Assessment of abalone stocks in Western Zone Victoria

Submission to the TAC setting process for 2024-25

Western Abalone Divers Association

March, 2024

ISBN 978-0-9870470-7-6 (revise when allocated)

Assessment of abalone stocks in Western Zone, Victoria: Submission to the TAC setting process for 2024-25

March 2024 (this document printed to pdf on April 4, 2025)

Contact Details

Name: Travis Baulch and Dr Duncan Worthington

Phone: 0488 285 891 and 0431 755 497

Email: travis@wada.com.au

Table of Contents

Background

This report provides an assessment of abalone stocks for the Western Zone (WZ) of the Victorian Abalone Fishery. The report attempts to provide an easily understood summary of the fishery and its performance, by reporting on the Primary and Secondary Performance Indicators and Reference Points of the fishery's Harvest Strategy, for use at the March 2024 TAC Workshop. This report should be read in conjunction with the fishery's Harvest Strategy and Management Plan, referring to Objectives and interpretations, previous Assessment reports and separate documents describing Technical Methods and Reefcode Reports.

Since AVG was confirmed in 2006, the Western Abalone Divers Association (WADA) and Victorian Fisheries Authority (VFA) have worked together to encourage conservative management and demonstrate rebuilding in the WZ Abalone Fishery. A 5-year Harvest Strategy was developed to continue recovery of abalone stocks in WZ from 2016-2020, through a combination of conservative catch and minimum size limits, spatial management of fishing and catch, and a combination of fishery-independent and fishery-dependent data collection to demonstrate ongoing recovery and guide future TAC setting. In early 2021, there was considerable optimism about the state of the stocks and their ongoing recovery, consistent with high fishery Performance Indicators.

On 1 May 2021, AVG was again observed impacting abalone stocks at Cape Nelson, near Portland. WADA and VFA worked together to manage the fishery with other stakeholders, while collecting information about the spread and impacts of AVG. Reefcodes near Cape Nelson, Cape Bridgewater and Lawrence Rocks were gradually closed to fishing as AVG spread and abalone stocks were impacted. WADA recommended no commercial catch from the Portland SMU in the subsequent 2 fishing periods, and has commenced development of an improved fishery-independent survey methodology for the Portland reefs. No AVG has been found in the remaining parts of the fishery where commercial fishing has continued.

Fishery Performance Indicators have remained high where commercial fishing has continued at Port Fairy, Warrnambool and Lady Julia Percy. More productive reefcodes (e.g. Crags, Killarney, Levys) have retained high fishery performance indicators and target catches, which are quickly landed following opening of the reefcode, allowing strong recovery from fishing before the following season. Despite that, some other areas (e.g. Lighthouse) have been less productive in recent years with declining performance indicators and target catch, which is reached later in the fishing period. Ongoing catch planning has already tailored catch targets to differences among reefcodes in fishery indicators and broad productivity, with greater precaution and more conservative catch targets in some reefcodes to encourage further recovery of stock. Maintaining recovery in productive reefcodes, and increasing recovery elsewhere, remains a key challenge for the fishery.

WADA and VFA have also worked together to commence review and revision of the fishery Harvest Strategy and Monitoring program, by extending and improving on the existing 2016-2020 Harvest Strategy, with the intent to implement a new Harvest Strategy as soon as possible. Perhaps most importantly, this includes the establishment of a new fishery-independent abalone abundance survey throughout WZ, and an approach to continue the intent of the previous 2016-2020 Harvest Strategy while the new survey and strategy was developed and implemented. A review of the FIS has suggested sites have not been broadly representative of fished areas, in the WZ and throughout much of Victoria, and particularly by avoiding shallow and more productive areas, may provide a

negatively-biased assessment of the broader abalone population (i.e. old sites measured greater decline in less productive areas, and similarly measured reduced recovery). The existing FIS has not been repeated since 2020, but new sites and sampling of previous sites have been established. The FIS review has recommended further development of the survey approach already commenced in WZ, to establish a more consistent and representative approach to the survey of abalone abundance in Victoria, and this is being progressed across all 3 fishing zones.

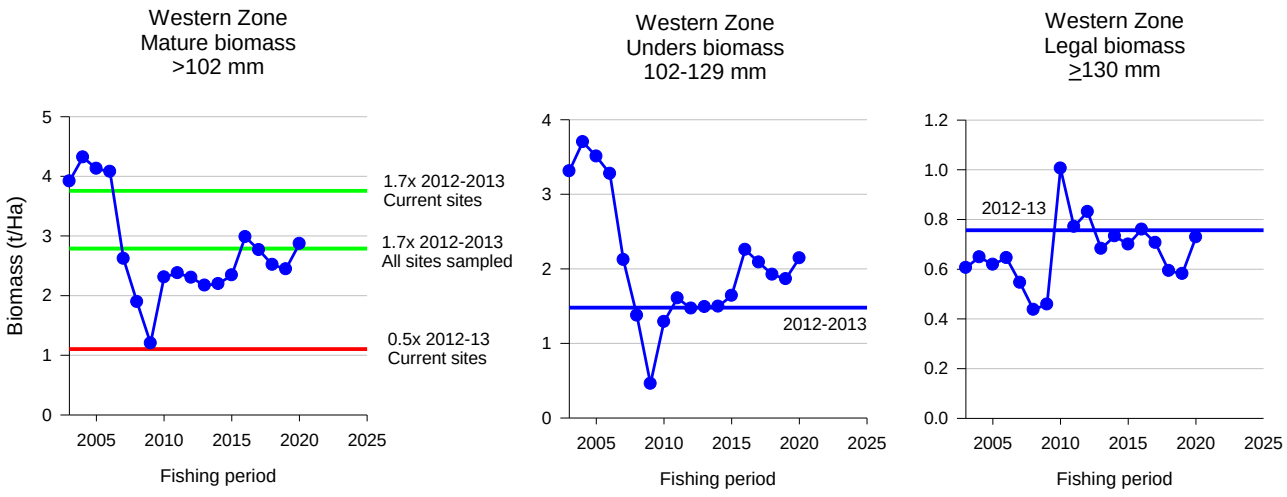
This assessment will again continue the approach of the 2016-2020 Harvest Strategy, as modified in the WADA Strategic Plan for Stock Assessment and Harvest Strategy development in the WZ Abalone Fishery, agreed with VFA. This approach will use the information and biomass estimates derived from the VFA fishery-independent abundance survey in 2020 at the scale of SMU, together with the extensive data available from fishery-dependent monitoring up to at least December 2023, at the scale of SMU and Reefcodes. Perhaps most importantly, evidence from the commercial fishery suggests the legal-sized biomass (i.e. as used in the Harvest Strategy) has at least been maintained, if not increased, since the last abundance survey in early 2020, providing some justification for the continued use of the 2020 estimate. The fishery Performance Indicators will be interpreted in the framework of the 2016-2020 Harvest Strategy at the scale of each SMU, except Portland where AVG impacts have occurred. Reefcode-scale reports are also provided for interpretation of Harvest Strategy Secondary Indicators at the TAC Workshop.

Primary Performance Indicators and Reference Points from the 2016-2020 Harvest Strategy are based only on the abundance survey. These include estimates of the Legal and Mature biomass, and the number of Prerecruit abalone, with the WZ-scale indicators used to assess overall status of the stock (i.e. consistent with the operational objectives and reference points in the Harvest Strategy), while the SMU indicators are used in guidance for TAC setting. Secondary Indicators include Commercial catch, catch rate and the lengths of abalone landed. This report presents the Primary Indicators compared to their Target and Limit Reference Points at the scale of WZ (i.e. and SMU to help interpretation), and then presents Primary and Secondary Indicators for each SMU.

Fishery Performance Indicators are calculated from several main data sources. Catch and catch rate are calculated from commercial logbook data that is released by VFA to WADA (i.e. real-time API with privacy release from divers), while sizes of abalone landed are from GPS loggers operated by WADA, and both include data until December 2023. Average length of abalone landed through GPS-enabled loggers are shown as raw (i.e. above the minimum size limit used at the time) and standardised for abalone $\geq$135 mm (i.e. to allow comparison with years where a 135 mm size limit was used in the fishery), and the proportion of abalone <135 mm in the Reefcode Reports (i.e. to help identify effects of recruitment to the fishery from Under-size abalone, by comparing change in the frequency and size of smaller and larger abalone). Raw, annual abundance survey data for Prerecruits (80-119 mm) and Recruits ($\geq$120 mm) from 2003 to 2020 are also released by VFA to WADA, and combined with length-frequency data to estimate biomass of Legal ($\geq$130 mm), Mature ($\geq$102 mm) and Under-sized (102-129 mm) abalone, and calculate standardised estimates of abundance. The recent review of the FIS suggested the sites sampled are not broadly representative of fished areas, and particularly by avoiding shallow and more productive areas, may provide a negatively-biased assessment of the broader abalone population in WZ (i.e. old sites measured greater decline in less productive areas, and similarly measured reduced recovery).

Despite the challenges of the past abundance survey, estimates of biomass from the survey sites across WZ demonstrate recovery of abalone stocks since the impacts of AVG in 2005 (Figure 1) and are associated with recovery of the fishery (e.g. Figure 2-6). Recovery of Mature biomass was encouraged (Figure 1 left) by leaving areas of the fishery closed for 3-5 years following AVG impacts, and restarting fishing with guidance from extensive additional abundance survey information and a larger minimum size limit of 130-135 mm. Conservative catch guided by structured fishing and independent survey information, followed by planned spatial management of catch among and within Reefcodes, contributed to estimates of the Legal biomass (≥130 mm) being maintained at or above that prior to AVG (Figure 1 right), while waiting for the recovery of Mature biomass (Figure 1 left) to again supply greater numbers of juvenile abalone and Under-size abalone biomass (Figure 1 middle) and their growth in to the fishery. Previous assessments noted the similarity of observed recovery of abalone in WZ and some predictions made by CSIRO modelling in 2014. This includes the observed decade-long recovery of Mature abalone, and then particularly from 2016, further recovery in Under-size abalone, while the fishery was managed to maintain the Legal-sized biomass. The CSIRO model estimates full recovery may take more than 20 years.

Figure 1. Estimates of the biomass of Mature (left), Under-size (center) and Legal (right) abalone in WZ from VFA abundance surveys from 2003 to 2020. Horizontal lines show Target and Limit Reference Points for Mature biomass, and average 2012-13 biomass for Under-size and Legal. Note, a recent review found survey sites were not likely to be representative of fished areas.



The 2016-20 Harvest Strategy provides a framework for guidance about future Total Allowable Commercial Catch (TACC) based on change in estimates of the total Legal biomass of abalone within each SMU, and an agreed range of Harvest Fractions (see Table 1). This approach was developed in the Western Zone fishery from 2009, as fishing restarted following AVG, and has been applied each year and interpreted during the TAC Workshops. Estimates of Legal biomass are calculated from

abundance surveys (i.e. both VFA and WADA fishery-independent abundance surveys have been used), and GPS logger and alternative approaches have also been developed to provide supplementary information. In this report, estimates of total Legal biomass are calculated only from density at the VFA abundance survey at sites during 2020 (i.e. with history for only those sites sampled in 2020), which are then extrapolated to estimates of historically-productive areas of reef, and various Harvest Fractions are applied to estimate catch. More detailed comparisons of sensitivity of biomass estimates to key uncertainties and alternative calculations can be found in previous year's assessments.

