Assessment of abalone stocks in Western Zone Victoria

Submission to the TAC setting process for 2025-26

Western Abalone Divers Association

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Victorian Fisheries AUTHORITY

WADA
Western Abalone Divers Association

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Assessment of abalone stocks in Western Zone, Victoria: Submission to the TAC setting process for 2025-26

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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 2025 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 first 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 Harvest Strategy was developed to continue recovery of abalone stocks in WZ with rebuilding targets from 2016-2021, 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 commenced development of an improved fishery-independent survey methodology for the Portland reefs, before recommending in 2024 a 7.5 t catch from the Portland SMU for 2024-25. 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) have retained high fishery performance indicators and target catches, which are quickly landed early in the year 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 encouraging greater recovery elsewhere, remains a key challenge for the fishery.

WADA and VFA have also worked together to commence review and update of the fishery Harvest Strategy and Monitoring program, by extending and improving on the existing Harvest Strategy, and with the intent to update rebuilding targets in an extended Harvest Strategy as soon as possible. Perhaps most importantly, this includes the continued development of a new fishery-independent abalone abundance survey throughout WZ, and an approach to continue the intent of

the Harvest Strategy while the new survey is being developed and implemented. A review of the old abundance survey has suggested sites have not been broadly representative of fished areas, but are often in marginal parts of the current and historic fishery (i.e. often to enable easier access by survey divers), in the WZ and throughout much of Victoria. Particularly by avoiding shallow and more productive areas, the old abundance survey sites are likely to have provided a biased assessment of the broader abalone population (i.e. greater decline in less productive areas, and similarly measured reduced recovery). Such habitat-related density-dependent differences in abalone populations appears quite common in many fished species, and stratified sampling designs are commonly used to reduce the potential bias from sampling only part of the population. The old abundance survey has not been repeated since 2020, but new sites have been established from 2021-2024, and together with some old sites, have been surveyed with a new fixed-transect methodology developed by WADA. The joint FIS Review, involving WADA, VFA and MRAG, 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.

Currently, WADA has established new fixed sites in productive areas of the fishery, within a plan for a stratified design of productive, intermediate and marginal sites. At each site, 2 permanent markers are drilled into the rock, and a 1 m transect is sampled between them. Transects are established across a range of abalone densities, from highly productive areas to adjacent less dense areas. Under-sized and legal-sized abalone are counted in 5 m sections of the Transect, and estimates of the density of abalone have ranged from ~0-20 abalone per sq m, with an average of ~5 abalone per sq m including ~4 under-sized and ~1 legal-sized abalone. Importantly, densities vary across the new fixed Transects from an average of ~7 abalone per sq m on productive reef, to ~1.5 abalone on less productive intermediate reef. In 2020 at old survey sites, the density of abalone averaged ~1 abalone per sq m, with ~0.85 under-size abalone and ~0.18 legal-sized abalone, again highlighting their lack of representation of productive abalone reef, and suggesting abalone are about 5 times more abundant on the new fixed sites. Resampling old FIS sites demonstrated concerns about fine spatial scale variation in habitat (e.g. old survey sites could estimate very low abundance, while being adjacent to productive abalone reef with very high densities of abalone) with the very low abundance of abalone, and particularly legal-sized abalone.

This assessment will again continue the approach of the 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 is consistent with the Harvest Strategy and will use the information and biomass estimates derived from the VFA fishery-independent abundance survey in 2020 at the scale of SMU as Primary Performance Indicators, together with Secondary Performance Indicators including the extensive data available from fishery-dependent monitoring up to at least December 2024, 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 short-term justification for the continued use of the 2020 biomass estimate. In addition, the assessment will also present two alternative approaches, involving use of the preliminary data from the new fixed site FIS as a Primary Performance Indicator, and application of the current Harvest Strategy used in Central Zone (CZ) and Eastern Zone (EZ) involving trends in commercial catch rate

as a Secondary Performance Indicator. Reefcode-scale reports are also provided for interpretation of Secondary Performance Indicators at the TAC Workshop.

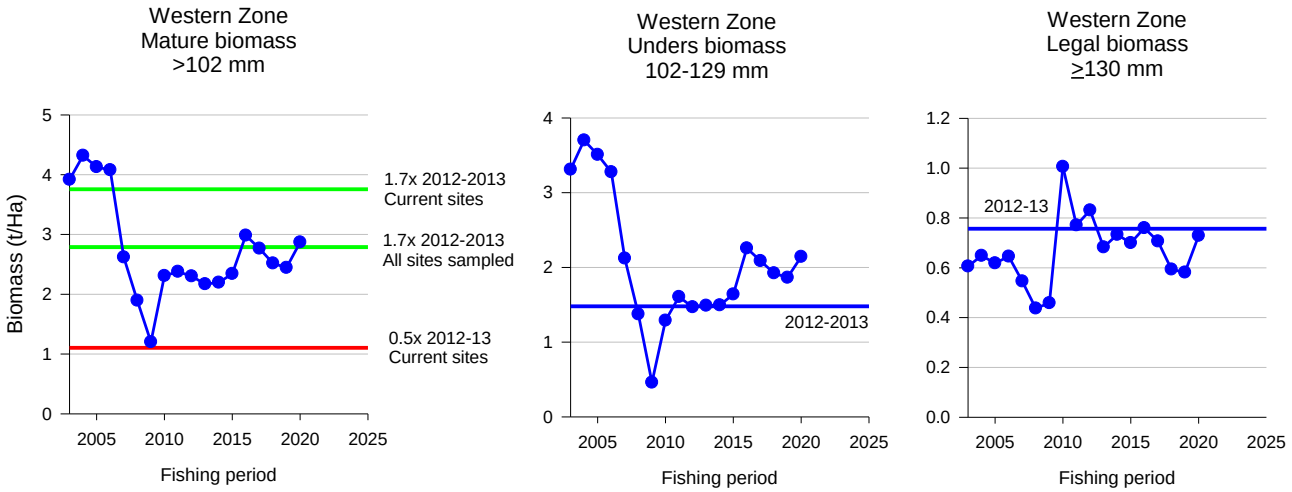
Primary Performance Indicators and Reference Points from the Harvest Strategy are based only on an abundance survey. These include estimates of the Legal and Mature biomass, and the number of Prerecruit abalone, with the WZ-scale indicators used to assess overall status of the stock (i.e. consistent 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, interpreted at various spatial scales. This assessment 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, including use of preliminary data from the new fixed site FIS, and application of the current CZ and EZ Harvest Strategy.

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, while sizes of abalone landed are from GPS loggers operated by WADA, and both include data until December 2024. 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 old abundance survey, estimates of biomass from the survey sites across WZ provide evidence for the recovery of abalone stocks since the impacts of AVG in 2005 (Figure 1) and are not inconsistent with broader recovery of the fishery (e.g. Figure 2-6). Recovery of Mature biomass (Figure 1 left) was encouraged by leaving areas of the fishery closed for 3-5 years following AVG impacts, and restarting fishing at levels consistent with conservative guidance from an approach using 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 ($\geq$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 mature stock and 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 estimated 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 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 fishery-dependent data including abalone measuring and GPS loggers are used to provide guidance on changes in Legal biomass. In this report, estimates of total Legal biomass are calculated from density in the VFA abundance survey at sites during 2020, and preliminary data from the new abundance survey in 2024. Estimates of density from the surveys extrapolated to estimates of historically-productive areas of reef, and compared with estimates of productive reef from GPS loggers used while fishing, 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 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 approaches to update the existing Harvest Strategy will include several strategic directions. Fishery-independent surveys of abalone populations will remain an important component of the new Harvest Strategy. WADA will continue to develop a new fixed site, fishery-independent survey involving a stratified design 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. Historic WADA and VFA survey sites will also be included in the stratified design and 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. Estimates of biomass, and biomass change through time, from a broad and representative new abundance survey site, and rebuilding targets will be developed and used to update the Harvest Strategy.

