TASMANIAN ABALONE FISHERY ASSESSMENT 2018

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Executive Summary

Total estimated landings for the 2018 Tasmanian abalone fishery were 1177.3 t of blacklip and 133.031 t of greenlip, from a total allowable commercial catch (TACC) of 1,333.5 t. This is a reduction of 227.5 t on the 2017 fishing year, principally from the Eastern Zone (150.5 t), and with minor reductions in the Northern Zone (49 t) and Greenlip Zone (7 t). The Bass Strait and Western Zones were unchanged at 77 t and 717 t respectively. There has been an overall reduction in TACC from a medium term high of 2,660 t in 2010 to address falling stock levels.

The fishery was assessed using an empirical Harvest Strategy (HS) with standardised Catch per Unit Effort (CPUE) data. The HS used three catch rate based empirical performance measures to provide a Recommended Biological Catch (RBC). The RBC from the HS was comparable to the outcomes of the FRAG weight of evidence process. The abalone industry also provided comment on relative stock status, particularly where local knowledge or changes to market preference assists with interpretation of trends. IMAS advice in the form of an RBC is given during the final FRAG and Abalone Fishery Advisory Committee (AbFAC) meetings held in October of each year. Thus this report is a trailing document and serves to summarise the major trends in each fishery, and to document the advice provided by IMAS to the FRAG and AbFAC process for the public record.

An overview and TACC actions taken are summarised below for each fishing zone.

- **Eastern Zone** Overfishing from the 1990s, long-term incremental reduction in fishing ground by destructive grazing from long-spined sea urchins, and multiple marine heat wave events over the past decade have collectively diminished the abalone resource in the Eastern Zone blacklip fishery. During the 2015/2016 austral summer, the East coast of Tasmania was exposed to the longest and most intense marine heat wave (MHW) on record (Oliver et al., 2017a). Reefs north of Cape Pillar were exposed to a 1 in 100 year storm event in June 2016. These two events will have increased natural mortality in stocks, although reduced recruitment from sub-lethal effects of the 2010 MHW may have had a more substantial impact on exploitable biomass in 2018. Patterns observed in the spatial performance measures strongly support the trends in catch rates of a significant reduction in abalone populations. Concerns by stakeholders over the evidence from various indicators for rapid decline in biomass in fishing blocks north of Cape Pillar resulted in a reduction of the Eastern Zone TACC from 293.4 t to 252.1 t for 2019.

- **Western Zone** Catch rates in the majority of Western Zone fishing blocks improved in 2018. As data available suggested stocks were not declining, the TACC of 717 t was maintained for 2019.

- **Central Western Zone** Note: as recommended in late 2017, the Central Western Zone blocks 6A-C were reassigned to the Northern Zone and the Central West Zone removed.

- **Northern Zone** Three of the four major fishing grounds in the Northern Zone (blocks 5, 6 and 31) appeared to be improving, and associated with metarules in the Harvest Strategy, the TACC of 99.7 t was maintained for 2019.

- **Bass Strait Zone** The Bass Strait fishery is stable, but two key fishing blocks, 33 and 38, may need catch reductions in the near future. The TACC of 92.6 t was maintained for 2019, including the newly incorporated fishing blocks of 47, 48, and 49 A–C.

- **Greenlip Zone** The Greenlip Zone has been relatively stable, but through 2018 a rapid decline in abundance was apparent in the Perkins Bay capped area and the Furneaux Group. At the time of the TACC setting process, there had been negligible fishing in Perkins Bay and a small reduction was agreed to, however it appears that declines in abundance were far greater than anticipated with major reductions in CPUE observed, and only 50% of the allocated catch taken by the end of 2018 due to fishers actively avoiding the area, and desire from all stakeholders to divert effort to other regions to minimise longer term consequences. The remainder of the Perkins Bay catch allocation of approximately 10 t was taken from the North-West and North-East capped areas in order to minimise further impact in Perkins Bay. The TACC for 2019 was reduced from 133 t in 2018 to 107.7 t.

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Chapter 1

Introduction

1.1 Overview

An assessment of the Tasmanian Abalone fisheries is required annually under the Tasmanian Abalone Deed of Agreement. This fishery assessment document contains a summary of the available data from 1992 to 2018. This report also provides a chronology of management changes over the history of the commercial fishery Appendix D. The electronic fisheries data logger program generates significant volumes of data than can be reproduced in this report. The spatial indicators provided here are those considered to be most useful at this stage in the development of new data technologies.

1.2 History of the Fishery

Commercial fishing for abalone in Tasmanian waters commenced in the late 1950s with annual catches in the order of 2000 t being landed by the mid 1960s. The fishery has predominantly focused on blacklip abalone (*Haliotis rubra*), with greenlip abalone (*H. laevigata*) typically accounting for around 5% of the total wild harvest in Tasmania. Digitised or hard copies of regulations and catch returns are not available for the fishery prior to 1975, and complete digital records exist from 1975 onwards (fig. 1.1) . Between 1975 and 1984 abalone catches were reported by the skipper of the fishing vessel as estimated weights on a monthly basis. Between 1985 and 1992, catches were reported as landed weights per landing by the diver, again on monthly returns. Estimated weights by block are unavailable for this period, because catches taken from several blocks in one trip may be reported as caught from only one of those blocks. Since 1992, abalone fishers were required to complete and submit daily reports of the landed weight and estimated catch weight in each block fished. The sum of estimated weights by zone is usually within 3% of the sum of landed weights by zone, but between 1992 and 1995 was up to 10% less.

1.3 Management Plan

A draft Abalone Managemnt Plan and Policy documents were prepared in the late 1990's and revised in 2000. A new Tasmanian Abalone Management Plan and Policy document will be completed in 2019. An operational document for the fishery is published prior to the commencement of each fishing year, detailing size limits, quota for each zone, spatial management arrangements and any other operational rules that govern the commercial harvest of abalone in Tasmania.

1.4 Non-commercial catch

A survey of recreational abalone fishing is conducted by IMAS biannually. The most recent survey of recreational abalone fishing catch was undertaken for the 2017-18 season and estimated that 22.1 t of

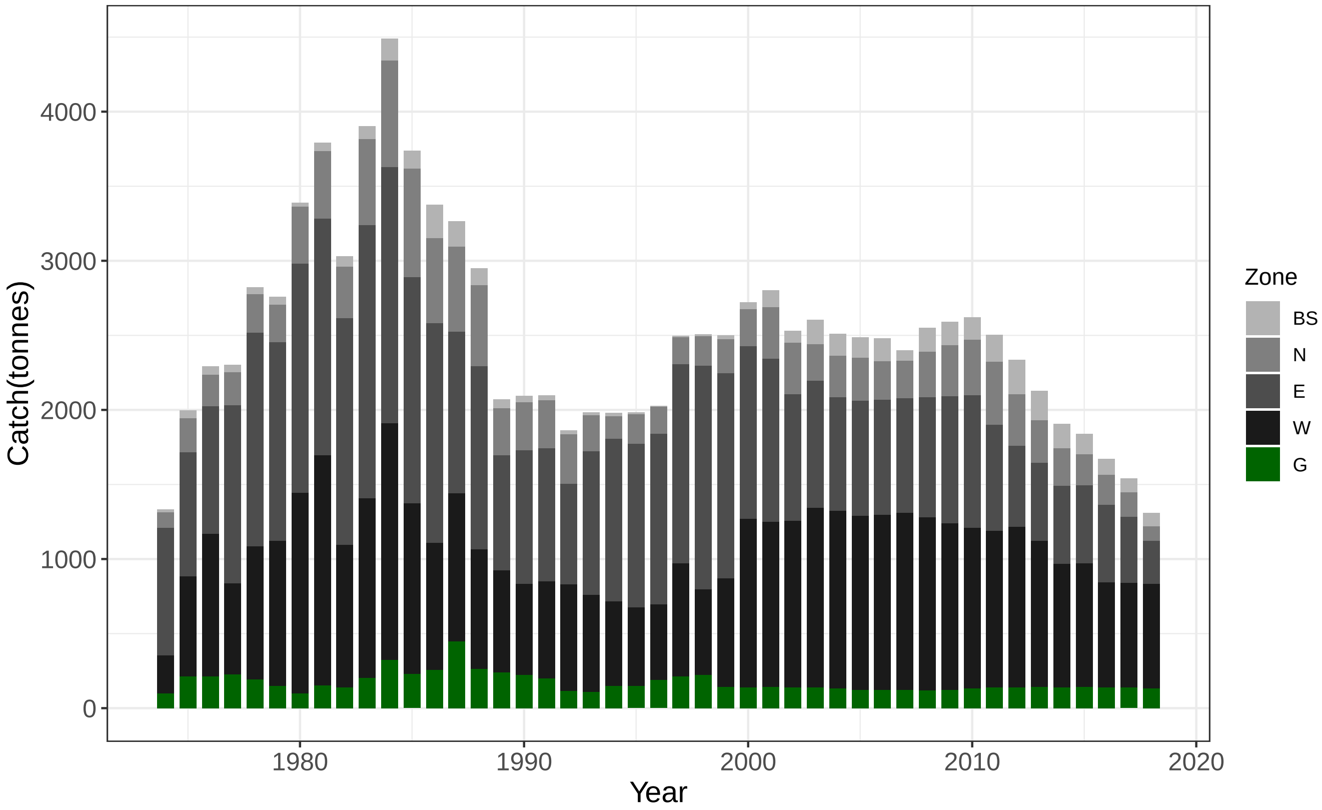


Figure 1.1: *Annual blacklip abalone (Haliotis rubra) and greenlip abalone (H. laevigata) from 1974 to 2018. Bars colour coded by current zonation system.*

blacklip and greenlip abalone, or 1.7% of the total Tasmanian abalone catch, was taken by recreational fishers (Lyle, 2018). The number of recreational abalone diving licenses issued by DPIPWE for the year ended 2018 was 10,797.

Abalone are caught in Tasmanian waters as part of cultural fishing activities by indigenous people. This catch is not quantified but is believed to be negligible. Catch is also taken under permits for special events and research purposes. Illegal fishing is known to occur but no estimates of this catch are available.

1.5 Abalone Biology

1.5.1 Reproduction and Dispersal

The commercially harvested abalone species in Tasmanian (blacklip abalone *Haliotis rubra* and greenlip abalone *H. laevigata*) are dioecious broadcast spawners with complex reproductive patterns, at least in Tasmania. Gravid animals can be found year round, with little strong evidence of a peak reproductive season. Larvae are lecithotrophic and while considered to be pelagic, the embryos are negatively buoyant for the first 24 hours before. The larval phase of *H. rubra* is relatively short (5 to 15 days), and dependent on water temperature (McShane, 1992). Manipulative field experiments with blacklip abalone suggested that local recruitment was highly dependent (Prince et al., 1987) on local abundance. Molecular studies were able to confirm that localised recruitment (approximately 100m) in blacklip abalone was a consequence of limited larval dispersal (Temby et al., 2007; Miller et al., 2009). These field and molecular studies are both suggestive of potential for a strong local stock/recruitment relationship, yet this has never been established as a general phenomena. Greenlip abalone in Tasmania generally occur in more simple habitats, with low profile reef and seagrass, and are commonly found on the reef/sand edge in areas with high tidal flows. Molecular studies of connectivity for greenlip abalone (Miller et al., 2014) suggest that connectivity among adjacent populations is also limited, but population structure is two orders of magnitude larger than found for blacklip abalone. Miller et al. (2014) confirmed the distribution and connectivity of this species does conform to a meta-population structure with populations linked over tens of Kilometres.

1.5.2 Movement and Diet

Movement of adult blacklip and greenlip abalone is limited, with most animals resident within small sections of reef (10's of metres) for months or years. Movements of individuals do occur over small spatial and temporal scales, but do not result in emigration from sites. Both species tend to remain on a recognisable home sites or 'scar', and feed predominantly on drift algae, but may also consume attached kelp (C. Mundy, personal observation). Both Tasmanian abalone species are known to consume algae from red, green and brown groups, though dietary preference and availability have been poorly studied in Tasmania. Guest et al. (2008) used isotope and fatty acid signatures to examine dietary habits of blacklip abalone on both East and West coasts of Tasmania, and found that brown algae formed the major portion of abalone diet, but that bacteria and diatoms are also feature in abalone diets, most likely from break down of detritus/drift algae.

1.5.3 Growth and Mortality

Research on individual growth of both blacklip and greenlip abalone has been conducted for more than three decades, yet robust descriptions of growth remain elusive. The two primary methods utilised were ageing by shell rings and growth increments by tag-recapture. Growth rings in the shell spire have been largely discarded as imprecise and the assumption of that growth rings are laid annually has not been well substantiated. Whereas growth increments based on recaptures after 12 month appear to routinely underestimate growth, and, recaptures are typically low and often too low to make meaningful conclusions about growth (Haddon et al., 2008; Helidoniotis and Haddon, 2013, 2012). Within Tasmania there is some evidence that the shape of the growth curve changes with latitude (Haddon et al., 2008), further complicating our understanding of growth and the calculations that depend on an accurate model of abalone growth. Where adequate data sets are available, the inverse logistic growth model (Haddon et al., 2008) appears to be most appropriate for describing abalone growth.

Annual growth increments of pre-reproductive blacklip abalone range between 20mm and 30mm annually (Haddon et al., 2008). A reduction in average annual growth increments coincides with onset of reproductive maturity, which occurs at approximately age five. The onset of emergence from the cryptic phase also coincides with the onset of reproductive maturation, although more variable. Full emergence from crypsis in the majority of Tasmanian blacklip abalone fisheries occurs at a shell length greater than the Legal Minimum Length. This behavioural trait differs from observations in mainland blacklip abalone fisheries, and, limits the usefulness of fishery-independent surveys of pre-recruit abundance.

Maximum size of Blacklip and greenlip abalone in Tasmania exceed 200mm in shell length, and longevity is thought to be in the order of 40 to 50 years. Natural mortality appears to be very low, with few significant predators of the adult phase. Predation on the juvenile phase is unknown, but assumed to be higher than on post-emergent abalone. The longevity of both blacklip and greenlip abalone means that stock are not lost with conservative management decisions.

1.6 Ecosystem Interactions

1.6.1 Climate change related effects

There have been clear changes in subtidal reef habitats on the East coast of Tasmania over the past four decades, with the southward retreat of *Macrocystis pyrifira* beds and the southward expansion of *Centrostephanus rodgersii* two easily observed examples. The majority of destructive grazing by *C. rodgersii* is deeper than the typical depth range exploited by abalone fishers (Johnson et al., 2011), but there are localised direct impacts on abalone populations in sheltered reef systems north of Maria Island. Destructive grazing of *C. rodgersii* in the Kent Group (north of Flinders Island) has been tracked over the past 30 years, and pre-dated the expansion of this species on the mainland coast of Tasmania (Johnson et al., 2005).

The frequency and intensity of Marine Heat Waves (MHW) has recently been documented for Tasmania's east coast (Oliver et al., 2017b). The East coast has experienced several minor and two major marine heat wave events over the past two decades (2009/2010 and 2015/2016). These MHW's to result in low level mortality of wild abalone in late summer, over most of the Tasmanian East coast (Bicheno south to the Actaeon region), although the magnitude of the extent of the MHWs on exploitable biomass remains unquantified. No mortalities were observed on the West or North coasts. There is possibly a third minor and localised event in the summer of 2000/2001, although no reports of mortalities of wild abalone were recorded from that period. There is no research and no understanding as to whether these changes have also affected coastal productivity in a way that might effect abalone population dynamics. In contrast to the East Coast, there are no reports from abalone fishers of dramatic ecosystem changes on the north, south or west coasts or from King and Flinders Islands.

1.6.2 Effects of removal of abalone on habitat

Associated with harvesting of abalone stocks, there have been persistent reports from divers of changes to reef habitat. These changes appeared to follow extensive depletion of abalone populations by fishing, suggesting a level of interdependency between abalone and habitat. Perceived changes include a reduction in coverage of crustose coralline algae and its subsequent replacement by sediment, other encrusting organisms and algae, and potential flow on effects to juvenile abalone recruitment (McShane and Smith, 1991; Shepherd and Turner, 1985). Globally, over-harvesting of herbivores is recognised as one of the main factors contributing to changes in marine systems (Burkepile and Hay, 2006). However, it appears unlikely that this broad concept applies to abalone fisheries. A review of ecological impacts of fishing found little evidence of ecological impacts of harvesting abalone (Jenkins, 2004), and concluded that abalone harvesting was relatively 'benign'. A field study exploring links between abalone abundance, fishing pressure and key habitat characteristics Valentine et al. (2010) found little evidence to support the assertion or perception that removal of abalone from subtidal reefs leads to environmental change. Manipulation of abalone densities also found little evidence to suggest direct effects of abalone on local benthic communities (Strain and Johnson, 2010), other than on encrusted red algae (ERA) (Strain and Johnson, 2012). An investigation of the degree of association between abalone and ERA (*Hildenbrandia spp* and *Peysonellia spp*) found that abalone were more frequently associated with these species than expected by chance, but it was not clear whether these species recruit to the substrate beneath abalone home-sites, or whether abalone choose home-sites where there these species are present (Valentine and Mundy unpublished data).

Since the mid 1980's Tasmanian abalone fishing vessels have fished live (i.e. not anchored), such that anchor damage is negligible in this fishery.

1.6.3 Bycatch and other species interactions

There is no bycatch associated with this fishery. All abalone are hand-harvested by divers operating on low pressure surface supply (hookah). The small vessel size used by most abalone fishers, and the shallow water and proximity to the exposed coast also limits negative impacts on other mobile fauna.

A poorly understood aspect of abalone fishing on ecosystems is whether there is a potential for a competitive release effect on other coexisting grazing species. Anecdotal information from abalone fishers in other states suggests significant depletion of abalone populations allows more rapid expansion and dominance by the long-spined sea urchin *Centrostephanus rodgersii*. Experimental manipulations of interactions between *H. rubra* and *C. rodgersii* are not conclusive (Strain and Johnson, 2009), and limited by the artificial environment in which the experiments were conducted.

1.6.4 Trophic effects

There are few significant predators of emergent *Haliotis rubra* in Tasmania, and most predation events are opportunistic or target weakened individuals. Reduced grazing pressure by removal of significant biomass of this macro-invertebrate grazer is unlikely to lead to habitat change (Valentine et al., 2010), as there is an oversupply of kelps across the fishery, which is subject to seasonal storms generating drift algae. Much of the food consumed by abalone is likely to be drift algae rather than attached growing plants.

Chapter 2

Methods

2.1 Catch and Effort Data - fisher returns

The primary data used in this assessment are sourced from fishery-dependent catch and effort logbook data. A research program has been in place at the IMAS Taroona laboratories to collect biological data on growth rate and reproductive maturation for several decades. There is however no strategic collection of fishery-independent abundance data or a time-series of fishery independent data on population size structure. The system for capturing Catch and Effort returns from fishers, and the requirements for reporting have changed since the inception of the fishery. Some of the original data is no longer available, and the working time series commences in 1974. From 1974 to 1991, the data are contained in archived extracts in electronic form from an original reporting system. Noting that computer systems and databases were not available in the 1970's and were unlikely to be mainstream in Government departments and agencies until at least the mid 1980's. A new production database was implemented in 1992, with an entirely new relational database structure. The 1992 production database was replaced in 1997, with minor structural changes. A further complication arises in 2000 with the introduction of defined management zones (Eastern Blacklip Zone , Western Blacklip Zone, and Greenlip Zone) each with their own TACC, and with the introduction of finer scale reporting sub-blocks. Further spatial partitioning of the blacklip fishery occurred in 2001 (Northern Blacklip Zone), 2003 (Bass Strait Blacklip Zone), 2009 and 2013 (Central Western Blacklip Zone). Several of the Zone boundaries were created at sub-block boundaries rather than block boundaries, which creates challenges for linking historic block level trends to current sub-blocks which are now split by zones.

2.1.1 Catch and Effort Reporting requirements

In the Tasmanian Abalone Fishery catch, effort and location are reported daily. As database structures are upgraded and operational rules are modified over time, this triggers changes in the data, including frequency of returns, whether the diver or the skipper was required to submit the returns, and the spatial scale of reporting. Since 1992 the diver has been required to submit catch dockets for every fishing day within a short mandatory return period, usually 48 hours. Up to and including 2000 catch and effort was reported by Block with 57 reporting blocks encompassing the coast of mainland Tasmania and offshore islands, and from 2001 the majority of reporting Blocks were split into between two and five sub-blocks. Currently, fishers are required to report estimated weight of catch and effort in each sub-block for each day of fishing, with a hard copy of the docket submitted within 48 hours.