The 2016-20 Harvest Strategy also describes a Reefcode and local-scale assessment process completed with divers at the annual TAC Workshop, to provide interpretation and guidance in addition to Primary and Secondary Indicators. Observations by commercial divers, and their interpretation of available data, assessment of stock and habitat conditions, and appropriate future catch, are an important part of the Harvest Strategy and considered in detail at the TAC Workshop. A summary of those observations and comments will be provided in the Workshop Minutes.

Ongoing development of the new Harvest Strategy, to extend the 2016-2020 Harvest Strategy, will include several strategic directions. Fishery-independent surveys of abalone populations will remain an important component of the new Harvest Strategy. WADA is developing a fishery-independent survey design involving commercial divers and focusing on productive abalone populations, to provide greater information about recent impacts of AVG together with ongoing changes in stocks for management of the fishery. The survey design developed by WADA responds directly to many of the recommendations made by the Hart Independent Review of abalone surveys in Victoria, and the joint Abalone Council of Victoria (ACV) and VFA review of the previous survey, which has now recommended the WZ-approach be extended throughout Victoria. In particular, the sampling frame for additional survey sites will be more focused on shallow reef habitats with abundant abalone populations, and where most commercial fishing is concentrated, to maximise understanding of currently productive populations and the recent impacts of fishing. Existing historic WADA and VFA survey sites will also be sampled when appropriate to provide additional information, such as about currently less productive areas (e.g. deeper sites, or AVG impacted), that may recover and become more productive again in the future.

The 2016-20 Harvest Strategy, and several independent reviews, also encouraged development and use of additional data sources in TAC setting, including particularly information from GPS-enabled loggers and related data (e.g. boat location, dive extent, abalone length, video, diver observation survey) collected while fishing. WADA has developed the use of GPS-enabled loggers for several years, and the current Succorfish loggers are enabled as part of the VFA legislated requirements for Vessel Monitoring Systems (VMS). More detailed data from all WADA loggers also go directly to an Abalone Council Victoria cloud site, where the data are stored, analysed and can be presented in online dashboards, allowing the extension of near real-time reporting to divers and other stakeholders as part of an ongoing Stock Assessment process through the fishing year. This allows greater assessment and decision making by Industry and VFA through the year, and its further development will also enable greater automation and improve annual assessments.

Assessment of Primary Indicators relative to Reference Points

During development of the new Harvest Strategy, the 2016-2020 Harvest Strategy framework will continue to be applied using the 2020 VFA abundance survey data (i.e. most recent available). The 2016-2020 Harvest Strategy has a Target Reference Point for planned recovery, and two Limit Reference Points that relate to rules for breakout and review of the Harvest Strategy. These reference points were developed from CSIRO modelling of the WZ abalone population and likely recovery scenarios, and assessment of data against these reference points are based only on abundance survey data from 2020 at the scale of the WZ fishery. The Target Reference Point refers to the target for Mature biomass in the fishery by 2020, and is measured relative to the Mature biomass in 2012-13. The Target Reference Point is a Mature biomass in 2020 that is 1.7x or 70% higher than that in 2012-13. One of the Limit Reference Points is also related to a Mature biomass of 0.5x or 50% lower than that in 2012-13. A further Limit Reference Point is related to estimates of the number of Prerecruit abalone in the abundance surveys (80-119 mm, and averaged over two years), and is measured relative to 0.44x or 44% of Prerecruits in 2003-06 prior to AVG.

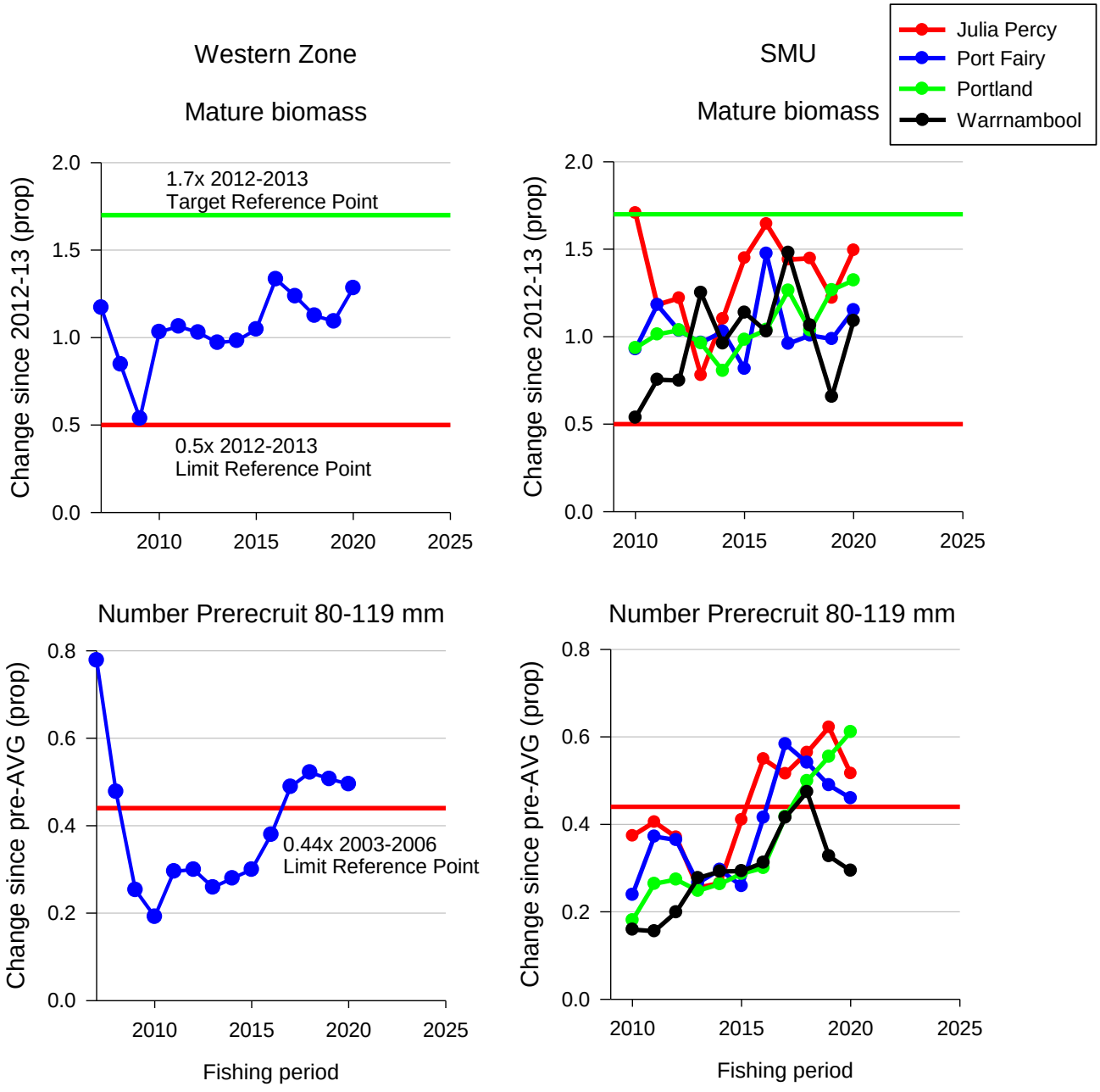
The change in design (i.e. from 2017) of the VFA abundance survey has implications for the Reference Points and interpretation of the data in the 2016-2020 Harvest Strategy framework. The Harvest Strategy Reference Points refer to estimates of density at survey sites during specific time periods (i.e. Mature Biomass 2012-13, and Prerecruit 2003-06), and were derived during development of the Harvest Strategy using all sites sampled at the time. The VFA abundance survey was revised in 2017 and dropped sites using three criteria, and that were lower in abalone density than those that were retained. Calculation of Reference Points and Indicators using current (i.e. higher density) sites only, rather than all site sampled at the time, increased the Reference Points and Indicators above that identified in the Harvest Strategy. Here, we present the Mature biomass Performance Indicator for 2020 from the sites currently surveyed relative to the Reference Points calculated from just the current sites surveyed (i.e. not all sites surveyed as described in the Harvest Strategy, Figure 2 left top), and note the comment in the Harvest Strategy on the need for consideration of any changes in survey design on application of the Reference Points. Both the original survey design, and the design maintaining some sites after 2017, will be considered during calibration of the old survey with the new survey design and Harvest Strategy being developed.

The Target Reference Point, and one of the Limit Reference Points, relate to estimates of Mature Biomass from the abundance surveys. Estimates of Mature biomass reached their lowest point in 2009 at about 50% of the 2012-13 biomass (Figure 2 top left), and then increased to 2012-13 and a density of 2.2 t per Ha. Estimates of Mature biomass then peaked in 2016, at 3.0 t per Ha or 33% above 2012-13, before declining to 8% above 2012-13 in 2019, and increasing again in 2020 to 2.9 t per Ha or 28% above the 2012-13 estimate. Estimates of Mature biomass have remained above the Harvest Strategy Limit Reference Point of 50% of the biomass in 2012-13, and below the Target Reference Point of 1.7x the biomass in 2012-13, and do not appear likely to reach either Reference Point in the near term following the last 2020 survey.

Estimates of Mature biomass are also available for each SMU (e.g. Figure 2 top right). While each SMU has shown considerable variation among-years in estimates of the density of Mature biomass, all SMU have remained within the Limit and Target Reference Points, and most have approached the Target Reference Point in some individual recent years. Mature biomass at Warrnambool,

estimated from the VFA surveys, dropped by more than 50% in 2019 over two years since a peak in 2017, but increased more than 50% in 2020 and is again more similar to the other SMU. The zone-wide increase in Mature biomass in 2020 (Figure 2 top left) included increases in both Unders (102-129 mm) and Legal biomass (e.g. Figure 6), but not Prerecruits (80-119 mm, Figure 2 bottom right).

Figure 2. Estimates of Mature biomass and number of Prerecruit abalone for Western Zone and each SMU, relative to Target (green line) and Limit (red line) Reference Points from the Harvest Strategy. Mature biomass is shown as proportional change since 2012-13, and number of Prerecruits since 2003-06. For Mature biomass all estimates are set to 1 in 2012-13, and show each year as a proportion of 2012-13, while for Prerecruits, all lines are set to 1 for the average of 2003-06, and are averaged across 2 years.