The 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 footprint, 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

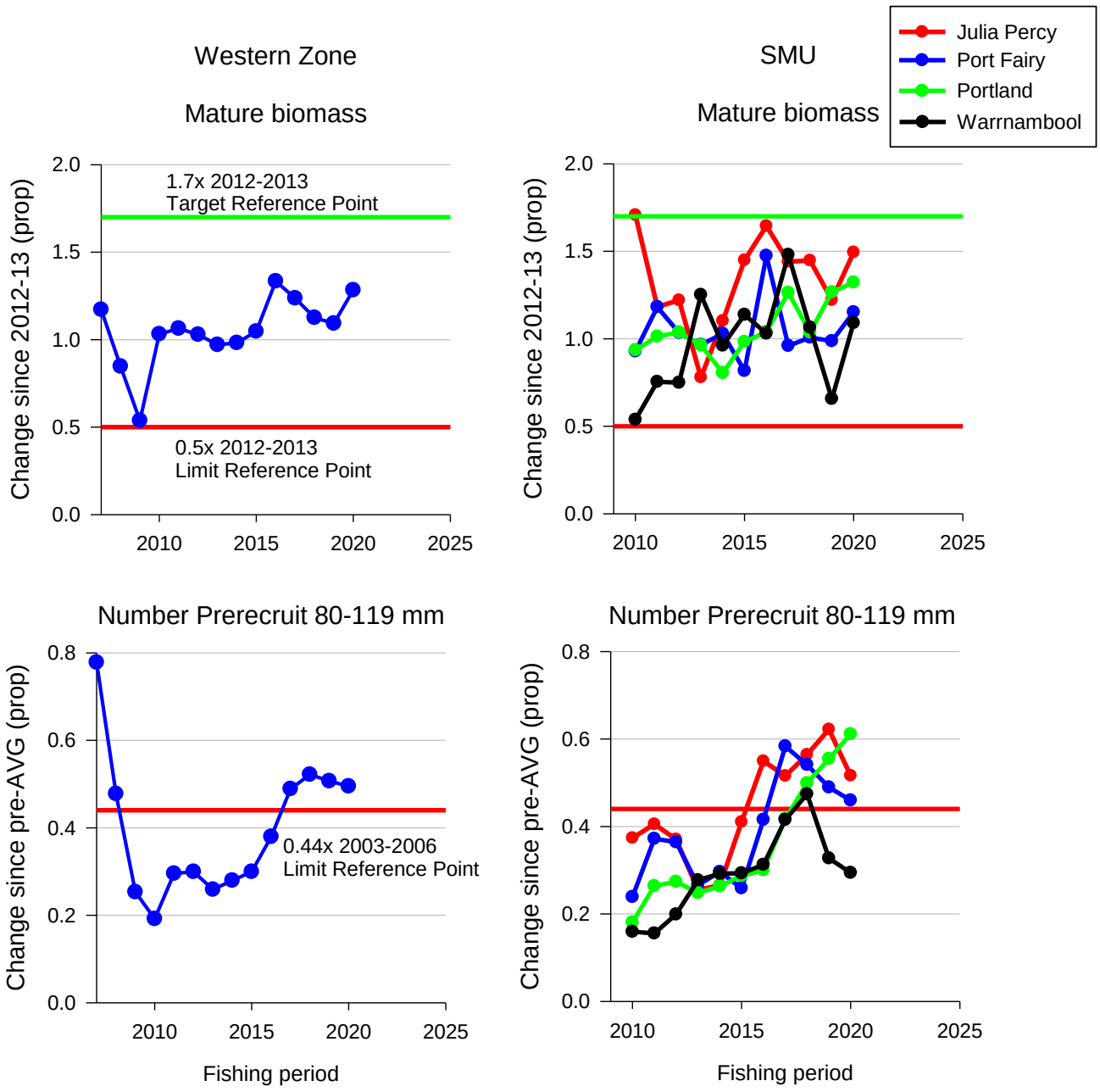
The Harvest Strategy will continue to be applied using the 2020 VFA abundance survey data, and preliminary data from the new abundance survey. The Harvest Strategy has a Target Reference Point for planned recovery, and two Limit Reference Points that relate to rules for breakout and review of the Harvest 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 currently 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 within the 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 2020 (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 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 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 old FIS sites in WZ (e.g. 2398 Prerecruit abalone were actually counted in the 2020 survey, with the new abundance survey currently including the same number of abalone). 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 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, to 28-32 t from 2014 to 2020. AVG was detected in May 2021, and led to the gradual closing of reefcodes throughout the SMU, with only 16.2 t caught of a 30 t target in 2021-22 (Figure 3).

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. This recommendation of no catch was repeated at the 2023 TAC Workshop, together with a need to collect greater information about 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 appeared not to be active for some time, but impacts still included 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. At the 2024 TAC Workshop, a 7.5 t catch target was agreed for 2024-25, and distributed among reefcodes to help collect further information about stocks and inform management decisions.

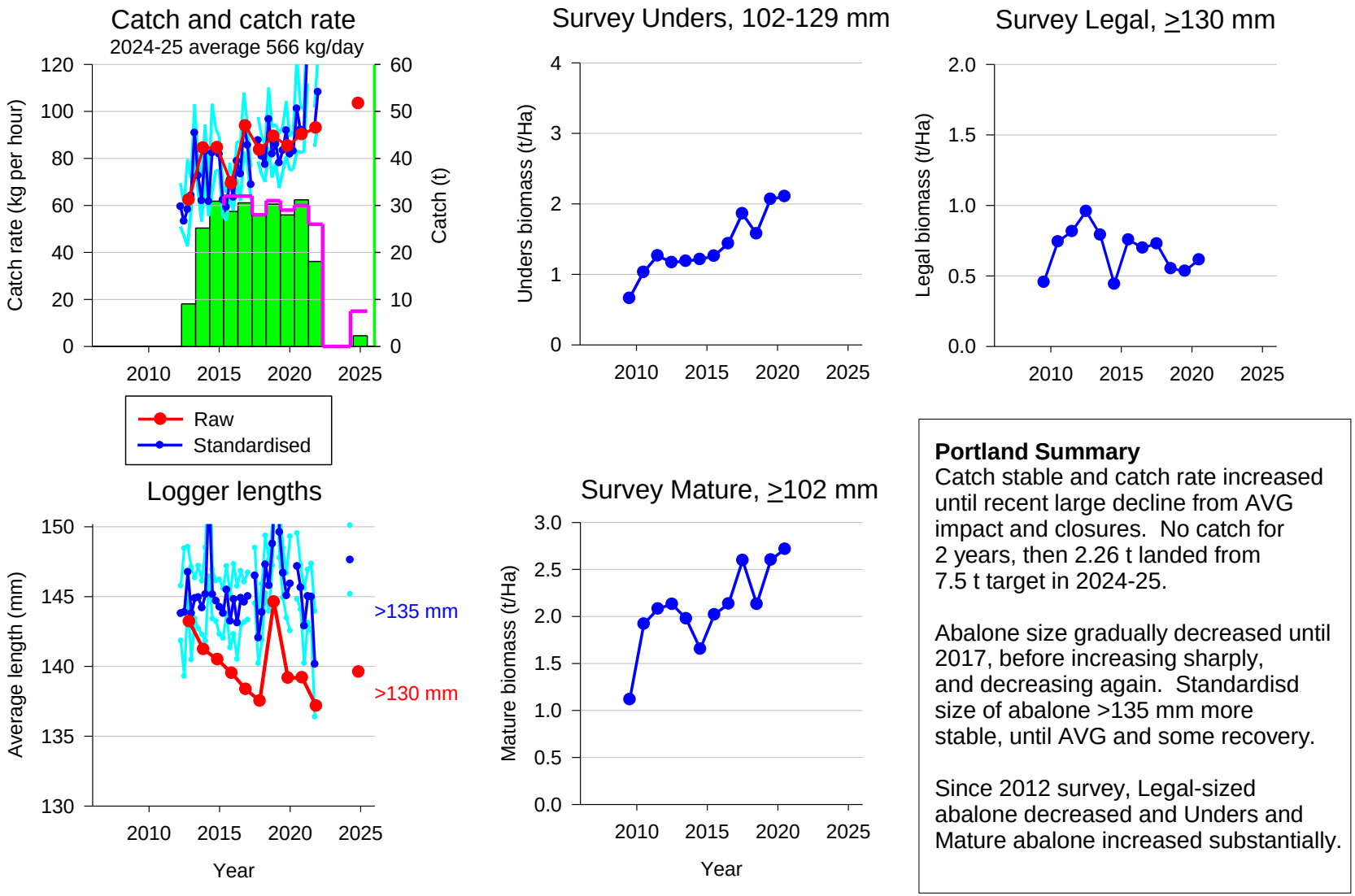
During 3 days in July 2024, two divers landed catch from 6 reefcodes at Portland, with a total of 2.26 t landed. Catch rates ranged from 41 kg/h (over 20 min in Outside Nelson) to over 160 kg/h (over 2 h at the Tits), and averaged 103 kg/h over almost 22 h fishing.

