the mean size of the commercial catch are more likely to be indicative of reduced fishing mortality rather than diminished recruitment. Results from future surveys will be critical in better informing this position.

It is unequivocal that the spatial extent of the fishery has contracted substantially in the last two decades, and now concentrates heavily on shallow water reefs. In recent stock assessment reports, uncertainty in the status of these shallow water stocks has required precautionary advice to be provided. The 2022/23 stock assessment incorporates additional measures to support the weight of evidence assessment, particularly at the zone scale, compared to previous reports. Although uncertainty in individual measures remain, the positive trends observed in all indicators over recent years suggests that the decline in zonal biomass has stabilised and is likely increasing on shallow reefs. Nevertheless, it's essential to recognise that this is the first year of consistently positive results across all indicators, and confidence in the assessment will improve if the upward trends persist. On this basis, a prudent approach to management would be to continue to invest in potential stock recovery by maintaining the TACC at current levels while continuing to monitor and improve biomass indicators, and the stock assessment approach.

5.4.2. SMU scale

The evaluation of stock status at the SMU scale involves analysing Performance Indicators and conducting a weight of evidence assessment in comparison to the outputs of the Draft Harvest Strategy. The reduction in number of FIS sites means that a robust analysis of FIS Performance Indicators cannot be undertaken at the SMU scale. Thus, the only SMU Performance Indicators assessed in this report are for CPUE. CPUE remains below 2003/04 and 2009/10 levels at all SMUs except Surfcoast. However, shorter term (4-year) comparisons demonstrate increases ranging from 1-39% at all SMUs except Cape Otway (2% lower).

These results are reflected in the more optimistic overall Draft Harvest Strategy outputs for this year because CPUE is its only input measure. The Back Beaches, Phillip Island, Prom West and Flinders SMUs each had an “Increasing” Final Category, suggesting that increases in OT could be considered. Cape Otway and Kilcunda were the only SMUs that had a “Decreasing” Final Category, suggesting that decreases in OT were required.

The examination of weight of evidence information suggested that the Back Beaches and Phillip Island SMUs were performing very well. While the indicators at Flinders SMU have been slowly improving, the stock clearly remains in a highly depleted state relative to its historic levels. While catch rates have been high at the Prom West SMU, catches in the last three years have been well above the respective OTs, FIS recruit and pre-recruit abundance declined substantially in 2023, and mean size of the commercial catch has not increased as it has at other SMUs. The Draft Harvest

Strategy suggests a reduction in OT is required at the Cape Otway SMU, however CPUE remains high in a historic context and mean size of the catch has increased substantially in recent years. Many of the lower catch SMUs appear to be stable, or where some reductions in recent indicators have occurred, total catches have reduced.

While this report provides a much clearer assessment at the zone scale than previous reports, analyses at the SMU scale remain largely uncertain. If agreement can be made to maintain the overall TACC at its current level, then small changes to OTs at the SMU scale may facilitate further improvement in regions where the biomass indicators are less positive. These decisions can be informed by the available data in this report, and the opinions of the industry at TACC setting.

Importantly, adjustment of OTs at the SMU scale should avoid large increases in OT on important stocks that are showing positive biomass indicators, such as the Back Beaches. The Phillip Island SMU is a good example to demonstrate the benefits of maintaining stable catches over time. Any increases considered for SMUs should be applied in small increments.

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 more than two years and one year, respectively. The need for other reviews has been identified, including review of performance measures, the 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. The active involvement of industry in the research planning process will be pivotal for enhancing the assessment framework and fostering acceptance of its outcomes.

This report is the first since 2021 to include size structure data from the Central Zone commercial logger program. These data will be critical for future assessments, and there is a need for a more formal approach to integrate them directly, or to review these analyses, within the assessment process. These and other data from the logger program offer great potential to provide additional biomass indicators that will strengthen future stock assessments.

The FIS review undertaken in 2023 was the first formal approach at utilising VMS spatial effort data for the fishery. As with the commercial logger data above, ways to integrate these data into the assessment process is a high priority for future research.

The FIS review was completed to the end of phase 1. The next steps are to finalise contractual arrangements to establish and survey new sites, and to repeat historic survey sites as required. The establishment of a reliable survey measure that integrates data from new sites established on shallow reefs indicative of the fishery, combined with data from previously established sites with a long research history, will substantially improve the assessment process.

It is imperative that the CPUE standardization approach is improved before the next stock assessments. Furthermore, there is a need to improve the current CPUE indicator, including the possibility of integrating data from dive loggers and examining the Tasmanian approach to addressing hyperstability. VMS data may be useful to examine the fishery footprint to ensure that hyperstability in CPUE measures is not being masked by spatial contraction of the fishery area.

There are a number of elements of the current Draft Harvest Strategy that require adjustment. The use of standardised CPUE as the key measure has resulted in changes to the reference points for 8 of the 10 SMUs assessed. Also, the outcomes can change depending on the scaling factor selected. Finally, given the positive bias in CPUE over longer time periods, the current reference period that extends back to 1979 should be reconsidered.

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7. Appendices

Appendix 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. Here, we compare 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 50). The standardised trends are essentially the same as the nominal, except the series is shorter. FIS data were not collected in 2022.

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). Unlike the Eastern Zone where CPUE generally increased and FIS recruit abundance generally decreased, there appears to be some correlation between these measures in the Central Zone at most SMUs, albeit the strength in the signals differs. In most cases, CPUE was initially well below the average, then increased until the early to mid-2000s before slowly declining. At most SMUs CPUE is currently around or just below the average. Recruit abundance at most SMUs started around the average, increased until the early 2000s before declining more rapidly than CPUE. Currently, FIS recruit abundance is below the average at most SMUs.

To further explore the relationship between CPUE and FIS recruit abundance, we repeated the analysis of Hart (2017) for each SMU and for the Central 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. Using data from 1992 to 2020 (Figure 51) and the same time series as Hart (2003 to 2016, Figure 52) for each SMU and for the Central Zone, we found weak positive correlations at most SMUs (Appendix 3). 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 more exaggerated than those observed.

The declining trends in both CPUE and FIS recruits adds strength to the conclusions of general decline in abundance of abalone stocks since the early to mid 2000s. The following sections of the report aim to provide an assessment of stock status considering these data.

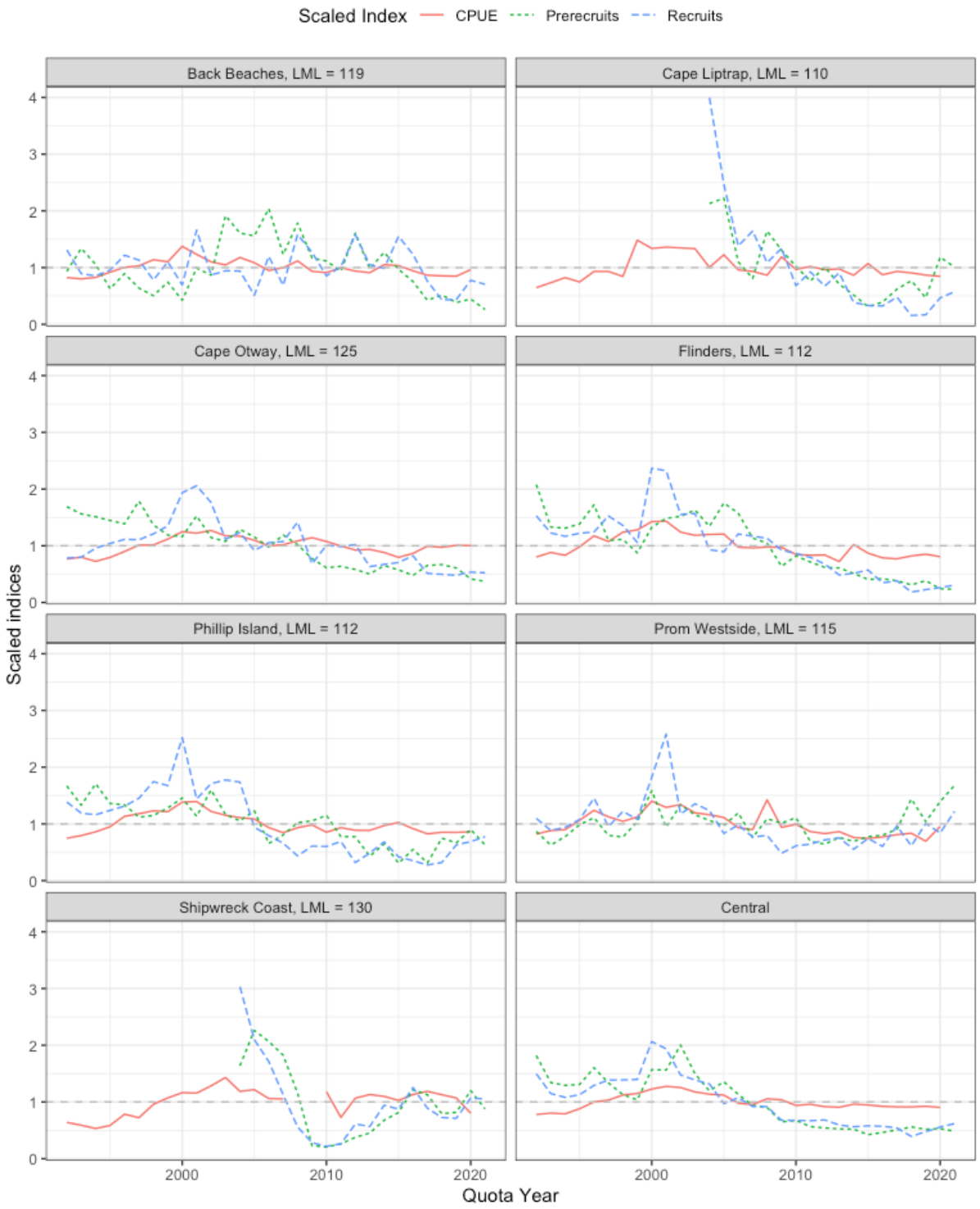


Figure 50: Relative trends in nominal commercial CPUE, nominal FIS recruits and nominal FIS pre-recruits from 1992 to 2020 for each SMU and for the Central Zone as a whole. Grey dashed line represents the average for each series.