2.1.2 Data extraction and filtering

A mirror of the DPIPWE Oracle catch and effort database is maintained by IMAS, inside its secure server farm. The mirror contains historic tables for data between 1985 and 1992, a static schema containing data from 1992 to 1997, and a dynamic schema containing data post 1997, with updates provided weekly. The catch, effort, vessel and fisher identity details are extracted via three views created in the IMAS mirror, and maintained by IMAS. Data are retrieved from the IMAS Oracle catch and effort database views via R statistical software R-Core-Team (2017) using the `RODBC` package (Ripley and Lapsley, 2015) for direct connection to databases. All filtering, error traps and subsequent analysis of the fishery-dependent data are undertaken within R. The first stage automates data extraction, filtering and removal of erroneous records, identification of doubling up (team dive) events, and preparation of mixed species effort values resulting in a working data set. The second data analysis stage, prepares data for and runs the CPUE standardisation, executes the empirical Harvest Strategy and produces a range of summary plots for the Abalone Fisheries Resource Advisory group meetings and this Assessment document.

2.1.3 Quality Assurance

The catch and effort database contains a very small proportion of detectable erroneous records. The nature of the detectable errors are incorrect effort or catch values leading to impossible catch rates (e.g. > 500 Kg/Hr; no effort; complete duplication of records. A significant number of records are not usable (equivalent to approximately 200 tonnes) from 1992 and 1993 as the estimated weight field is NULL, even though there were hours and landed weights recorded. The majority of the records where estimated weight is NULL may be usable, but requires further validation and filtering procedures to be developed.

2.1.4 Standardisation

Catch per Unit Effort (CPUE: Kg/Hr) were standardised prior to use in the Harvest Strategy. Standardisation was completed using the `r4cpue` R package (Haddon unpublished) with the following base model;

CPUE = Year + Diver + Month + DoubleUps

All four variables are categorical and specified as Fixed Effects. The Doubleups variable identifies fishing events where two divers fish from same boat, usually on hookah with a T-piece. Geometric mean CPUE presented are always bias-corrected (BC), and standardised means are always displayed with 95% confidence limit error bars.

At this stage changes in size limits are not captured in the standardisation, although research on how best to achieve this is underway. Initial increases in size limits may decrease CPUE depending on the level of depletion of stocks. Size limit increases in the Tasmanian abalone fishery are usually in the order of a few millimetres at a time (although size limit decreases have often been in the order of 5mm and on occasions 13 mm), and animals that might have been taken at the start of the fishing year under the old size limit will usually grow through the size limit in under six months.

2.1.5 Treatment of mixed species fishing data

Mixed species (blacklip and greenlip) fishing occurs across a number of reporting blocks, but accounts for relatively little of the overall blacklip catch. Divers primarily target one species and take the other as a by-catch, but there are some locations where one species is targeted in the morning and the other targeted in the afternoon. Calculation of catch per unit effort (CPUE) is non-trivial when mixed species fishing occurs as several permutations of fishing practices are confounded with permutations in the way catch is reported.

For this assessment, the following adjustments were made to the effort component for calculating CPUE when mixed species fishing occurred (greenlip and blacklip abalone are landed on the same day by one diver);

- Where the target species accounts for less than 10% of the daily total catch, those records are excluded from the CPUE calculations for the target species.
- Where the bycatch is greater than 10% of the daily total catch, a new continuous variable containing the proportion of daily catch is added to the CPUE standardisation as an independent covariate.
- All records are retained for catch totals.

2.2 Catch sampling - factory measuring of length-frequency

Collection of length-frequency data from samples of landed commercial abalone catches (catch sampling) was patchy up to 1998 with no data collection occurring within large blocks of years. From 1998, a trial photographic catch sampling program was implemented, with divers submitting photographic samples of their catches with details of the location from where the catch was taken. The photographic program was terminated in 2000 due to inconsistencies in the photographs and a declining participation.

Between 2000 and 2008, diver's catches from around the State were routinely sampled by IMAS research staff at abalone processing factories. For each catch sampled, a tray or crate of abalone was selected at random and the first 100 abalone from that sample measured. Most samples were obtained from catches landed from the south east and east coasts. The reason for this focus was the challenge of identifying source locations of abalone landed within multi-day, multi-diver, multi-block fishing trips to the west coast and northern remote islands. Catches from the north and west coasts have also been sampled, at a lower frequency. The majority of samples obtained are from the blacklip fishery, but a small amount of samples from the greenlip fishery have been sampled although with patchy spatial coverage. Since 2008, market measuring has been undertaken by several of the major processors who together process over 50% of the Tasmanian blacklip catch. Processor staff measure samples of 100 abalone from catches using electronic measuring boards. Length measurements were obtained using the same IMAS supplied electronic measuring board and protocol used by IMAS staff described above. From 2015 the catch sampling program declined due to difficulties in maintaining voluntary participation in the program despite the efforts of IMAS staff.

2.3 Geo-referenced fishery-dependent data

Fine spatial scale information has been routinely obtained from fishers in the Tasmanian Abalone Fishery since 2012. This was achieved by issuing all commercial abalone divers with a robust vessel GPS receiver/data logger unit with internal Lithium Ion battery, encased in an IP65 housing, and an submersible depth/temperature logger. The position data loggers were pre-set to record standard National Marine Electronics Association (NMEA) strings (RMC, GSA) at 10 second intervals to a standard SD memory card. An important component of monitoring activity of a dive fishery is the depth profile at which fishing occurs. The depth data loggers (Sensus Ultra, Reefnet Inc), also pre-set to record at 10 second intervals, were attached to each fishers weight vest. The depth loggers commence logging when pressure exceeds a pre-set pressure threshold, typically equivalent to 0.5m depth (1111 mBar), and cease logging when pressure drops below that threshold, providing an automated system for determining when fishing is taking place.

At three monthly intervals the GPS and dive loggers, are exchanged to enable data retrieval. The separate position and depth data streams are merged on the date/time stamp, and position data are filtered so that only position information is used where fishers are diving. This provides a data stream of date/time, position, depth and temperature at 10 sec intervals for the duration of every dive. The position and depth data streams are merged on the date/time stamp, and position data are filtered to exclude non-diving position data. The data are archived in a SQL Server database utilising Open Geospatial Consortium (OGC) compliant geometry data types to store the raw position data as spatial points. Details of the dataloggers, database and analytical methods applied to the spatial dataset are described in detail by Mundy (2012).

In this assessment several spatial indicators are presented as supporting indicators for the CPUE based performance measure. As a measure of the gross area supporting the fishery, a zone level count of the number of hexagonal grid cells where a minimum of 30 minutes of fishing was observed is provided, along with the reported catch divided by the number of hex cells as a measure of average productivity per hex cell. For each reporting block, three simple spatial indicators area presented –Kilograms Landed/Hectare (KgLa/Ha), Maximum dive distance (Max Distance), and metres of reef fished/Hour (Lm/Hr). All three spatial indicators are derived from the spatial dive data, with the dive area obtained from the area of the bivariate Kernel Utilisation Distributions (KUD) 90% isopleth. The 90% isopleth identifies the maximum footprint of the dive, but the area actually searched by the diver is typically much less. The distance measure used in the Max Distance and Lm/Hr spatial indicators are derived from the maximum distance between any pair of vertices on the 90% isopleth for a given dive (Mundy, 2012; Mundy et al., 2018b). These three indicators provide alternative information about fishing performance, and combined with CPUE (Kg/Hr), provide all possible combinations of weight, time and area (weight/time, weight/area, and area/time).

Effort captured on the GPS and depth data loggers is summarised by 5 m depth bands (0 -5, 5 -10, 10 -15, 15 - 20, > 20) in order to assess changes in the proportion of fishing effort across the normal depth range. This is achieved by summing the number of points in the raw XY data series within each depth band, pooling across divers. The recording frequency of the depth and GPS data loggers is 10 seconds, thus six points equates to one minute of fishing effort. Catch rate (CPUE Kg/Hr) is also calculated for each depth band, using the average dive depth from the KUD 90% isopleth. Summary figures are only presented for area where there has been substantial change over the six year data period (2012 - 2017).

The total area of reef utilised to land the catch taken is determined by an overlay analysis of the raw position/depth spatial points dataset with a 1Ha Hexagonal grid (Mundy, 2012; Mundy et al., 2018b). This analysis provides a summary spatial grid dataset with the total annual effort in minutes, total catch, and number of divers working in each 1 Hectare grid cell. This spatial grid database is used here to produce concentration area curves as a measure of changes in overall reef area utilised to support annual harvests, and any changes in the inequality or spread concentration of harvest across the total reef area.

2.4 Harvest Strategy

An Empirical Harvest Strategy (HS) has been developed for the Tasmanian Abalone Fishery with the primary inputs being fishery-dependent catch rate data. This eHS is based on a Multi-Criteria Decision Analysis (MCDA) framework, in the form of a simple weighted-sum approach. The HS has been reviewed (Buxton et al., 2015), and subjected to testing via Management Strategy Evaluation (Haddon and Mundy, 2016; Mundy et al., 2018b). This HS identifies aspirational targets for the fishery and attempts to manage the fishery towards that target. The HS is conditioned and run at the scale of individual reporting Blocks to arrive at a combined score, followed by a Control Rule to assign a recommended management action based on the combined score. Impacts of CPUE changes are taken into account when reviewing any changes in recommended biological catch suggested by the empirical Harvest Strategy.

2.4.1 Selection of Performance Measures

Over the past decade annual reviews of abalone fishery performance was through an expert driven, weight of evidence approach, considering magnitude of catch rates, trends in catch rates and spatial structure in the distribution of effort. The HS formalises the previously subjective process, by developing Reference Points (RP) for three Catch per Unit Effort (CPUE) performance measures (PM) previously evaluated in graphical form. In this assessment, the three performance measures used were:

1. Target CPUE – the current CPUE scored against a target CPUE defined by Block
2. Gradient1 - gradient of change in CPUE in the past 12 months (current year over the previous one year).
3. Gradient4 - gradient of change in CPUE over the past four years including year to date.

2.4.2 Performance Measure scoring functions

The scoring functions incorporate targets and limits that are analogous to classical target and limit reference points. A scoring function is established for each PM, with the value of the PM (e.g. Target CPUE) scoring between 0 and 10. For all PMs the target is always a score of 5, with 0 implying the worst under-performance and 10 the highest over-performance. The reference period for determining the Target and Limit Reference Points for the scoring functions was restricted to catch and effort data between 1992 and the year preceding the current year i.e. for the 2017 assessment year, the reference period is 1992 –2016. Prior to 1992 there were substantial differences in the reporting and return of catch dockets, such that the recorded daily effort prior to 1992 is not considered sufficient for assessment purposes (see section section 2.1.1).

For the 2015 Tasmanian Abalone Fishery Assessment the upper and lower limits for the CPUE Target scoring function was set at $\pm$ 45% of the CPUE target value where the target was less than 90 Kg/Hr, and $\pm$ 55% where the target CPUE was above 90 Kg/Hr, and the upper and lower limits of the Gradient 1 and Gradient 4 PM's were set at $\pm$ 0.4. Investigations of these one-size-fits-all global parameters indicated that one or more of the PMs were ineffectual in some blocks where the range of the PM over the history of the fishery was much smaller than the global settings, and/or the rate of improvement was substantially different from the rate of decline. For this assessment (2017) the upper and lower scoring function limits for all three PMs were determined for each individual statutory reporting block as follows. Firstly the reference period is defined as all years up to but not including the current year i.e. 1992 –2016. The range of each PM was determined over the reference period, and then that range was extended by 10% in either direction. The rationale for extending the observed range is that within the reference period, fishing pressure has not led to biological collapse of populations, thus using the actual range observed would risk creating an overly conservative Harvest Strategy. For the majority of the high yielding statutory reporting blocks, the extended range values used in this assessment are smaller than the global parameters used in the 2015 fishery assessment, and therefore more conservative (Mundy and Jones, 2017).

Scoring functions for CPUE Performance Measures

1. Target CPUE The objective of the Target CPUE PM is to maintain CPUE at or above a target value (i.e. 5 or greater on the PM scoring function). Following initial presentations of the MCDA Harvest Strategy at the June 2014 FRAG meeting, and at a subsequent workshop research/industry workshop (19/06/2014) it was agreed that an empirical process would be used to determine CPUE targets for each reporting block, based on mean annual CPUE back to 1985. A range of options for establishing appropriate CPUE targets were proposed included median annual CPUE (50^{th} quantile), and more precautionary targets such as the 55^{th}, 65^{th} and 75^{th} quantile of the annual CPUE. As the time series of data used to determine the CPUE target excludes the period of low CPUE during the late 1980's and early 1990's, a mildly precautionary approach using the 55^{th} percentile was adopted.

   The Target CPUE was determined for each statutory block, and scoring function (fig. 2.1) implemented according to the magnitude of the CPUE Target (see section 2.4.2, orange arrow). Where the current standardised CPUE is below the target CPUE, a low score is achieved (red arrow), and when the current CPUE exceeds the CPUE Target a high score is achieved (green arrow).

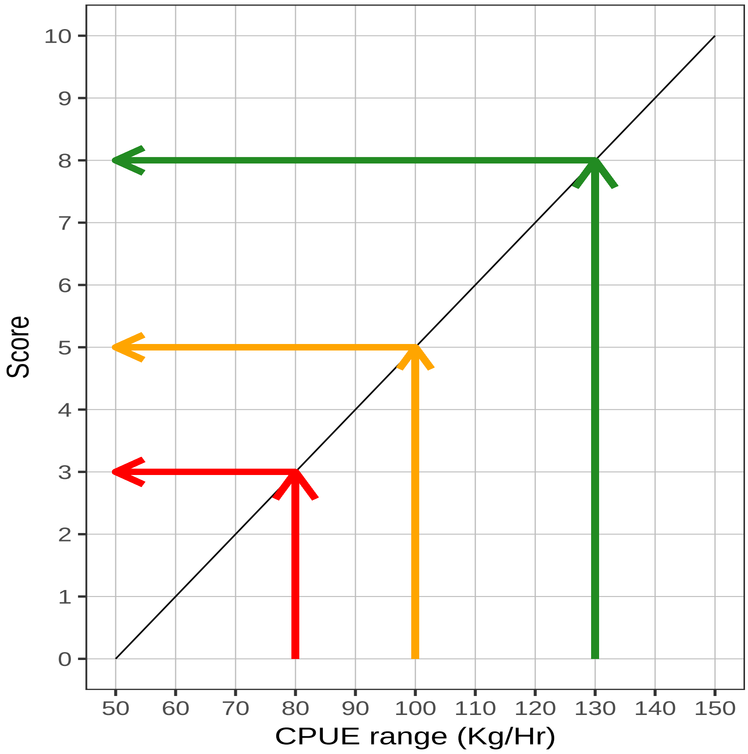


Figure 2.1: *Illustration of the translation of an observed CPUE relative to a defined Target CPUE into an MCDA score. Two instances are shown, the $CE_{b,T}$ are 80 and 120 Kg/Hr and the ΔCE are 40 and 60 Kg/Hr.*

2. Gradient 4 CPUE The objective of this scoring function is to recommend positive increases in the TACC if the gradient of CPUE over a four year period is increasing (provisionally $n = 4$) and conversely it recommends decreases in the TACC if that gradient is negative (fig. 2.2). The assumption is that where TACC is constant or decreasing, and a negative CPUE gradient is observed, the harvest level is likely to exceed recruitment to the fishery. As CPUE is a relative measure for particular spatial assessment units, so the changes in CPUE through time need to be converted to proportional changes through time otherwise areas of different productivity would be treated differently.

   CE$_{b,y}$ is the CPUE in block b in year y, and *pCE*$_{b,y:z}$ is the proportional change of CPUE in year y relative to year z. If w years are used as the comparative period then $z = y_0 - w - 1$, and $x = 0..w-1$, where y_0 is the current year. Thus if w is four years,

$$pCE_{b,y-x:z} \quad = \quad CE_{b,y-x}/CE_{b,z} \tag{2.1}$$

   The performance measure is the gradient of the linear regression between the *pCE*$_{b,y}$ and the sequence $1..w$:

$$pCE_{b,y} = const + grad \times y \tag{2.2}$$

   With limits imposed such that the score is constrained between 0 – 10. If these limits are reached often or never reached, then the range of potential changes $(-a–a)$ would need to be modified. For this assessment, the range of observed slopes over the reference period for each individual block is extended by 10%, with $-a$ and a set as the lower and upper extent of the extended range. As for the CPUE Target example, where the current CPUE gradient is below the target of zero a low score is achieved (red arrow), and when the current CPUE gradient exceeds the Target a high score is achieved (green arrow).

3. Gradient1

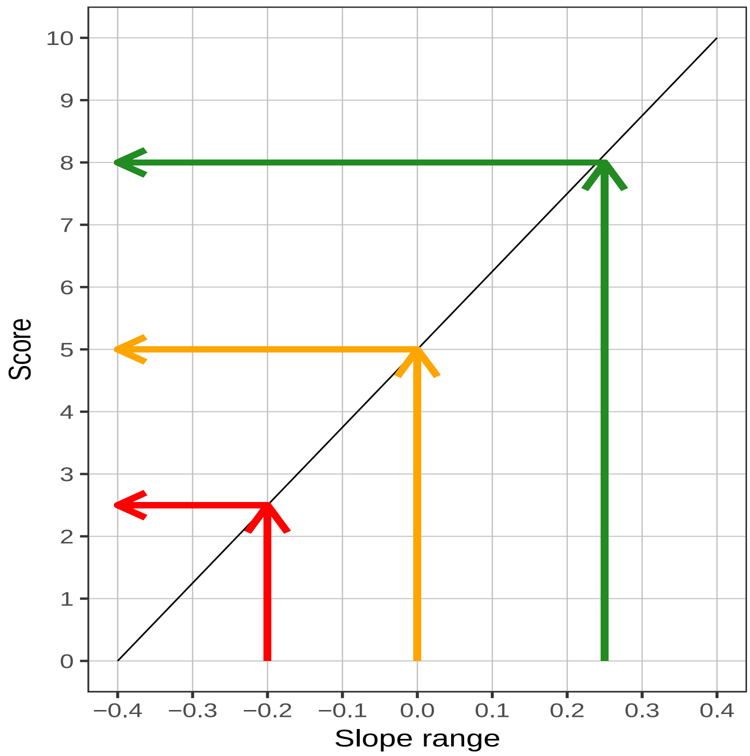


Figure 2.2: *Illustration of the translation of CPUE gradient across a four year period into a score.*

The objective of this scoring function is to highlight occasions when performance of the fishery is changing rapidly. Thus where rapid increases in CPUE between the current year and the previous year are observed, it acts in addition to the Gradient 4 PM to recommend increases in TACC, and conversely recommend decreases in the TACC if there are recent rapid decreases in CPUE. The scoring function process for Gradient 1 is the same as for Gradient 4 (fig. 2.2)

$CE_{b,y}$ is the CPUE in block b in year y and this is used to calculate the performance measure Gradient 1:

$$Gradient1 = \left(\frac{CE_{b,y}}{CE_{b,y-1}} - 1 \right) \tag{2.3}$$

2.4.3 Performance Measure Weighting and Combined Score

A level of importance is assigned to each PM in the Harvest Strategy, by applying a weighting variable. The PM weights can be varied according to the preferred strategy, to emphasis or dampen the contribution of the PMs. For example in a rebuilding phase a higher weight is given to the CPUE Target PM, whereas once the fishery has reached the CPUE Target, this variable can be down-weighted, and emphasis placed on the Gradient 4 PM to maintain continuity. The final combined index of performance is then a sum of the PM score x PM weight, for all PMs (table 2.1).

Table 2.1: *Harvest Strategy performance measures and weights for this assessment.*

	TARGET CPUE	**RATE1**	**GRADIENT CPUE**
PM SCORE	a	b	c
PM WEIGHT	0.65	0.25	0.10
PM TOTAL	a x 0.65	b x 0.25	c x 0.10
COMPOSITE INDEX SCORE	Σ((a x 0.65) + (b x 0.25) + (c x 0.15))		

2.4.4 Control Rule for TACC Adjustment

A control rule system is applied to the composite score to determine the action to be taken. The control rule system proposed is based on a similar system suggested by Dichmont and Brown (2010). If the composite index score is close to the target score of 5, there is no change in TACC for a given spatial assessment unit (e.g. Block). A TACC reduction is required if the composite index score is less than 4.5, and a TACC increase may be taken if the score is greater than 6 (table 2.2).