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. Abalone landed during 2024 were large, averaging almost 140 mm, with larger abalone landed in Blowholes (see Reefcode Reports). The standardised length of abalone $\geq$135 mm has been more stable through time and with abalone landed $\geq$135 mm in 2024 larger than most other fishing since 2012.

Undersize abalone recovered strongly (i.e. biomass more than doubled) at historic abundance survey sites from 2009 to 2020. Abundance survey sites were historically mostly in deeper water, with some adjacent to productive shallow water populations, but sites were not representative of fished populations (i.e. few VMS points while fishing over FIS sites) or their recovery. New fixed abundance survey sites have been placed in several reefcodes, particularly around Cape Bridgewater.

WADA is considering 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 2024 (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 last surveyed in 2020.



Portland Summary
Catch stable and catch rate increased until recent large decline from AVG impact and closures. No catch for 2 years, then 2.26 t landed from 7.5 t target in 2024-25.

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

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 5.0 t in 2017-18, and peaking at 7.5 t in 2020-21. Reefcode catch targets were then reduced to a total of 4.8 t and have remained stable to 2024-25. Catch has historically 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 to 3 t in recent years. Only 2 days fishing have been completed to December in 2024-25, with 0.6 t landed.

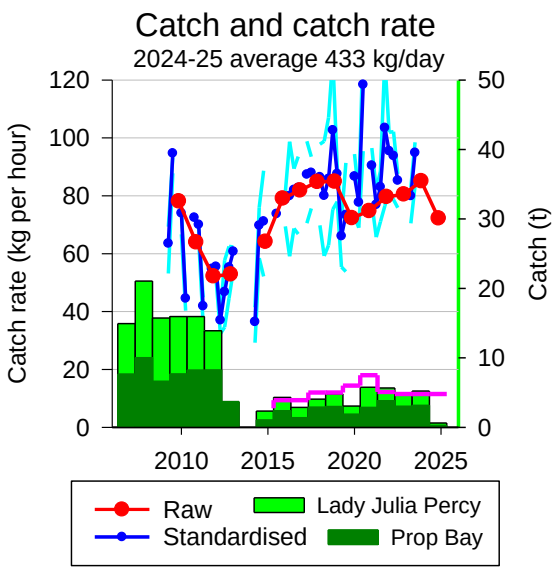
Raw and standardised catch rates declined to about 50-60 kg/h before closure in 2013, but following reduced catch, increased to above 80 kg/h on the higher 130 mm size limit from 2015, before declining in 2019-20, and recovering above 80 kg/h again in the subsequent years (Figure 4). In 2024-25, with 0.6 t landed, catch rates have averaged 76 kg/h, including almost 0.3 t at 97 kg/h in Prop Bay.

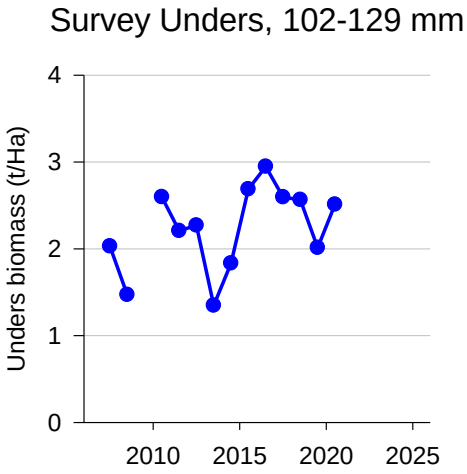
Both the raw and standardised length of abalone increased from 2009-2012 to 2014, following the closure and reduced catch. In recent years, both raw and standardised length of abalone have been variable but generally higher than previous years (Figure 4). Increases in length have occurred mostly at Prop Bay, although smaller increases also occurred at reefcodes on the northside.

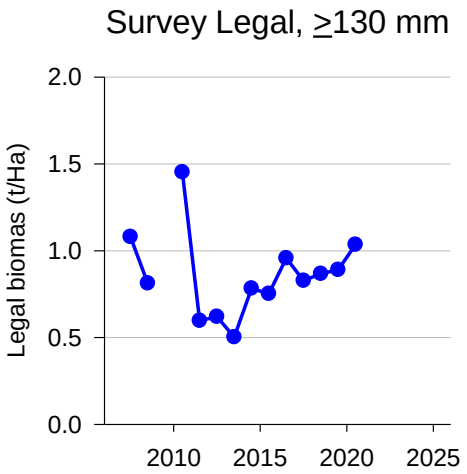
Under-size and legal-sized abalone increased at historic abundance survey sites after the closure from 2014 to 2020. One abundance survey site sample from 1992 to 2020 (i.e. JPE) suggested Prerecruits (<120 mm) in 2020 were 50% of those in 1992, while Recruits (>120 mm) in 2020 were 200% of 1992.

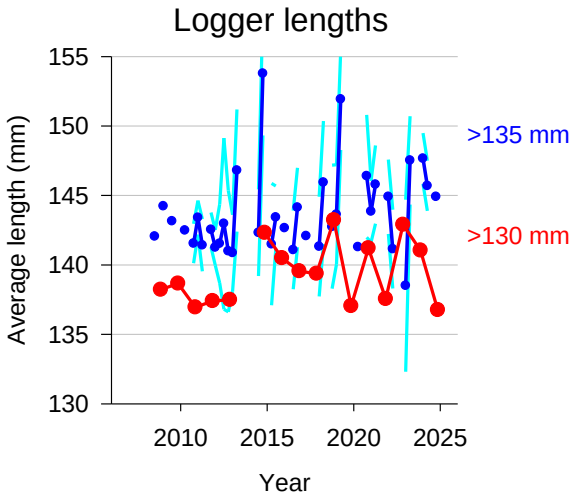
Total biomass of legal-sized abalone is estimated from the density of Legal abalone on survey sites in 2020, which is extrapolated to the area of historically-productive reef (Table 1). The area of historically-productive reef was estimated at 59 Ha from GPS logger data during the period of higher catch prior to 2013. More recent estimates of the active area of reef fished at LJP are lower with the lower catch (Table 1). The estimate of total Legal biomass in the 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%).

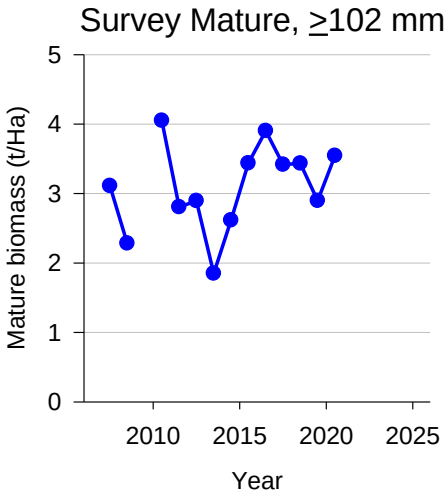
Figure 4. Fishery performance indicators for the Lady Julia Percy SMU. Actual catch is shown to December 2024 (green bar, and average catch per day above) with full year Targets (pink line and light grey bar), raw (red) and standardised (blue ±SE) catch rate and length of abalone logged (i.e. Raw ≥130 mm and Standardised ≥135 mm). Abundance survey figures show estimates of biomass of Unders, Mature and Legal-sized abalone at sites last surveyed in 2020.











Lady Julia Percy Summary
Catch increased to 2020-21, but reduced since and well below historic. Only 1 days catch in 2024-25.

Standardised catch rate stable at about 80 kg/h, with only 1 day in 2024-25.

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 13-14 t for 2 years, and then increased again to over 22 t from 2018, and gradually reduced to 13.5-14.5 t in 2024-25 with 8 t caught by December 2023 mostly from Crags (Figure 5). Catch has been stable at the Crags about 8-9 t in recent years, but has declined particularly at the Lighthouse where catch was reduced from 4 t to 1 t since 2023-24, and Watertower was reduced from catch of 5.8 t to 2 t since 2023-24.