Correlation between nominal CPUE and nominal FIS recruit abundance

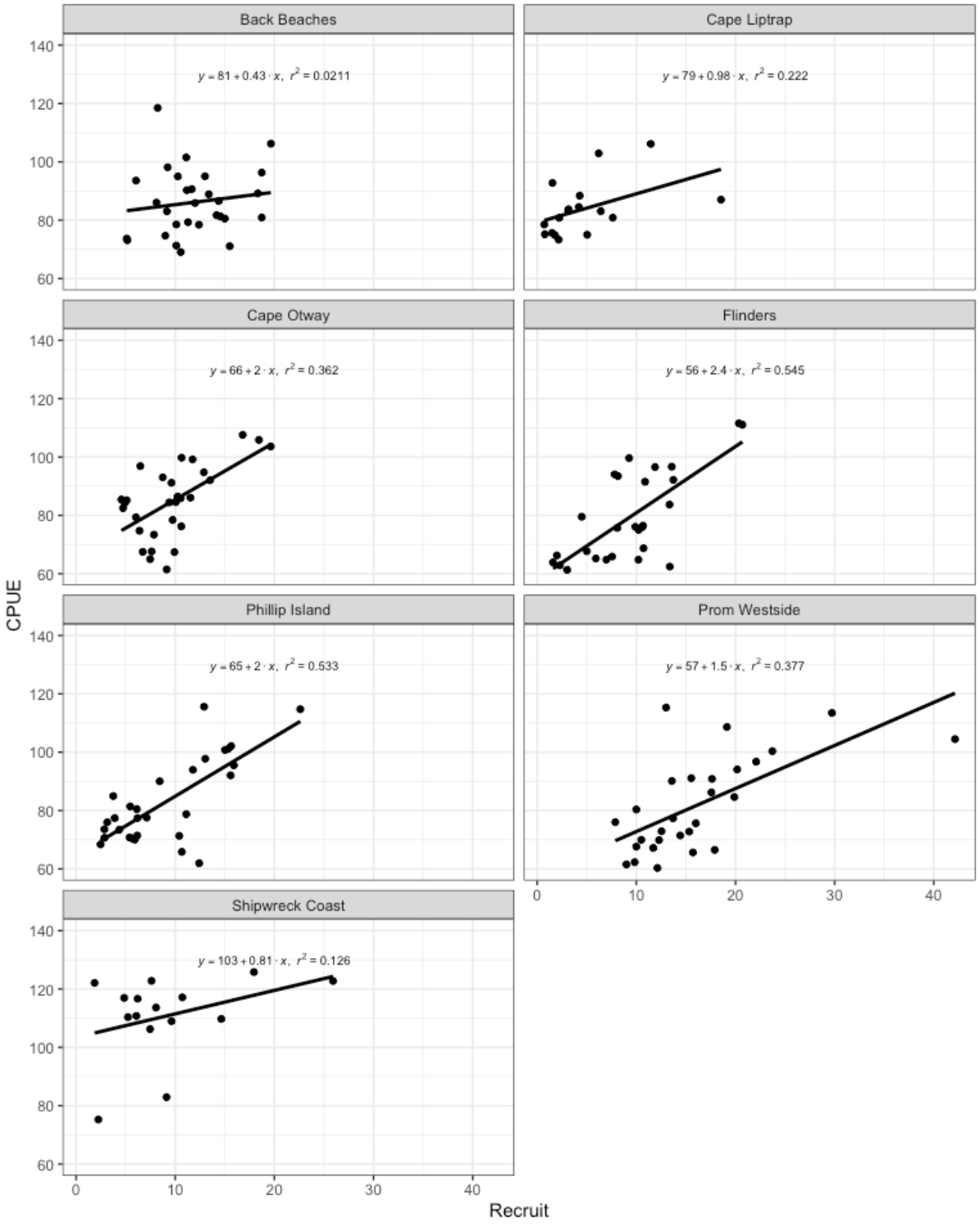


Figure 51: Comparison of nominal commercial CPUE (kg/h) and FIS recruit abundance (no. per site) from 1992 to 2020 for all SMUs

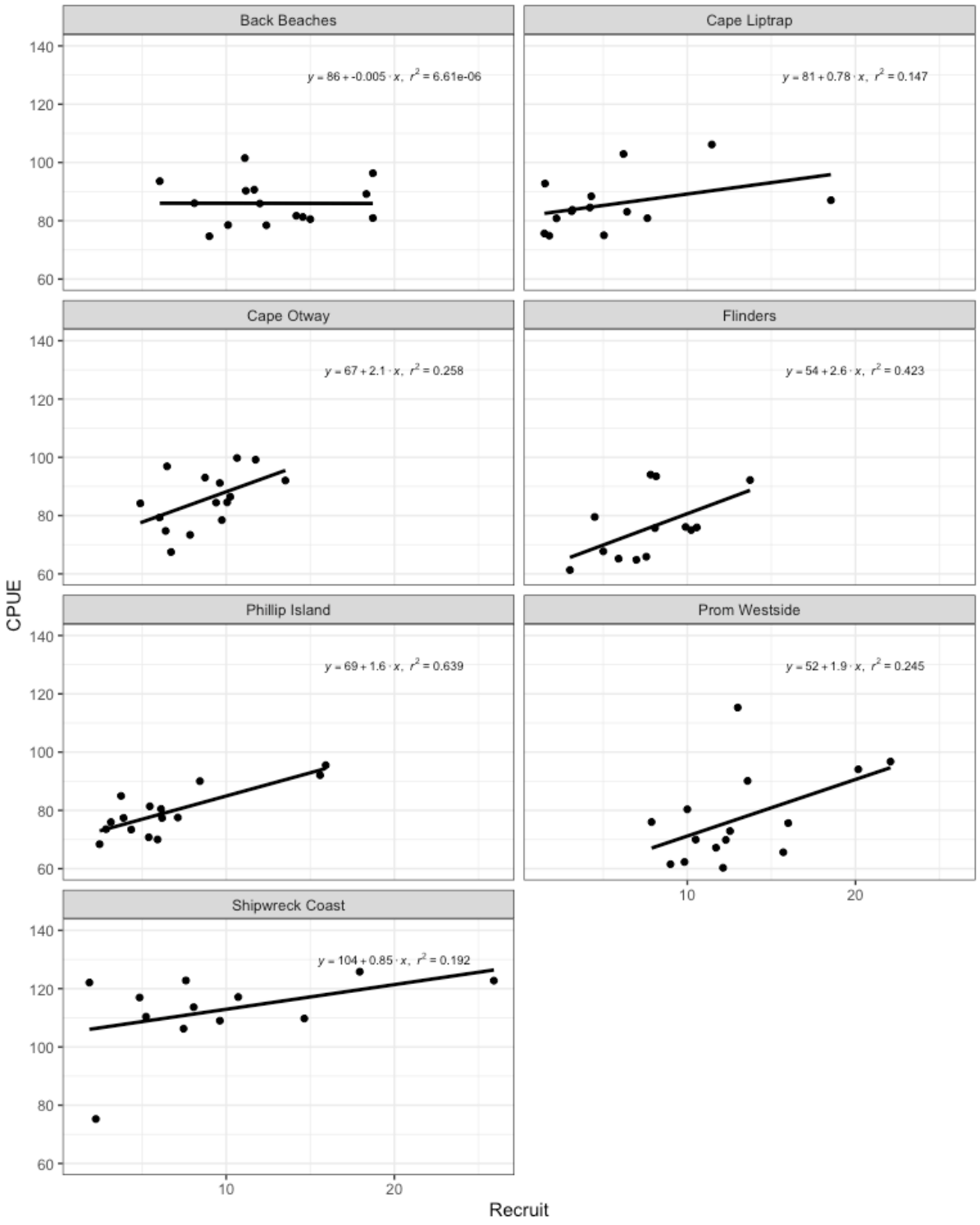
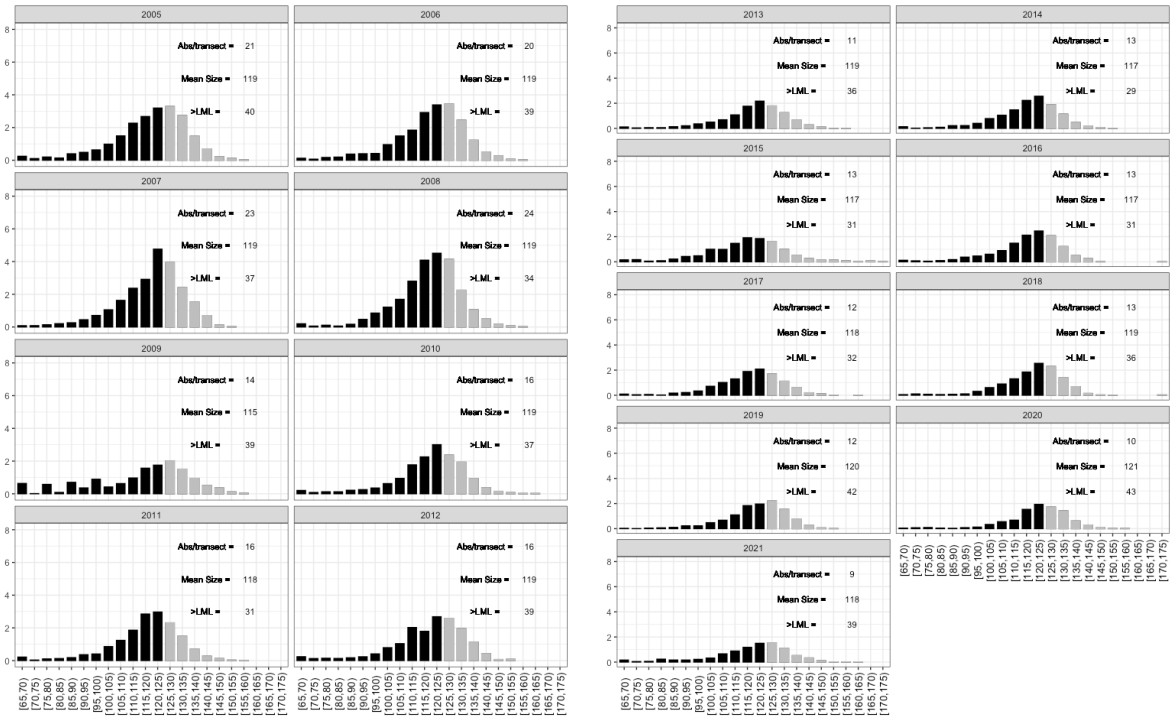


Figure 52: Comparison of nominal commercial CPUE (kg/h) and FIS recruit abundance (no. per site) from 2003 to 2016 for all SMUs.