Where the control rule results in a TACC decrease, the Control Rule specifies the minimum reduction required given the Composite Score, whereas for TACC increases, the Control Rule specifies the maximum increase. TACC increase could optionally not be taken if arguments can be rationalised to support the status quo (e.g. market dynamics). The logic here is that for long-lived species such as commercially exploited haliotids where adult mortality is relatively low, from a biological stand point there is little to be lost in delaying a TACC increase by 12 months.

Table 2.2: *Control rule applied to combined performance management score*

Composite Score	< 1.0	1.0 –2.0	2.0 –3.0	3.0 –4.0	4.0 –5.0	5.0 –6.0	6.0 –7.0	7.0 –8.0	8.0 –9.0	> 9.0
TACC Adjust	−75%	−25%	−20%	−15%	−10%	NC	5%	10%	15%	20%

Consideration of individual scoring systems, weighting coefficients, the control rules and any constraints are on-going through a series of formal workshops with experienced fishers. This Harvest Strategy has been tested by Management Strategy Evaluation (Haddon et al., 2014) and found to be effective. Ongoing testing and exploration of the properties of the Performance Measures used here and any new Indicators, determination of Reference Points and revision of Control Rules is essential.

2.4.5 Spatial scale at which Harvest Strategy is applied

Each reporting Block (= spatial assessment unit) within a fishing zone has a different long term productivity and catch rate, thus the harvest strategy is applied to each Block. The zone-wide TACC is determined by summing the recommended catch to be taken from each Block. The question arises about which Block catch should be modified to determine the projected Block catch for the following year. In practice, the TACC decision made in year$_t$ for the fishing year$_{t+1}$ must be made in October of year$_t$. Thus the final catch and CPUE for a given block is not known at the time of the decision, and the CPUE analysis must be conducted on either partial year data (January – September), or the full years data from the previous year (i.e year$_{t-1}$). When the fishery is declining or rebuilding rapidly, then there is a strong argument and preference by Industry to utilise all available data especially the data obtained in the year to date. In terms of the Block catch value that the adjustment will be applied to, when the analysis includes the partial year data, then the allocated catch for year$_t$ (defined during the assessment in year$_{t-1}$) will form the base value for Block catch adjustment.

2.4.6 Phase plot summary of fishery status through time

A benefit of applying an empirical Harvest Strategy using performance measures with defined reference points, is the capacity to use internationally accepted tools for summarising fishery status such as the 'Kobe Plot'. For an empirical HS with no direct estimates of biomass or fishing mortality, we must use proxies for B and F. Currently there is no accepted proxy biomass in abalone fisheries. Here we use the catch-weighted Target CPUE PM score as a proxy for abundance, and the catch-weighted four-year Gradient CPUE PM score as a proxy for fishing mortality. The zone-wide proxy score is calculated by taking the catch-weighted arithmetic mean of the individual block proxy score. An abundance proxy (Target CPUE) score of one is defined as the limit reference point (LRP), and a value of 5 is defined as the threshold reference point (TRP). A negative zone gradient score gives evidence that fishing mortality is increasing and the magnitude of the gradient provides some information on the magnitude of fishing mortality. In order to use this proxy to emulate a normal Kobe Plot, five is subtracted from the 4-year Gradient PM score to provide a score range of −5 to +5, where the limit reference point is zero. The combination of a negative 4-year gradient and near-record low CPUE Target score represents a cautious proxy for the true recruitment overfished reference point. No reporting blocks have collapsed within the reference period, providing a degree of certainty that the LRP is conservative, which is supported by MSE testing of the HS. Catch rate based proxies for abundance should not be considered as a direct measure of biomass. Rather, we believe catch rates are a measure of the parity between the TACC and the available exploitable biomass.

2.5 Fishery Independent Research Surveys

Historically there has been a paucity of fishery independent abundance and population size structure information collected in the Tasmanian Fishery. Primarily this has been a consequence of the geographic scale of the fishery relative to available field resources, along with the challenges of obtaining representative samples where abundance is patchy on multiple spatial scales from meters to kilometres. Juvenile abalone (i.e. below the size at reproductive maturity) are entirely cryptic. The size at emergence from crypsis for blacklip abalone in Tasmania is around the same size as the size limit, creating challenges in quantifying density and size structure of sub-legal size classes using traditional FI survey techniques. Monitoring of cryptic abalone (2+ to 4+ year classes) using Abalone Recruitment Modules (ARMS) could provide an early warning of a potential reduction in future fishable biomass, and address the inability of visual surveys to quantify change in density of these smaller size classes. From the early 2000s effort has been applied to developing suitable survey methods quantifying abundance for the Tasmanian abalone fishery, with robust sampling methods developed during FRDC projects 2001-074, 2005-029 and 2014-010 (Mundy et al., 2006, 2010, 2018a). Since 2015 IMAS have conducted a pilot program to collect fishery independent data for cryptic (ARMs) and emergent abalone (LEGs).

2.5.1 Monitoring of juvenile abundance with Abalone Recruitment Modules (ARM)

Juvenile abalone are currently monitored using an artificial habitat or abalone recruitment module (ARM) developed by IMAS which consists of a flat plastic disc secured to the reef to create a cryptic space underneath. The Tasmanian ARM design provides data on cryptic blacklip abalone in a size range (6 mm - 100 mm). Strings of 20 ARMs per site are currently maintained to account for high local scale variation in recruit abundance. Initial trials suggest this is the minimum number of ARMs required per site to detect a magnitude of 80-100% change in abundance. Paired sites separated by approximately 50 m are established to examine local scale variation in juvenile abundance.

ARMs are deployed at six sites along the east coast of Tasmania (i.e. n = 12);

1. The Gardens (GAR)
2. Seymour Point (SEY)
3. Betsey Island (BET)
4. George III Rock (GEO)
5. Black Reef boulder (BRB)
6. Black Reef slab (BRS)

Where possible sites are surveyed seasonally (Summer, Winter, Spring), and all abalone found under the ARM are measured to the nearest millimetre. Seasonal data have been collected since 2015 and IMAS continue to assess the performance and suitability of ARMs as a stock recruitment indicator. Data presented in the 2018 stock assessment are useful as a secondary indicator only and are therefore not currently used for direct input to the stock assessment.

2.5.2 Length Evaluation and Growth surveys of emergent abalone

Permanent Length Evaluation and Growth survey (LEGs) sites have also been established at the same locations where each ARM string (n = 12) is deployed to establish a time-series of abalone abundance and size structure as a relative measure of stock performance. Where possible LEG sites have also been established to span the ARM strings to examine stock-recruitment relationships. The design uses a 60 m long baseline transect marked by permanent SS eye bolts, with ten replicate 15 m x 1 m belt transects randomly located along the baseline. Randomised numbers (0 m to 60 m in 2.5 m increments) are used to determine the start position of the transect along the baseline and a randomised binary value (left/right) determines the direction of each 15 m belt transect perpendicular to the baseline. Sampling is non-destructive within the belt, and all abalone observed within the belt are measured to the nearest millimetre. Surveys of LEG sites are normally conducted on the same day as the ARMs whenever possible. Two additional sites are also deployed on the Tasman Peninsula and sampled annually when resources are available.

1. The Gardens (GAR)
2. Seymour Point (SEY)
3. Munroes Bite (MUN)
4. The Thumbs (THU)
5. Betsey Island (BET)
6. George III Rock (GEO)
7. Black Reef boulder (BRB)
8. Black Reef slab (BRS)

Chapter 3

Fishery Dependent Catch and Effort Results

3.1 Eastern Zone

3.1.1 Zone Overview

Catch from the Eastern Zone blocks peaked at 1500 t in 1998, and has oscillated downwards thereafter with evidence of a cyclic pattern of depletion and recovery in CPUE (fig. 3.1). Declines in CPUE appear to precede declines in catch (fig. 3.1). In 2018, the allocated catch target was below the 25th percentile of annual catch (1992 and 2018) for every block in the Eastern Zone (fig. 3.3). Of the areas south of Cape Pillar where normal fishing occurred during 2018, CPUE in only blocks 13 and 21 were above the 25th percentile of annual standardised CPUE (fig. 3.3). In 2018, 50% of the catch landed was harvested from less than 15% of the fished area (fig. 3.5), which is typical for the Eastern Zone. The overall reef area exploited by the fishery declined sharply in 2017 and 2018 (fig. 3.6), while the average catch per Hectare has declined by approximately 10 KgLa/Ha between 2012 and 2018.

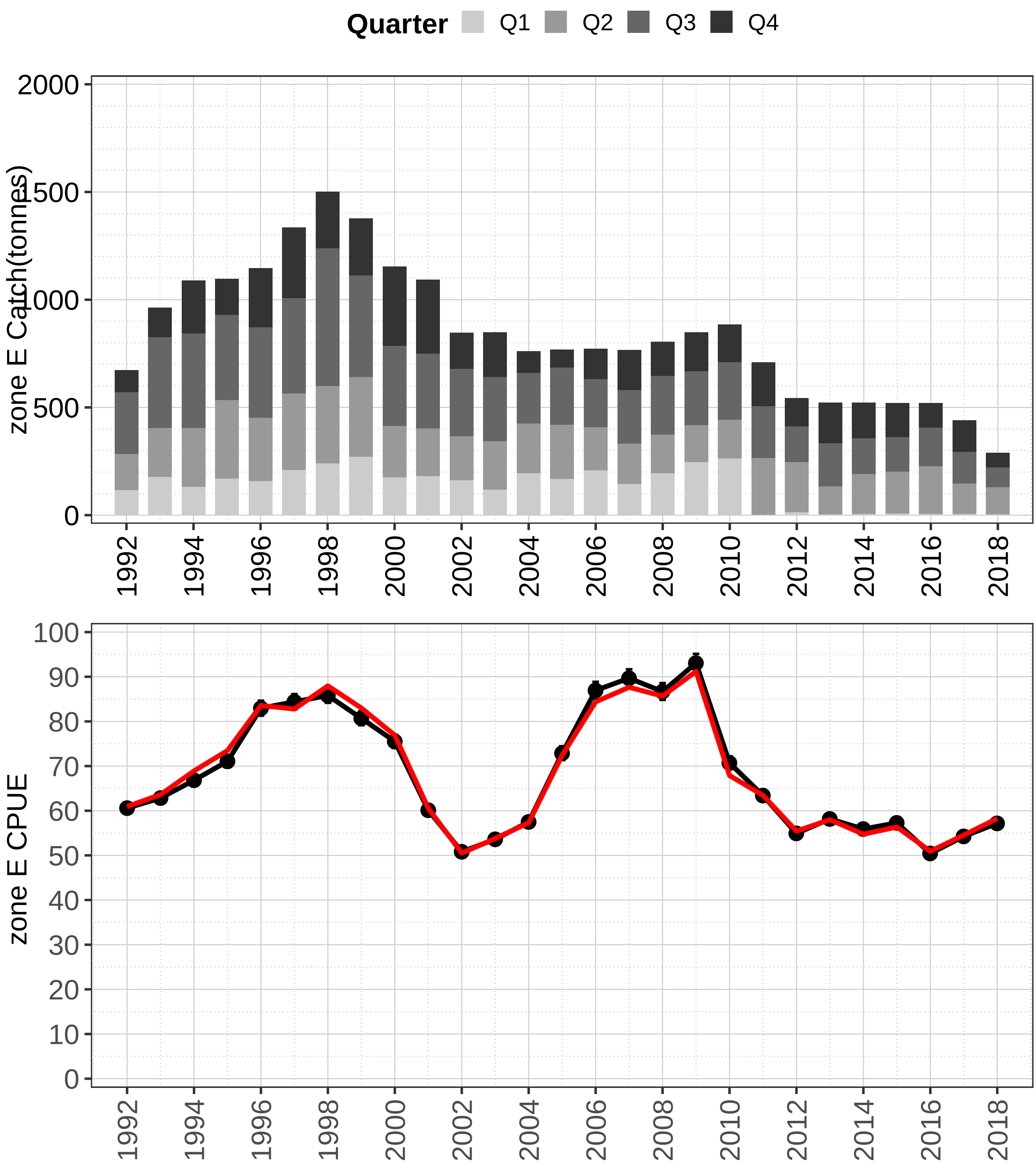


Figure 3.1: *Zone-wide catch and catch rate for Eastern Zone blacklip abalone, 1992–2018. Upper plot: catch (t) by quarter pooled across blocks currently classified as Eastern Zone. Lower Plot: standardised CPUE (black line) and geometric mean CPUE (red line).*

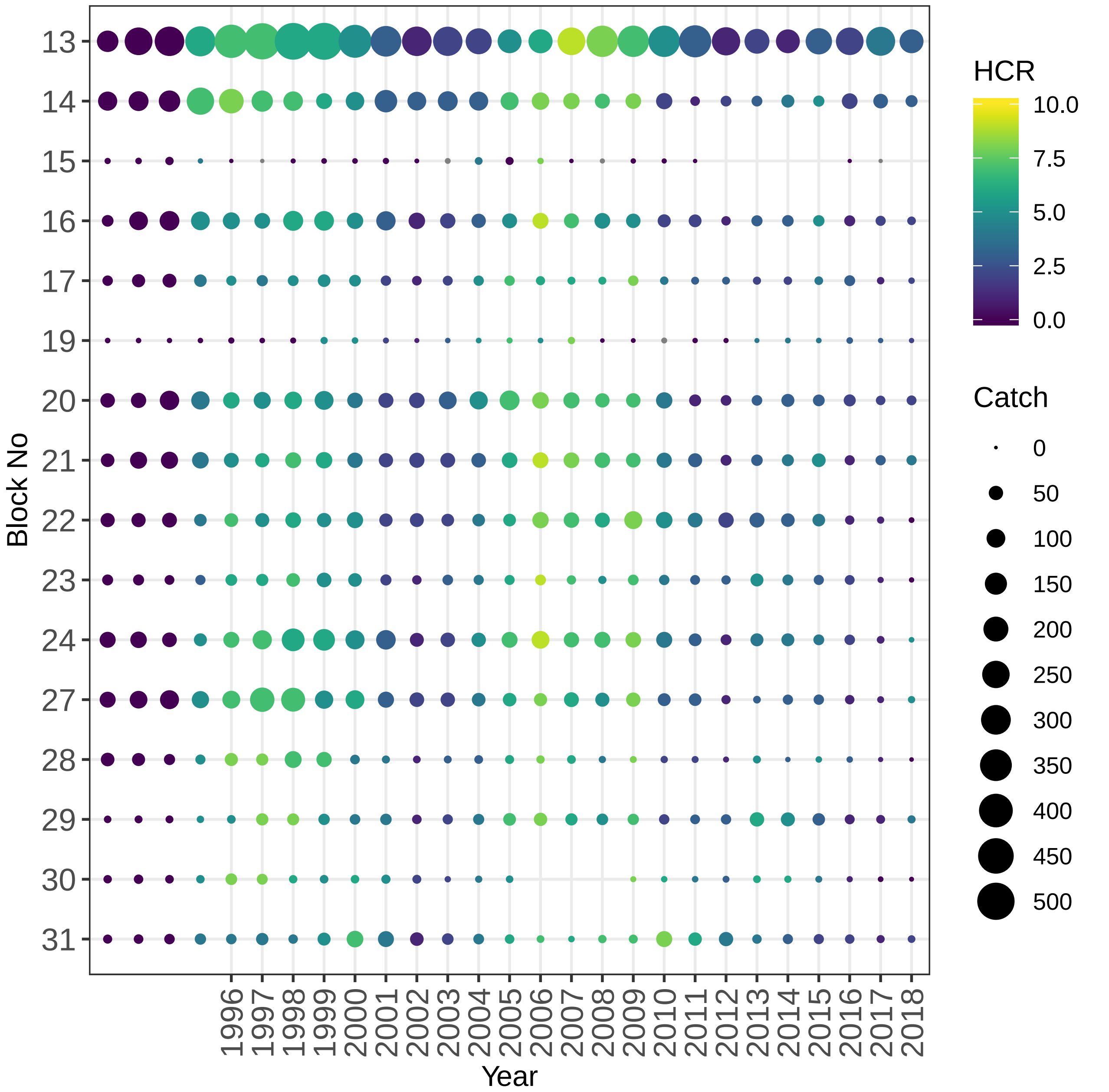


Figure 3.2: *Bubble plot of harvest strategy combined score (bubble colour) and catch (bubble size) for Eastern Zone blacklip abalone.*

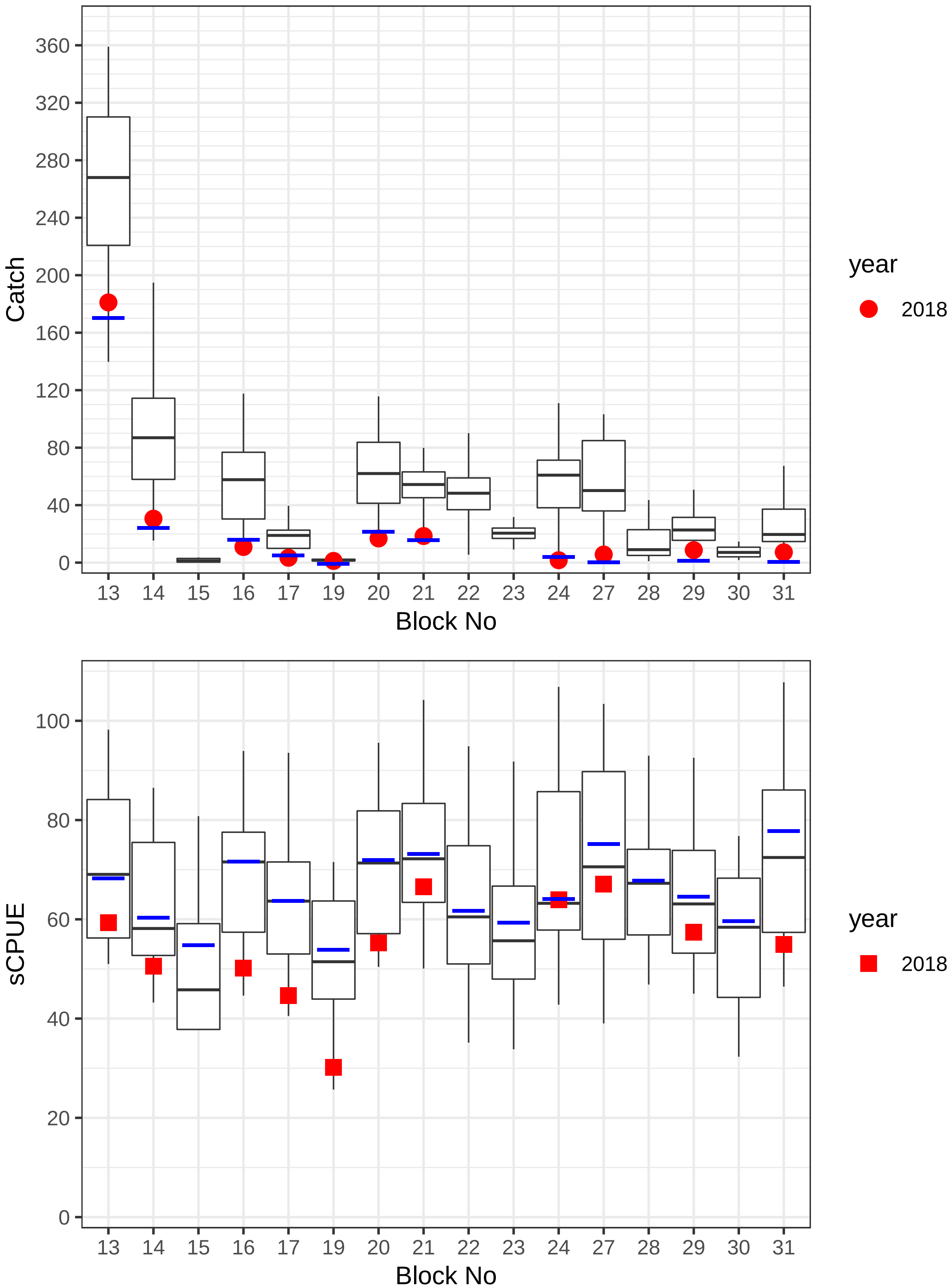


Figure 3.3: *Boxplot of catch and standardised CPUE by statistical block for the Eastern Zone blacklip abalone fishery.* ***Upper Panel****: Boxplot of annual catch. Blue line indicates catch target allocated for 2018. Red dot indicates catch taken in 2018.* ***Lower Panel****: Boxplot of annual standardised CPUE. Blue line indicates the CPUE target reference point. Red square indicates sCPUE in 2018.*