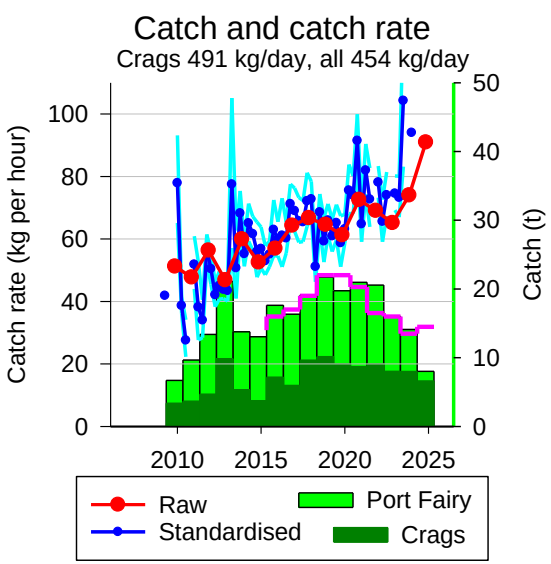
Raw and standardised catch rates have gradually increased from 40- 50 kg/h to over 60 kg/h on a 130 mm size limit, before a further increase to about 80 kg/h in 2023-24 and higher in early 2024-25 (Figure 5). Raw catch rates are influenced by the increased proportion of catch coming from Crags, where catch rates are higher and generally landed earlier in the year, compared to Lighthouse and Watertower where catch rates are lower. Catch rates during 2024-25 averaged over 100 kg/h at Crags with 6.6 t landed to December 2024, but 40-65 kg/h in other reefcodes with 1.4 t landed.

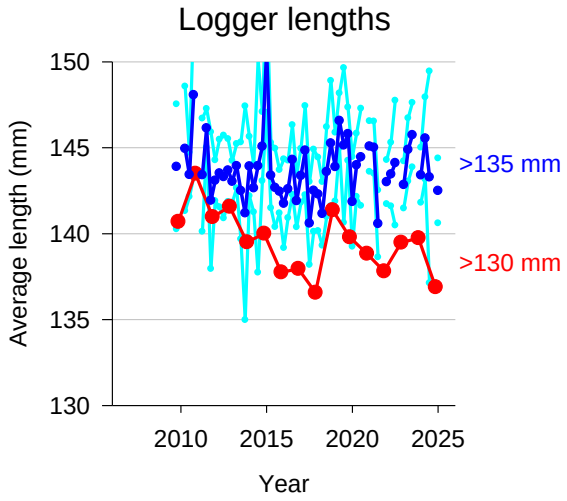
The average length of abalone landed decreased from 143.5 mm soon after the recommencement of fishing in 2010 (i.e. 135 mm size limit), reaching a low of 136.5 mm in 2016-17 (i.e. 130 mm size limit), before increasing sharply and then declining again to 138.0 mm in 2021-22 (Figure 5). Standardised length of abalone $\geq$135 mm, has been more stable and with abalone lengths $\geq$135 mm in recent years similar to those soon after restarting fishing. There was a small reduction in the average length of abalone $\geq$135 mm, and the frequency of smaller abalone increased at Crags in 2024-25 (see Reefcode Report).

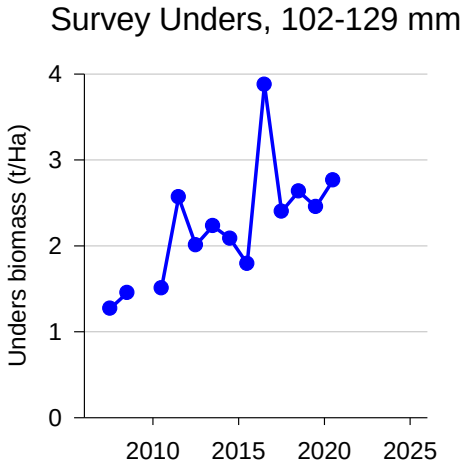
Under-size abalone increased substantially at 6 historic abundance survey sites from 2009 to 2020, with most sites at the Crags. New fixed-transect sites have been installed at Crags, including some at historical sites and nearby, and in other reefcodes at Port Fairy. Surveys of abalone at Crags in 2022 and 2024, suggest a 16.7% increase in the abundance of mostly under-sized abalone in 2024.

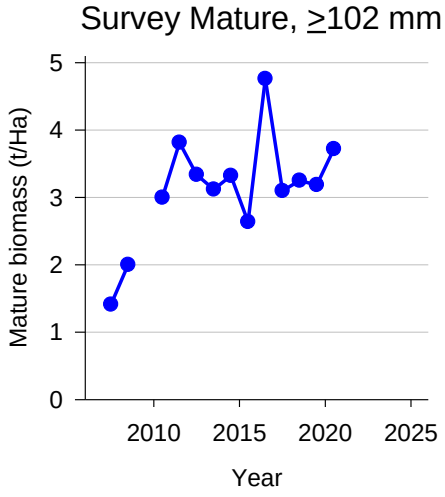
Total Legal biomass is estimated from the density of Legal abalone on survey sites, which is extrapolated to the area of historically-productive reef (Table 1). Estimates of Legal-sized abalone density in 2020 of 0.845 t per Ha were extrapolated to 215 Ha of productive reef, to estimate a total biomass of 182 t. Several Secondary Indicators from the Harvest Strategy suggest Legal-sized biomass has not declined since 2020, with an increase at new abundance survey sites of 16.7% between 2022 and 2024, a 34% decrease in catch, and increased catch rates from 2019-20 to 2023-24 of 120%, and 149% to 2024-25 (Table 1). Despite these potential increases in legal-sized biomass since 2020, WADA has continued to take a conservative approach by using and not increasing the 2020 biomass estimate.

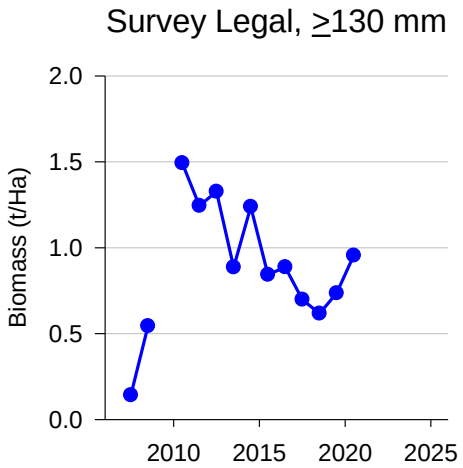
Figure 5. Fishery performance indicators for the Port Fairy SMU. Actual catch is shown to December 2024 (green bar, and average catch per day above) with full year Targets (pink line and light grey bar), raw (red) and standardised (blue ±SE) catch rate and length of abalone logged (i.e. Raw ≥130 mm and Standardised ≥135 mm). Abundance survey figures show estimates of biomass of Unders, Mature and Legal-sized abalone at sites last surveyed in 2020.











Port Fairy Summary
Catch peaked again in 2019-22 at ~20 t, but reduced in recent years.

Catch rate increased again with reduced catch and to date in 2024-25.

Standardised size of >135 mm abalone stable, with some decrease in >130 mm in 2024-25.

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 catch increased to about 10 t during 2013-15. Catch during this period was 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 Killarney, and greater catch from Levys and Thunder Point. Catch then increased to 12-13 t during 2016-2023, with catch and catch rates particularly increasing at Killarney and Levys, before the catch target increasing to 16 t in 2024-25. Increased catch targets in 2024-25 were associated with size limit reductions from 130 to 125 mm to spread catch within Mills, Killarney and Cutting (Figure 6). A total of 8.4 t was landed to December 2024, with target catch reached at Killarney, mostly caught at Mills and Levys, and substantial catch remaining at Thunder Point with lower catch rates. Only 1.8 t of the 3.5 t target at Thunder Point was landed in 2023-24.

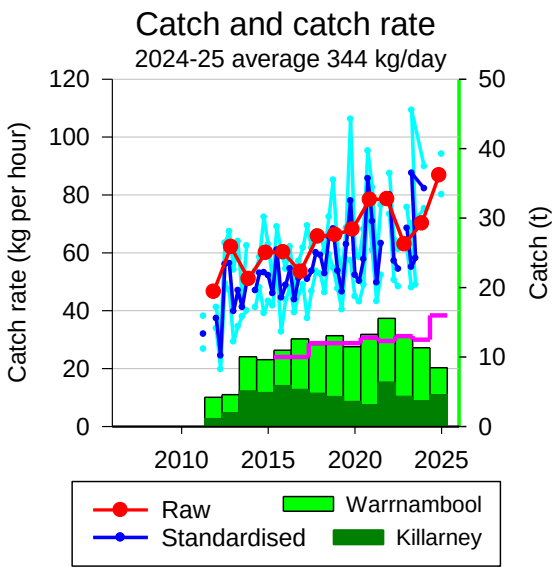
Raw and standardised catch rates gradually increased from below 60 kg/h to 70-80 kg/h in 2023-24, and are above 80 kg/h to December in 2024-25, but with catch remaining at the lower catch rate Thunder Point (Figure 6). Standardised catch rates have also increased, particularly driven by higher catch rates at Levys and Killarney. With a reduced size limit in Mills, Killarney and Cutting, catch rates have been mostly stable.