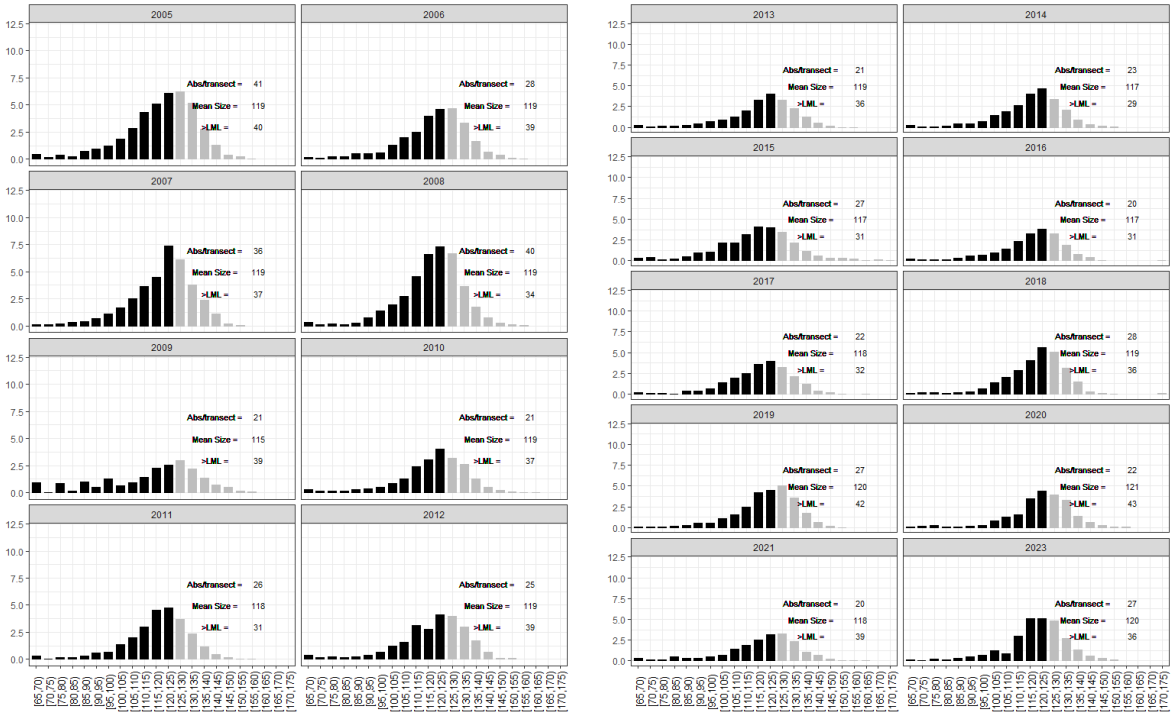
Appendix 2: FIS length frequency data for (a) all sites and (b) Top 15 sites at each SMU where FIS were conducted historically.

Size frequency distributions for the Cape Otway 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. Note scales differ slightly.

(A)

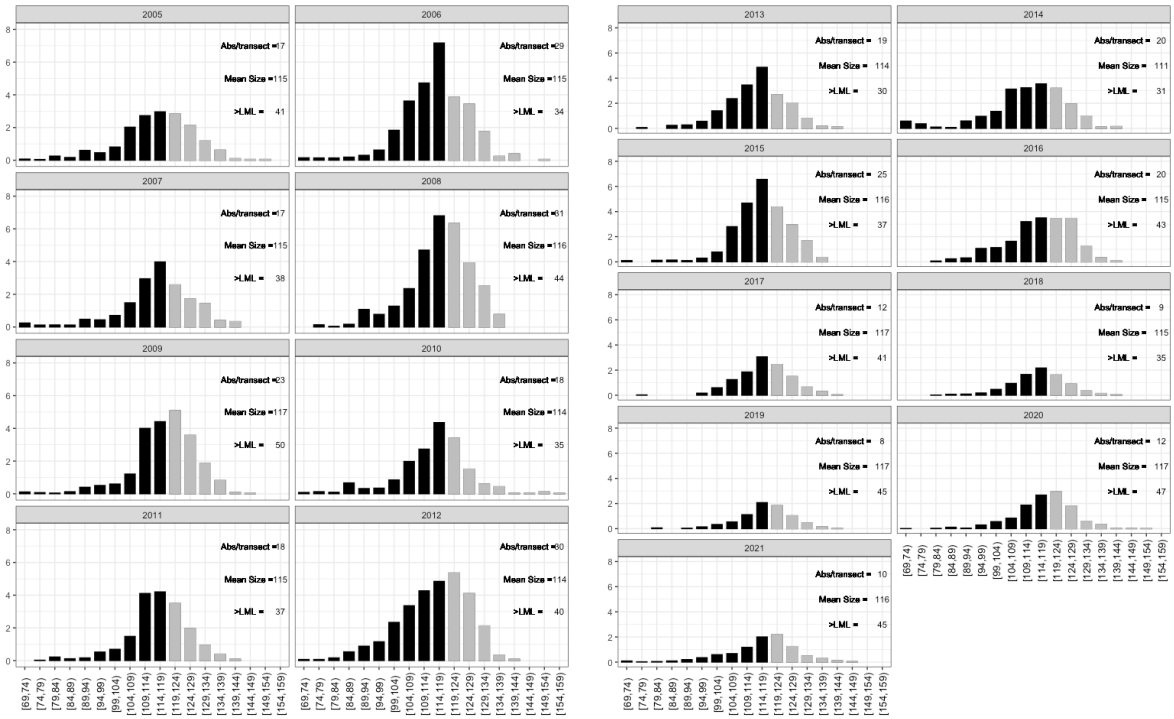


(B)

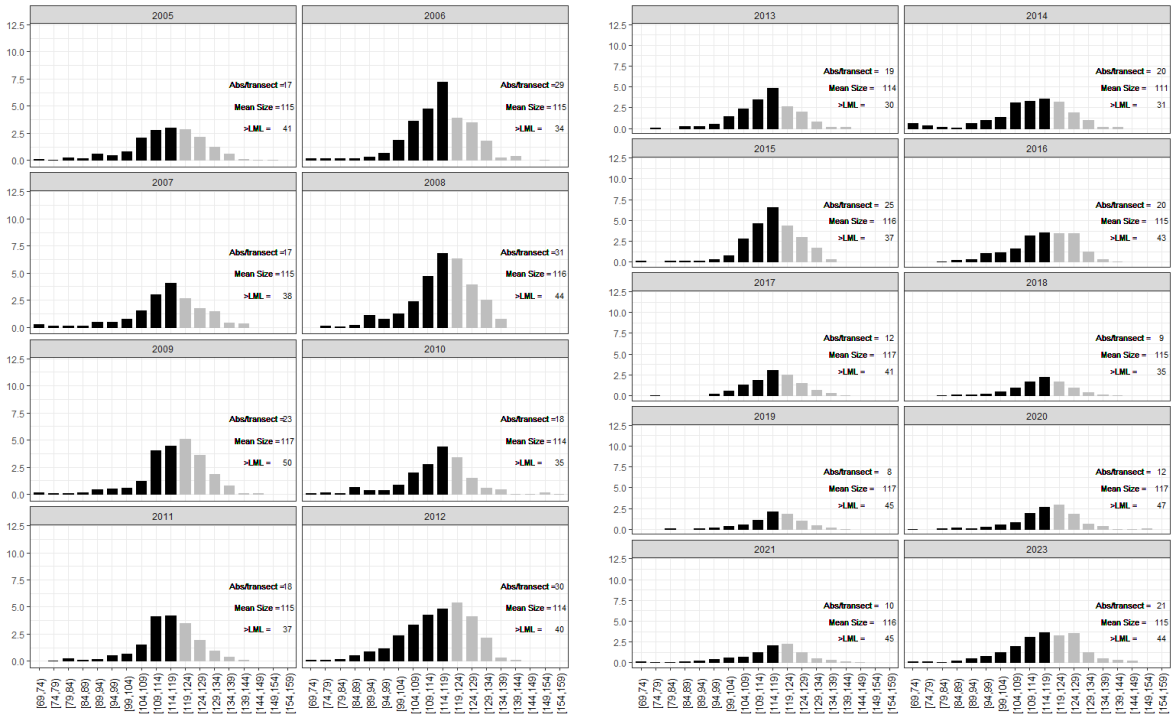


Size frequency distributions for the Back Beaches SMU from (A) 2003 to 2021 for all sites and (B) from 2003 to 2023 for the three Top 15 sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022.

(A)

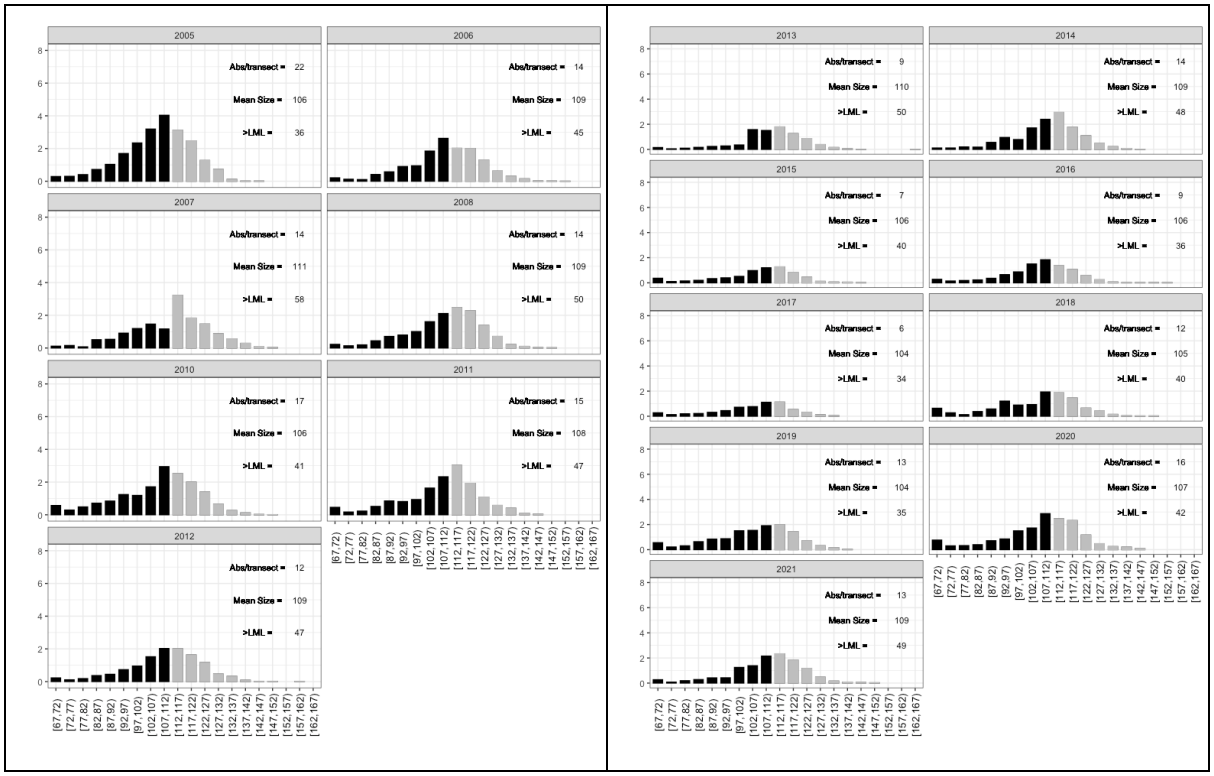


(B)