The second Limit Reference Point refers to the number of Prerecruit (80-119 mm) abalone in the abundance surveys, and is measured relative to the Prerecruits in 2003-06 prior to AVG. The Limit Reference Point is 0.44x or 44% of the Prerecruits estimated in 2003-06, is calculated from a 2-year average (e.g. 2019 is average of 2017-18 and 2018-19), and is only assessed from 2018 to 2020. Estimates of Prerecruits at the scale of the WZ reached their lowest point in 2010 at about 18% of the 2003-06 numbers, increased to a peak in 2018 at about 52% of 2003-06, and remained at 50% of 2003-06 numbers in 2020 (Figure 2 left bottom). This represents an average of about 18 Prerecruit (80-119 mm) abalone per transect, or about 2500 Prerecruit abalone at the 23 sites in WZ (e.g. 2398 Prerecruit abalone were actually counted in the 2020 survey). The review of the FIS has suggested sites are not broadly representative of fished areas, and particularly by avoiding shallow and more productive areas, may provide a negatively-biased assessment of the broader abalone population in WZ (i.e. old sites measured greater decline in less productive areas, and similarly measured reduced recovery).

Estimates of Prerecruits are also available for each SMU (e.g. Figure 2 bottom right). While each SMU has shown considerable among-year variation in estimates of Prerecruits (i.e. noting estimates presented are an average of two years), there has also been a general increasing trend in each SMU, despite declines in recent years at Warrnambool and Port Fairy. In 2018, all SMU were above the Limit Reference Point, but in 2019 and 2020, a decline in Prerecruits at Warrnambool to about 30% of the 2003-06 levels, dropped estimates below the Limit Reference Point. Survey estimates of at Warrnambool represent an average of about 9 Prerecruit abalone per transect or about 270 Prerecruit abalone at 5 sites (e.g. 289 Prerecruit abalone were counted in the 2020 survey). As noted in the Harvest Strategy, such variation among years in the number of Prerecruit abalone is also likely to be influenced by annual variation in year-class strength, but if survey estimates of abundance are representative (i.e. noting the FIS review has suggested they are not), ongoing recovery in Warrnambool is likely to need a greater abundance of Prerecruit (80-119 mm) abalone.

The 2016-2020 Harvest Strategy also details an approach to determine the status of the WZ fishery and stock, relevant to the assessment for the Status of Australian Fish Stocks (SAFS). The fishery and stock are determined to be Sustainable when the Mature biomass is above the Limit Reference Point from the Harvest Strategy, and the calculated Harvest Fraction of the Legal biomass is below 15%. Estimates of the Mature biomass in 2020 are well above the Limit Reference Point, and Harvest Fractions estimated at the 2023 TAC Workshop ranged among SMU from 8.4% to 11.8%, and have been relatively stable for several years. Further, fishery-dependent indicators (e.g. catch rates) suggest legal biomass (i.e. which is a substantial component of mature biomass) at the scale of WZ has increased since early 2020. As a consequence, the approach described in the Harvest Strategy determines the WZ fishery and stock of blacklip abalone as **Sustainable**. This is consistent with the independent assessment summarised in the 2020 SAFS assessment, where the fishery was also determined to be Sustainable using the same criteria. It is also important to note the more recent impacts from AVG in the Portland SMU, and that greater fishery-independent information becoming available as more WADA survey sites are sampled.

Summary of Primary and Secondary Indicators

Portland

Fishing restarted at Portland in 2012 and increased from 9 t with Structured Fishing (i.e. fine scale planned allocation of catch), to 28-32 t from 2014, with 16.2 t caught of a 30 t target in 2021-22 (Figure 3). The remaining 13.8 t of allocated catch was unable to be landed at Portland because of Reefcode closure, and was allowed to be landed with a specific limit from Reefcodes in other SMU. For several years, catch at Portland was concentrated in a few key Reefcodes including Watersprings, Blowholes, South Bridgewater, Jones Bay and Outside Nelson. Raw and standardised catch rates gradually increased from about 60 kg/h in 2012 to over 80 kg/h in 2016, and about 90-100 kg/h in 2021 (Figure 3). Following detection of AVG in February 2021, Reefcodes with observed infection were gradually closed to fishing, limiting catch in the SMU.

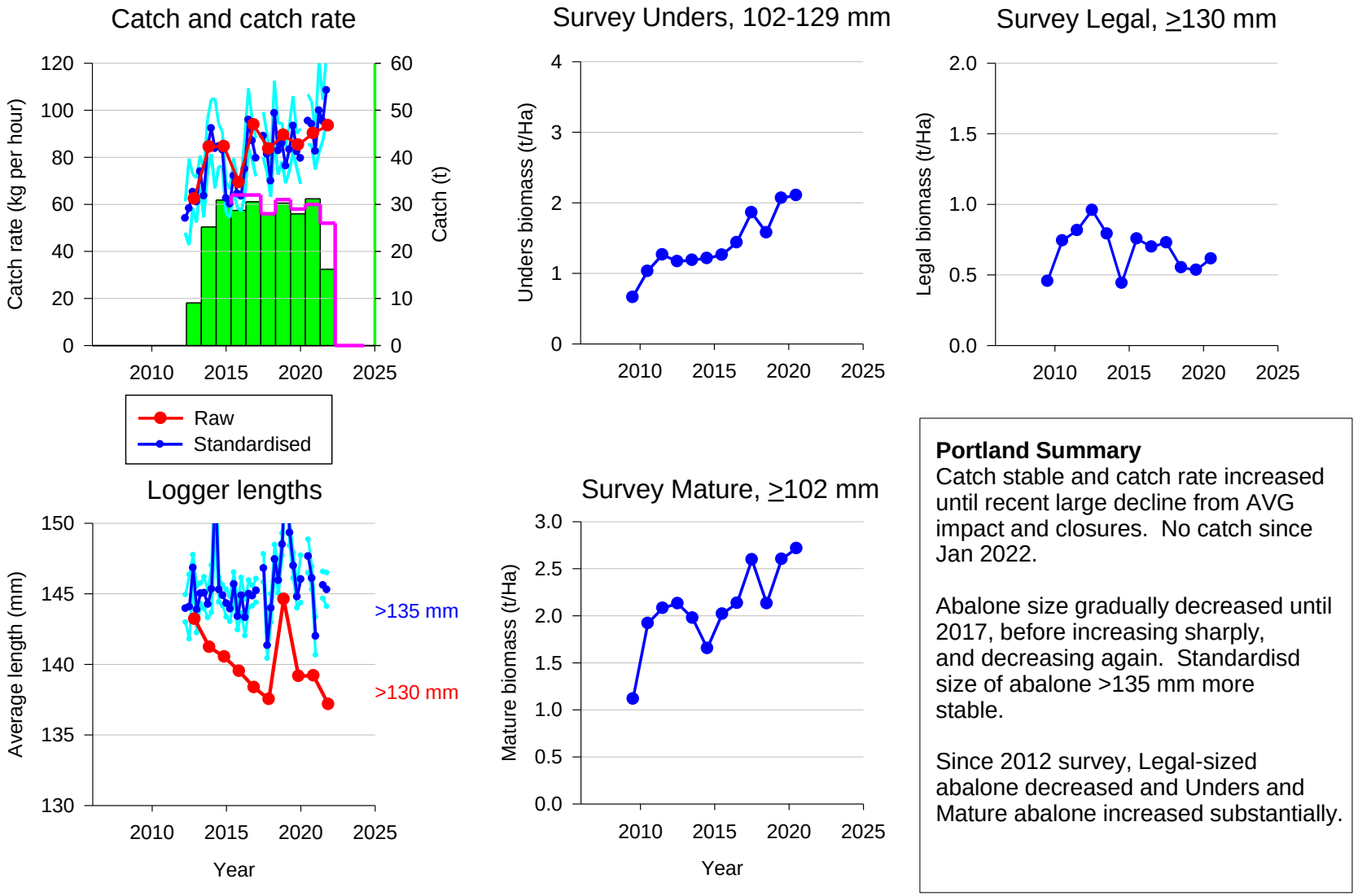
The average length of abalone landed decreased from 143.2 mm after the recommencement of fishing in 2012-13 (i.e. 135 mm size limit), reaching a low of 137.5 mm in 2016-17 (i.e. 130 mm size limit), before increasing sharply and declining again to 137.2 mm in 2021-22. In contrast, the standardised length of abalone $\geq$135 mm, has been more stable and with abalone $\geq$135 mm in recent years sometimes higher than 2012-13.

Abundance survey sites were mostly in deeper water, with some adjacent to productive shallow water populations, but were not representative of fished populations (i.e. few VMS points over FIS sites). New abundance survey sites have been placed in several reefcodes, particularly around Cape Bridgewater, following the spread of AVG, and one site (i.e. Devils Kitchen) was able to be established and resampled prior to and after AVG impacts.

At the April 2022 TAC Workshop, observations of the impact of AVG were discussed, and included heavy mortality in some areas, while other areas had much lower impacts. WADA and the Workshop recommended closure of the Portland SMU with no catch (i.e. removal from the current Harvest Strategy approach). This recommendation of no catch was repeated at the 2023 TAC Workshop, together with need to collect greater information about the decline and recovery of stocks to advise future management of the area. Further impacts of AVG on a population still recovering from previous AVG impacts, suggest the population is heavily depleted. Subsequent observations by several commercial divers have confirmed AVG appears not to be active for some time, but impacts still include heavy depletion in some areas, while other areas have much lower impacts, leaving patchy remaining stocks of abalone that are recovering strongly in some areas.

WADA is developing a plan for collection of data from abalone stocks at Portland (i.e. including the new fishery-independent abundance survey sites already installed), to provide a basis for an assessment of stocks, and reconsidering management of fishing at Portland.

Figure 3. Fishery performance indicators for the Portland SMU. Actual catch is shown to December 2023 (green bar, and average catch per day above) with full year Targets (pink line and light grey bar), raw (red) and standardised (blue ±SE) catch rate and length of abalone logged (i.e. Raw ≥130 mm and Standardised ≥135 mm). Abundance survey figures show estimates of biomass of Unders, Mature and Legal-sized abalone at sites currently surveyed.



Portland Summary
Catch stable and catch rate increased until recent large decline from AVG impact and closures. No catch since Jan 2022.

Abalone size gradually decreased until 2017, before increasing sharply, and decreasing again. Standardisd size of abalone >135 mm more stable.

Since 2012 survey, Legal-sized abalone decreased and Unders and Mature abalone increased substantially.

Lady Julia Percy (LJP)

Catch at LJP was around 13-21 t from 2006-11, declined to 3.7 t all from Prop Bay in 2012, and was closed to fishing in 2013 to encourage recovery (Figure 4). Catch then increased from 2.3 t in 2014 to 4.8 t in 2018, and a catch target of 7.5 t in 2020-21 with only 5.8 t caught. The catch target was reduced to 5.1 t for 2021-22, but a total of 5.7 t was caught (i.e. some allocated catch not landed at Portland was allocated to Prop Bay), and the target was reduced to 4.8 t for 2022-23. Catch has been concentrated in Prop Bay, with about 70% of the island catch in most years, and the target at Prop Bay reduced from 4.9 t (i.e. 2.9 t caught 2020-21) to 3 t (i.e. 3.8 t caught in 2021-22).