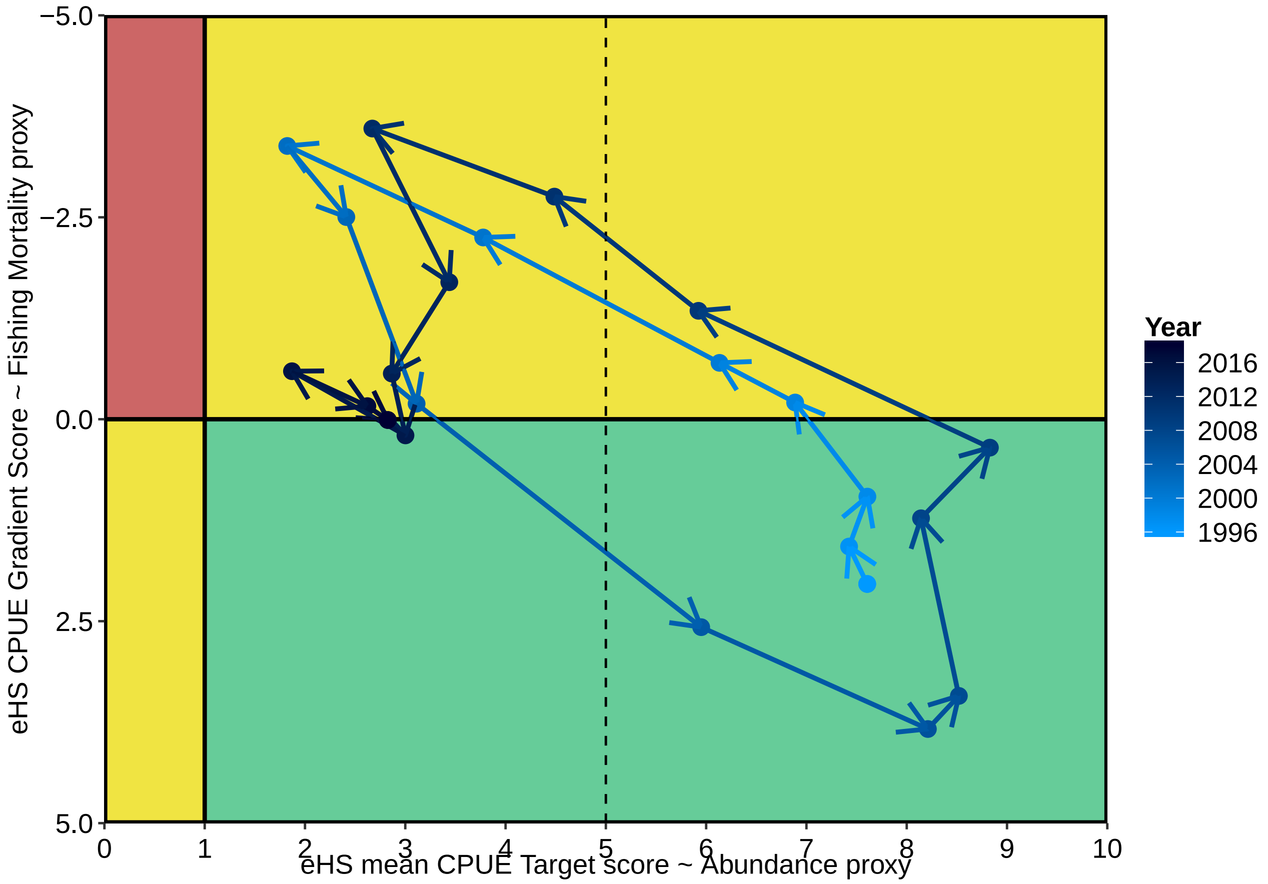
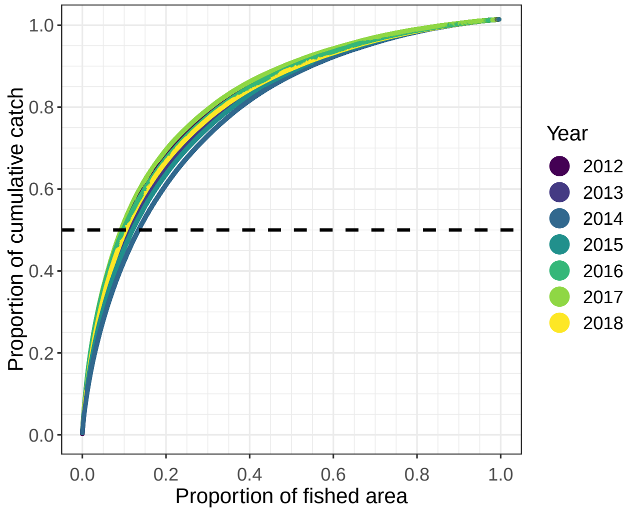
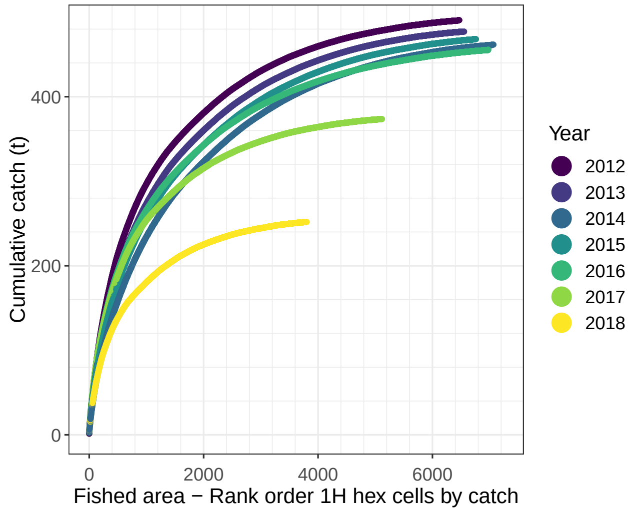


Figure 3.4: *Phase plot of fishing mortality and abundance proxies for Eastern Zone blacklip abalone , 1996–2018. The Gradient 4 PM (y-axis) is used as a proxy for fishing mortality, and the Target CPUE PM is used as a proxy for abundance. Zone score is calculated as a catch-weighted mean of individual block scores.*





(a) (b)

Figure 3.5: *Concentration area curves for catch in the Eastern Zone: a) Proportion of catch (y axis) against proportion of reef utilised (x axis). Hashed line represents 50% of catch; b) cumulative catch (y axis) against rank order of hex cells, descending from highest to smallest catch. Data filtered to exclude hex cells where less than 5 minutes of effort observed.*

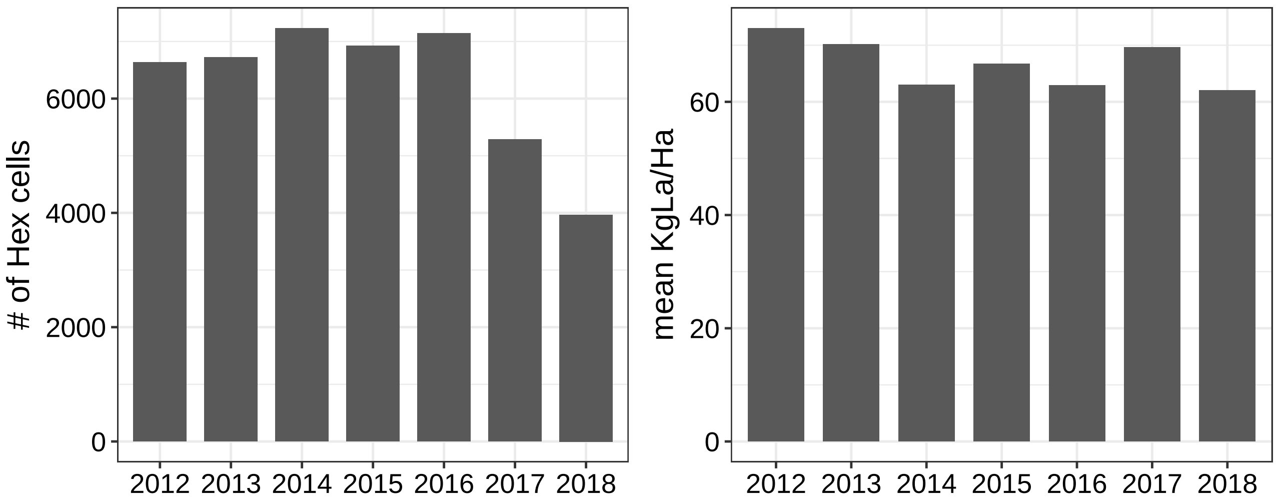


Figure 3.6: *Number of 1 Hectare grid cells where at least 5 minutes of fishing was observed for Eastern Zone blacklip abalone, and the total catch landed divided by the number of hex cells visited as the mean catch landed per hex cell.*

3.1.2 Fishery Trends by Statistical Block

Blacklip: Block 13 - Actaeon's (Whale Head to Actaeon Island)

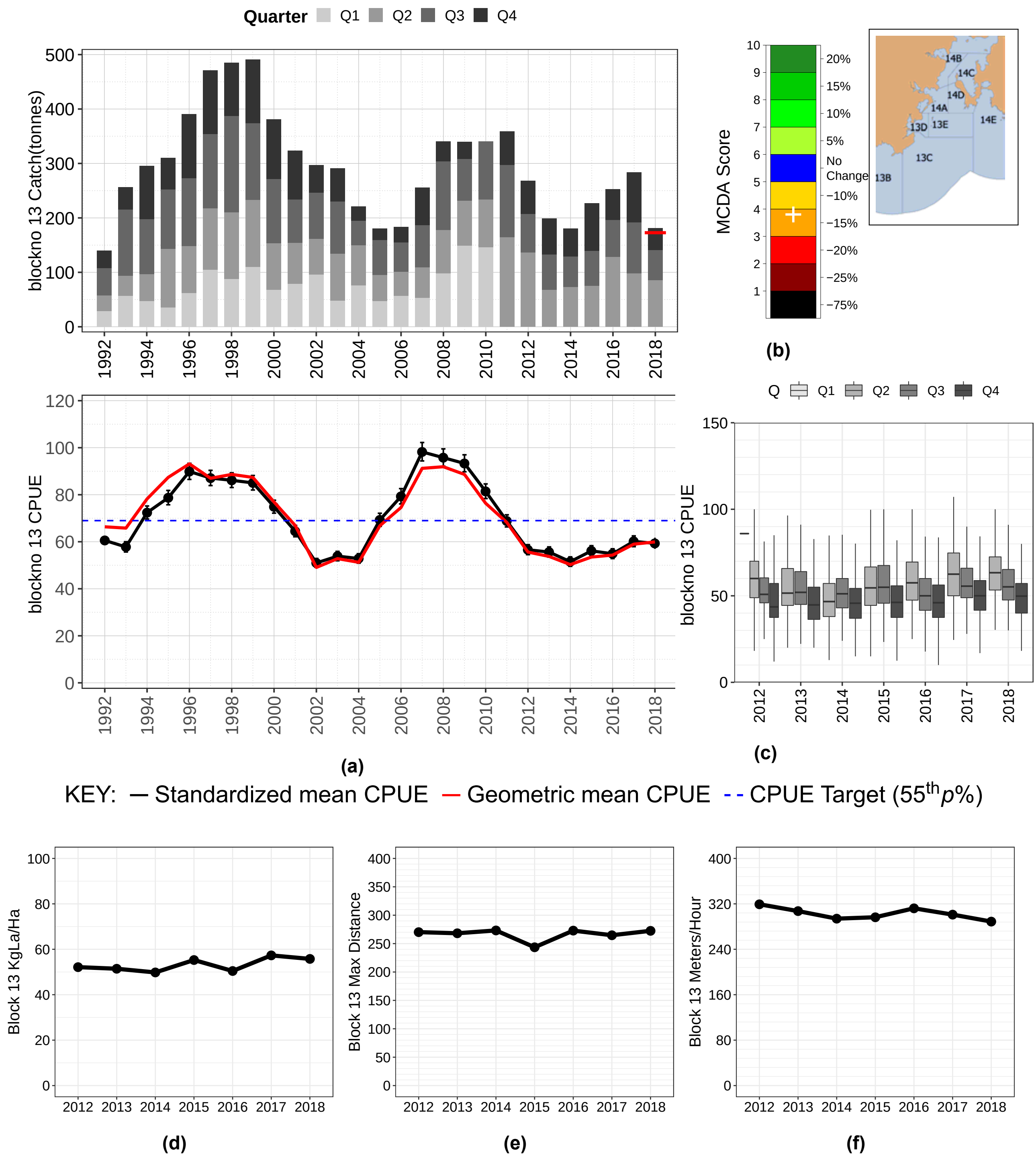


Figure 3.7: *Block 13 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 14 - Lower Channel and South Bruny

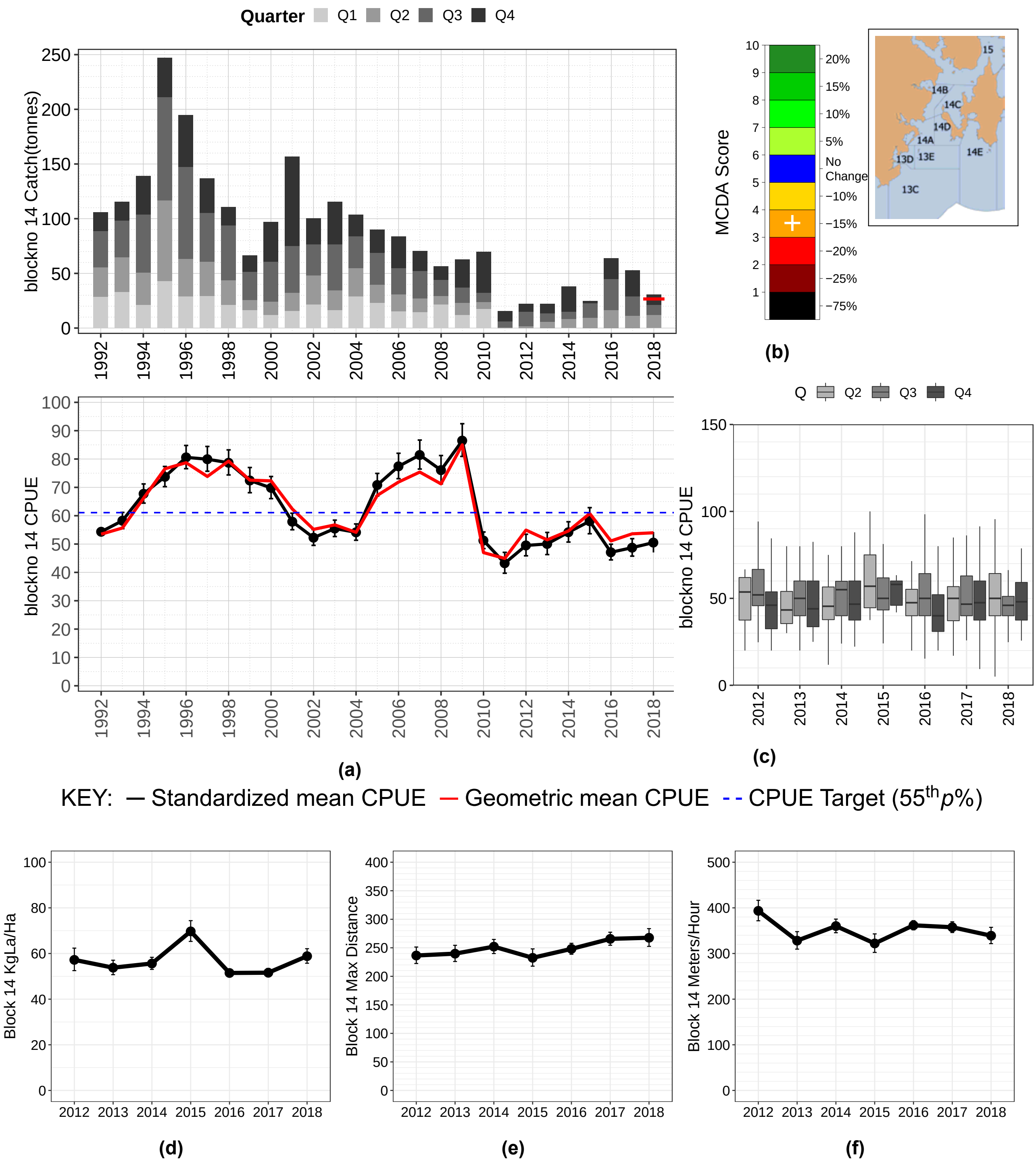


Figure 3.8: *Block 14 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 16 - Bruny Island (Boreel Head to Dennes Point)

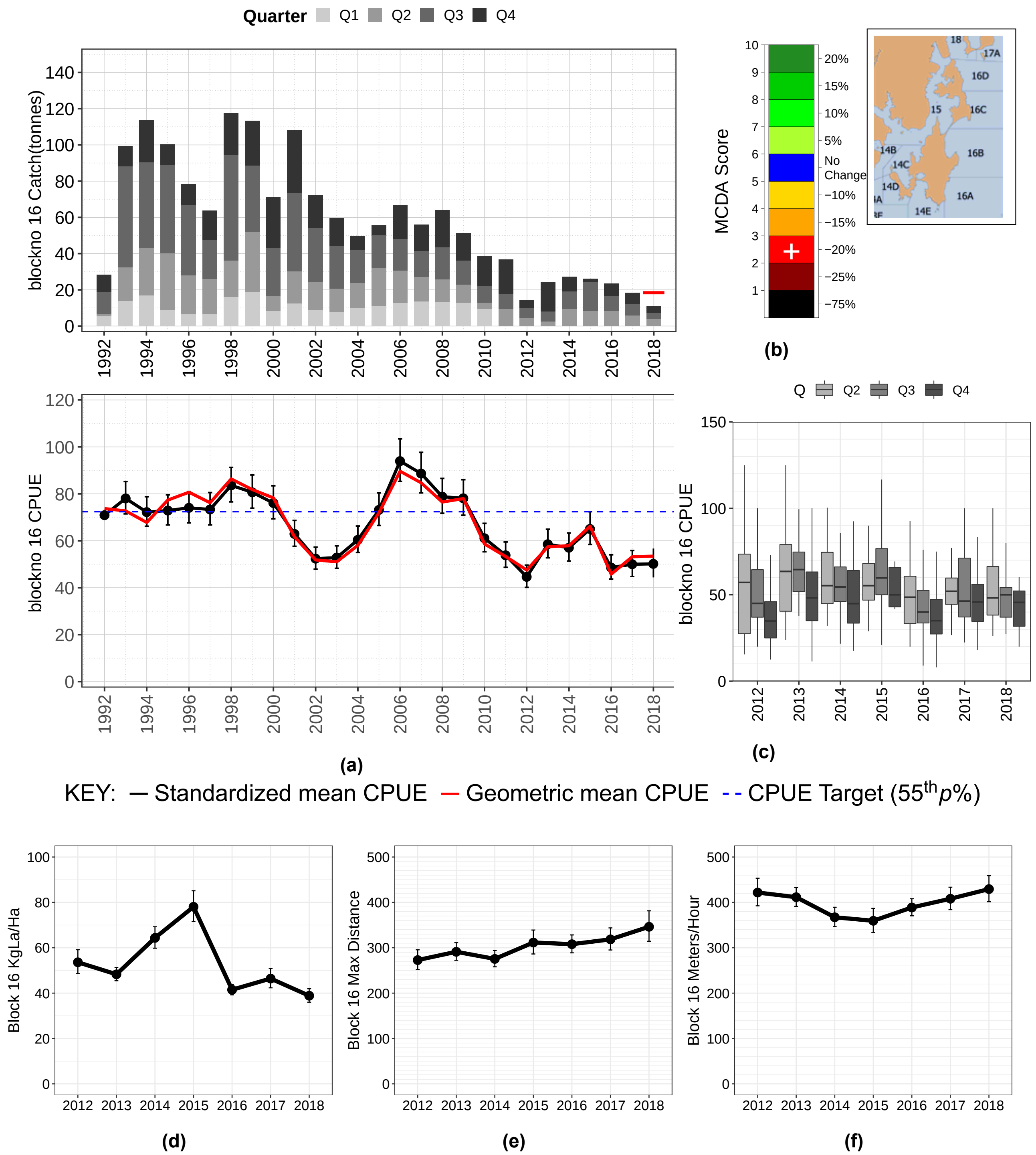


Figure 3.9: *Block 16 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 17 - Storm Bay