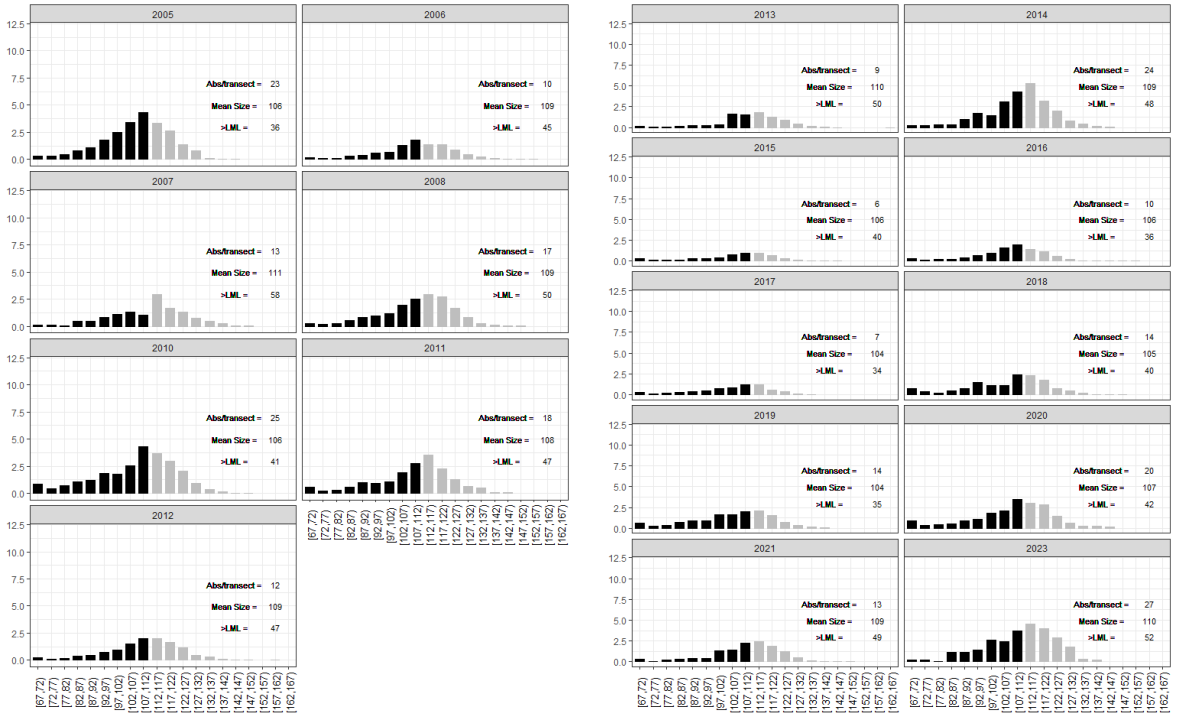


Size frequency distributions for the Phillip Island SMU from (A) 2003 to 2021 for all sites and (B) from 2003 to 2023 for the two Top 15 sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022.

(A)

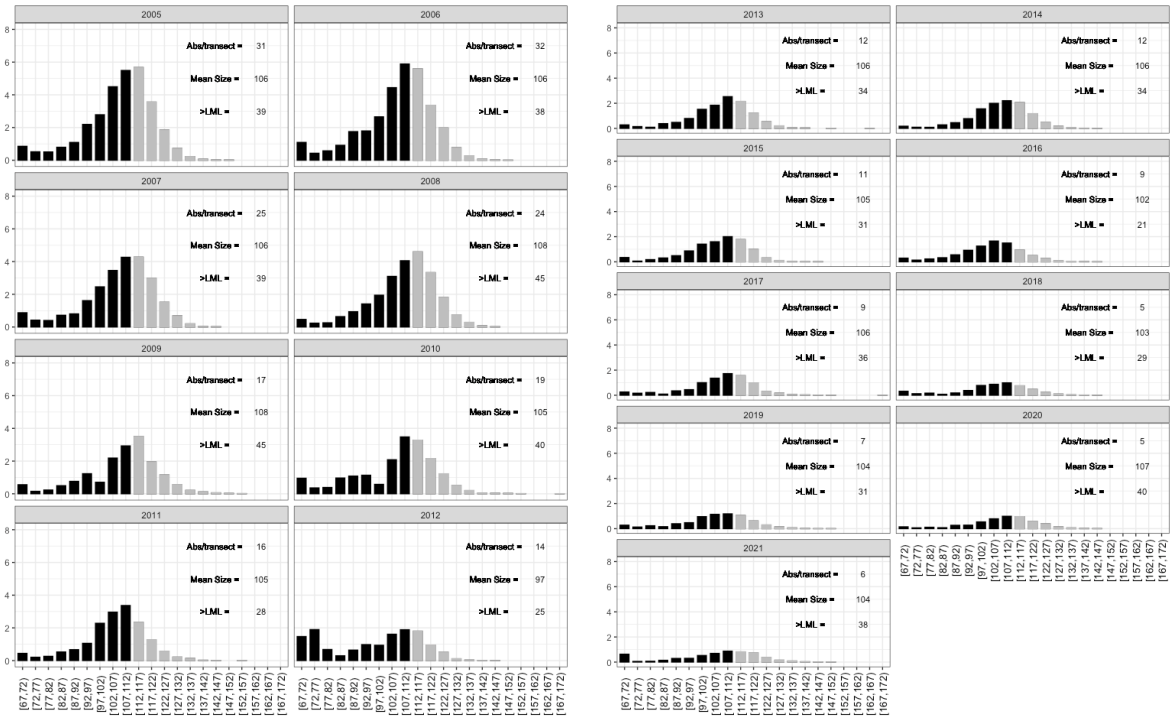


(B)

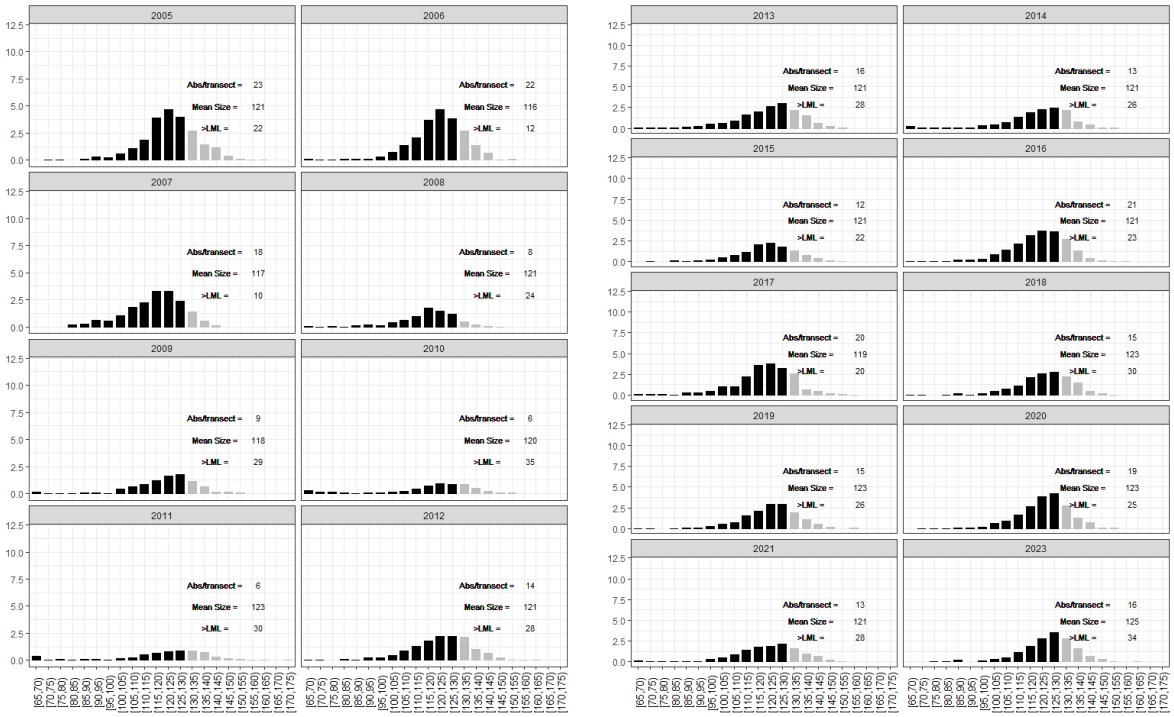


Size frequency distributions for the Shipwreck Coast SMU from (A) 2003 to 2021 for all sites and (B) from 2003 to 2023 for the two Top 15 sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022.

(A)

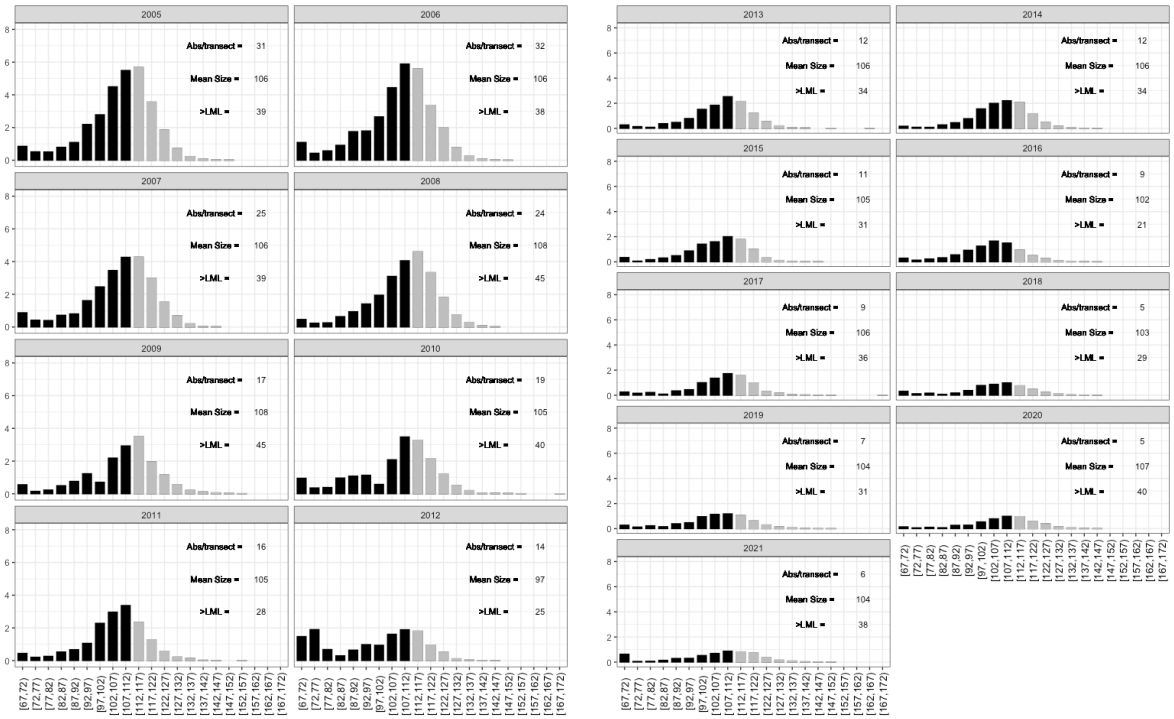


(B)