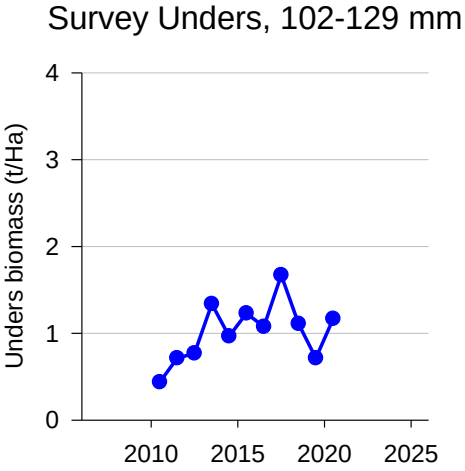
The average length of abalone landed increased from 136.1 mm after the recommencement of fishing in 2011-12, and reached a peak during 2014 at 142.1 mm, coincident with the first of larger catches at Levys, before declining to a low in 2024-25 co-incident with the size limit reduction in 3 reefcodes, where average lengths have declined particularly in Mills and Killarney (Figure 6 and Reefcode Report). In contrast, the standardised length of abalone $\geq$135 mm has been more stable. Average length has also recently declined at Levys, together with an increase in the frequency of smaller abalone landed (see Reefcode Report).

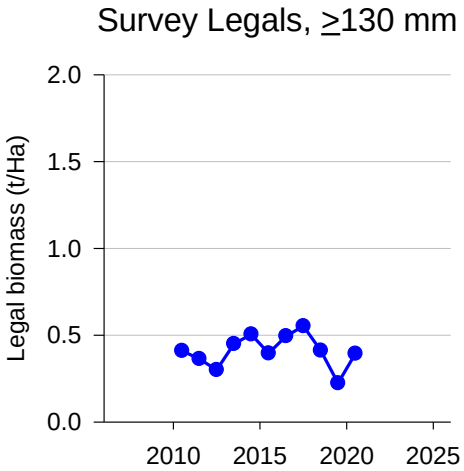
Under-size abalone doubled at 5 historic abundance survey sites from 2009 to 2020. New fixed-transect sites targeting productive areas of reef have been installed at Mills, Killarney and Cutting, including some at historical sites and nearby. Surveys of abalone at Killarney between 2022 and 2024, suggest a 34.6% decrease in the abundance of mostly under-sized abalone.

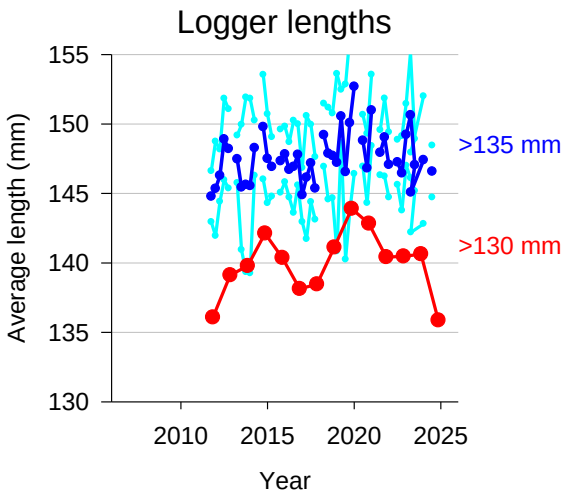
Total Legal biomass is estimated from the density of Legal abalone on survey sites, which is extrapolated to the area of historically-productive reef (Table 1). Estimates of Legal-sized abalone density in 2020 of 0.309 t per Ha were extrapolated to 343 Ha of productive reef, to estimate a total biomass of 106 t. Estimates of density from WADA surveys suggest this estimate of density is likely to be biased low, while estimates of reef area from loggers while fishing suggest the reef area estimate used is biased high. Secondary Indicators from the Harvest Strategy suggest Legal-sized biomass has not declined since 2020, with increased catch rates from 2019-20 to 2023-24 of 118%, and 187% to 2024-25 (Table 1), despite the decline in mostly under-sized abalone between 2022 and 2024 at new abundance survey sites. Similar to Port Fairy, WADA has continued to take a conservative approach by using and not increasing the 2020 biomass estimate.

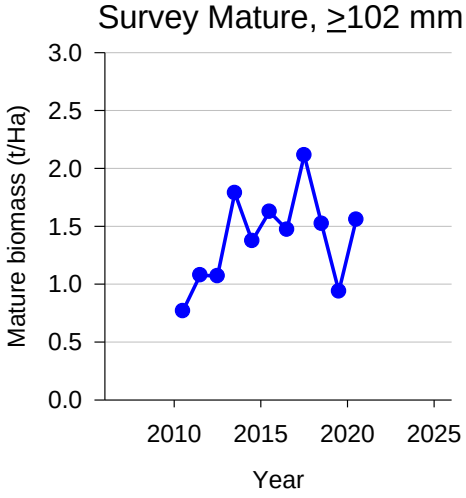
Figure 6. Fishery performance indicators for the Warrnambool SMU. Actual catch is shown to December 2023 (green bar, and average catch per day above) with full year Targets (pink line and light grey bar), raw (red) and standardised (blue ±SE) catch rate and length of abalone logged (i.e. Raw ≥130 mm 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 and target mostly stable in recent years, but increased for 2024-25.

Standardised catch rate has increased for several years, dominated by good catch rates at Killarney early in the year.

Abalone size >130 mm decreased in 2024-25 consistet with size limit change. Standardised size of abalone >135 mm has remained stable.

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

Estimates of legal-sized biomass

The WZ Harvest Strategy uses estimates of biomass from the historic abundance survey as Primary Performance Indicators, and notes the need to change the design to target productive fishing areas, sample the broader abalone population. Calculation of estimates of legal-sized biomass (Table 1) include estimates of abalone density from the abundance survey in 2020, productive reef area (i.e. developed in 2009-2012), change in standardised catch rate from 2019-20, and the catch related to different Harvest Fractions from the estimated biomass. The biomass and Harvest Fractions are used to calculate a catch that is used to limit the possible TAC derived from a bottom-up approach using diver interpretation of data and their observations at the scale of reefcodes.

The last abundance survey was completed in 2020 using the old sampling design, with ongoing development of a new survey approach from 2022-2025. While preliminary data and estimates of biomass, and its change through time, are possible from the new survey approach (see Table 1 and 2), calibration of data from the two FIS designs is limited until more data is available from the new survey design. More sites will be added in 2025, and a consistent approach to design and analysis will be coordinated and developed in conjunction with development of the survey in the other fishing Zones. Interpretation of the Harvest Strategy Secondary Indicators relevant to legal-sized biomass, such as commercial catch, catch rate and length of landed abalone, with extensive recent data since 2020, help to reduce the uncertainty about the 2020 biomass estimates. For example, catch has declined and catch rates have increased from 2020 to 2024 at Port Fairy (Table 1), and catch rates have also increased at Warrnambool and Lady Julia Percy, while in all 3 SMU standardised lengths of abalone landed have generally been stable or increased. This provides some evidence of increased biomass, particularly in productive reefcodes, and little evidence for a broad decline in biomass across the SMU since 2020. Alternatively, there have also been declines in indicators in some less productive reefcodes (e.g. Lighthouse), and including declines (i.e. mostly under-size) in preliminary data from the new abundance survey at Killarney from 2022 to 2024. This spatial variation and potential uncertainty in estimates of biomass since 2020 provide emphasis on the need for continued development of the new abundance survey.

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 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
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
BIOMASS						
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						
CPUE 2023-4/2019-20	%		-	124%	120%	118%
CPUE 2024-5/2019-20	%		-	138%	149%	187%
Catch 2024-5/2019-20	%		-	80%	66%	133%
Catch Target		t				
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
2024-25			7.5	4.8	14.5	16.0

Potential uncertainty in estimates of legal-size biomass in 2024 can also be considered with application of the two other Victorian Abalone Zones' Harvest Strategy approach in the Western Zone. The Eastern (EZ) and Central Zone (CZ) Harvest Strategy estimates change in biomass over 4 years using trends in standardised catch rates, and classifies 4 year and 1 year trends into a broad categorization of Increasing, Stable or Declining. As part of application of the other EZ and CZ Harvest Strategy to WZ, this has been applied using standardised catch rates from the current standardisation approach in WZ (i.e. fixed-effect GLM), and with a new approach being developed and applied in the other Zones (i.e. mixed-effect GLM), and results from application of the EZ and CZ Harvest Strategy to both approaches to standardise catch rates are presented here (Table 2).