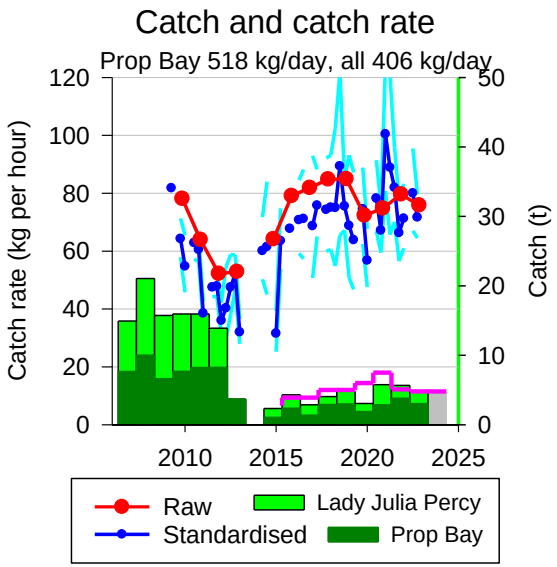
Raw and standardised catch rates declined to about 50-60 kg/h before closure in 2013, but following reduced catch, increased to above 80 kg/h on the higher 130 mm size limit from 2015, before declining in 2019-20, and recovering above 80 kg/h again in the subsequent years (Figure 4).

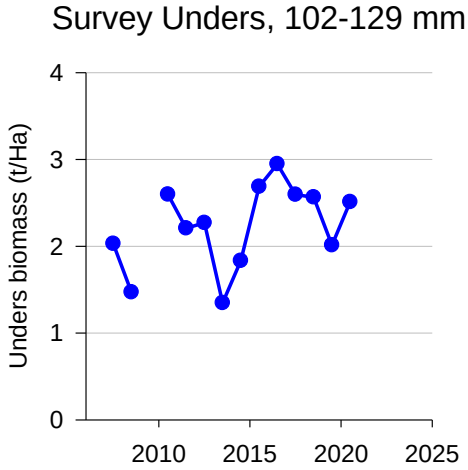
Both the raw and standardised length of abalone increased from 2009-2012 to 2014, following closure and reduced catch. In recent years, both raw and standardised length of abalone have been higher but variable among years (Figure 4). Increases in length have occurred mostly at Prop Bay, although smaller increases also occurred at reefcodes on the northside, and the larger increases appear to represent some divers moving away from the core areas fished by most divers in previous years, and by fishing to market preferred sizes.

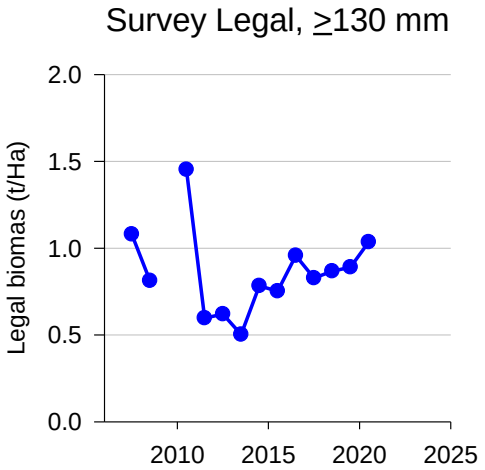
Abundance surveys included 2 sites at Prop Bay, and one on North East Reef and the East side. All sites were sampled since 2000-01, and by 2019-20 Prerecruits at 3 sites have declined (-75% average), while 1 site has increased (+380%), while Recruits have declined at 2 sites (-27% average), and increased at 2 sites (+11% average). Prerecruits (i.e. 80-119 mm) and the biomass of Unders (i.e. 102-129 mm) decreased to a long-term low in 2013 at about 1348 kg/Ha, before increasing to a peak in 2016, and remaining high in 2020 at 2510 kg/Ha (Figure 4). Legal biomass peaked in 2010 and declined to 503 kg/Ha in 2013, before gradually increasing to 1035 kg/Ha in 2020. Biomass of Mature ($\geq$ 102 mm) abalone is less dominated by individuals under the Legal-size (i.e. about 70% below v 30% above 130 mm), and reached a bottom in 2013 before recovering to 3000-4000 kg/Ha. While both Prerecruits and Recruits declined to 2013, Prerecruits have only partially recovered since then, while Recruit numbers appear more consistent with relatively stable numbers since all Current sites were surveyed in 2000. Further, for the one site sampled before 2000 since 1992 (i.e. JPE), Prerecruits in 2020 were 50% of 1992, while Recruits in 2020 were 200% of 1992.

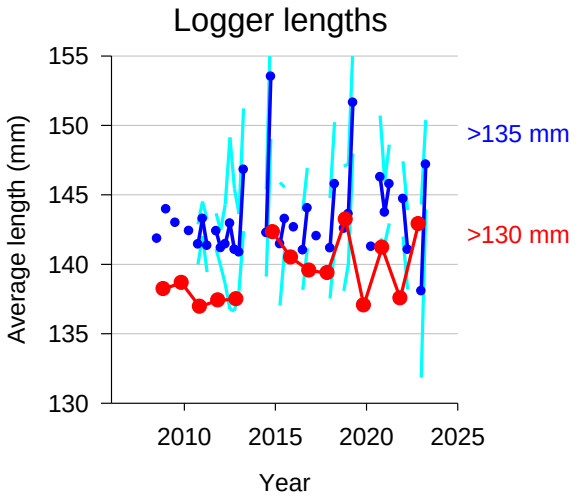
Total Legal biomass is estimated from the density of Legal abalone on survey sites, which is extrapolated to the area of historically-productive reef (Table 1). The area of historically-productive reef at LJP was estimated at 59 Ha from GPS logger data during the period of higher catch prior to 2013. More recent estimates of the active area of reef fished at LJP are lower with the lower catch (Table 1). The best estimate of total Legal biomass in the LJP SMU during 2020 was 57 t, and the 2023-24 target catch of 4.8 t is an 8.4% Harvest Fraction (Table 1). Alternative estimates of reef area range from 41-55 Ha or 69-93% of the previously used estimate, suggesting biomass (i.e. 39-53 t) and Harvest Fraction (i.e. 9-12%).

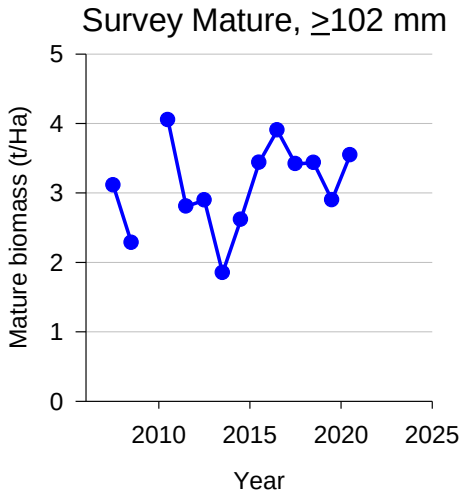
Figure 4. Fishery performance indicators for the Lady Julia Percy SMU. Actual catch is shown to December 2023 (green bar, and average catch per day above) with full year Targets (pink line and light grey bar), raw (red) and standardised (blue ±SE) catch rate and length of abalone logged (i.e. Raw ≥130 mm and Standardised ≥135 mm). Abundance survey figures show estimates of biomass of Unders, Mature and Legal-sized abalone at sites currently surveyed.











Lady Julia Percy Summary
Catch increased to 2020-21, but reduced since and well below historic.

Standardised catch rate stable at about 80 kg/h.

Standardised size of abalone >135 mm stable in recent years. Size of abalone mostly larger than historic.

Since 2013 survey, Legal-sized, Unders and Mature abalone increased.

Port Fairy

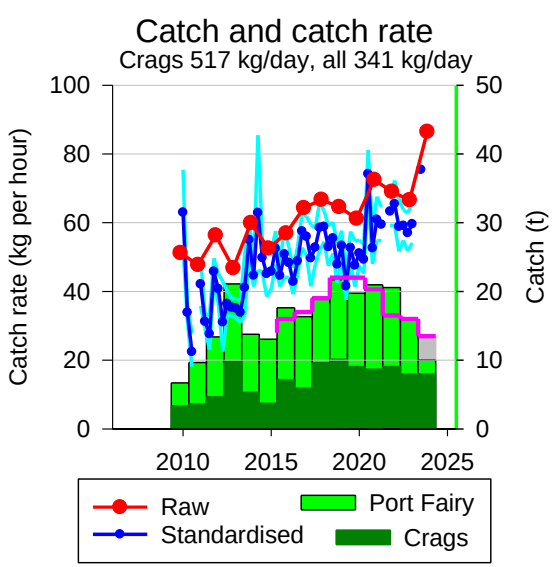
Fishing restarted at Port Fairy in late 2009, with catch of 7 t during Structured Fishing, that was increased to over 21 t in 2012, reduced to about 13-14 t for 2 years, and then increased again to over 22 t from 2018, and gradually reduced to 13.5 t in 2023-24 with 10 t caught by December 2023 (Figure 5). Catch has been stable at the Crags about 8-9 t in recent years, but has declined particularly at the Lighthouse where the target was reduced from 3.5 (i.e. with 4 t caught) to 1 t in 2023-24, and Watertower was reduced from a target of 5.9 t to 2 t in 2023-24. Catch at Crags, Burnetts and Watertower in 2021-22, included some allocated catch that was not landed at Portland.

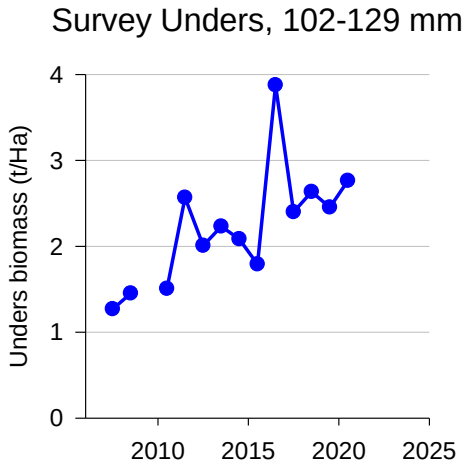
Raw and standardised catch rates have gradually increased from 40- 50 kg/h to over 60 kg/h on a 130 mm size limit, before a further increase to about 80 kg/h in 2023-24 (Figure 5). Raw catch rates are influenced by the increased proportion of catch coming from Crags, where catch rates are higher, related to the reduced catch at Lighthouse and Watertower where catch rates are lower. The average length of abalone landed decreased from 143.5 mm soon after the recommencement of fishing in 2010 (i.e. 135 mm size limit), reaching a low of 136.5 mm in 2016-17 (i.e. 130 mm size limit), before increasing sharply and declining again to 138.0 mm in 2021-22 (Figure 5). Variation in average length of abalone has been related to different divers and some fishing to market preferred sizes. In contrast, the standardised length of abalone $\geq$135 mm, has been more stable and with abalone $\geq$135 mm in some quarters of 2023-24 similar to those soon after restarting fishing.