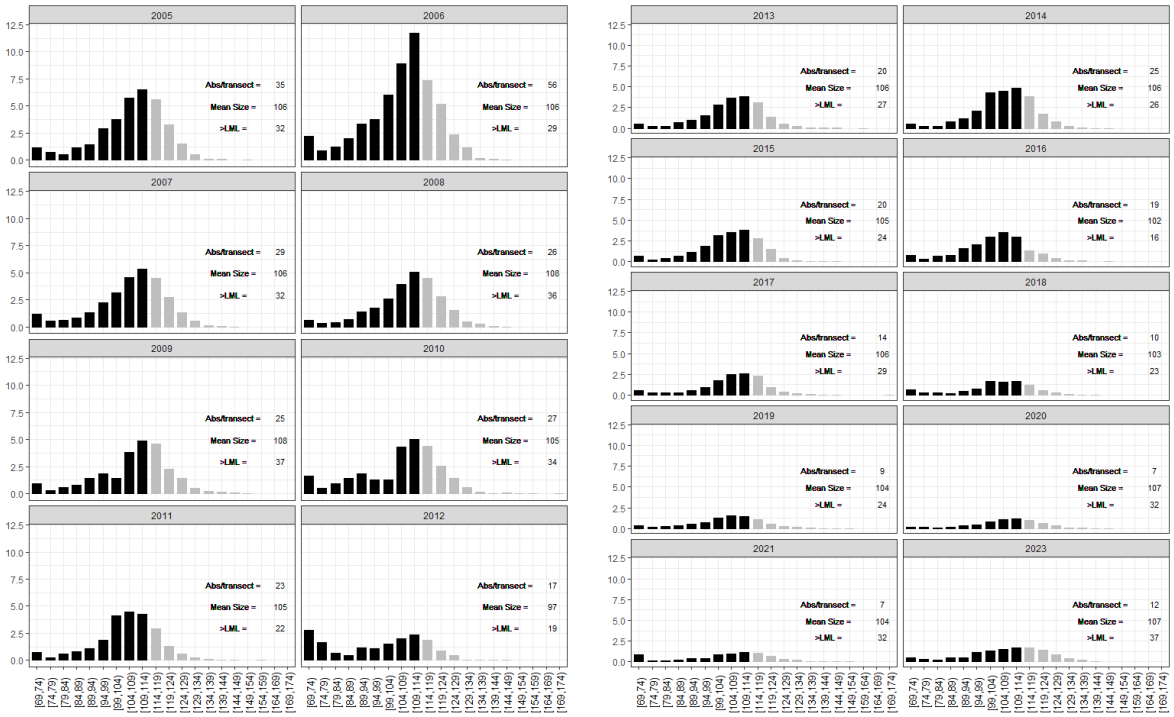


Size frequency distributions for the Flinders SMU from (A) 2003 to 2021 for all sites and (B) from 2003 to 2023 for the two Top 15 sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022.

(A)

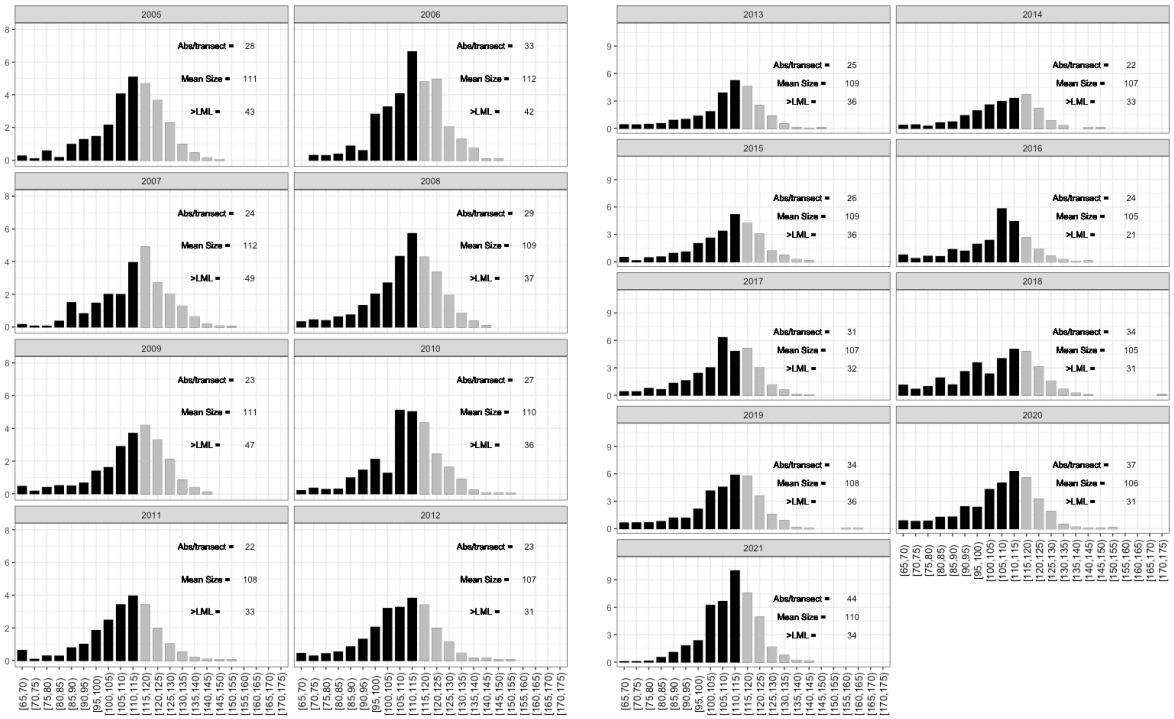


(B)

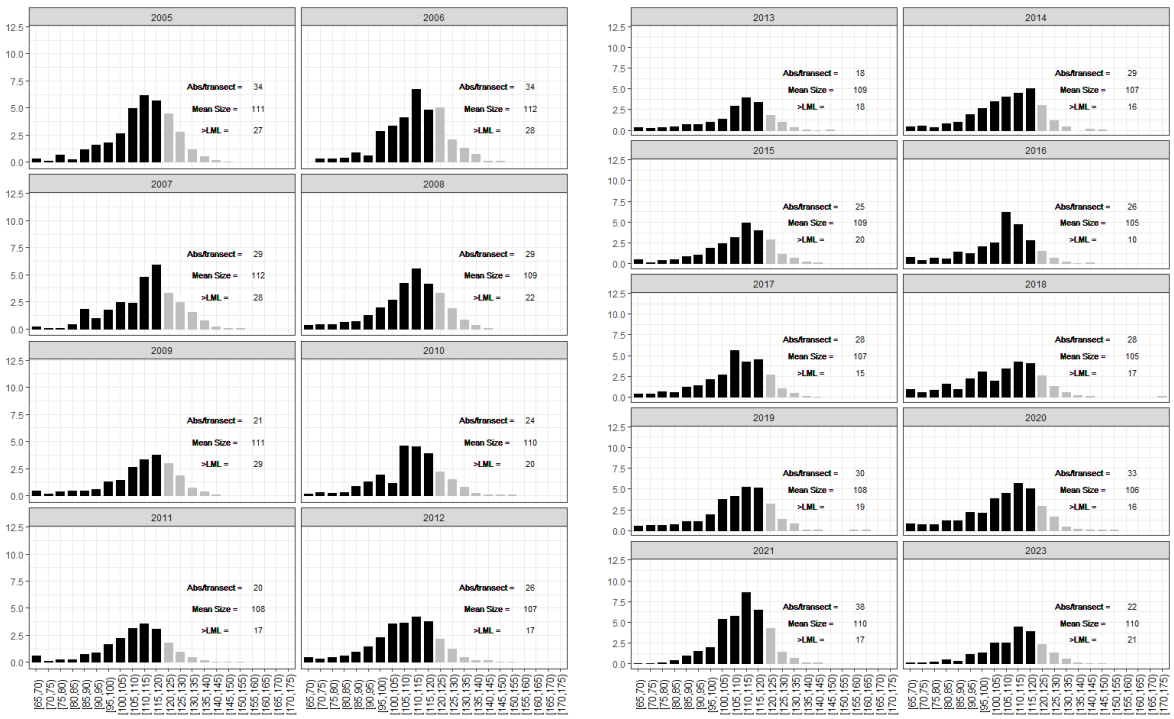


Size frequency distributions for the Prom West SMU from (A) 2003 to 2021 for all sites and (B) from 2003 to 2023 for the two Top 15 sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022.

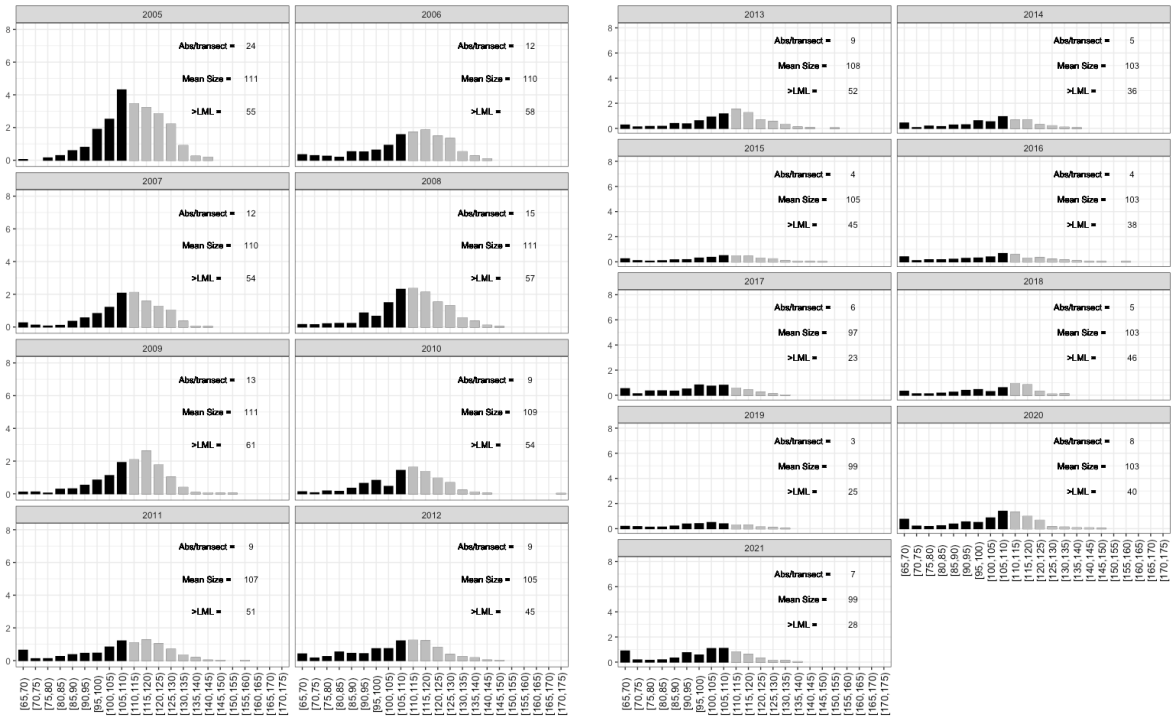
(A)



(B)



Size frequency distributions for the Cape Liptrap SMU from 2003 to 2021 for all sites. Black bars represent undersize abalone, grey bars represent (current) legal size abalone. FIS data were not collected in 2022 or 2023.