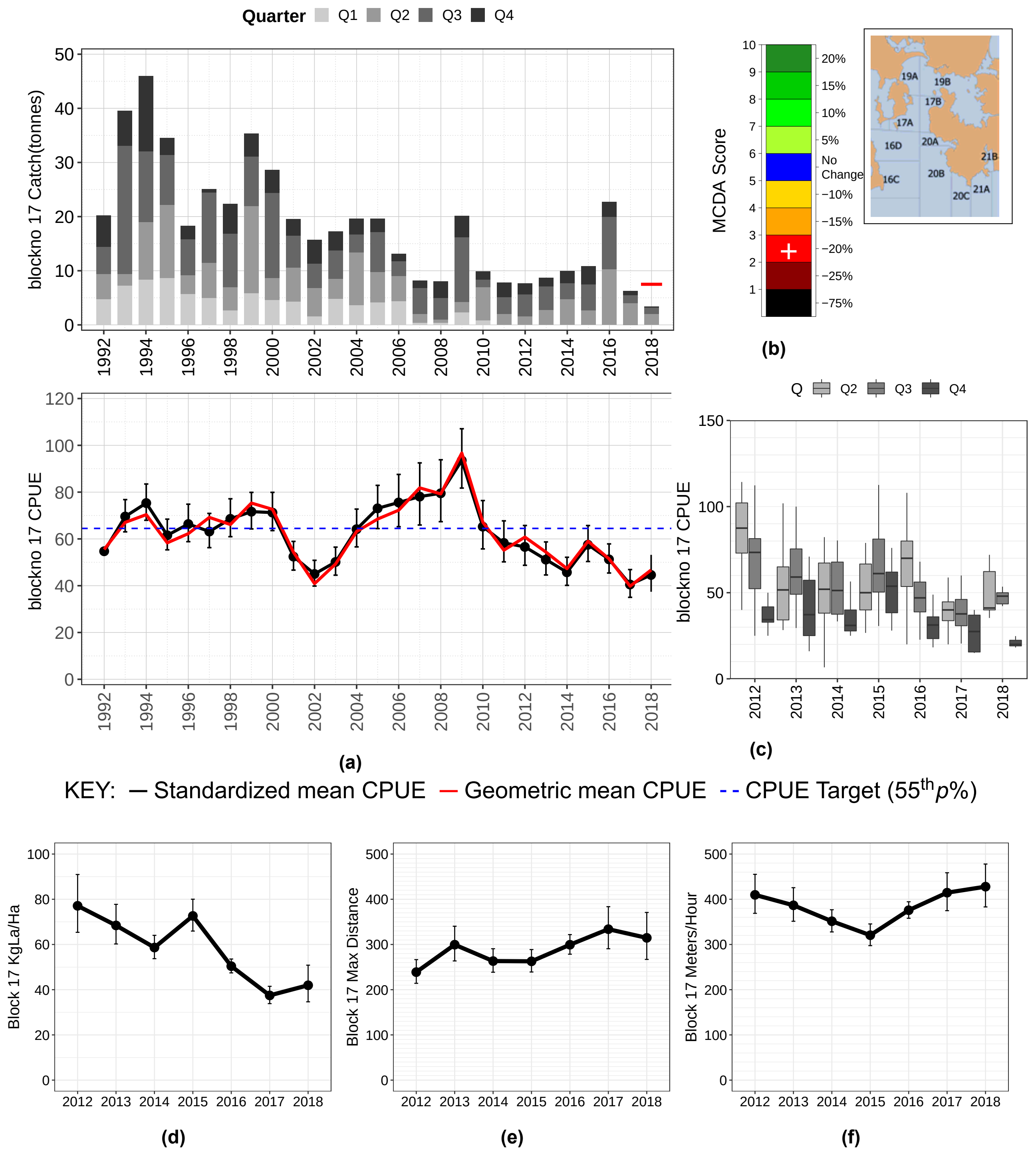


Figure 3.10: *Block 17 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 19 - Fredrick Henry Bay

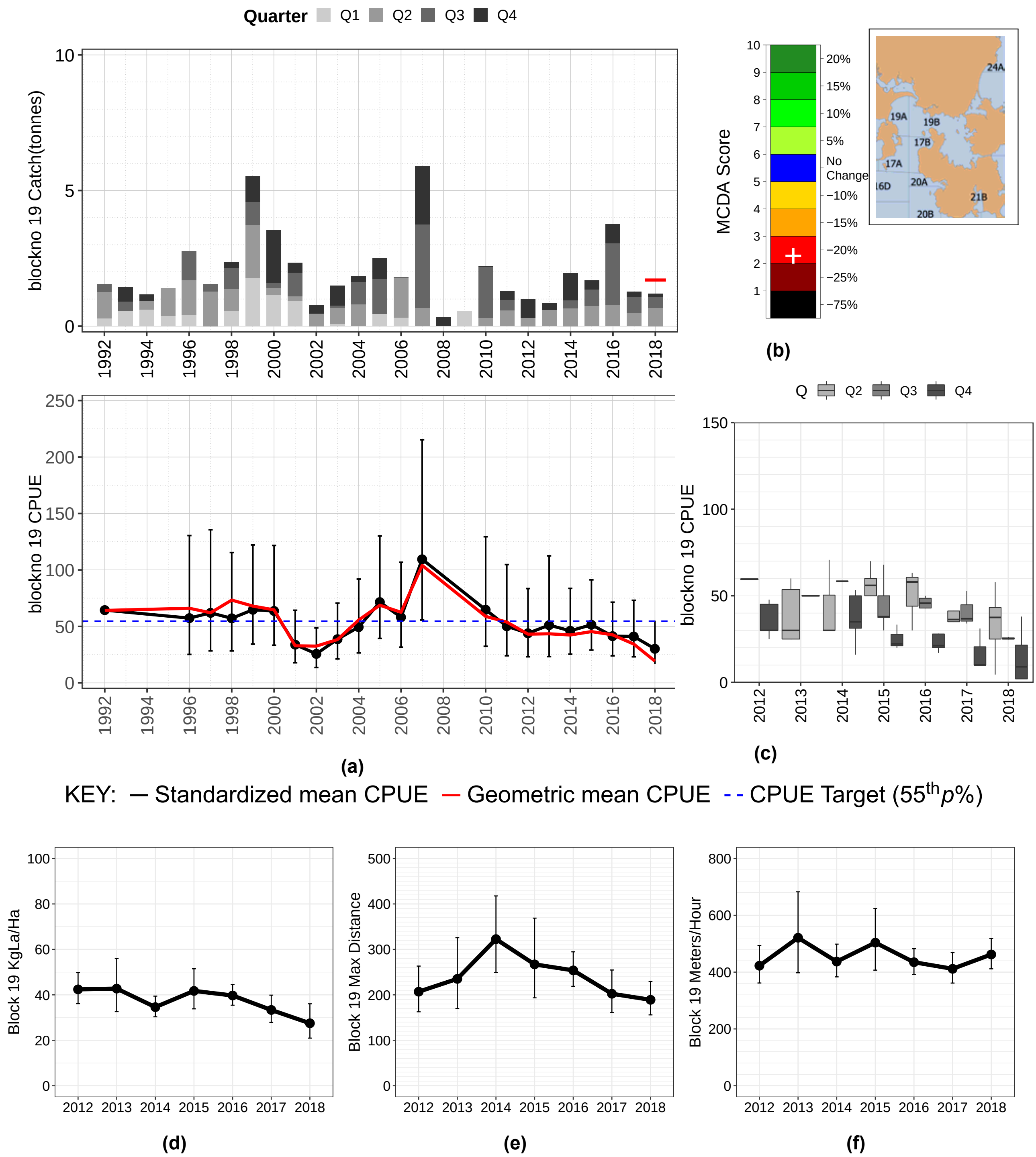


Figure 3.11: *Block 19 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 20 - Storm Bay (Outer North Head to Cape Raoul)

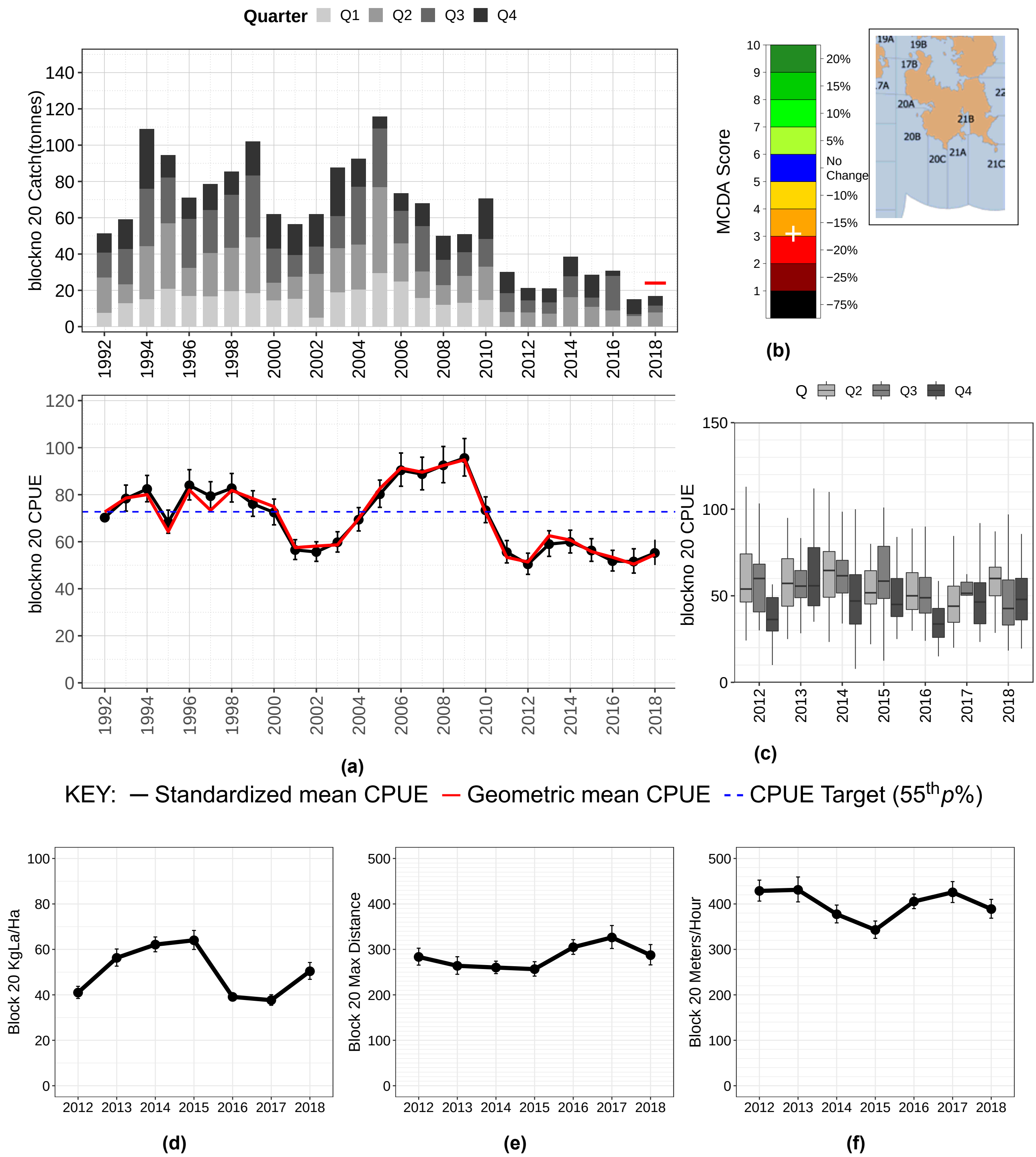


Figure 3.12: *Block 20 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 21 - Cape Raoul to Cape Pillar

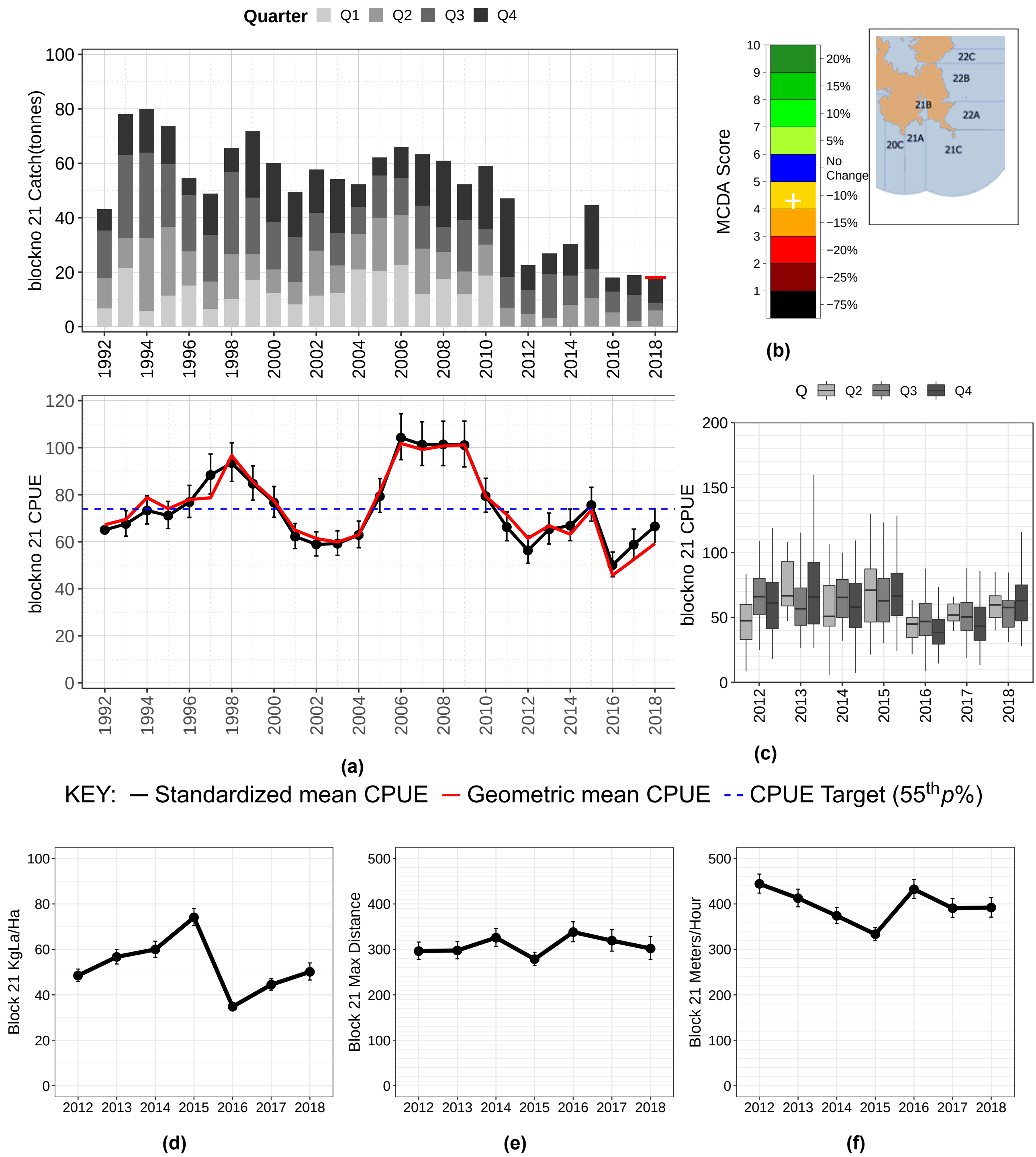


Figure 3.13: *Block 21 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 22 - Cape Pillar to Deep Glen Bay

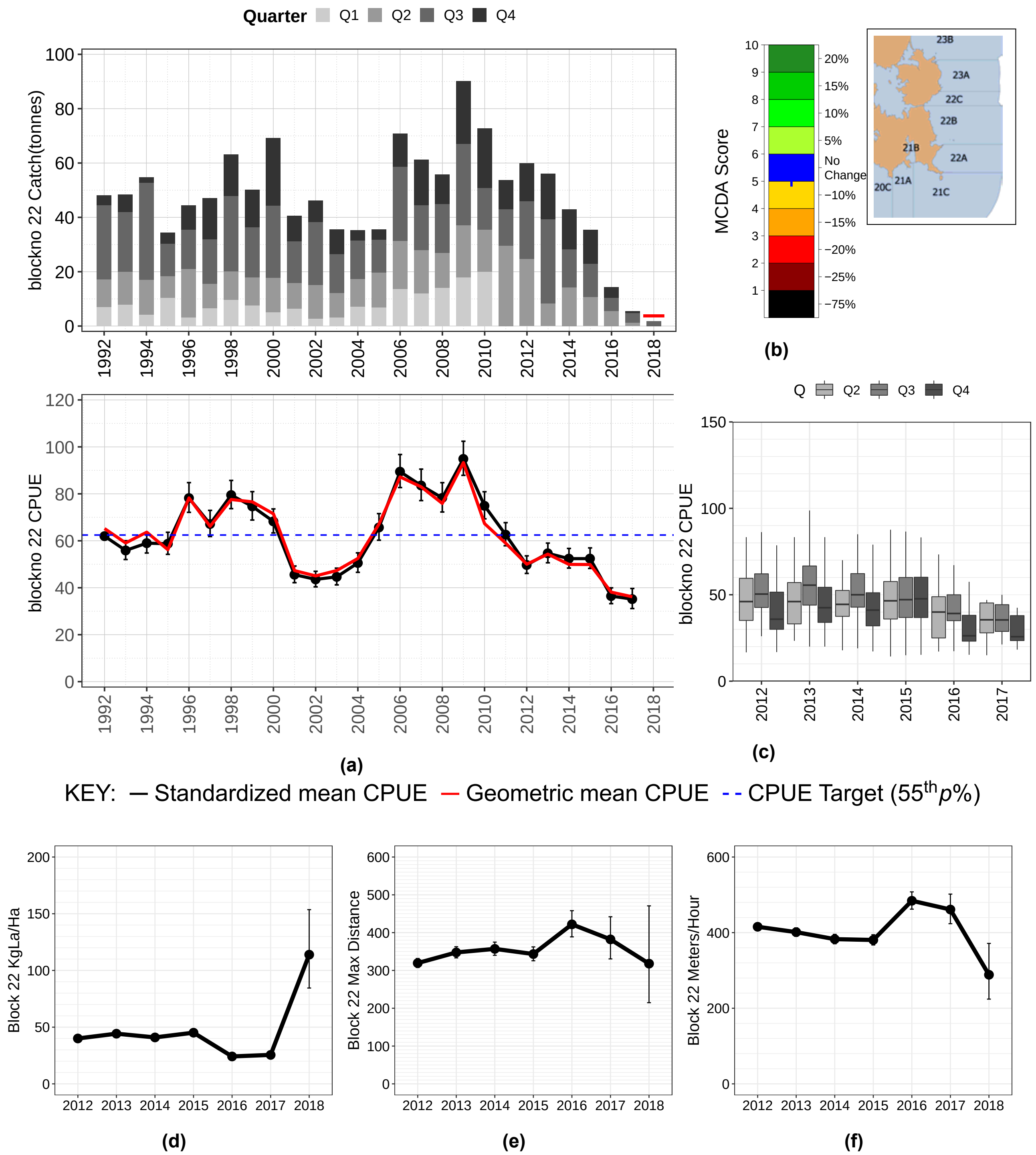


Figure 3.14: *Block 22 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 23 - Deep Glen Bay to Marion Bay