Application of the EZ and CZ Harvest Strategy to WZ, using 2 different approaches to standardisation of catch rates, provides an assessment that 3 of the WZ SMU are Stable with increasing trends in the Primary Indicator (i.e. standardised catch rates over 4 years from 2020-24 to 2023-24), except Lady Julia Percy using one of the standardisation methods, which was assessed as Declining. Using the new mixed-model GLM to standardised catch rate, the EZ and CZ Harvest Strategy determines all 3 SMU as Stable with a recommended catch change of $\pm$5%. Application of the EZ and CZ Harvest Strategy to WZ in previous year's demonstrates the benefit of the WZ Harvest Strategy approach, with WZ making significant reductions in catch when the EZ and CZ Harvest Strategy recommended increases. Despite that, consideration of Secondary Indicators from the WZ Harvest Strategy, and application of the EZ and CZ Harvest Strategy, provides some evidence of increasing performance indicators and stable biomass, and little evidence for a broad decline in biomass across the SMU since 2020. This further supports use of the estimates of biomass in WZ during 2020, with conservative catches and Harvest Fractions in the application of the WZ Harvest Strategy for 2025-26.

Table 2. Application of the EZ & CZ Harvest Strategy to WZ from a) the current and b) a proposed new standardisation model, as would have been applied in 2023 for TAC in 2023-24 and 2024 for 2024-25, and this year for 2025-26. Increased catch guidance is shown in green, and decreased in yellow. Actual TAC changes for 2023-24 and 2024-25 are also shown. The Size limit was modified in 2024 for the 2024-25 Quota Year in some Reefcodes within Warrnambool.

a) current fixed-effect GLM standardisation

	Applied 2023				Applied 2024			
	Catch rate 2018-22		TAC		Catch rate 2019-23		TAC	
	4 yr	1 yr	Guidance	Actual	4 yr	1 yr	Guidance	Actual
Portland								
Lady Julia Percy	0.3%	stable	-5 to 5%	0%	12%	increasing	0 to 15%	0%
Port Fairy	20%	increasing	0 to 15%	-16%	3%	declining	-15 to -5%	+7%
Warrnambool	-1%	stable	-5 to 5%	-4%	7%	increasing	0 to 15%	+28%sl

	Applied 2025			
	Catch rate 2020-24		TAC	
	4 yr	1 yr	Guidance	Actual
Portland				
Lady Julia Percy	3%	declining	-15 to -5%	
Port Fairy	4%	increasing	-5 to 5%	
Warrnambool	-3%	stable	-5 to 5%	

b) new mixed-effect GLM standardisation

	Applied 2023				Applied 2024			
	Catch rate 2018-22		TAC		Catch rate 2019-23		TAC	
	4 yr	1 yr	Guidance	Actual	4 yr	1 yr	Guidance	Actual
Portland								
Lady Julia Percy	4%	stable	-5 to 5%	0%	3%	increasing	-5 to 5%	0%
Port Fairy	7%	stable	0 to 15%	-16%	3%	declining	-15 to -5%	+7%
Warrnambool	5%	stable	0 to 15%	-4%	2%	declining	-15 to -5%	+28%sl

	Applied 2025			
	Catch rate 2020-24		TAC	
	4 yr	1 yr	Guidance	Actual
Portland				
Lady Julia Percy	2%	increasing	-5 to 5%	
Port Fairy	2%	increasing	-5 to 5%	
Warrnambool	1%	increasing	-5 to 5%	

Development of the FIS Primary Indicator, and its use in the Harvest Strategy

The historic abundance survey design was last completed in WZ during 2020. Since then, a joint FIS Review completed by MRAG, with the Scientific Working Group involving WADA, VFA and all fishing Zones, concluded historic FIS site were not representative of current or historic fished areas and are likely to be a biased indicator of stocks. WADA commenced a new abundance survey approach in 2021 using fixed transects sampling particularly productive abalone sites used by the fishery, but also including less productive and marginal sites in a stratified design. The other Victorian Abalone Zones are currently involved in a government tender to establish new sites over 2025-2027 to be sampled using the design developed by WADA.

As part of the abundance survey design developed by WADA, old and new surveys will be calibrated, and new Primary Indicators will be developed for use in the Harvest Strategy, involving both absolute and relative estimates of under-size and legal-size biomass and their change through time. Table 3 presents a preliminary assessment of the new abundance survey and estimates of biomass (i.e. WADA 2024), and a comparison to previous survey estimates (i.e. VFA 2020 and WADA 2020). Estimates of density at new survey sites that have been targeted to productive fishing areas are much higher than the very low estimates of density at the old abundance survey sites. Old abundance survey sites monitored a different component of the abalone population, in the hope it would reflect trends in the more productive and fished component. As was clear in WZ as the population recovered after the first AVG mortality, decline was greater and recovery slower on old abundance survey sites, than in productive fished sites. Monitoring the effects of fishing in productive fished sites vulnerable to decline, and the broader population, are both a priority for the fishery and Harvest Strategy, and are the objective of the new stratified abundance survey design.

Higher estimates of density in the new survey sites will not be extrapolated to the same historically-productive reef area as the very low density estimates from the old survey. Current estimates of the area of reef used by the commercial fishery are available from the use of VMS with 1 min logging by all divers while fishing, and now provides good estimates of the area of reef fished at different intensity. New abundance survey sites are targeted to areas with higher fishing intensity, and will only be extrapolated to the area of productive reef identified with higher fishing intensity. Lower density estimates can be extrapolated to broader areas of reef with lower fishing intensity. While the concepts of the design have been finalized, further data about abalone abundance and its variation among strata is needed through time (i.e. years) from the new surveys, to finalise an appropriate design.

Preliminary data from the new survey, together with the data from 1 min VMS, is used to provide preliminary new estimates of biomass (Table 3). Higher densities of abalone from the new survey sites are extrapolated to much smaller areas of reef than the previous survey, and produce similar and higher estimates of biomass to the old abundance survey. Importantly, the new estimates of biomass include the areas with much higher abalone densities and intensity of fishing, and so will also better reflect changes to fished stock. As higher densities of abalone were not included in the old abundance survey, estimates of biomass from the new survey are larger, and with corresponding lower estimates of Harvest Fraction (Table 3). Once more data is available from the new WZ survey, and the similar EZ and CZ surveys, the stratified design and approach to calculation of Primary Indicators will be completed consistently across the 3 fishing Zones.

Table 3. Estimates of Legal biomass density from 3 different abundance surveys within 2 SMU, Reef area for extrapolation of density to Total Legal biomass, and catch targets for different Harvest Fractions and since 2014. These include estimates of density from the 2020 VFA abundance survey at fixed sites, the WADA 2010-2012 survey at random sites calibrated to 2020, and the WADA survey at new fixed sites in 2024. Catch rates are also presented as a percent of those in 2019-20, as an indicator of change in Legal density since the last VFA abundance survey in 2020.