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

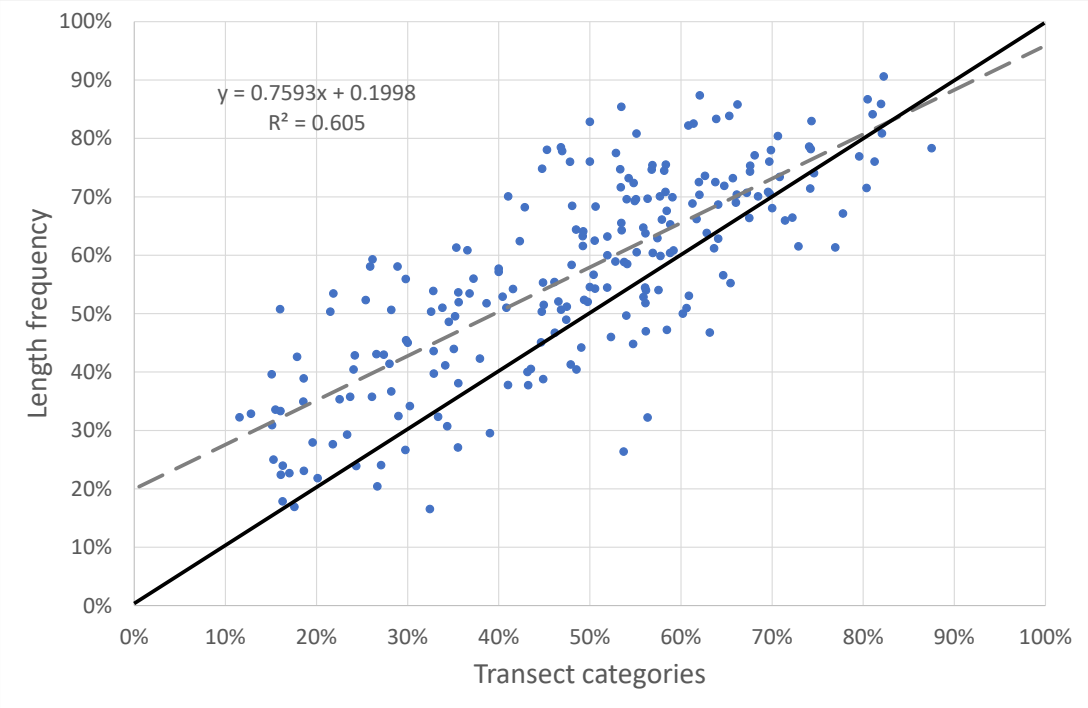
The manner in which length frequency data were gathered from historic FIS changed considerably over time. Originally, all abalone encountered on a transect were collected and brought to the surface to be measured before being returned to the bottom at the same site. This approach was modified when concerns 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.

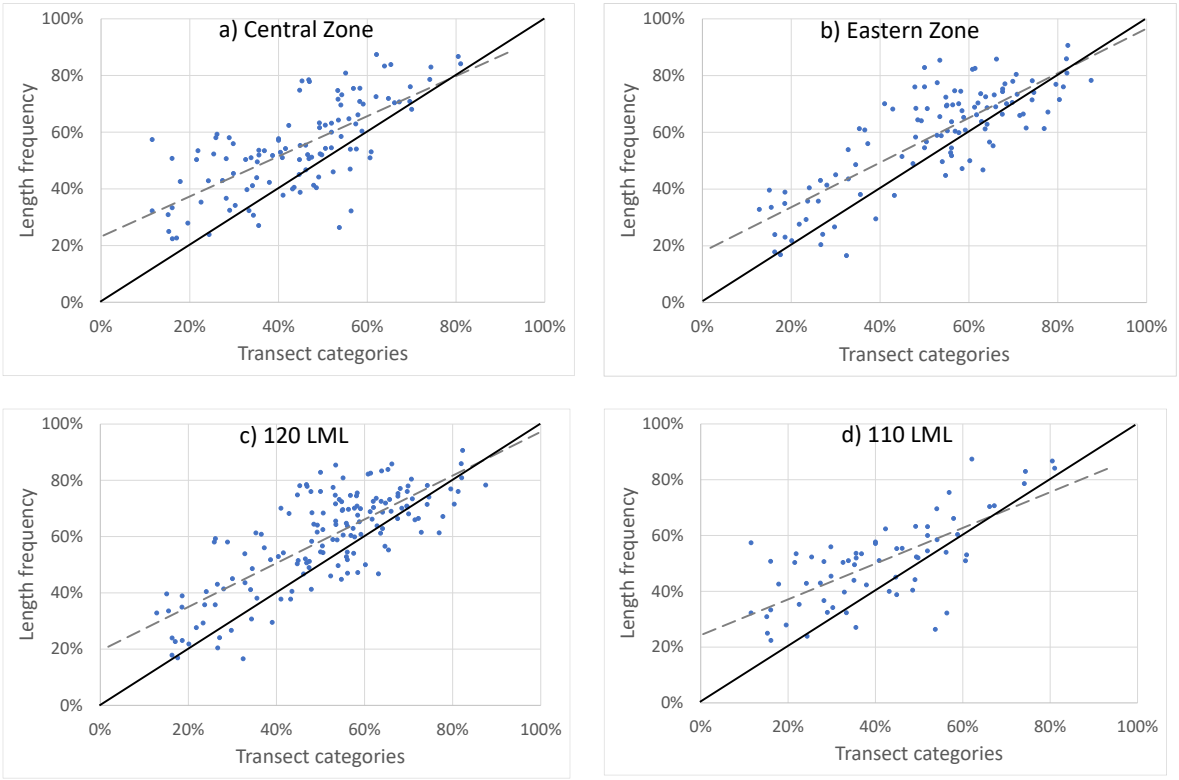
Figure 2 shows the proportion of recruits versus pre-recruits expressed as percentage of recruits for all data combined. The dashed grey line represents the line of best fit for these data. The solid black line that runs from the origin of the axis should be the theoretical line of best fit if there 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: Summary of abalone length measuring in CZ updated to December 2023.

Prepared by Dr Duncan Worthington, 31 January 2024

Background

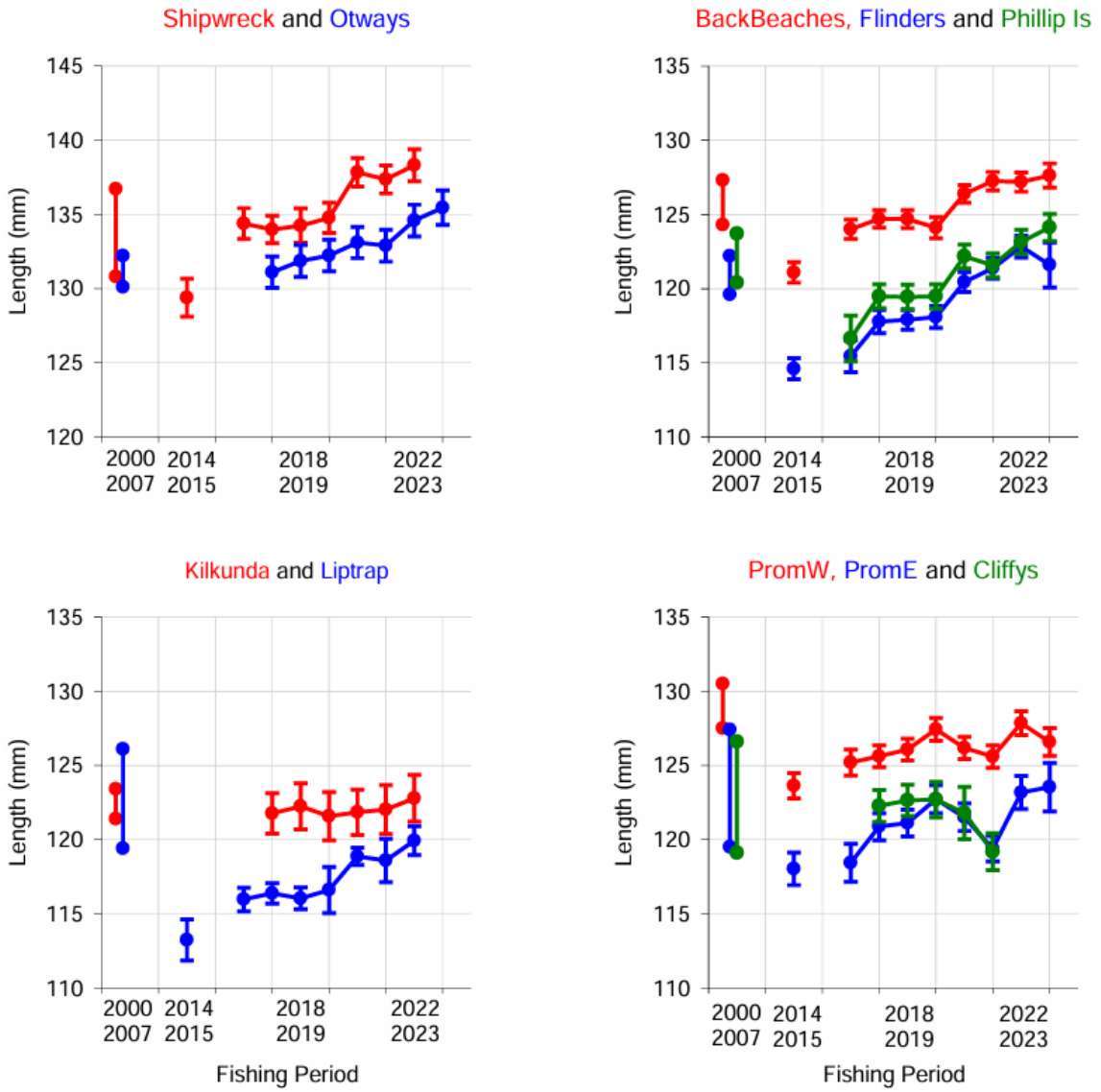
Following a request from MRAG and ACV, an updated summary of the Central Zone (CZ) length measuring program at the scale of SMUs was completed, including all data available from the fishery until December 2023. This document will be attached as Appendix 2 to an earlier more detailed document summarising the measuring program and approach to analysis, which was first completed in June 2020 and last updated in February 2021 and with Appendix 1 added in April 2023. This document provides a brief update and summary of the available data, with fine-scale analysis summarised at the scale of SMU, brief interpretation and recommendations for further development, particularly including interpretation at finer spatial and temporal scales, and importantly together with other fishery indicators. This document updates the data summarised in April 2023 from December 2022 to December 2023 (i.e. new data for the two most recent fishing periods). Previous reports have described substantial increases in the average length of abalone landed by the commercial fishery in CZ from 2014 to 2022. This report describes further increases in the length of abalone in several SMU since December 2022. Increases in average length are often a positive indicator of change in the abalone stock, including from reduced fishing mortality. Despite that, interpretation of trends in average length can be confounded by several factors, and the data summarised here should be further investigated and interpreted with other fishery indicators in the broader stock assessment and at finer spatial scales. These data showing an increase in the length of abalone landed by the commercial fishery highlight the importance of also collecting estimates of abalone length from fishery-independent surveys in areas that are representative of the fishery. In the CZ measuring program during 2022 and 2023 there has been a significant reduction in the number of abalone measured and available for analysis, the number of divers measuring (e.g. only 3 divers measured most of the abalone in 2023, noting data from 3 divers measuring boards are still pending because of technical problems), and the spatial extent of their measuring. There has also been reduced funding available for the QA/QC needed for appropriate management of the measuring board program, its data and analysis. This reduced collection and resourcing for management of the data could impact the utility of the data set, particularly estimates of length within some SMU and at finer scales, and development of the important data set used for stock assessment in CZ.