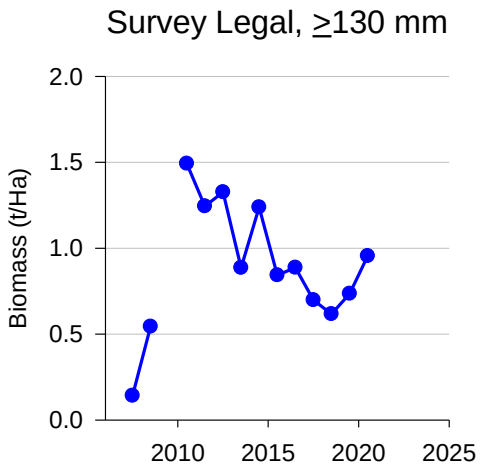
Past abundance surveys included 5 sites at the Crags, and a newer site in Watertower (although this site was added in 2014 and only had a total of 1 Recruit abalone >120 mm in 2020). Over 99% of Legal abalone surveyed were in the Crags reefcode, with all 5 sites sample since 2000-01 and by 2019-20 Prerecruits were down at 3 sites and up at 2 sites (-47% and +67% average) and Recruits down at 1 site and up at 4 sites (-54% and +50% average). Prerecruits (i.e. 80-119 mm) and the biomass of Unders (i.e. 102-129 mm) have both increased substantially since 2008-10, with the biomass of Unders increasing from 1270 kg/Ha in 2007 to 3875 kg/Ha in 2016 and declining to 2763 kg/Ha in 2020 (Figure 5). In contrast, Legal biomass increased from 142 kg/Ha in 2007 to a peak of 1492 kg/Ha in 2010, before mostly declining to 735 kg/Ha in 2019, and increasing to 955 kg/Ha in 2020. Mature biomass is dominated by individuals under the Legal-size (i.e. about 75% below v 25% above 130 mm), and like the Unders biomass, has increased substantially since 2007 from 1412 kg/Ha to 4760 kg/Ha in 2016 and 3718 kg/Ha in 2020. While Prerecruits have declined since 1992 (i.e. particularly following AVG), and recovered since their low in 2007, Recruits (i.e. >120 mm) have recovered to levels similar to before AVG.

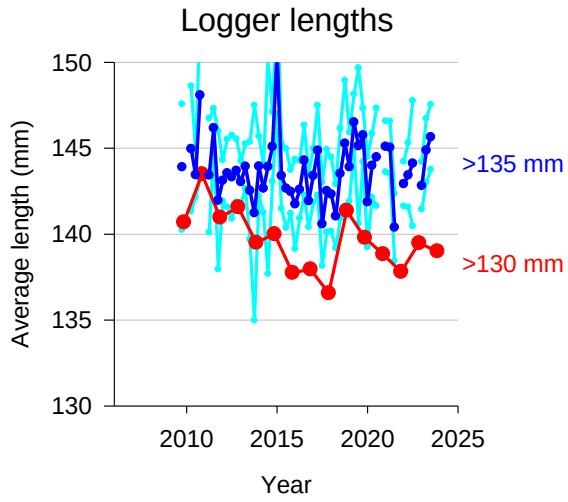
Total Legal biomass is estimated from the density of Legal abalone on survey sites, which is extrapolated to the area of historically-productive reef (Table 1). Estimates of the area of historically-productive reef was increased in the 2018 TAC Workshop from 215 Ha to 387 Ha, based on logged dive activity within a 1 Ha grid over 3 years prior to 2018 with high catch. More recent and alternative estimates of active reef area are lower (i.e. mostly 196-242 Ha, Table 1). The best estimate of total Legal biomass in the Port Fairy SMU during 2020 was 182 t (e.g. 166-204 t for 196-242 Ha), and the 2023-24 target catch of 13.5 t is a 7.4% (e.g. 6.6-8.2%) Harvest Fraction (Table 1). Estimates of density from the WADA surveys in 2009-10 were also 20% lower than the revised VFA sites in the same year (i.e. mostly at Crags), and would reduce (increase) estimates of total biomass (Harvest Fraction).

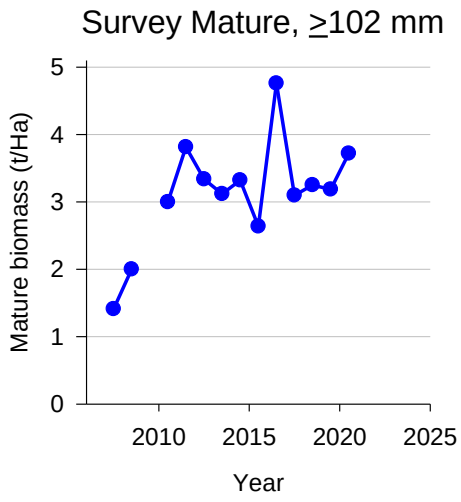
Figure 5. Fishery performance indicators for the Port Fairy SMU. Actual catch is shown to December 2023 (green bar, and average catch per day above) with full year Targets (pink line and light grey bar), raw (red) and standardised (blue ±SE) catch rate and length of abalone logged (i.e. Raw ≥130 mm and Standardised ≥135 mm). Abundance survey figures show estimates of biomass of Unders, Mature and Legal-sized abalone at sites currently surveyed.











Port Fairy Summary
Catch peaked again in 2019-20 at ~20 t, but reduced in recent years.

Catch rate increased with reduced catch and to date in 2023-24.

Standardised size of >135 mm abalone stable, andsome increase with reduced catch in recent years.

Since 2010 survey, Legal-sized abalone decreased and Unders increased, while Mature abalone are stable.

Warrnambool

Fishing restarted at Warrnambool in 2011 at 4.2 t with Structured Fishing, and increased to about 10 t during 2013-15 and then 12-13 t in recent years, with 8.0 t caught by December in 2023 (Figure 6). Catch was originally concentrated on the inshore areas at Killarney and Mills, and despite some good daily catches comparatively little was caught towards Warrnambool. This changed particularly from 2016, with less catch from Mills, and greater catch from Levys and Thunder Point. Killarney had a 3.0 t target with 6.5 t caught in 2021-22 (i.e. included some allocated catch that was not landed at Portland).

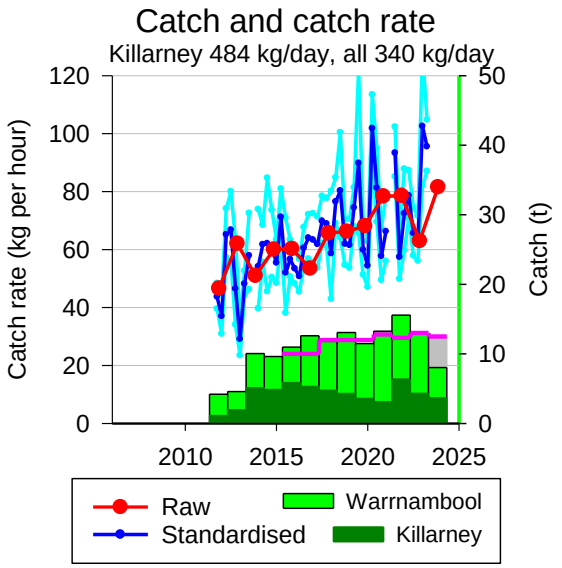
Raw catch rates gradually increased from below 60 kg/h to 65-70 kg/h from 2017-2020, and to about 80 kg/h in 2023-24, although catch rate declined in 2022-23 (Figure 6). Standardised catch rates have also increased, particularly driven by higher catch rates at Levys, but standardised catch rates have also been more variable and remained lower, particularly at Mills, the Cutting and Thunder Point.

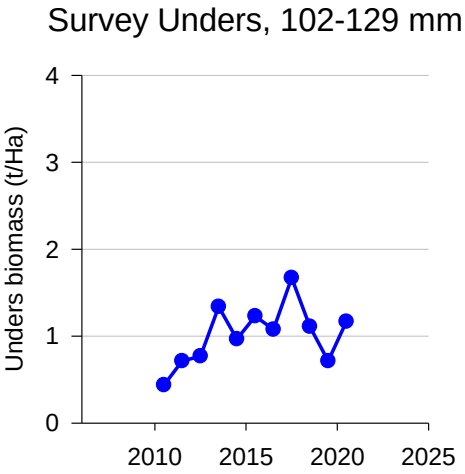
The average length of abalone landed increased from 136.1 mm after the recommencement of fishing in 2011-12, and reached a peak during 2014 at 142.1 mm, coincident with the first of larger catches at Levys, before declining to a low in 2017 of 138.1 mm, and increasing to another peak in 2019 of 143.9 mm (Figure 6). In contrast, the standardised length of abalone $\geq$135 mm has been more stable but has still increased in recent years.

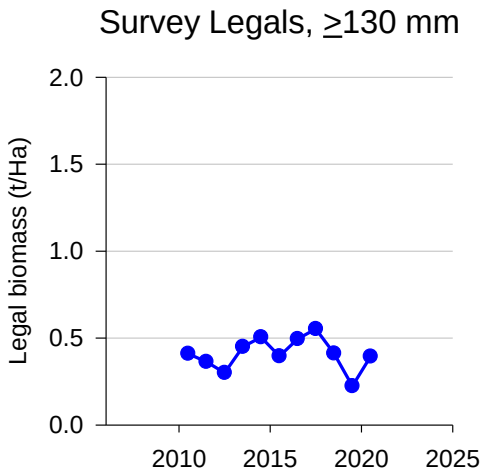
Abundance surveys included two inshore sites at Mills and Killarney, with another offshore site at Killarney (although this site only had a total of 2 Recruit abalone >120 mm in 2020), and sites at the Cutting, and offshore and distant from most fishing at Levys. With all 5 sites sample since 2000-01, both Prerecruits and Recruits were down at all sites by 2019-20 (-50% and -65% average). Prerecruits (i.e. 80-119 mm) and the biomass of Unders (i.e. 102-129 mm) increased substantially from 2010 to 2017, with the biomass of Unders increasing from 438 kg/Ha in 2010 to 1670 kg/Ha in 2017, before declining sharply to 714 kg/Ha in 2019 and recovering to 1168 kg/Ha in 2020 (Figure 6). Similarly, Legal biomass increased from 300 kg/Ha in 2012 to 553 kg/Ha in 2017, before declining to 224 kg/Ha in 2019 and recovering to 394 kg/Ha in 2020. Biomass of Mature ($\geq$ 102 mm) abalone is dominated by individuals under the Legal-size (i.e. about 75% below v 25% above 130 mm), and like the Unders, increased substantially from 881 kg/Ha in 2010 to 2100 kg/Ha in 2017, but declined to 932 kg/Ha in 2019 and recovering to 1558 kg/Ha in 2020. While Prerecruits have recovered since their low in 2010, Recruits $\geq$120 mm (i.e. mostly 120-130 mm) were near the lowest density observed at 3.7 abalone per transect in 2019, before recovering in 2020.