Density (t per Ha)

	VFA 2020		WADA 2020	WADA 2024		% Difference	
	Overs	Unders	Overs	Overs	Unders	Overs	Unders
Crags	1.140	3.270		4.150	10.670	362%	326%
Port Fairy	0.850	2.760	0.680	3.260	8.930	341%	323%
Killarney	0.180	0.270		3.380	4.270	1835%	1580%
Warrnambool	0.310	0.560	0.460	1.880	2.370	477%	419%
All	0.730	1.000		2.890	6.060	397%	607%
Low site	0.060	0.070		1.200	3.870	2000%	5524%

Reef area (Ha)

	Old	New			% Difference	
		Low	Med	Hi	Med/Old	Low/Old
Portland	376	264	156	97	41%	26%
Lady Julia Percy	59	47	28	25	47%	42%
Port Fairy	215	222	151	113	70%	53%
Warrnambool	343	210	138	83	40%	24%

Biomass (t)

	Old	Old/New	Hi	vHi 200min	
Port Fairy	182	74-92	368	156	
Warrnambool	106	39-39	156	56	

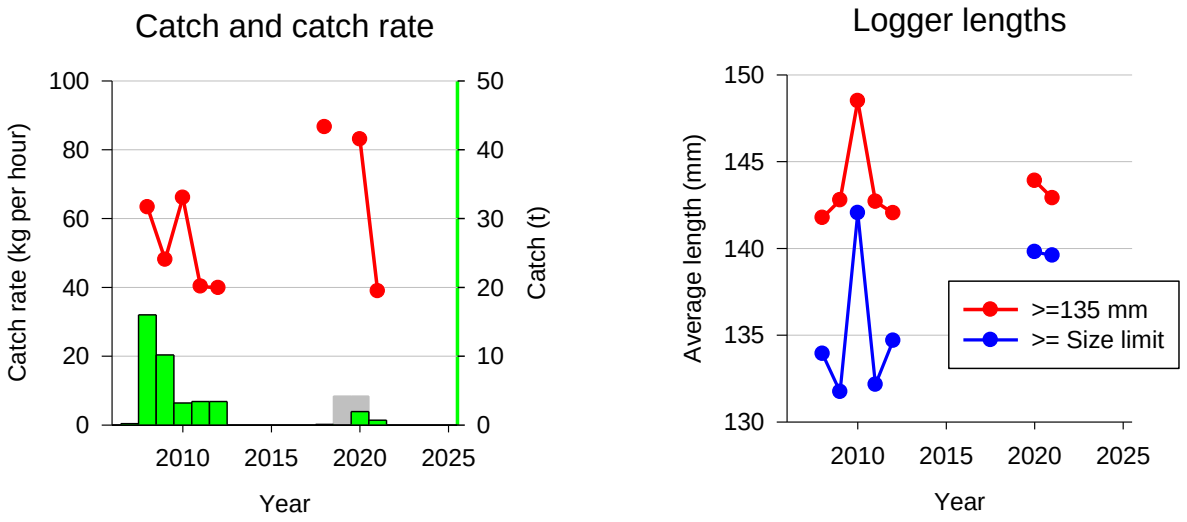
Catch (t)

					Current	Top
	HF%				**14.5**	**22**
Port	**5%**	9.1		18.4	7.8	
Fairy	**10%**	18.2		36.8	15.6	
	HF%				**16**	**16**
Warrna	**5%**	5.3		7.8	2.8	
mbool	**10%**	10.6		15.6	5.6	

Discovery Bay

In recent years, no blacklip abalone catch target has been set for Discovery Bay (i.e. no TAC allocation), and 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.



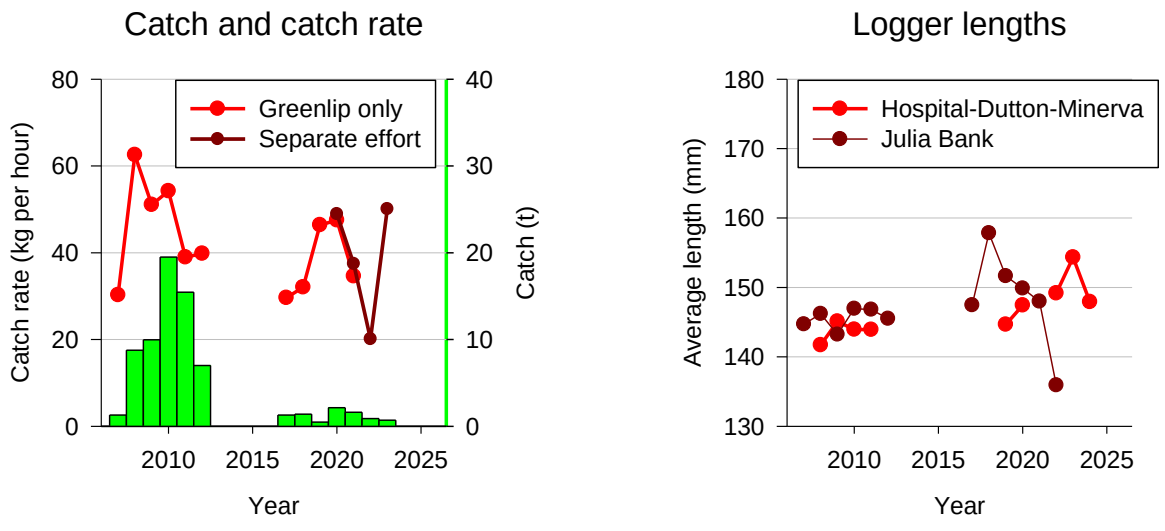
Greenlip abalone

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. Re-fishing 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 6000 greenlip have been measured from 2017-2024.



In recent years, greenlip catch has remained low (i.e. <2.1 t per year, Figure 8) compared to previous years, and 0 t has been landed in the current fishing period to December 2024. 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, catch has returned to the Hospital-Dutton and average lengths have been increasing to about 150 mm, well above lengths landed at Hospital-Dutton during 2007-2015 (Figure 8). As well as changes in average length, the frequency of larger greenlip measured >=160 mm has also increased from the 2007-15 period (average among years of 5.5%) to 2017-2024 (12.5%).

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), that was revised at the 2023 Workshop by reducing the Julia Bank target to 300 kg and a 1.05 t TAC at a voluntary 135 mm size limit.

Table 2. Catch (kg) of greenlip by Reefcode or SMU from April 2017 until December 2024. 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	684	0	12	0	0	696
2024-25	0	0	0	0	0	0	0

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, particularly including 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 Harvest Strategy describes the need to review and revise its approach, and rebuilding targets, during its ongoing development.

WADA and VFA have worked together to review and update the fishery's Harvest Strategy and Monitoring program, while maintaining the intent of the Harvest Strategy. Perhaps most importantly, this has included the establishment of a new fishery-independent abalone abundance survey, and an approach to continue to apply the intent of the Harvest Strategy in the interim, while the new survey was developed and implemented, and with adequate new data available to guide new rebuilding targets. The new approach to the abundance survey involves 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 new sites with fixed transects, 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 across the fishery. In the interim, the stock assessment will continue an agreed approach to application of the Harvest Strategy using the latest available fishery-independent abundance survey data, from both the VFA survey in 2020 and new abundance survey sites, together with the data available from Secondary Indicators in the Harvest Strategy including fishery-dependent monitoring.

In this assessment, estimates of biomass derived from the 2020 VFA abundance survey, and preliminary estimates from the new abundance survey sites to 2024, are used as Primary Indicators, including interpretation relative to the Harvest Strategy Target and Limit Reference Points. Estimates of Legal biomass density from the new survey sites in 2024 are also used to calculate total biomass and Harvest Fractions for future catch recommendations consistent with the Harvest Strategy. Fishery-dependent Secondary Indicators from the Harvest Strategy are also used to interpret change in Legal-biomass from 2020 to 2024, between the different fishery-independent surveys.

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), with two of the five sites 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). From sampling during 2022-24, change in estimates of under-size abalone biomass are available at Crags and Killarney (i.e. +16.7% and -34.6%). The Harvest Strategy details breakout rules if Primary Indicators are below Limit Reference Points at the scale of WZ, but both Primary Indicators 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. Even with consideration of continued development of the new abundance survey, with the stratified design including key fishing areas, there remains uncertainty in temporal biomass changes since 2020. Despite that, increase in standardised catch rates from the commercial fishery since 2020, particularly in productive, high catch reefcodes (e.g. Crags, Killarney etc), suggest further increases in biomass up to 2024-25, while other reefcodes are less optimistic (e.g. Lighthouse). Concerns also remain that the 2020 and historic abundance surveys have not been representative of stocks and their ongoing recovery, and this has been confirmed in the FIS Review and its recommendations to develop the new abundance survey (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 be developed as more data is available from the new abundance survey, and these will form part of the updated 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 declines in Legal biomass in some reefcodes, and broad 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. This provides the basis for strong recruitment to continue the rebuilding of abalone stocks and the fishery over the long-term.

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, should translate to increasing 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 initially declined, they are now more stable. 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 would provide further support for this. 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 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 using the old survey design 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 previous 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 previous 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, to develop the new abundance survey and coordinate its ongoing development with progress in the other zones. Assessment and management of all zones will benefit from the new and coordinated approach to the fishery-independent abundance survey.

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 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 develop a 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 further establishment of new fishery-independent survey sites at Portland, and comparison with historic data. Away from Portland, the WZ stocks and fishery continue to recover from the impacts of AVG over the last >15 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, 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), will be a key challenge for further recovery of stocks and the fishery. Looking further ahead, development of the broader monitoring program and Harvest Strategy rebuilding targets 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 rebuilding, production and 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 its SMU.