The measuring program, trends in length and their interpretation

From April 2014 until December 2023, over 1.4 million individual abalone (i.e. weighing >450 t) have been measured with a GPS-enabled measuring board by commercial divers in the CZ abalone fishery (see Table 1 for count per SMU). Table 2 also shows a history of changes in legal minimum length (LML) within each SMU. Individual lengths and associated detail of collection time, date and location were initially downloaded from boards manually, then with upgraded internet-enabled measuring boards to an FTP site, and now mostly direct to a separate cloud-based MySQL database. Data were initially stored and combined with historical data in a SQL Server database, and now the FTP and MySQL files are transferred to the SQL Server database for summary and analysis. The data is filtered to remove outliers, and the average length of abalone landed per diver day within each of 134 Sites is calculated and standardised by a GLM with factors including the Year (i.e. Fishing Period), Diver, Site and SMU. Standardised estimates are then normalised to the raw average length within each SMU during the most recent full year (see Appendix 1 for raw means). Note this normalises PromW to a higher length consistent with more catch and measuring from the islands, and with standardised trends through time modelled as consistent across length.

During the current measuring program since 2014, the average length of abalone measured has increased in all SMU (see Figure 1 for standardised, and Figure 4 for raw), except Cliffys where average length had declined by 2020-21 (i.e. and no data are available yet at Cliffys from July 2022 to Dec 2023). Increases in length were largest at Liptrap, Shipwreck, Flinders, Back Beaches and Phillip Is, and lower at Kilkunda. In most SMU, increase in average length occurred coincident with LML increases in some years, and similar increases in average length also occurred in years with no LML increase (Figure 1 and see Figure 2 which shows the impact of increased LML). In several SMU, the largest increase in average length occurred following the period of reduced catch in the 2020 calendar year (i.e. 109 t throughout CZ, related to Covid and weak markets), and LML increases in April 2020.

Figure 1. Trends in the average length of abalone landed for each SMU since 2014, with error bars showing SE among diver-days, and standardised values normalised to the raw average in the most recent fishing period with data in each SMU. The range of annual un-standardised average length from the earlier 2000 2007 dataset are also shown for individuals above the size limits in 2019-20.



With the latest data in the most recent two fishing periods, the average length of abalone measured increased in all SMU with good data available in 2023-24, except Flinders (i.e. only data from 1 diver-day available to date with more available once outstanding board data is received) and PromW (i.e. data from 8 diver-days). Change in average length among adjacent SMU were similar, with strong inter-annual correlation at Flinders and Phillip Is, in particular (Figure 1). Using the measured lengths to estimate weight, the weight of an individual abalone has also increased ranging from a >20% increase at Shipwreck and Liptrap to a >10% increase at Back Beaches, Flinders and Phillip Is, and a >5% increase at Otways, PromW and PromE, to a 6% decline at Cliffys (Appendix 1). An increase in the average weight of individuals leads to fewer individuals being landed for the same catch or TAC. For example, at current average lengths, a 5 mm increase in length can increase weight by 11-13%, and so reduce abalone landed to catch the TAC.

This document provides estimates of trends in the average length of abalone for interpretation in stock assessment, ideally together with other indicators. Increase in average length are often a positive indicator for change in fishing mortality and the abalone stock. Despite that, interpretation of trends in average length can be confounded by several factors. For example, average length can increase with more larger abalone (e.g. from lower fishing mortality), or fewer small abalone (e.g. a decline in recruitment to the fishery). To investigate this, further analysis should develop other indicators from the length-frequency distributions, including change in the frequency of smaller and larger abalone (e.g. recent recruits compared to larger abalone, as is done in WZ) and their relationship with other stock indicators. Change in average length can also be impacted by change in the spatial distribution of catch and measuring. Effects of spatial change in the distribution of catch and measuring have been standardised by making comparisons through time at 134 Sites throughout CZ (i.e. averaging length within sites, not across them). Trends in average length can also be impacted by change in the minimum length limit (LML), diver's daily catches and abalone size preference (e.g. market driven), and recent change in total catch and stock biomass (i.e. local and broader fishing mortality). For example, total catch in CZ in the 3 fishing periods prior to the start of the 2014-2024 measuring program was ~300 t, compared to ~240 t and below in the 3 most recent periods. Some SMU have also seen significant change in catch and LML over the 2014-2024 measuring program.

Importantly, the large reduction in catch during the 2020 calendar year (i.e. 109 t throughout CZ), coincident with Covid impacts and LML increases, appears to have strongly influenced the length of abalone in several SMU. Despite the range of possible confounding factors, ongoing increases in the average length of abalone landed, particularly when temporally consistent with reductions in catch (e.g. during 2020 and among years) and correlated among SMU, are likely to be associated with reduced fishing mortality (i.e. the relationship between total catch and the availability of legal-sized abalone and stock biomass). Further, an increase in the average length and weight of individuals also leads to fewer individuals being landed for the same catch. While changes in length appear to have gained momentum during 2020, it is also important that the increases in length continue through more recent years, including 2023-24.

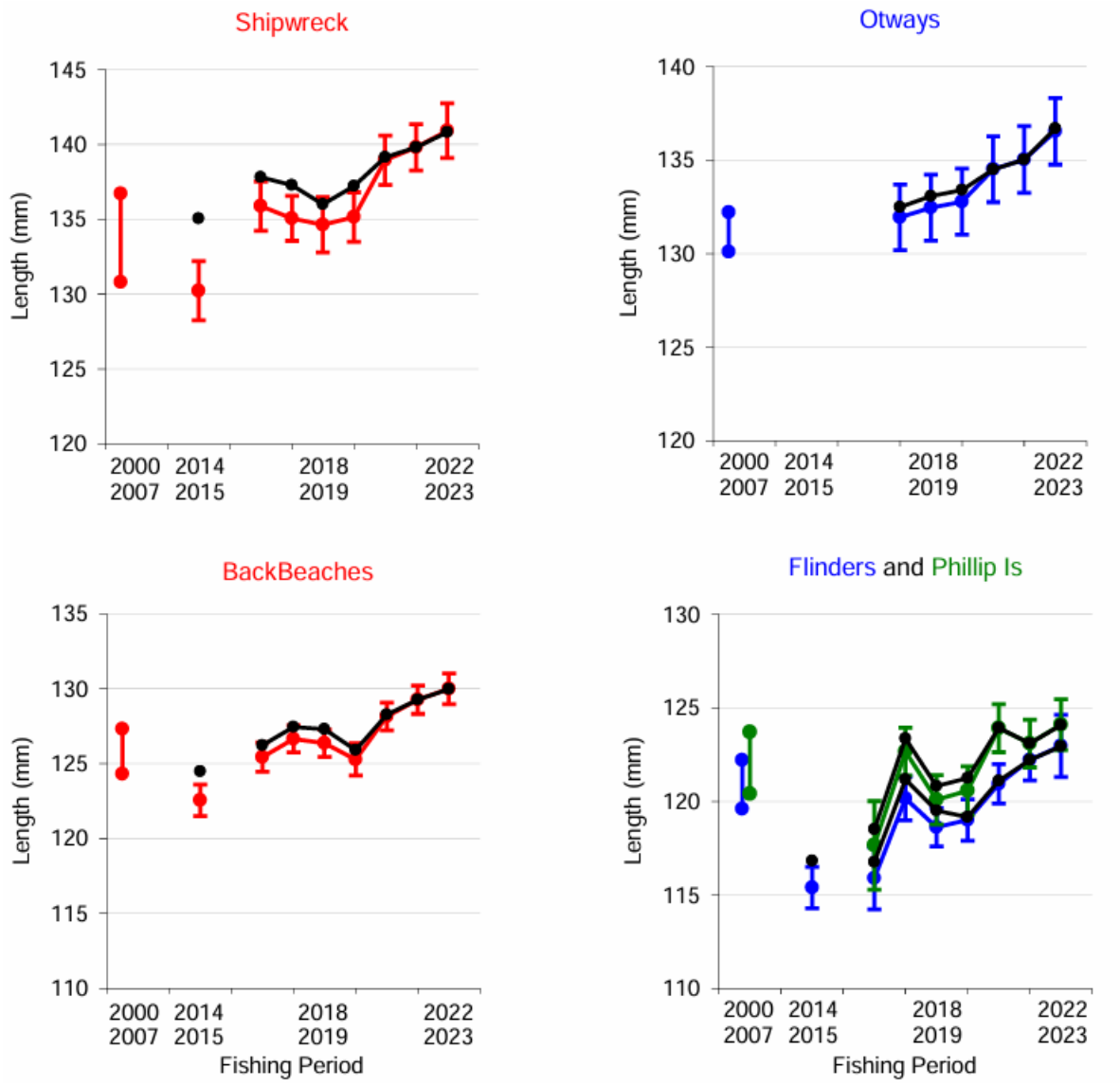
Effect of change in minimum size limits

During the time covered by the measuring program the LML within many SMU has changed (see Table 2 for history of LML changes). To estimate the effect of the LML changes on the average length of abalone landed, the standardisation was calculated for abalone at the active LML each year, and then repeated for all years at the current LML (i.e. 2022-23) for 5 selected SMU (Figure 2). Increases in average length for the active LML each year (i.e. coloured lines in Figure 2) were greater than those from the average length in each year above the current LML (i.e. black lines in Figure 2). This suggests increases in LML have increased the average length of abalone landed, as expected, but that increases related to the LML changes are small compared to the ongoing increases in length. There have been increases in average length in most SMU and years that have not been related to LML increases (i.e. black lines in Figure 2). As described above, there are a range of possible factors

contributing to increases in average length, in addition to increased LML and spatial changes in effort (i.e. with some removed in standardisation), including reduced fishing mortality and other factors (e.g. recruitment changes and market preferences). Despite that, the consistency of patterns among SMU (e.g. particularly Flinders and Phillip Is) suggest broader-scale factors are also influencing the increase in average length within the CZ abalone fishery.

Historic length measuring data from 2002-07 were previously summarised using the 2019-20 LML, to aid comparison with more recent years. Since 2019-20, further LML changes have been made in several SMU, and the historic length-measuring data should be re-summarised consistent with the most recent LML. The historic length measuring data from 2002-07, also provides considerable information about the spatial location of the fishery in the early 2000s, to help interpret the spatial location of fishery-independent abundance survey sites.

Figure 2. Estimated effect of change in LML on trends in average length of abalone within 5 SMU. Coloured lines show length at the LML active in each year, and black lines show length above a constant minimum length equal to the LML in 2021-22 (i.e. Shipwreck 130 mm, Otways 125 mm, Back Beaches 119 mm, Flinders and Phillip Is 112 mm). The black line shows the estimated trend in average length if there was no change in LML.