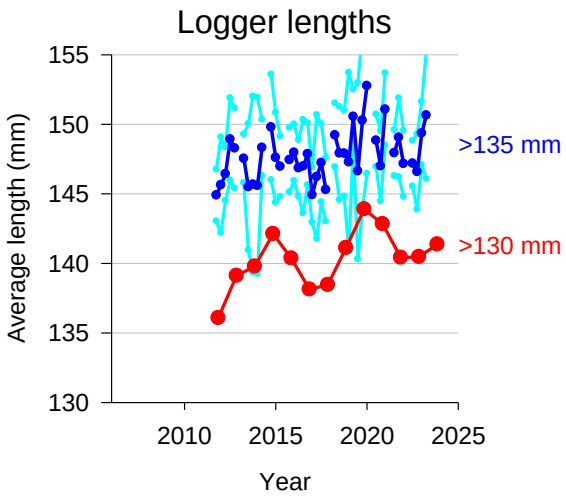
Total Legal biomass is estimated from the density of Legal abalone on survey sites, which is extrapolated to the area of historically-productive reef (Table 1). Estimates of the area of historically-productive reef (i.e. previously estimated by divers) are also consistent with recent estimates of the area of fishing activity recorded on GPS loggers (Table 1). The best estimate of total Legal biomass in the Warrnambool SMU during 2020 was 106 t, and the 2023-24 target catch of 12.5 t is a 11.8% Harvest Fraction (Table 1). Estimates of the reef area used to extrapolate biomass are above the range of alternative estimates from recent logger activity (i.e. 343 Ha with alternatives 180-255 Ha), but estimates of density from the WADA surveys in 2011-12 were 50% higher than the revised VFA sites in the same year, and in contrast would increase (reduce) estimates of total biomass (Harvest Fraction).

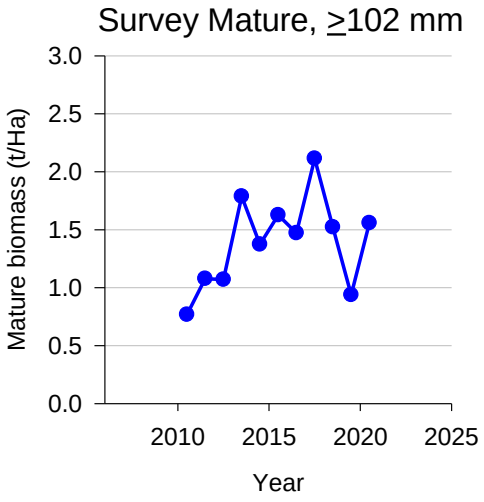
Figure 6. Fishery performance indicators for the Warrnambool SMU. Actual catch is shown to December 2023 (green bar, and average catch per day above) with full year Targets (pink line and light grey bar), raw (red) and standardised (blue ±SE) catch rate and length of abalone logged (i.e. Raw ≥130 mm and Standardised ≥135 mm). Abundance survey figures show estimates of biomass of Unders, Mature and Legal-sized abalone at sites currently surveyed.











Warrnambool Summary
Catch stable in recent years, but over target at Killarney in 2021-22.

Catch rate increased for several years.

Abalone size decreased until 2017, before increasing sharply, although reduced in last 2 years. Standardised size of abalone >135 mm has increased in recent years.

Since 2010 survey, Legal-sized abalone stable, while Unders and Mature abalone increased.

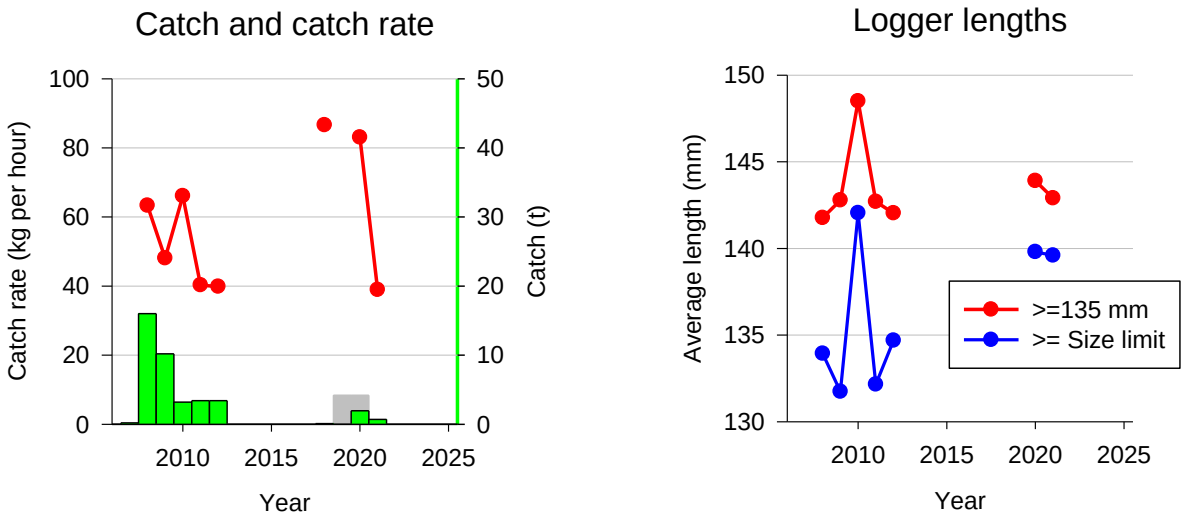
Table 1. Estimates of Legal biomass density from abundance surveys within each SMU, estimates of historically-used Reef area for extrapolation of density to Total Legal biomass, and catch targets for different Harvest Fractions and since 2014. These include estimates of total Legal biomass from the estimated density in the 2020 VFA abundance survey, extrapolated to the historically-used Reef area estimates. Reef area estimates are also shown for two alternative calculation methods (i.e. >10 and >20 min/Ha). Catch rates 2023-24 are also presented as a percent of those in 2019-20, as an indicator of change in Legal density since the last abundance survey in 2020.

	SMU		Portland	Julia Percy	Port Fairy	Warrnambool
	Reefcode		**1.02-2.10**	**3.01-3.04**	**3.05-3.08**	**3.09-3.14**
DENSITY						
2020 Legal density	t/Ha		0.575	0.963	0.845	0.309
Calibration to WADA	t/Ha		0.524	-	0.677	0.462
CPUE 2023-4/2020	%		-	-	124%	115%
AREA	Ha					
Historic Reef area			376	59	215	343
2020-2022, 3 year			-	43-59	208-266	171-231
2021-2023, 3 year			-	41-55	196-242	180-255
DENSITY x AREA						
2020 Total	t		216	57	182	106
Legal biomass						
	HF					
Catch per	5%	t	10.8	2.8	9.1	5.3
Harvest Fraction	10%	t	21.6	5.7	18.2	10.6
	15%	t	32.4	8.5	27.3	15.9
Catch Target		t				
2014			30.0	2.75	14.0	10.0
2015			32.0	3.9	16.0	10.0
2016			32.0	3.9	17.0	10.0
2017			28.0	5.0	19.0	12.0
2018			31.0	5.0	22.0	12.0
2019			29.0	6.0	22.0	12.0
2020-21			30.0	7.5	20.3	12.8
2021-22			26.0	5.1	16.5	12.3
2022-23			0	4.8	16.0	13.0
2023-24			0	4.8	13.5	12.5

Discovery Bay

In recent years, no blacklip abalone catch target has been set for Discovery Bay (i.e. no TAC allocation), but catch has been landed by permit. Previously, catch peaked in 2008 at 16.0 t (and 170 kg of greenlip), at an average daily catch of 314 kg (Figure 7). Earlier catch from 1979 to 2007 was variable, and averaged about 1.0 t per year. One days catch of 80 kg was landed in 2018, with 4 days catch of 1.96 t at ~80 kg/h in late 2020 and 5 days catch of 0.70 t at ~40 kg/h in early 2022. No catch has been reported from Discovery Bay since April 2022. Between 2008 and 2012, GPS loggers were used to measure more than 27 000 abalone on 47 diver-days, and the average length of abalone remained above 130 mm (i.e. 120-125 mm size limit, with 125 mm from 2010), peaking over 141 mm in 2010 following a shift in the spatial distribution of catch. Over 5400 abalone were measured in late 2020 and early 2022, with a wide distribution across previously fished reef, and an average length about 140 mm (Figure 7). Comparison of the length of abalone >=135 mm, suggests larger abalone are more common in recent years than 4 out of the 5 earlier years (Figure 7).

Figure 7. Catch (green, t) and catch Targets (grey), with catch rate (red, kg/h) and average length of abalone logged (red ≥135 mm and blue above the size limit at the time) in Discovery Bay.



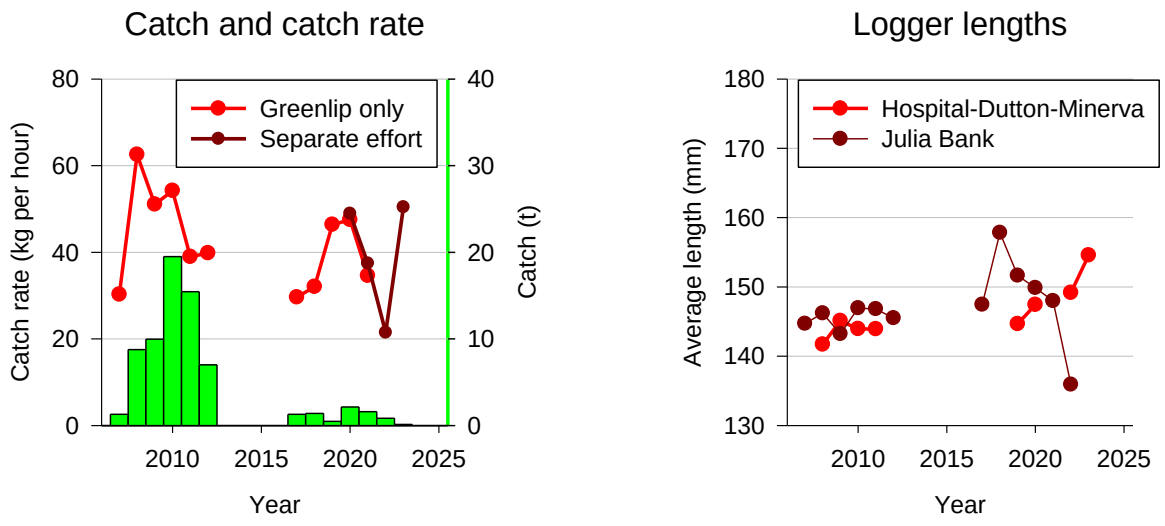
Greenlip abalone

Historical catch of greenlip in WZ has been small, with a total of 41.6 t reported landed from 1965-2005, including 37.6 t from 1969-1980 and only 850 kg from 1981-2005. The report by Prince (2008) described "Dutton Way and Hospital Reef reefcodes that were fished regularly during the 1970s, but landings fell to virtually zero during the 1980s. WADA members attribute this decline in catches to the principal abalone reefs being covered up by sand, the westward flow of which was disrupted by the construction of the deep-water port. According to the older WADA members what was left was a broader area of scattered reef that traditionally was considered to hold fairly sparse 'stunted' greenlip stocks which were of relatively little interest while the moratorium on fishing greenlip was in place and while there were better diving options around the zone." The report concluded that

with a 7 t catch from Hospital and Dutton, “and considering the conservative nature of the LML recommended and the recent history of light exploitation, will pose no risk to the long-term sustainability of the resource on these reefs.”