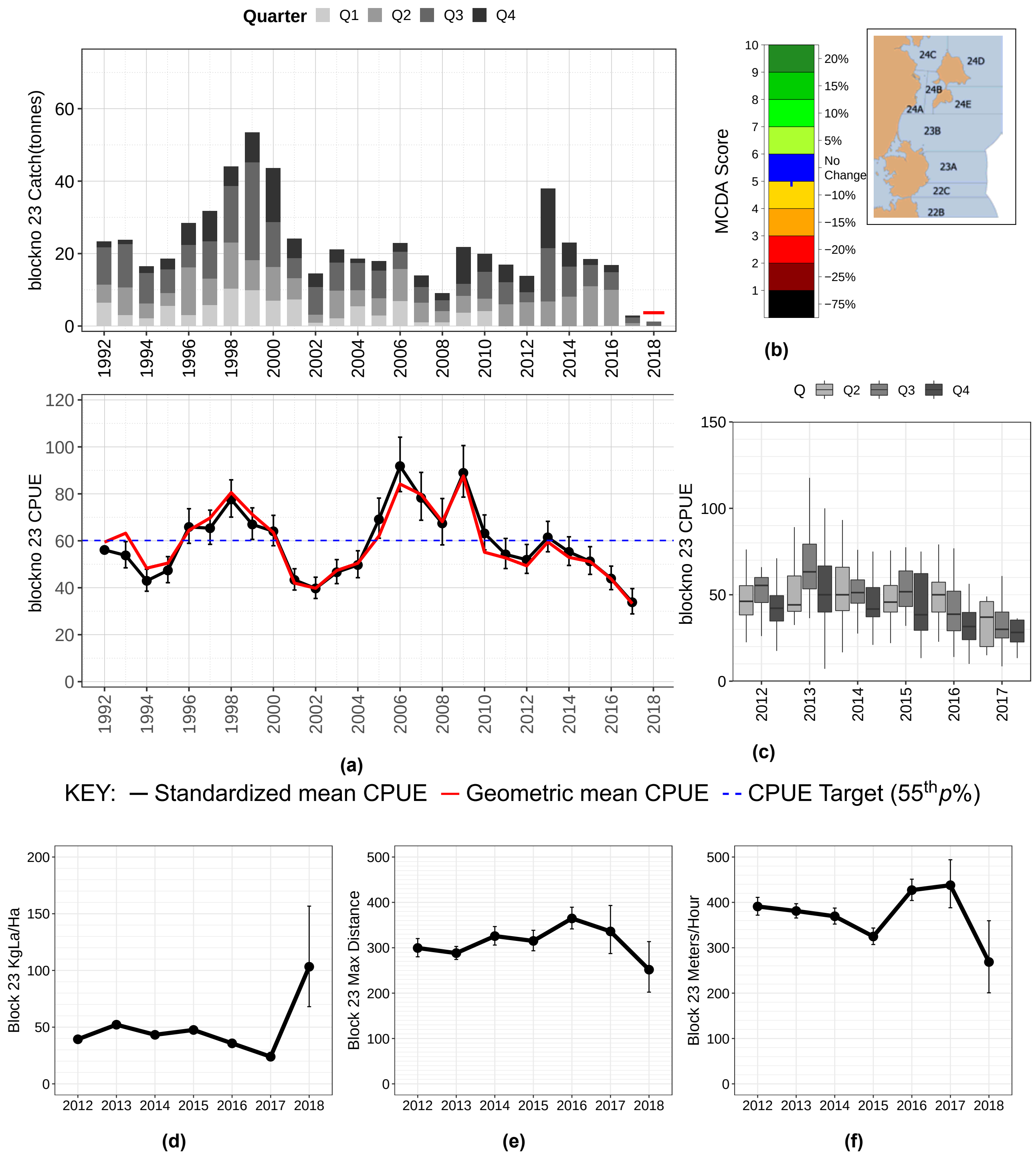


Figure 3.15: *Block 23 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 24 - Maria Island (Marion Bay to Cape Bougainville)

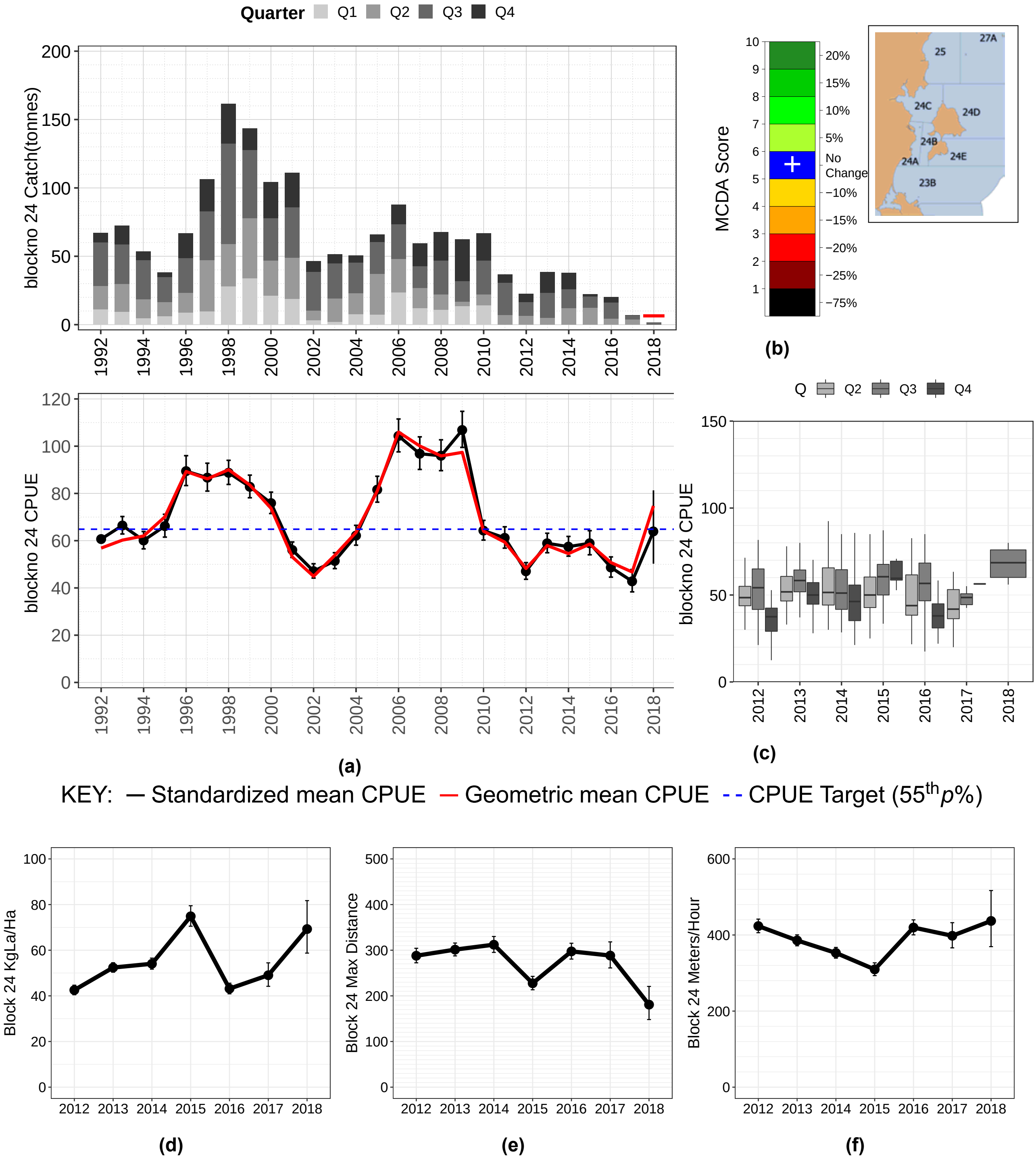


Figure 3.16: *Block 24 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 27 - Freycinet (South Shouten Island to Friendly Beaches)

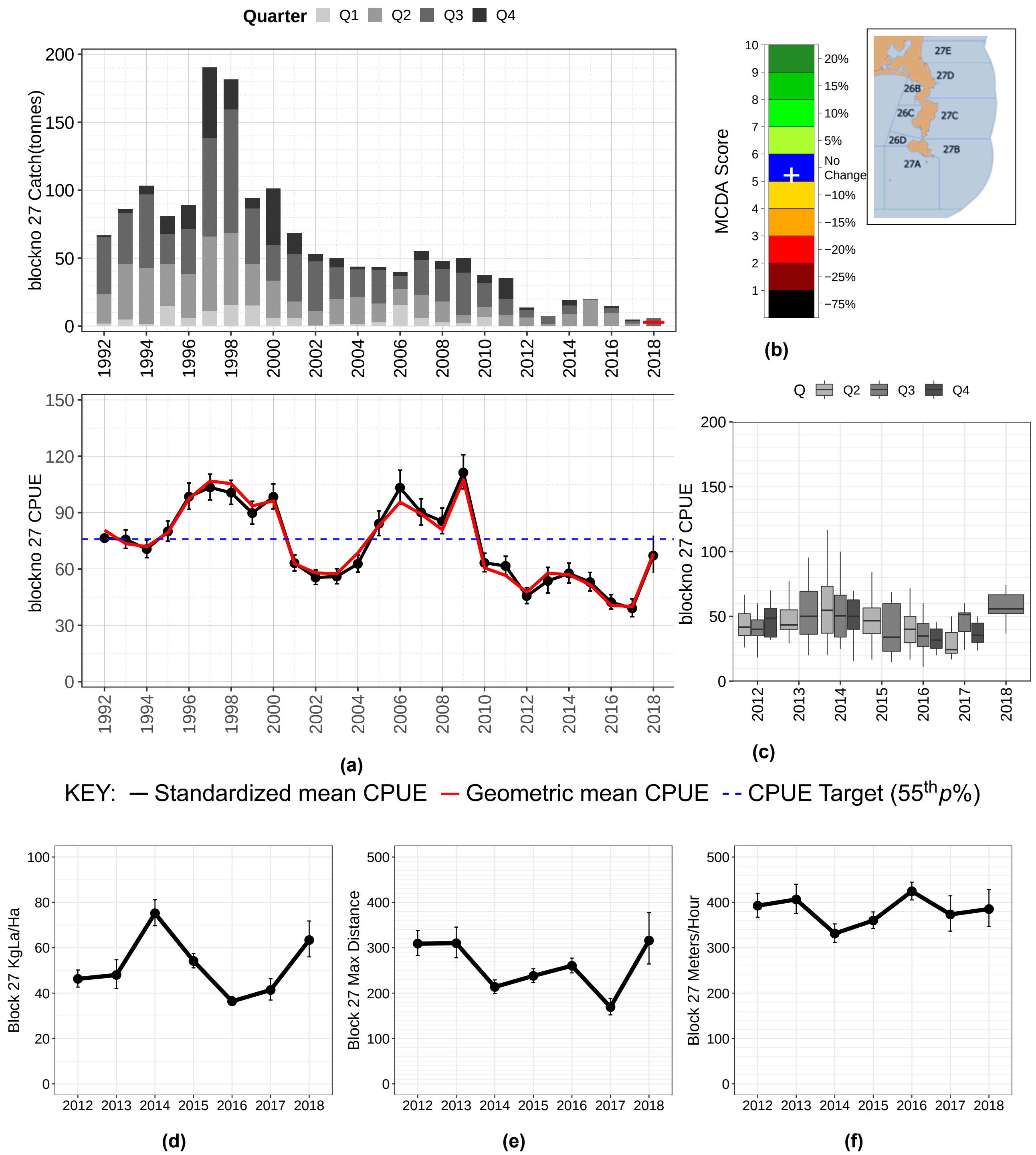


Figure 3.17: *Block 27 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 28 - Friendly Beaches to Bicheno

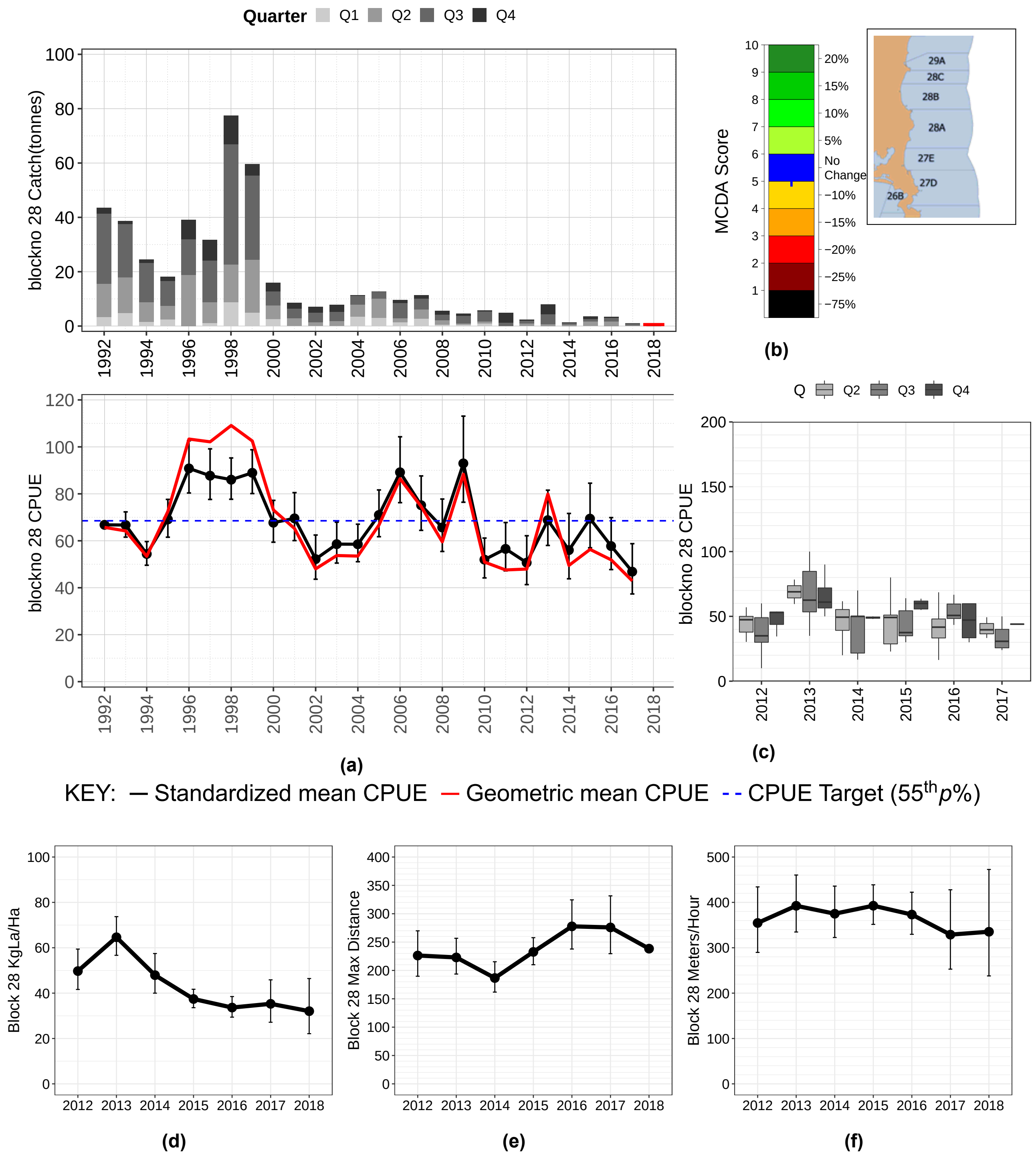


Figure 3.18: *Block 28 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 29 - Bicheno to St Helen's Point

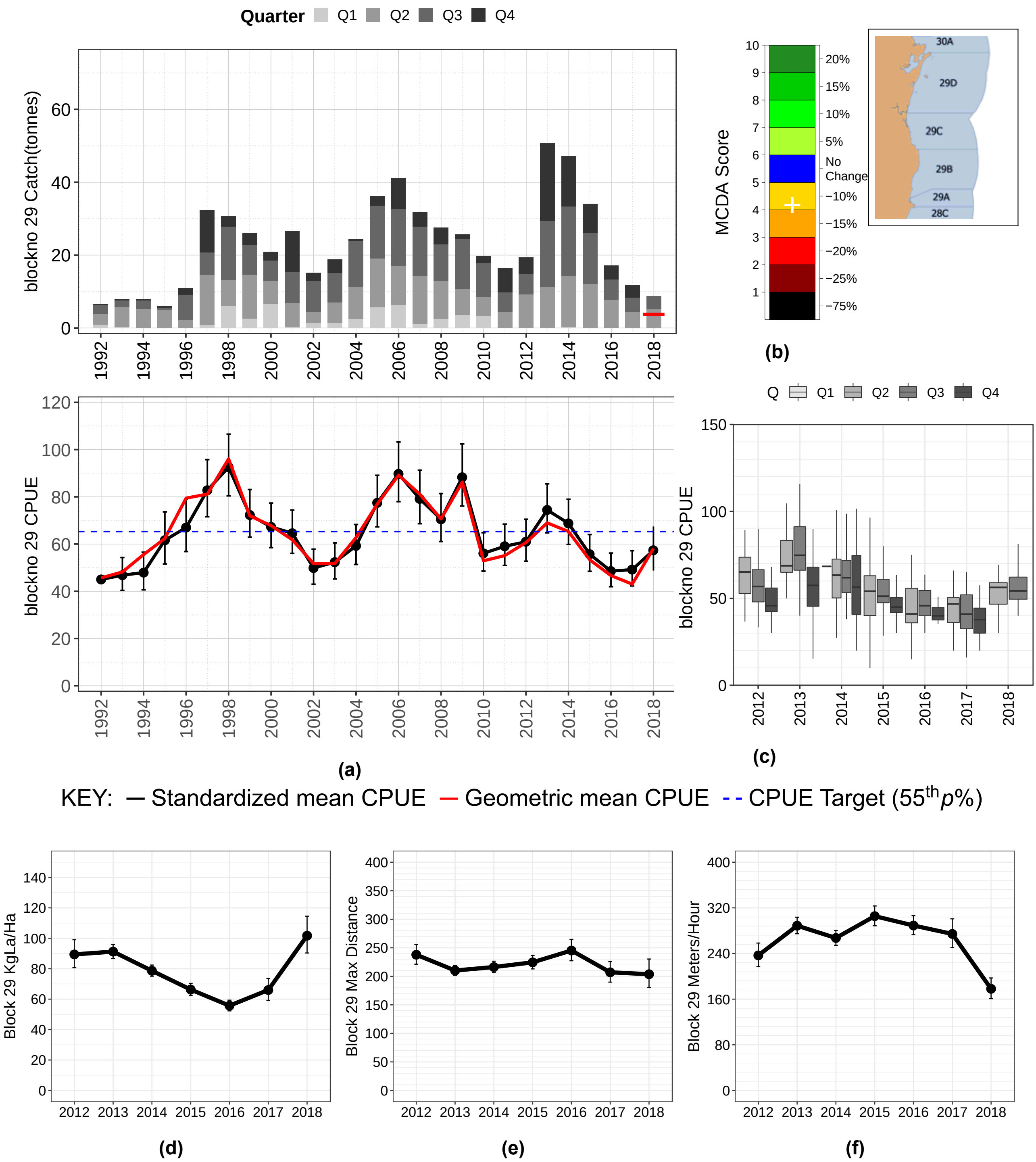


Figure 3.19: *Block 29 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 30 - St Helen's Point to Eddystone Point