Developing the approach to using length measuring

This report has repeated the previous approach of standardisation developed in 2020. Appropriate resources should be allocated to further develop and automate the approach for analysis and presentation of length measuring data in CZ. This should include development of indicators for smaller and larger abalone to aid interpretation (e.g. frequency of individuals near the LML, and length of abalone >20 mm above the LML), summary of historic data with current LML applied, greater consideration and development of spatial structure and the impact of both daily catch and total catch per SMU in recent years, and include more fine scale assessment (e.g. Reefcode and below, and within years). There has also been interest in the development of approaches like SPR, that combine demographic models with observed length data to provide estimates of likely stock depletion and their relationship to target lengths. Two technical issues also need further investigation. Figure 3 shows the potential for quarterly standardisation of data within the Back Beaches SMU on the left, and on the right the impacts of a potential malfunctioning measuring board are demonstrated at the Otways, and both need further investigation. For example, in several SMU, quarterly assessment of several fishery indicators, including catch, catch rate and lengths appear to show significant change in the stock, and particularly increase in average length, coincident with reduced catch related to Covid impacts during the 2020 calendar year (e.g. 27 t average catch per quarter in 2020, compared to 65 t for previous and subsequent 2 years) and LML increase (Figure 2). This quarterly change in fishery indicators in several key SMU, and catch at several spatial and time-scales (i.e. within 2020, and pre-2014 to recent years), each potentially related to reduction in fishing mortality suggested by the coincidence of reduced catch and increasing average length, does not appear to be considered in previous fishery Stock Assessment.

Significant resources have already been committed by Industry to the collection of data in the recent length measuring program for almost a decade. Appropriate resources should also be used to allow better analysis, summary and use of the now large and growing data set. Change in the length of abalone observed in the measuring program for the CZ fishery are already significant for interpretation and understanding of the fishery and stock dynamics, at SMU, Reefcode and smaller spatial scales, as well as trends within and among years. There is very limited other data or stock indicators in areas frequently used by the fishery, and particularly with the Fishery Independent Survey sites not in areas frequently used by the fishery (i.e. as highlighter by FIS Review). As a consequence there is an urgent need to appropriately develop the length measuring data and its interpretation into stock assessment approaches used by the fishery. An important part of this will be to encourage more divers to again ensure more abalone are measured throughout all SMU, and that appropriate resources are allocated for QA/QC, data management and analysis of this important data.

Figure 3. Trends in average length in two SMU, when standardised quarterly at Back Beaches, and when a possibly malfunctioning board is removed from the data set at Otways.

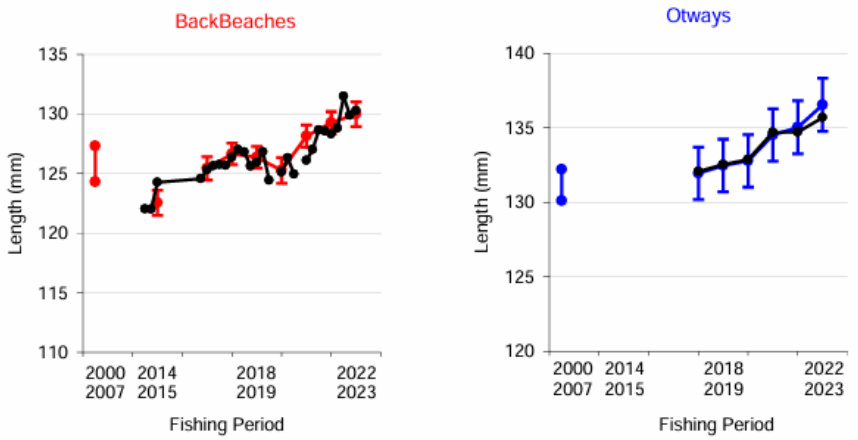


Figure 4. Trends in the raw average length of abalone landed for each SMU since 2014, with error bars showing SE (i.e. SD among means). The range of annual raw average length from the earlier 2000-2007 dataset are also shown for individuals above the size limits in 2019-20 (i.e. before the most recent LML increases).

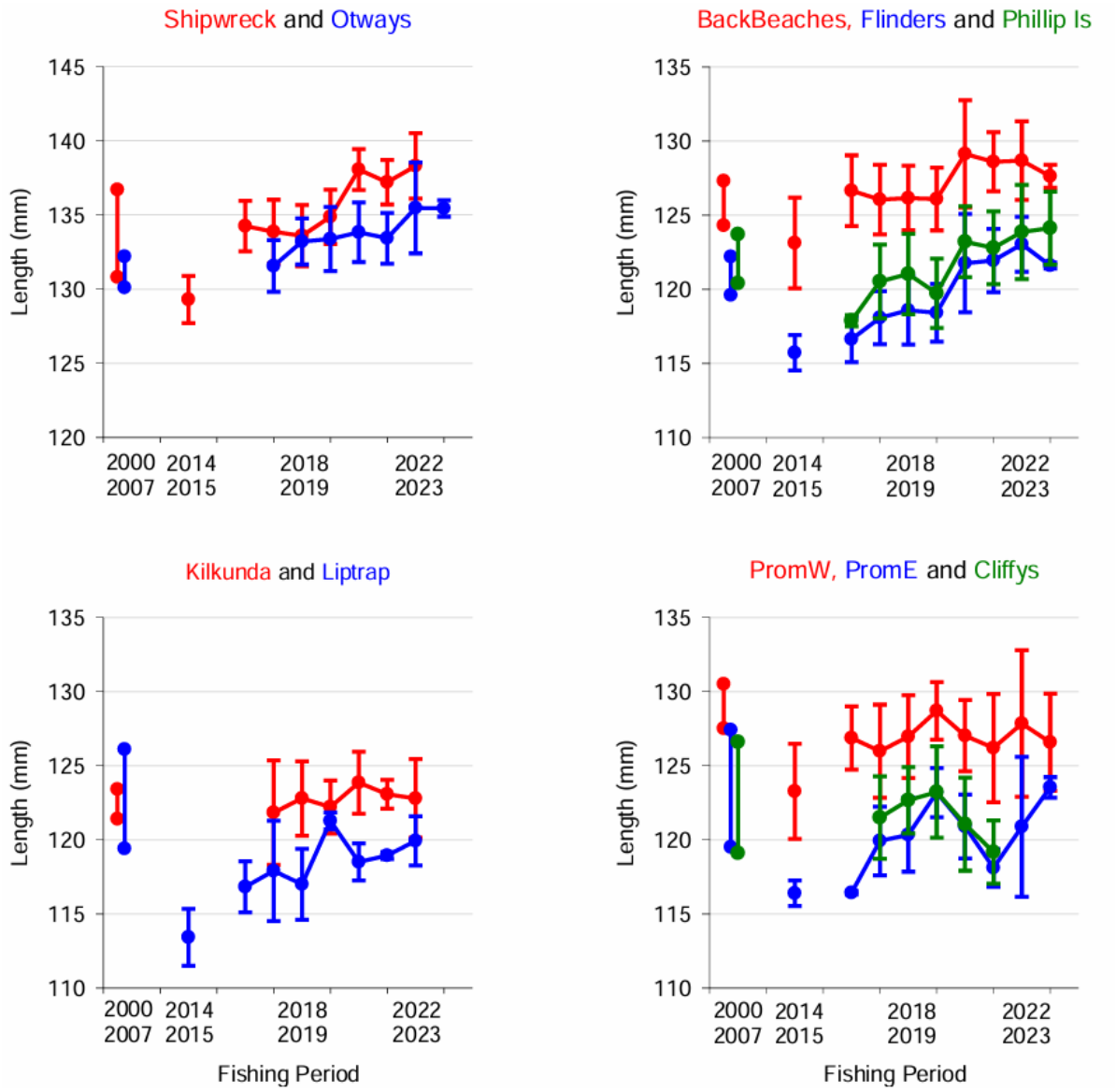


Table 1. Total number of abalone measured within each SMU and Fishing Period from 2014 until December 2023. Note, this includes filtering the data to abalone.

	SMU										
Fishing Period	**Shipwreck**	**Otways**	**Back Beaches**	**Flinders**	**Phillip Is**	**Kilkunda**	**Liptrap**	**PromW**	**PromE**	**Cliffys**	**Total**
2014-15	1553		10739	10026			2435	3449	4026		32228
2016-17	5825		17708	4510	1270		13477	3850	2383		49023
2017-18	16830	58261	37134	7670	44029	9574	20384	29315	12793	7426	243416
2018-19	5847	25675	40104	18362	28946	14583	12891	20564	20701	12364	200037
2019-20	14773	58555	13217	12214	29807	7108	2755	11702	3018	3371	156520
2020-21	14334	59903	35280	18068	49858	23228	24927	41488	10965	2179	280230
2021-22	9545	21735	35634	12650	27101	3380	629	15609	3887	2041	132211
2022-23	3113	9636	17824	8753	23856	12337	5721	18046	1663		100949
2023-24		1086	5887	1304	14891			6846	301		30315
Total	**71820**	**234851**	**213527**	**93557**	**219758**	**70210**	**83219**	**150869**	**59737**	**27381**	**1224929**

Appendix 5: Summary of LML changes

Table 28: Summary of changes in LML for the Central Zone. All measurements are in millimetres. Multiple LMLs indicate different LMLs for reefcodes within an SMU.

Date from	Shipwreck Coast	Cape Otway	Surf Coast	PPB	Back Beaches	Flinders	Phillip Island	Kilcunda	Cape Liptrap	Prom Westside	Prom Eastside	Cliffy Group
1 Apr 1998	120	120	110 & 120	100	110	110	110	110	110	110	110	110
1 Feb 2007	123	123	115 & 123	100	115	115	115	115	115	115	115	115
5 Mar 2009	123	123	115 & 123	105	120	115	113 & 115	113 & 115	105	115	115	115
1 Apr 2010	123	123	115 & 123	105	120	115	113 & 115	110 & 115	105 & 110	115 & 120	115	115
1 Apr 2012	123	123	110 & 123	105	120	115	113 & 115	110 & 115	105 & 110	115 & 120	115	110
1 Apr 2014	123	123	110 & 123	105	117	110	110	110 & 115	105 & 110	115 & 120	110	110
1 Apr 2016	123	123	110 & 123	105	117	110	110	110 & 115	105 & 110	115 & 120	110	110
1 Apr 2017	125	123	110 & 123	105	117	110	110	110 & 115	105 & 110	115 & 120	110	110
1 Apr 2018	125	123	110 & 123	105	117	110	110	110 & 115	105 & 110	115 & 120	110	110
1 Apr 2019	125	123	110 & 123	105	117	110	110	110 & 115	105 & 110	120	110	110
1 Apr 2020	130	125	110 & 123	105	119	112	112	115	110	115 & 120	110	110
1 July 2021	130	125	110	105	119	114	112	110 & 115	110	115 & 120	110	110