Catch of greenlip recommenced in 2006-07 with a 4.2 t TAC, following the mortality from AVG and reduced catch of blacklip abalone from 2005-06. With increased interest in the greenlip fishery, a research survey of a small part of Julia Bank (Gorfine, 2007), and a small permit-based research catch survey of Hospital and Dutton/Minerva reefs was completed in May 2008 (Prince, 2008). Following this research, a TAC of 7 t was implemented for the 2008-09 fishing period. During 2007-2012, a total of 32.8 t was landed from Julia Bank, mostly from inshore reefs, and 28.5 t from the adjacent Hospital-Dutton-Minerva reefs (Figure 8). Gorfine (2007) described greenlip on Julia Bank as being ‘seldom fished’ particularly as it was considered stunted with few individuals above the 130 mm size limit, more recent Industry comments suggest the Julia Bank greenlip stock was not fished prior to 2007, and no information is available to confirm any commercial fishing prior to 2007. GPS logger data distributed across localized fishing areas across a large area of offshore Julia Bank has now also demonstrated many lower-density but larger-sized greenlip populations (e.g. often averaging >160 mm), interspersed with extensive areas of deeper reef that are likely to support such populations and with little or no past fishing. Refishing of inshore reefs on Julia Bank in recent years suggest little recovery of populations from the 2007-2012 fishing.

Figure 8. Catch (green, t) and catch Target (grey), with catch rate (red, kg/h where no blacklip catch, and where greenlip effort reported separately) and average length (red, ≥135 mm) of greenlip logged. About 5000 greenlip have been measured from 2017-2023, and some remain to be downloaded.



In recent years, greenlip catch has remained low (i.e. <2.1 t per year, Figure 8) compared to previous years, and 0.15 t has been landed in the current fishing period to December 2023. Compared to earlier catch, which were dominated by Hospital, Dutton and Minerva reefs, and then inshore on Julia Bank, catch in recent years has been dominated by Hospital and Cutting reefcodes,

and areas further offshore on Julia Bank. In the last 4 years, Hospital and Cutting reefcodes have contributed most of the catch, while small catches have also come from other reefcodes (Table 2). Catch rates have ranged from about 20 kg/h to 60 kg/h, with higher catch rates at Hospital and Cutting, and have been influenced by different size limits (i.e. regulated and voluntary) and the gradual shift of catch among different areas. Fishing effort has been reported separately for greenlip since 2020-21, and catch rates estimated on days with greenlip-only and with blacklip (i.e. and separate effort reported) are very similar (Figure 8 left). Following a period of relatively stable average lengths from 2007 to 2012 (i.e. mostly from inshore Julia Bank), average lengths of greenlip landed increased significantly to near 160 mm in 2018, and are likely to be related to the shift of catch among different areas and particularly to further offshore on Julia Bank mostly by one diver. In recent years, average lengths have returned to levels more similar to earlier years, and dropped further again in 2022-23 consistent with more fish being landed from inshore areas. The frequency of larger greenlip measured >=160 mm has remained steady in the 2008-15 v 2017-2022 periods at (6.8 and 7.3%) and in 2020-22 (9.6%).

In the 2021 TAC Workshop, WADA recommended movement from zonal to reefcode specific catch limits for greenlip. WADA has been successful at managing blacklip catch targets and limits, so greenlip catch limits for specific reefcodes should provide significant spatial catch control. In the April 2022 TAC Workshop, it was agreed WADA would implement greenlip catch limits of 0 kg at the Cutting, 100 kg at Dutton and Minerva, 200 kg at Hospital and 1.5 t at Julia Bank (i.e. for a 1.9 t TAC allocation for 2022-23), and would also further develop assessment methods for greenlip stocks. The proposed catch limits would have greatest impacts on encouraging recovery in the most productive greenlip reefcodes at the Cutting and Hospital-Dutton-Minerva. A total of 890 kg of greenlip were landed in 2022-23 and 151 kg by December 2023 in 2023-24. In the 2023 TAC Workshop, the Julia Bank target was reduced from 1.5 t to 300 kg, to provide protection for inshore stocks. Divers repeated observations of depletion and lack of recovery on what were high density inshore reefs, and in contrast, offshore were lower density stocks with very limited past fishing.

Table 2. Catch (kg) of greenlip by Reefcode or SMU from April 2017 until December 2023. Reefcodes with catch were Killarney and the Cutting at Warrnambool, Burnets, Watertower and Lighthouse at Port Fairy, Blowholes at Portland, and Eastside at Lady Julia Percy.

	Reefcode or SMU						
Fishing Period	**Julia Bank**	**Hospital Dutton Minerva**	**Warrnambool**	**Port Fairy**	**Portland**	**Lady Julia Percy**	**Total**
2017-18	599	243	437	8	8	1	1296
2018-19	1018	112	263	2	0	0	1395
2019-20	423	0	64	0	0	0	487
2020-21	280	1348	389	0	0	0	2016
2021-22	100	670	798	5	0	0	1601
2022-23	220	644	25	0	0	0	890
2023-24	0	151	0	0	0	0	151

Summary

The Harvest Strategy for the Western Zone abalone fishery was developed, consistent with the Victorian Wild Harvest Abalone Management Plan, and based on the approach developed and used for TAC advice from 2009-2015 as the fishery rebuilt following AVG. The Harvest Strategy describes an assessment of Primary Performance Indicators against specific Target and Limit Reference Points, and when above Limit Reference Points, a Workshop process involving consideration of Primary and Secondary Indicators, including particularly commercial diver observations, interpretation and assessment. Guidance on the TAC is provided to the Workshop by estimates of change in Legal biomass and the application of a range of Harvest Fractions for each SMU. The 2016-2020 Harvest Strategy describes the need to review and revise its approach during development of a new Harvest Strategy.

WADA and VFA have worked together to review and revise the fishery's Harvest Strategy and Monitoring program, by extending and improving on the 2016-2020 Harvest Strategy, with the intent to implement a new Harvest Strategy as soon as possible. Perhaps most importantly, this includes the establishment of a new fishery-independent abalone abundance survey, and an approach to continue the intent of the previous 2016-2020 Harvest Strategy in the interim while the new survey was developed and implemented. The new approach to the FIS will involve the establishment of new fixed survey sites in shallow and more productive abalone populations, and stratification of all established surveys sites to provide better estimates of stocks (i.e. lower variance and bias). While WADA have established sites, and preliminary data is available from the new fishery-independent abundance survey, it will be several years before more detailed information about changes in the stock are available. The stock assessment will continue an agreed approach to extension of the 2016-2020 Harvest Strategy using the latest available fishery-independent abundance survey data, from the VFA survey in 2020, together with the extensive data available from fishery-dependent monitoring up to at least December 2023. With the significant impact of AVG in the Portland SMU during 2021, and no catch from Portland in the last 2 years, the assessment in this report will concentrate on the remaining SMU.

In this assessment, estimates of biomass derived from the 2020 VFA abundance survey are used as Primary Indicators and interpreted relative to the 2016-2020 Harvest Strategy Target and Limit Reference Points. Estimates of Legal biomass from the survey in 2020 are also be used to calculate Harvest Fractions of recent and future catch recommendations. Standardised fishery catch rates in 2023-24 are 15-24% higher than 2019-20, suggesting possible increases in Legal biomass since the 2020 survey. The Primary Indicator of Mature biomass in 2020 was well above the Limit Reference Point across WZ and in each SMU. The Primary Indicator of the number of Prerecruit abalone (80-119 mm) in 2020 was also above the 2018-2020 Limit Reference Point across WZ and in each SMU, except Warrnambool (i.e. noting it was above in Warrnambool in 2018). Numbers of Prerecruit abalone at three of the five sites sampled in Warrnambool were close to the Limit Reference Point (i.e. 44% of the 2003-06 average), and two of these sites have been well above the Reference Point for at least 2 of the last 4 years (i.e. suggesting stronger but variable recruitment), but two sites have remained well below (i.e. offshore Killarney and the Cutting). Maintenance of Prerecruit numbers above the Limit Reference Point will also be strongly influenced by variation in year-class strength (i.e. noting the indicator is an average across two years). The Harvest Strategy details

breakout rules if Primary Indicators are below Limit Reference Points at the scale of WZ, but both are above Limit Reference Points at this scale.

Despite the signs of recovery, the 2020 Mature biomass from the abundance survey remains below the Target Reference Point (i.e. the target was modelled biomass increasing to 69% of full recovery in 2020, average recruitment and a 10% harvest fraction, and with expected recovery below that target in 50% of scenarios), and declined for 3 years before an increase in 2020. Recent decline in Mature biomass followed a large increase in the biomass of Under-size abalone from 2016, and are also related to declines in Legal-sized biomass in recent years, followed by both an increase in Legal and Mature biomass in 2020. No broad-scale or representative fishery-independent survey data are available since 2020, and this contributes uncertainty to the assessment since then. Despite that, increase in standardised catch rates from the commercial fishery since 2020, particularly in some high catch reefcodes (e.g. Crags, Killarney etc), suggest further increases in biomass up to 2023-24, while other reefcodes are less optimistic (e.g. Lighthouse). Because of the reduced catch below target within the Portland SMU in 2021-22, which led to remaining catch being shifted to other SMU and reefcodes (e.g. Crags, Killarney etc), at least some of the increased biomass was likely to have been removed in 2021-22, although since then catch targets in these reefcodes are stable or have increased. Concerns also remain that the abundance surveys have not been representative of stocks and their ongoing recovery, and this has been confirmed in the FIS Review (see also further discussion in previous assessments). To reach the Target Reference Point for Mature biomass a further strong recruitment of Under-size abalone would be required, of at least similar magnitude to the 2016 peak, together with maintenance or further increase of the Legal biomass. The Harvest Strategy does not detail any actions if the Target Reference Point was not met by 2020 or subsequent years, and population modelling by CSIRO noted considerable variation in recovery within the same management scenarios (i.e. driven by variation in recruitment, including with low and no commercial catch). Further guidance on expected recovery targets for the stock, and how they will be assessed, will form part of the new Harvest Strategy.

In addition to the zonal-scale assessment, this report also provides a summary of Primary and Secondary Indicators within each SMU to provide guidance for future TAC and help interpretation, particularly by divers, during the TAC Workshop process. These indicators suggest that stocks of Mature and Under-sized abalone have been well-protected by the increased 130 mm size limit, and the biomass of Under-sized abalone has been increasing strongly (i.e. more than doubled over 10 years), particularly in some but not all areas previously impacted by AVG. These increases are consistent with predictions of timing for recruitment and growth of Under-sized abalone from the CSIRO modelling. Despite some recent declines in Legal biomass, and increases since 2020, abalone >=130 mm are generally being maintained across the fishery, at levels well above that prior to AVG on a 120 mm SL.