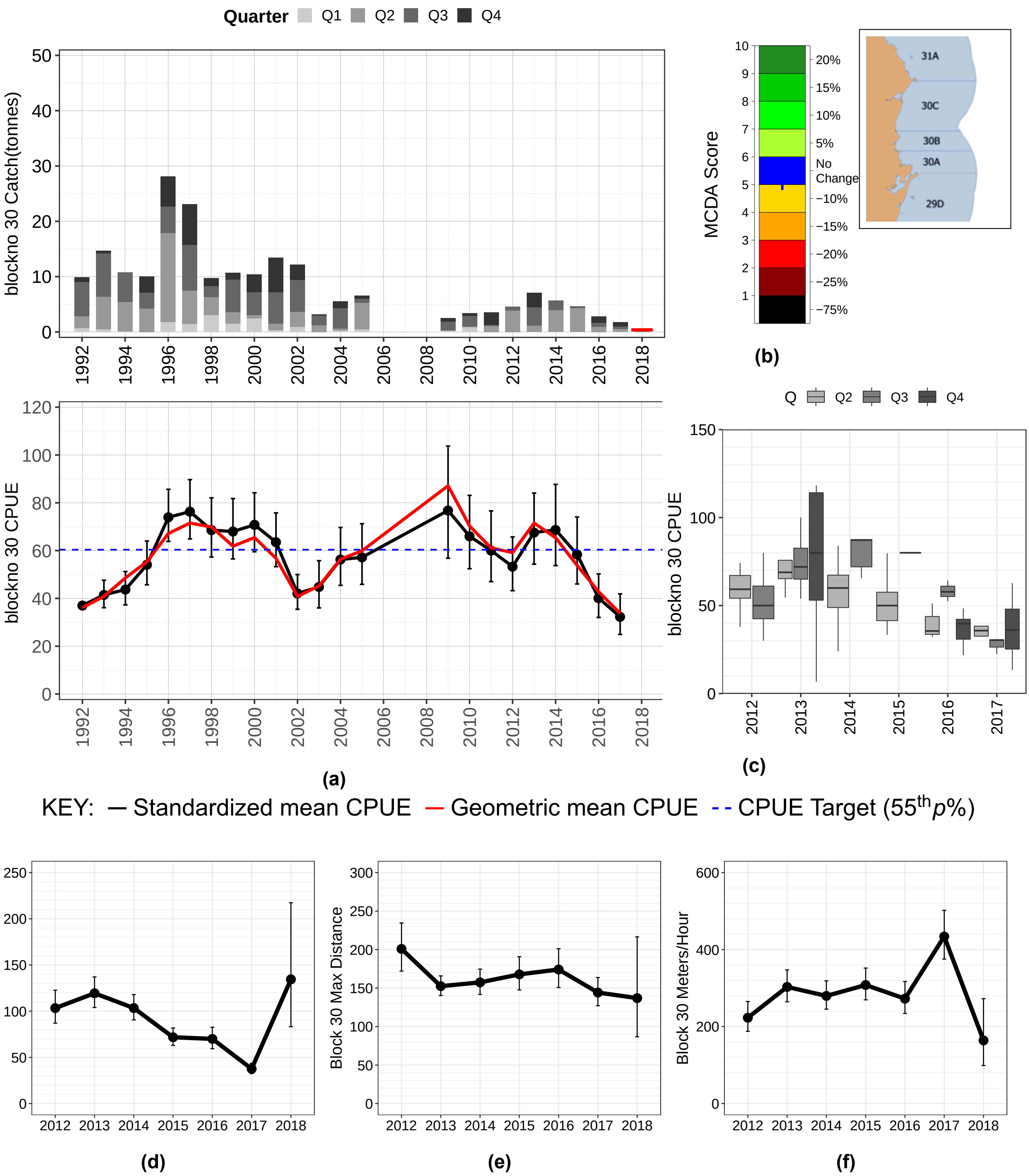


Figure 3.20: *Block 30 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 31 - Eddystone Point to Cape Naturaliste

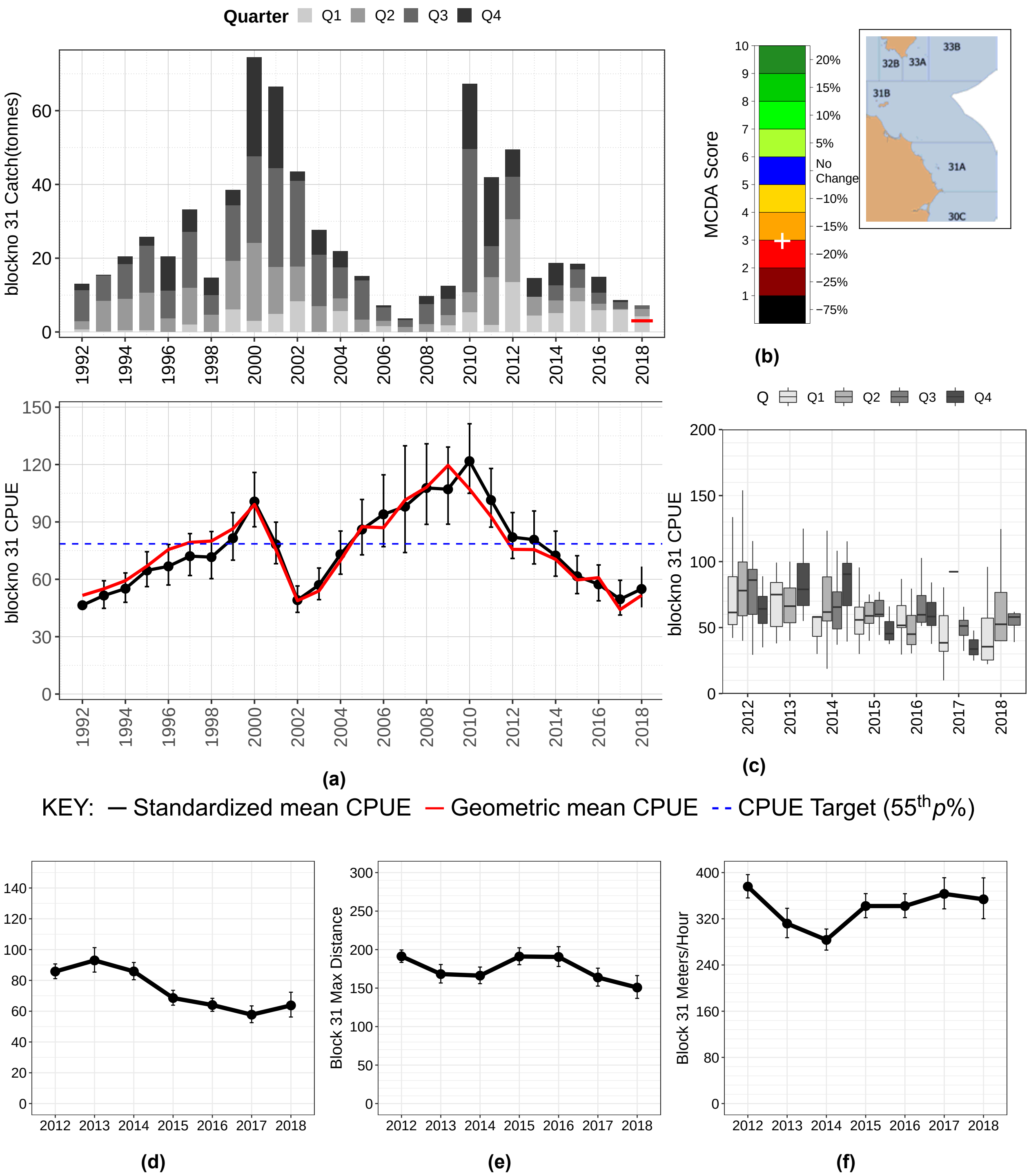


Figure 3.21: *Block 31 EZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

IMAS Summary Notes to FRAG –Eastern Zone

- Stock declines in the Eastern zone due to multiple factors
  - Overfishing during the 1990's
  - Reduction in fishing grounds by *Centrostephanus*
  - Marine heat wave mortality
  - Marine heat wave sub-lethal effects (growth, reproduction)
  - Storm events (2007, 2016)
- Understanding contribution of these events critical for informing management decisions
  - e.g. Block 16 catch and CPUE declining for many years, but no *Centrostehpanus*, and before MHW events?
  - Cost of rebuilding stocks will be significant and require 8 - 10 years of restoration work.
  - Minimising fishing mortality in the short term will increase rate of recovery.
- Block 13 catch rates stable but no clear evidence of stock rebuilding.
  - CPUE in Block 13 likely to be lower by year end given history of lower CPUE in Q4.
- CPUE in blocks 17, 20, 21, 29 and 31 improving in 2018.
- Review catch targets for blocks north of Cape Pillar for 2019 (long-term gain vs short-term benefit).

Table 3.1: *Eastern Zone Catch, CPUE, Harvest Strategy scores and projected TACC for 2018. CPUE Targets are based on the 55th percentile of standardised annual mean CPUE, with a weighting of 65:25:10 on CPUE, Gradient 4 and Gradient 1 performance measures respectively*

Block No	Catch 2017	Catch Targ	Catch YTD	CPUE YTD	Score CPUE	Score Grad4	Score Grad1	Score	HS adj	IM adj	MCDA 2019	IMAS 2019	FRAG 2019
13	285.0	172.8	181.3	59.3	3.0	5.4	4.7	3.7	0.85	0.85	146.9	146.9	
14	53.1	26.6	30.6	50.5	2.3	4.1	5.5	3.1	0.85	0.80	22.6	21.3	
15	0.2	0.0								1.00		0.0	
16	18.7	18.4	10.9	50.2	0.9	3.1	5.0	1.9	0.75	0.75	13.8	13.8	
17	6.3	7.5	3.4	44.6	3.7	3.9	6.3	4.0	0.85	1.00	6.4	7.5	
19	1.3	1.7	1.2	30.2	3.2	3.4	3.9	3.3	0.85	0.85	1.4	1.4	
20	15.1	24.0	16.8	55.2	1.5	4.8	6.5	2.9	0.80	1.00	19.2	24.0	
21	18.8	18.0	18.5	66.5	3.8	4.3	6.8	4.2	0.90	1.00	16.2	18.0	
22	5.5	3.8	1.8					0.0		1.00		3.8	
23	2.9	3.7	1.2					0.0		1.00		3.7	
24	7.1	6.4	1.7	63.9	4.8	5.2	10.0	5.4	1.00	1.00	6.4	6.4	
27	4.7	2.8	5.7	67.1	3.8	6.1	10.0	5.0	1.00	1.00	2.8	2.8	
28	1.0	0.6	0.3					0.0		1.00		0.6	
29	11.9	3.8	8.7	57.4	3.2	5.2	7.3	4.1	0.90	1.00	3.4	3.8	
30	1.8	0.4	0.7					0.0		1.00		0.4	
31	8.6	3.0	7.2	55.0	2.0	3.9	6.5	2.9	0.80	1.00	2.4	3.0	
Total	441.9		290.1								241.6	257.3	0.0

3.1.3 Eastern Zone Summary

In 2018 the zone wide catch weighted mean $SCPUE_{cw}$ was 58.2 Kg/Hr and only marginally higher than in 2002 (mean $SCPUE_{cw}$ 51 Kg/Hr), the lowest year in the time series 1992 –2018 (fig. 3.1). While Block 13 has always been a major contributor of catch, the Eastern zone TACC is now heavily reliant on catch from Block 13 (fig. 3.2). Over the past 5 years the contribution of catch from the East coast blocks between cape Pillar and Bicheno to the overall zone catch has declined rapidly, with a 95% reduction in catch from these blocks between 2000 and 2018 (fig. 3.2). Blocks 20, 14 and 21 are the other key contributors to the Eastern Zone TACC in 2018 (fig. 3.2). Historically, blocks 16, 24 and 27 were also important contributors to the TACC, but catches from these blocks have been relatively low for the past decade. In particular blocks 16 and 27 have declined by around 75% since the early 2000's, whereas the Eastern Zone TACC has only declined by approximately 50%. North of Cape Pillar to Eddystone Point the CPUE trends have declined rapidly. Of concern are all major fishing blocks north of Cape Pillar (22, 23, 24, 27, 28 and 29). All of these areas have yielded higher catches at various times over the past five years, and do not appear to have the resilience to sustain even moderate levels of fishing pressure. Only blocks 13 and 21 show clear signs of improving CPUE, with CPUE in all other Eastern Zone blocks either declining or stable. In 2017, a significant catch overrun was permitted in Blocks 13 and 14 to relieve pressure on Storm Bay fishing blocks affected by the Marine Heat Wave (MHW) in 2016 and the rapidly depleting fishing blocks north of cape Pillar. In 2018, a small catch overrun occurred in Blocks 13 and 14, largely through fishers preferentially choosing the southern areas over blocks 16 and 20.

In the previous assessment we alluded to the immediate effects of the 2015/2016 (MHW) on abalone populations (Oliver et al., 2017a, 2018). In addition to the direct impact of the 2015/2016 MHW on stock levels, we hypothesize that sub-lethal effects incurred during the 2010 Marine Heat Wave have contributed to a reduced reproductive output in that year, leading to a smaller than normal cohort entering the fishery in 2016 and 2017. Destructive grazing by the long-spined sea urchin *Centrostephanus rodgersii* is considered to be incrementally reducing the area of productive abalone fishing grounds. Collectively, these climate change related impacts on Eastern Zone abalone stocks are compounding the challenges in rebuilding Eastern Zone stocks following over-fishing during the 1990's (fig. 3.1).

Trends evident in the spatial indicators show strong coherence with trends in CPUE. For most reporting blocks trends in KgLa/Ha are correlated with trends in CPUE (Kg/Hr), while trends in the swim rate (Metres/Hr) are inverse to CPUE. As CPUE improves we expect that productivity per hectare will also improve, and that the swim rate will decrease as divers spend more time harvesting and less time searching. Sharp declines in CPUE associated with the MHW are mirrored by decreases in KgLa/Ha and increases in the rate at which reef is being covered by divers (Metres/Hr). Of concern is a trend of increasing mean maximum distance (MaxDist) of dive events and swim rate (Metres/Hr) in Blocks 16 and 17, while CPUE (Kg/hr) remains stable. A precautionary interpretation is that CPUE is displaying hyper-stability while stocks are declining. Similarly, the rapid increase in catch rate in Block 21 is not supported by a similar rapid decrease in swim rate in the past two years, highlighting the potential for fishers to quickly adapt to improving stock levels even though actual improvement maybe marginal.

The zone-wide proxy for abundance is 2.9 and above the LRP of 1 (section 2.4.6) and the zone-wide proxy for fishing mortality is 0.01 and just on the TRP for sustainability (fig. 3.4).

3.2 Western Zone

3.2.1 Zone Overview

For the period 1993–1999, the majority of what is now the Western Zone was under-fished (catch ranging from 500–750 t) in preference to the Eastern Zone where a higher beach price could be achieved. This lead to substantial accumulation of biomass and very high catch rates (1993 mean $SCPUE_{cw}$ 104.5 Kg/Hr; 1999 mean $SCPUE_{cw}$ 163.0 Kg/Hr). With the introduction of zones in 2000–2001 to manage the distribution of effort, the Western Zone TACC was elevated to 1260 t, and remained at this level through to 2008 with mean $SCPUE_{cw}$ declining to below 130 Kg/Hr. Through the mid 2000's selective fishing to deliver medium size abalone to the live market was suggested to be widespread. This took form in either targeting of sites known to have a smaller size structure, and avoiding areas which were non-preferred by the market, particularly the northern region of the Western Zone. Concerns about damaging effects on the resource, along with long-term declines in SCPUE were collectively addressed by partitioning the northern blocks of the Western Zone into a new Central West Zone, and implementation of spatial catch caps set annually for four broad geographic regions within this zone, to prevent excess catch being harvested due to economic pressures. The TACC in this management unit was reduced in 2009 to 924 t. In 2013 Blocks 7 and 8 were moved from the Central Western Zone back into the Western Zone and the TACC increased to 1001 t associated with the increased fishing area, but effectively retaining the same level of overall catch as in 2012. In 2013 mean SCPUE declined to 111.7 Kg/Hr, triggering a TACC reduction to 840 t for 2014 and 2015. By late 2015, mean $SCPUE_{cw}$ had declined to 91.9 Kg/Hr, necessitating further reductions in TACC for 2016 to 717 t, with this TACC retained for 2017 and 2018.

While catch and catch rates in the Western Zone have declined gradually since 2000, there is no evidence of a cyclic pattern of depletion and recovery (fig. 3.22). The distribution of catch across blocks has been relatively stable (fig. 3.24), with the exception of block 12 where catch has remained unchanged over the past two decades, compared to the overall TACC reduction within this period. Blocks 11 and 12 remain the highest producers of blacklip abalone in this zone. The Western Zone fishery is reliant on a relative small area of productive reef, with less than 15% of the reef area fished supporting 50% of the catch in most years (fig. 3.26). The overall area of reef utilised decreased in 2016, likely as a consequence of reduced TACC, and was largely unchanged in 2018 (fig. 3.27).

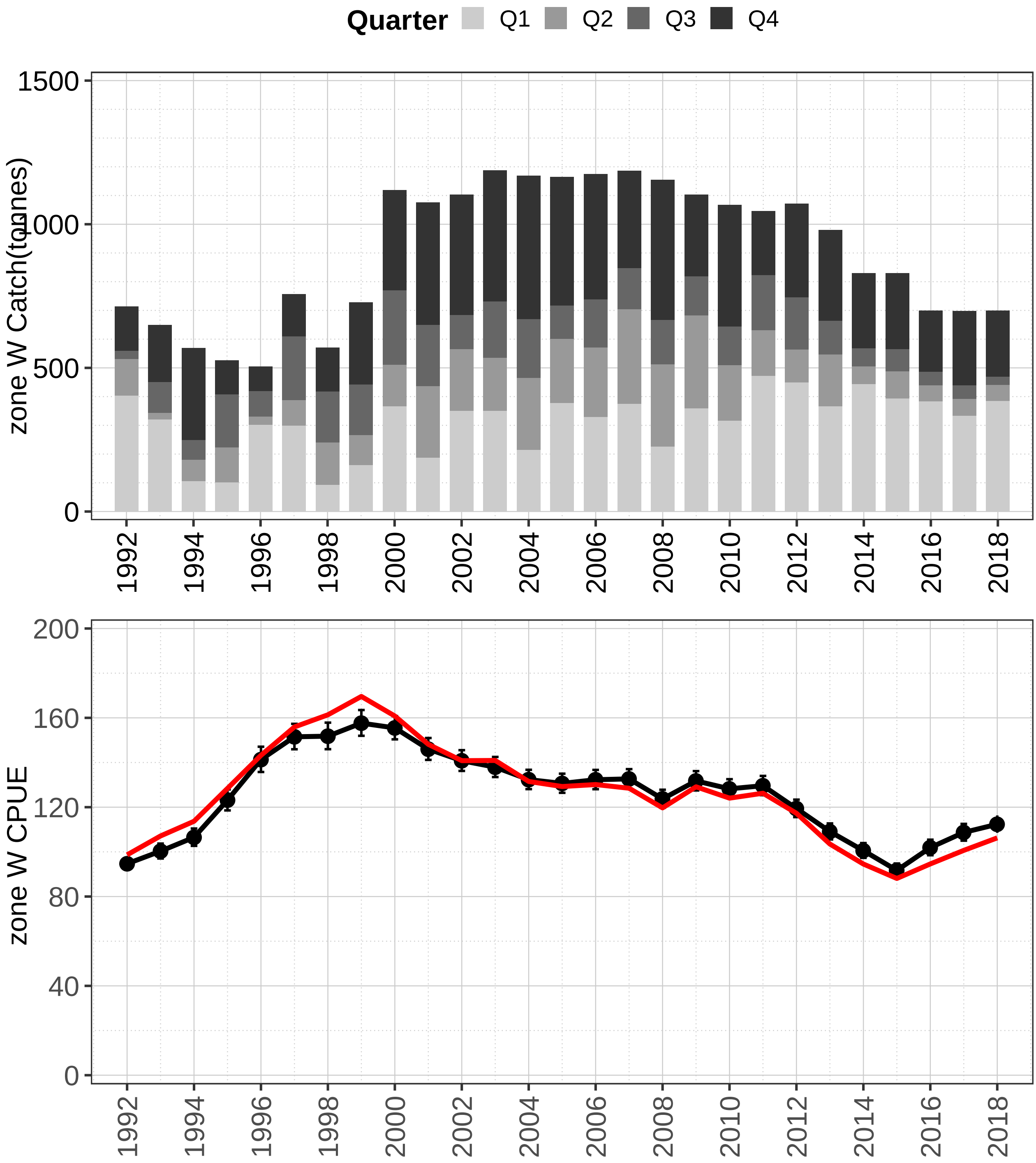


Figure 3.22: *Zone-wide catch and catch rate for Western Zone blacklip abalone, 1992–2018. Upper plot: catch (t) by quarter pooled across blocks currently classified as Western Zone. Lower Plot: standardised CPUE (black line) and geometric mean CPUE (red line).*