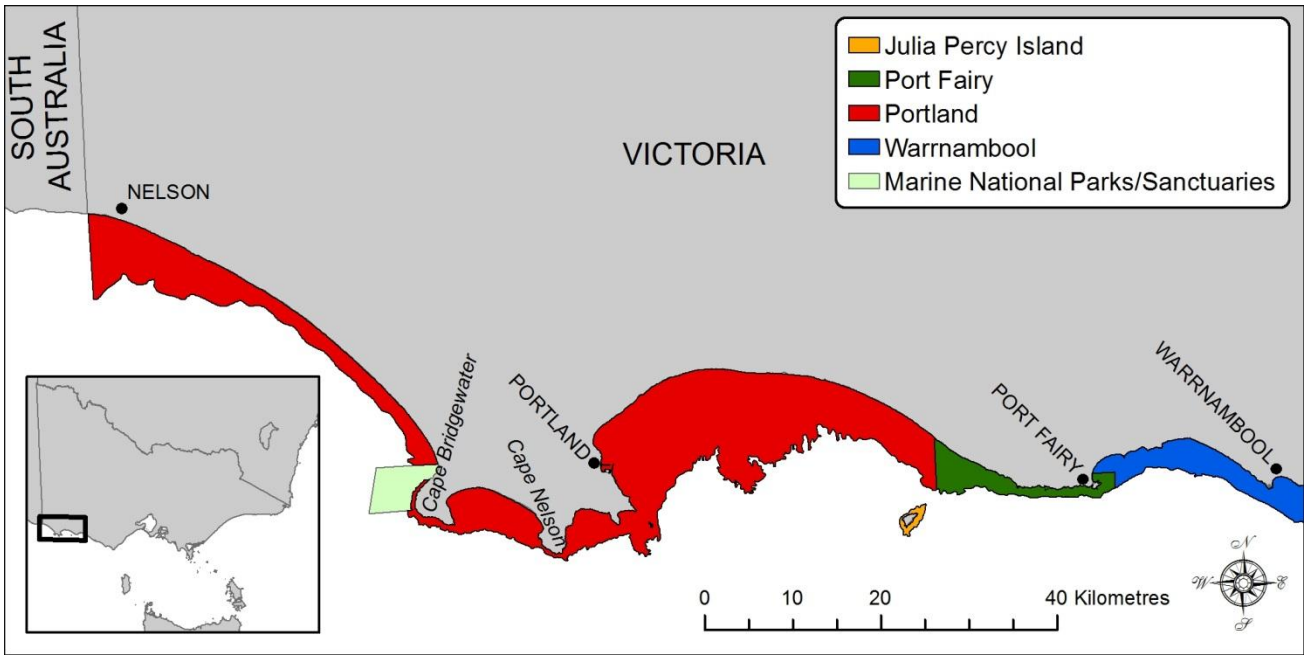
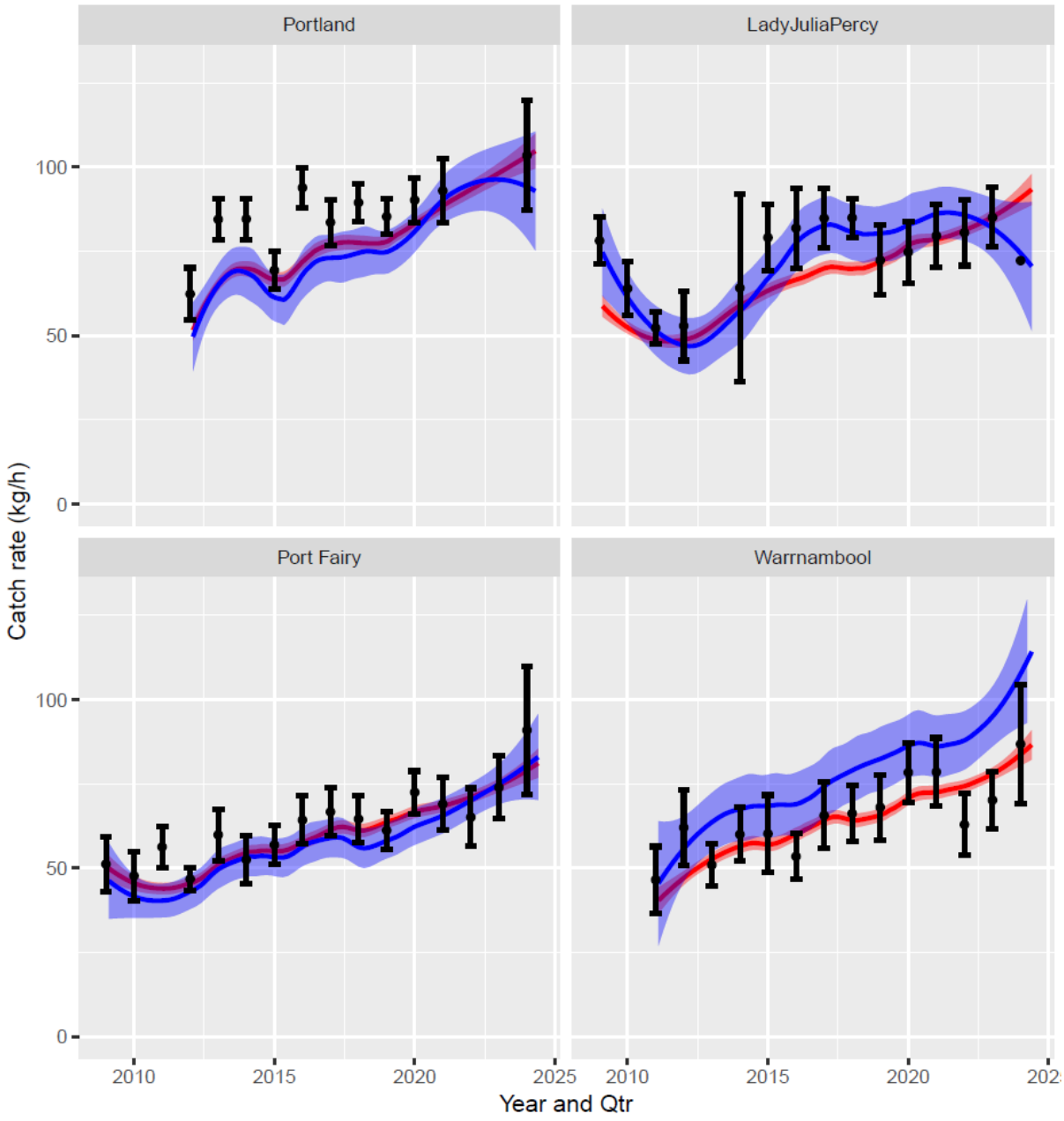


Figure 9. Map of the Western Zone Abalone Fishery, showing Spatial Management Units.

Appendix 2. New approach to standardisation of catch rates.

WADA has been working with VFA as part of the Abalone Scientific Working Group to progress several issues in stock assessment, including an improved and more consistent approach to standardisation across the 3 fishing Zones. Approaches to standardise catch rate are being replaced in the other two Zones by a new approach developed in WZ involving a mixed-effect general linear model. The new approach includes fixed effects for Year and SMU, and random effects for the interaction of Year and SMU, Year and Reefcode within SMU, Quarter within Year, and Diver. The mixed-effect model fits log(Catch) using an offset for log(Effort), that produces the same fit (given the same independent variables) as log(Catch/Effort) used in the existing fixed-effect model, and produces coefficients and predictions for each Area and SMU during each Quarter and Year. A comparison of the two approaches is shown below, and demonstrates the different approaches produce largely similar estimates of standardised catch rate, but also some differences in trend in recent years. While the Working Group continues to develop and consider the new approach, it is expected to replace the existing model and lead to a more consistent approach across the Zones.

Figure 10. Standardised catch rates using the current fixed effect GLM (blue line ± se for each quarter smoothed), an alternative mixed-effect GLM (red line ± se for each quarter smoothed), and raw catch rate (black annual mean and 95% CI of daily catch/effort) for each SMU and Year (i.e. Quota year). Note estimates are adjusted for log-normal bias, the fixed-effect model shows catch rate for the average diver (and other effects) while the random-effect model shows catch rate without the random diver effect (and other random effects), and raw catch rate can be influenced by more days of catch by high catch rate divers.



Appendix 3. 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.