The Harvest Strategy notes the time required to enable recovery of the Mature biomass following AVG, and then allow increased successful reproduction, followed by the growth of newly recruited abalone to be fully visible in an abundance survey (i.e. 100-110 mm), and then to grow further to above the 130 mm size limit to be available to the fishery. CSIRO modelling estimated an increase in the Mature biomass following AVG would increase successful reproduction from about 2011 (i.e. from 19% to 28% R/R0), leading to an increase in recruitment to be visible in the abundance survey

from 2017 (i.e. 6-7 years old, 100-110 mm). The growth used in the CSIRO modelling also estimated a further 3-4 years before the 2011 year-class would then reach the fishery at 130 mm. If this timing is correct, with increased recruitment and growth of abalone born after some recovery of the Mature biomass from AVG, then the 2011 year-class would be expected to reach 130 mm and be available to the fishery after 9-11 years, or from 2020-2022. If this increase in average recruitment occurs, the increase in Prerecruit numbers and Under-size biomass, visible to commercial divers and in the abundance surveys in past years, should increasingly translate to recovery of the Legal-sized biomass and fishery in the WZ.

In the 2020 survey there was a further increase in the Under-size abalone, together with increases in Mature and Legal biomass. This follows 2-3 years of some declines in the abundance survey and commercial diver catch rates, and a period of reduced catch late in the 2019-20 fishing period (i.e. Jan-Mar) and 3 month delay in the fishing period (i.e. Apr-Jun). Since then commercial catch rate has increased in most SMU, while average lengths of abalone landed declined, but have started to increase. Such a pattern is consistent with the predicted increase in recruitment of Under-size abalone to the fishery (i.e. lowering average lengths), but additional data collected independent of the fishery would provide further support for this idea. In recent years, commercial catch data has also been influenced by fishing to market, including mostly for larger abalone often at a slower catch rate, and new divers entering the diving group. Together, these observations of change can be summarised in the context of the WZ stock and fishery continuing to recover from the impacts of AVG over the last >10 years, while experiencing shorter-term fluctuations in productivity, particularly from recruitment, environmental influences and fishing. With the impact of such fluctuations, TAC should continue to be set conservatively to encourage ongoing recovery, consistent with the long-term recovery predicted in the CSIRO modelling.

Reference Points from the Harvest Strategy are based only on data from the 2020 abundance survey, and it appears from the FIS Review that sites have not been in representative parts of the recent fishery or wider abalone population in WZ (i.e. density and trends may be negatively-biased). For example, some sites surveyed are rarely fished with low numbers of legal-sized and/or under-sized abalone, others are clumped within SMU (e.g. Crags sites represent >99% of Legal abalone surveyed at Port Fairy), and all mostly in deeper water than most logged dive effort and catch, and this can bias estimates of recovery trend and biomass. High variation in the estimated recovery among sites within SMU also complicates the ability of the abundance survey to be representative, while fewer well-placed sites may be able to estimate density and its change with greater precision. Challenges to the abundance survey design and its use in managing the fishery have been discussed for some time, including during development of the Harvest Strategy (e.g. Dichmont, Worthington and Gorfine, 2017), and were summarised in the Independent Chair's Workshop summary in March 2016, where it was noted "site representativeness is an issue with any fixed site survey approach", and "the Western Zone does have a potential way to progress this through use of a combination of the logger and survey information. This could take advantage of the best features of both – the standardised sites and methods of the surveys and the more comprehensive area/habitat coverage and flexibility of the commercial operations". An independent review of the Abundance Surveys (Hart, 2016) recognized the concerns about the design of the abundance survey, and made a series of clear recommendations about improvements

in design and interpretation, and use with GPS logger data from the commercial fishery. WADA continues to work with VFA through the FIS Review to develop and implement an improved fishery-independent survey, incorporating past recommendations, to provide guidance about Under-size and Legal biomass in areas impacted by AVG and throughout the fishery.

The current Harvest Strategy notes "If there are significant changes to the way that the indicators are calculated, for example through changed survey design or changed standardisation, then the implications to reference points, decision rules and harvest strategy performance should be re-examined", "In the course of application of this harvest strategy methods to estimate density of exploitable biomass from commercial diver GPS logger data should be developed, evaluated and, as appropriate, included as a primary indicator" and "With more consistent and extensive data now available from GPS loggers, and greater opportunity for calibration of estimates of density from loggers and surveys, it expected that the use of data from loggers in the estimation of Performance Indicators will increase".

WADA continues to develop an approach to using loggers and real-time digital data to assess fishery performance and help advise divers. This approach was also highlighted in the 2019 National Abalone Assessment and Management Workshop supported by FRDC, where the benefits of bringing together real-time digital data (e.g. catch reporting, VMS and fishing and habitat maps, abalone measuring, diver observations) to enable more frequent monitoring and assessment (e.g. monthly by Industry within reference points), including within season management responses by Industry (e.g. adjusting catch planning), and in turn improve annual assessments and management responses. WADA continues to work with VFA to extend an online, shared-dashboard to enable this approach. For example, a detailed spatial map of recent fishing effort over different times (e.g. 1-2 weeks and 1-2-3 months) for comparison with the current and past fishing periods, is now available to divers. This is also currently being extended to link related catch and abalone measuring information. The current Harvest Strategy describes ongoing development actions and timeframes, including revision of the Harvest Strategy itself, to ensure the opportunity for improvement in fishery Performance Indicators are incorporated quickly into management of the fishery.

The 2016-2020 Harvest Strategy also details an approach to determine the status of the WZ fishery and stock, relevant to the assessment for the Status of Australian Fish Stocks (SAFS). The fishery and stock are determined to be Sustainable when the Mature biomass is above the Limit Reference Point from the Harvest Strategy, and the calculated Harvest Fraction of the Legal biomass is below 15%. The approach described in the Harvest Strategy determines the WZ fishery and stock of blacklip abalone as **Sustainable**. This is consistent with the independent assessment summarised in the 2020 SAFS assessment, where the fishery was also determined to be Sustainable using the same criteria. It is also important to note the more recent impacts from AVG in the Portland SMU, and that greater fishery-independent information is becoming available as more WADA survey sites are sampled.

AVG has impacted stocks of abalone in the Portland SMU, which were all gradually closed to fishing during 2021-22, and no catch was allocated in 2022-23 or 2023-24. WADA continues to work on a strategic plan to ensure appropriate data is collected about the impacts of AVG, the subsequent

recovery of stocks, and a data-based approach to recommence the fishery and demonstrate sustainability. Most importantly this includes establishment of new fishery-independent survey sites, and comparison with historic data. Away from Portland, the WZ stocks and fishery continue to recover from the impacts of AVG over the last >10 years. Expected rates of growth suggest increases in Prerecruit and Under-sized biomass observed in recent years, should lead to the ongoing recovery of the Mature and Legal biomass, consistent with recent increases in the commercial fishery. Estimates of the Harvest Fraction of current catches generally remain around 10%, which is also consistent with ongoing recovery of the abalone stocks in Western Zone. Despite that, several challenges and improvements remain to further recovery of the stocks and fishery. While some reefcodes are performing well, some other reefcodes have declined or remained low, even with limited fishing (e.g. Lighthouse, Thunder Point). Increasing stocks and production from these reefcodes, to levels more consistent with reefcodes currently with greater stocks and production (e.g. Crags, Killarney and Levys), will be a key challenge for further recovery of stocks and the fishery. There is also an urgent need in WZ and other Victorian zones, to extend the abundance survey with a new approach that samples across the full productive stock of abalone. As a result, and combined with greater risk and uncertainty from AVG and its impacts at Portland, ongoing conservative decisions about TAC are particularly prudent. Looking further ahead, development of the broader monitoring program and Harvest Strategy need to be completed and incorporated into plans for future management of the fishery. While the Western Zone abalone stocks and fishery have come a long way in the last decade, with the substantial recovery forming the base for future catch, there remains much to complete to ensure good management of the ongoing recovery of stocks and the fishery for the next decade.

Appendix 1. Map of WZ and SMU.

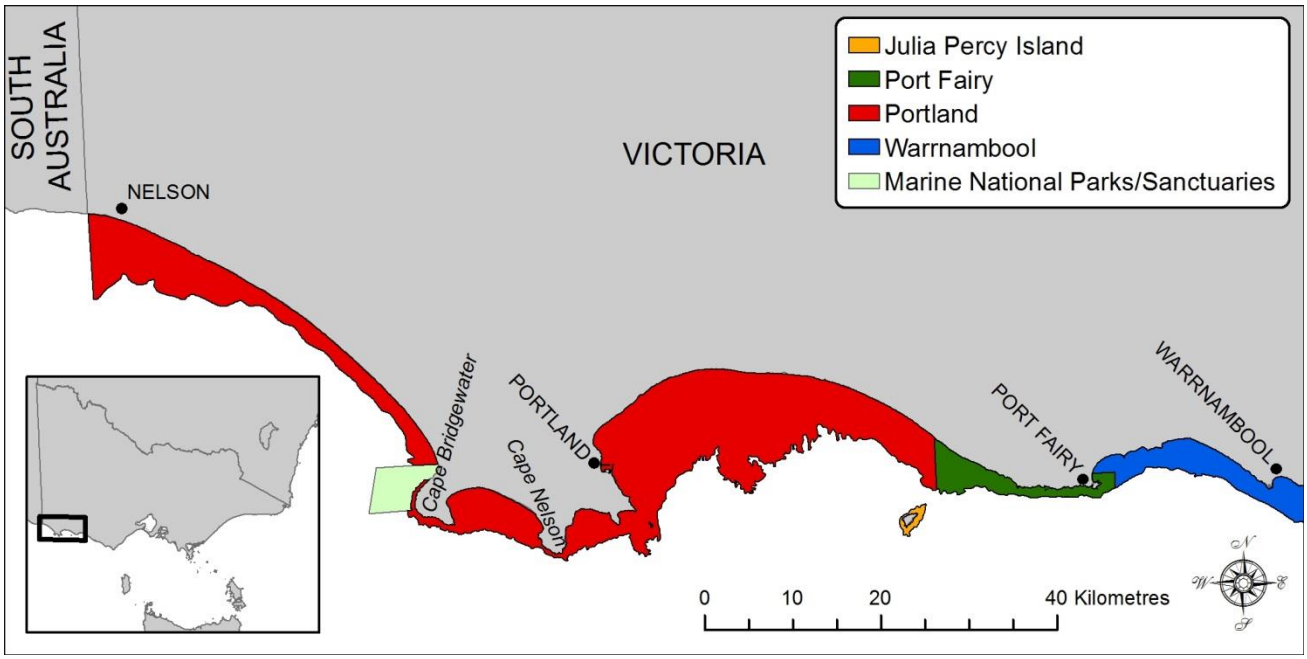


Figure 9. Map of the Western Zone Abalone Fishery, showing Spatial Management Units.

Appendix 2. Reefcode Reports.

Reefcode Reports produced by WADA are referred to here, but are available in a separate document produced immediately prior to the TAC Workshop to include the latest data.