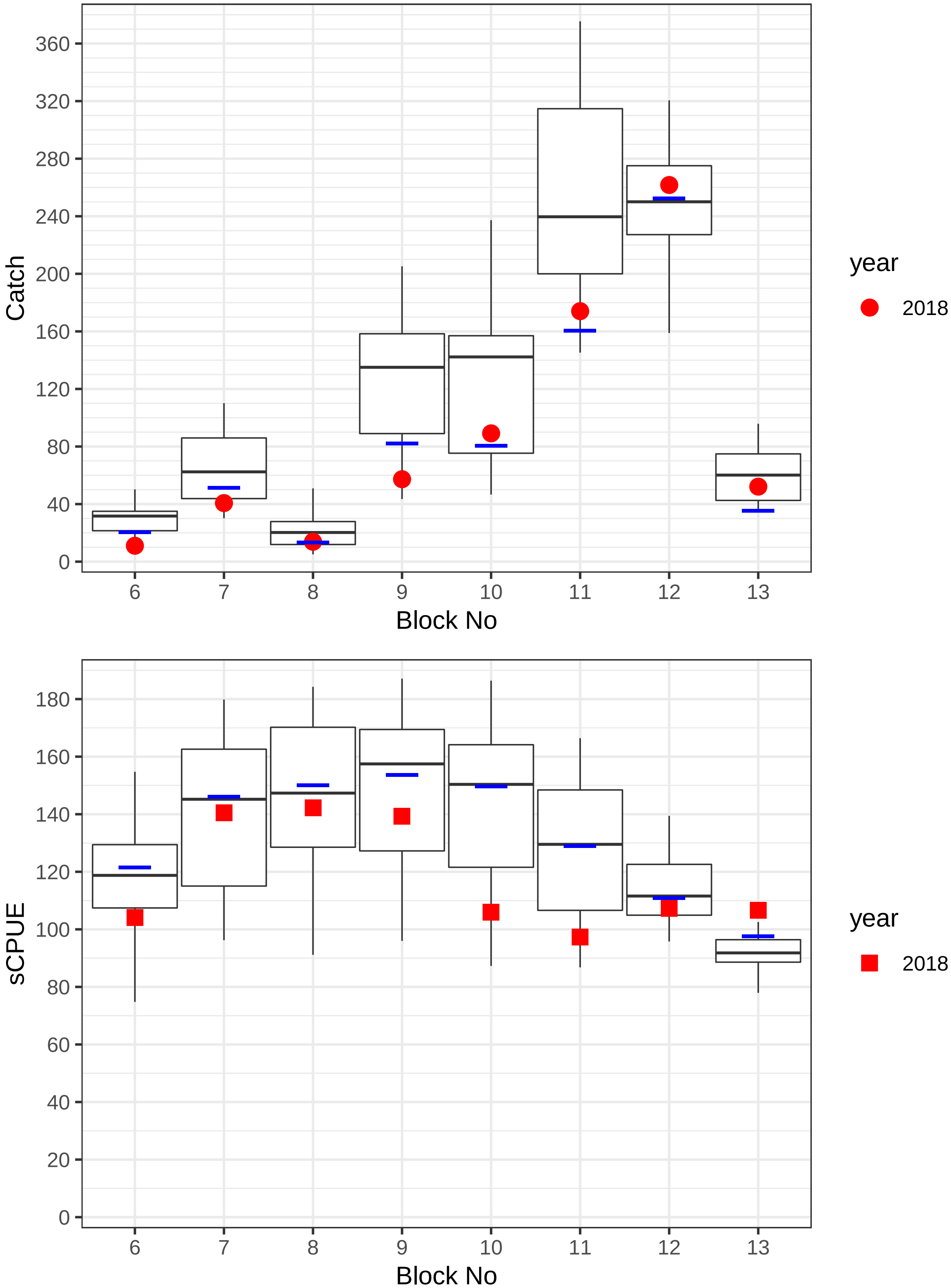


Figure 3.23: *Boxplot of catch and standardised CPUE by statistical block for the Western Zone blacklip abalone fishery.* ***Upper Panel****: Boxplot of annual catch. Blue line indicates catch target allocated for 2018. Red dot indicates catch taken in 2018.* ***Lower Panel****: Boxplot of annual standardised CPUE. Blue line indicates the CPUE target reference point. Red square indicates sCPUE in 2018.*

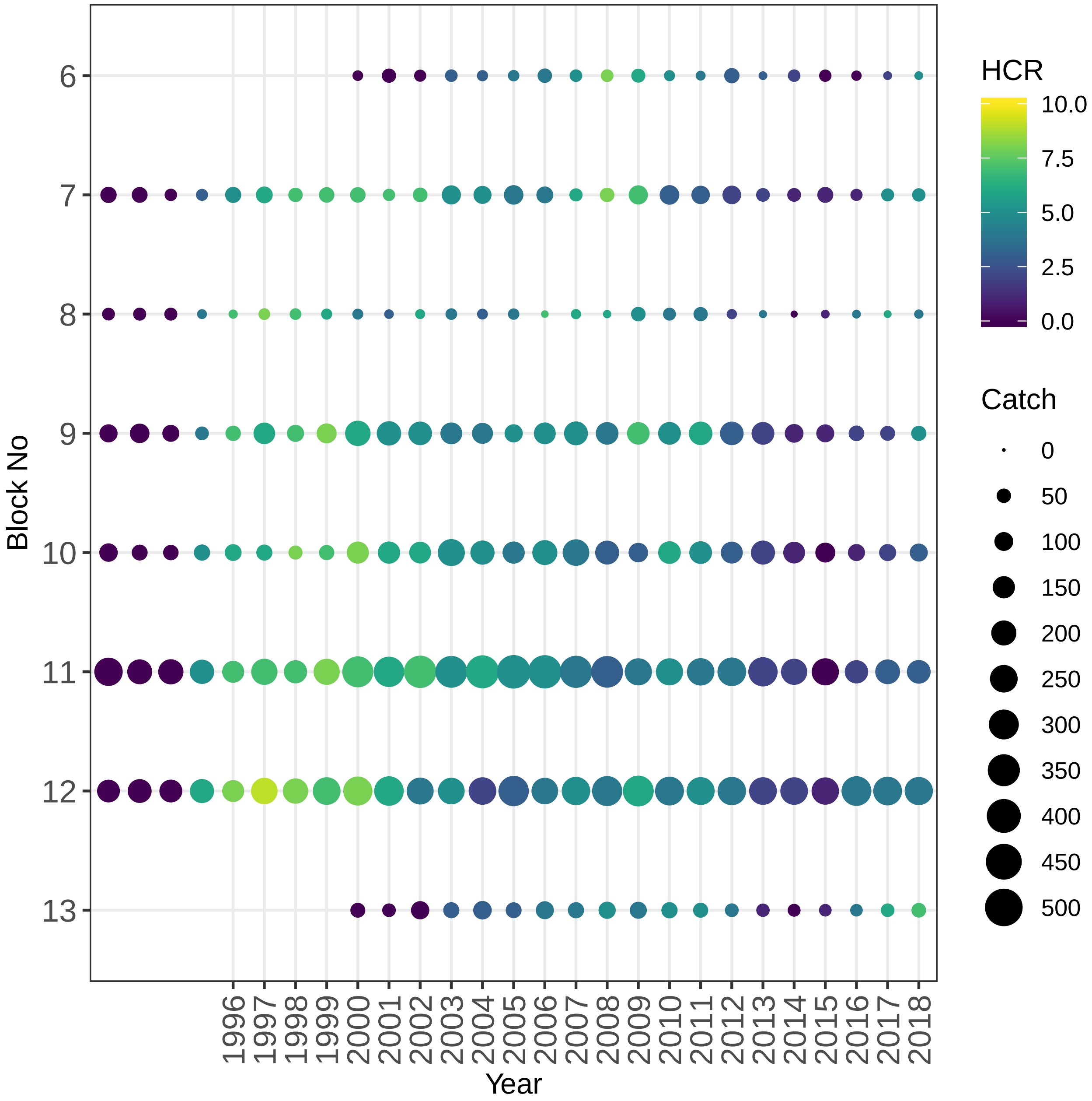


Figure 3.24: *Bubble plot of harvest strategy combined score (bubble colour) and catch (bubble size) for Western Zone blacklip abalone. Block 6 catch prior to 2000 included in Central Western Zone and Block 13 included in Eastern Zone*

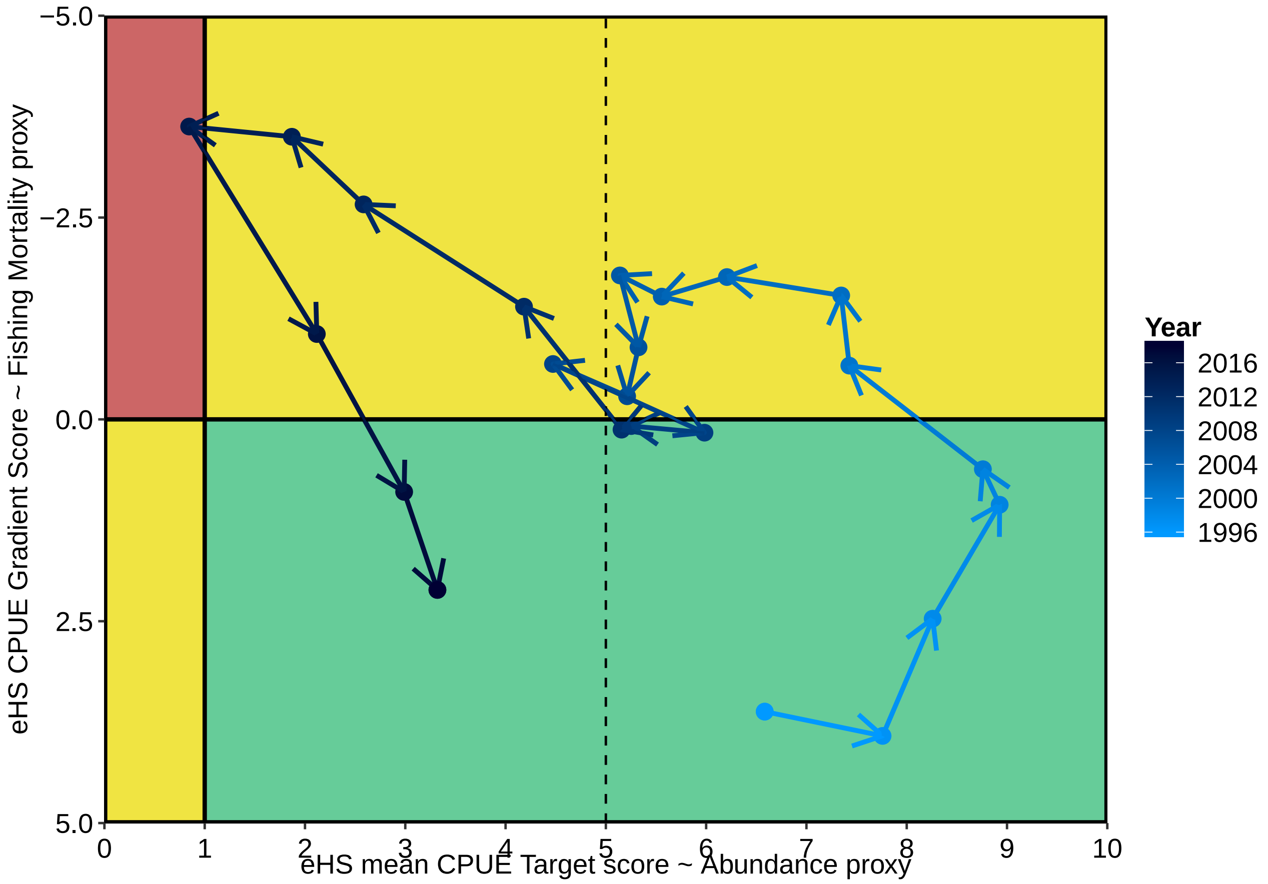
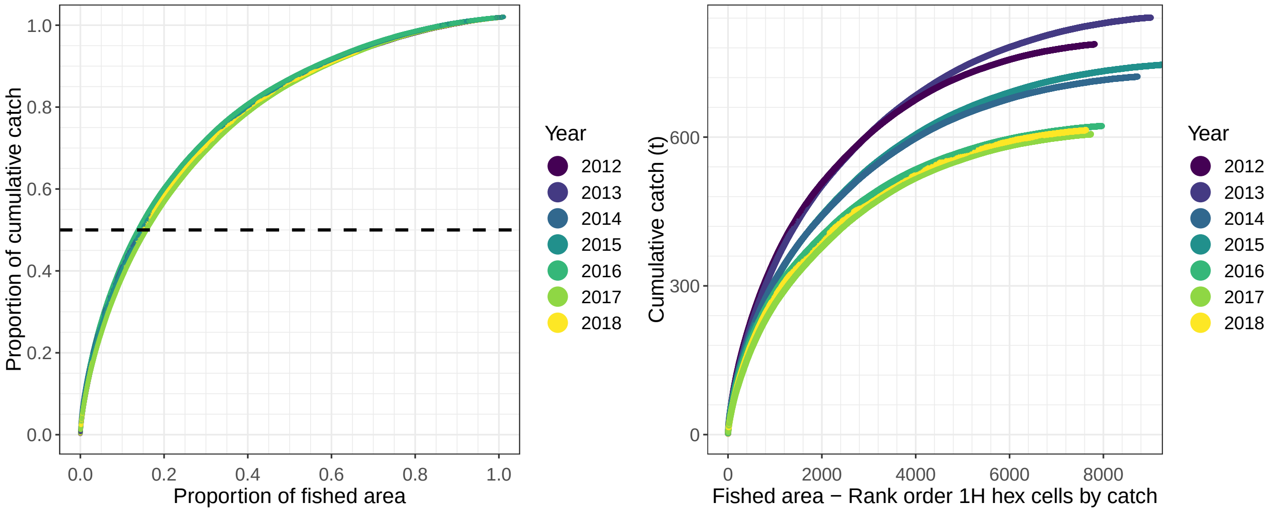


Figure 3.25: *Phase plot of fishing mortality and abundance proxies for Western Zone blacklip abalone , 1996–2018. The Gradient 4 PM (y-axis) is used as a proxy for fishing mortality, and the Target CPUE PM is used as a proxy for abundance. Zone score is calculated as a catch-weighted mean of individual block scores.*



(a) (b)

Figure 3.26: *Concentration area curves for catch in the Western Zone: a) Proportion of catch (y axis) against proportion of reef utilised (x axis). Hashed line represents 50% of catch; b) cumulative catch (y axis) against rank order of hex cells, descending from highest to smallest catch. Data filtered to exclude hex cells where less than 5 minutes of effort observed.*

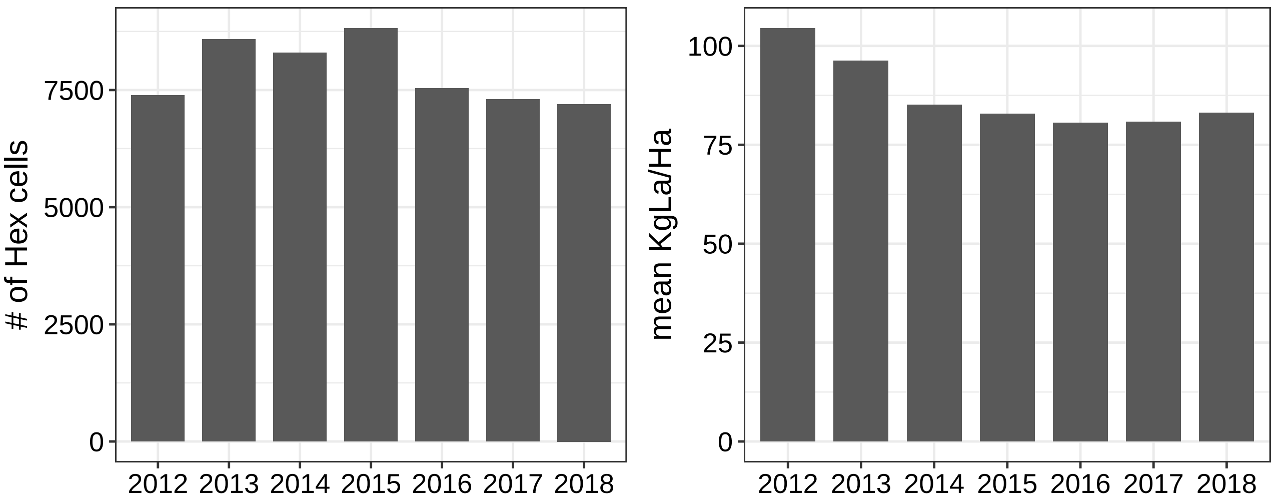


Figure 3.27: *Number of 1 Hectare grid cells where at least 5 minutes of fishing was observed for Western Zone blacklip abalone, and the total catch landed divided by the number of hex cells visited as the mean catch landed per hex cell.*

3.2.2 Fishery Trends by Statistical Block

Blacklip: Block 6D - Wild Wave River to Italian River

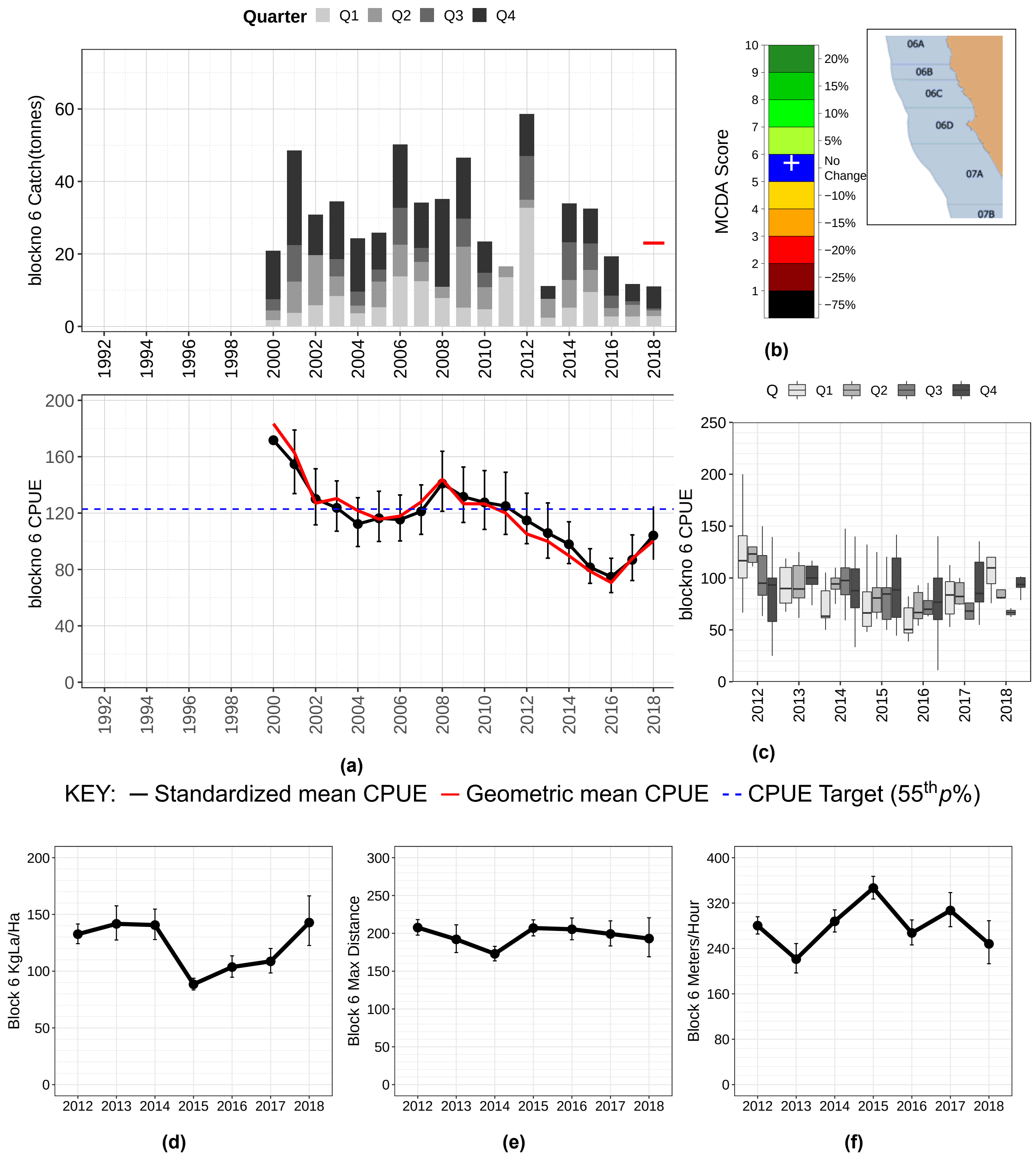


Figure 3.28: *Block 6D WZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 7 - Italian River to Granville Harbour

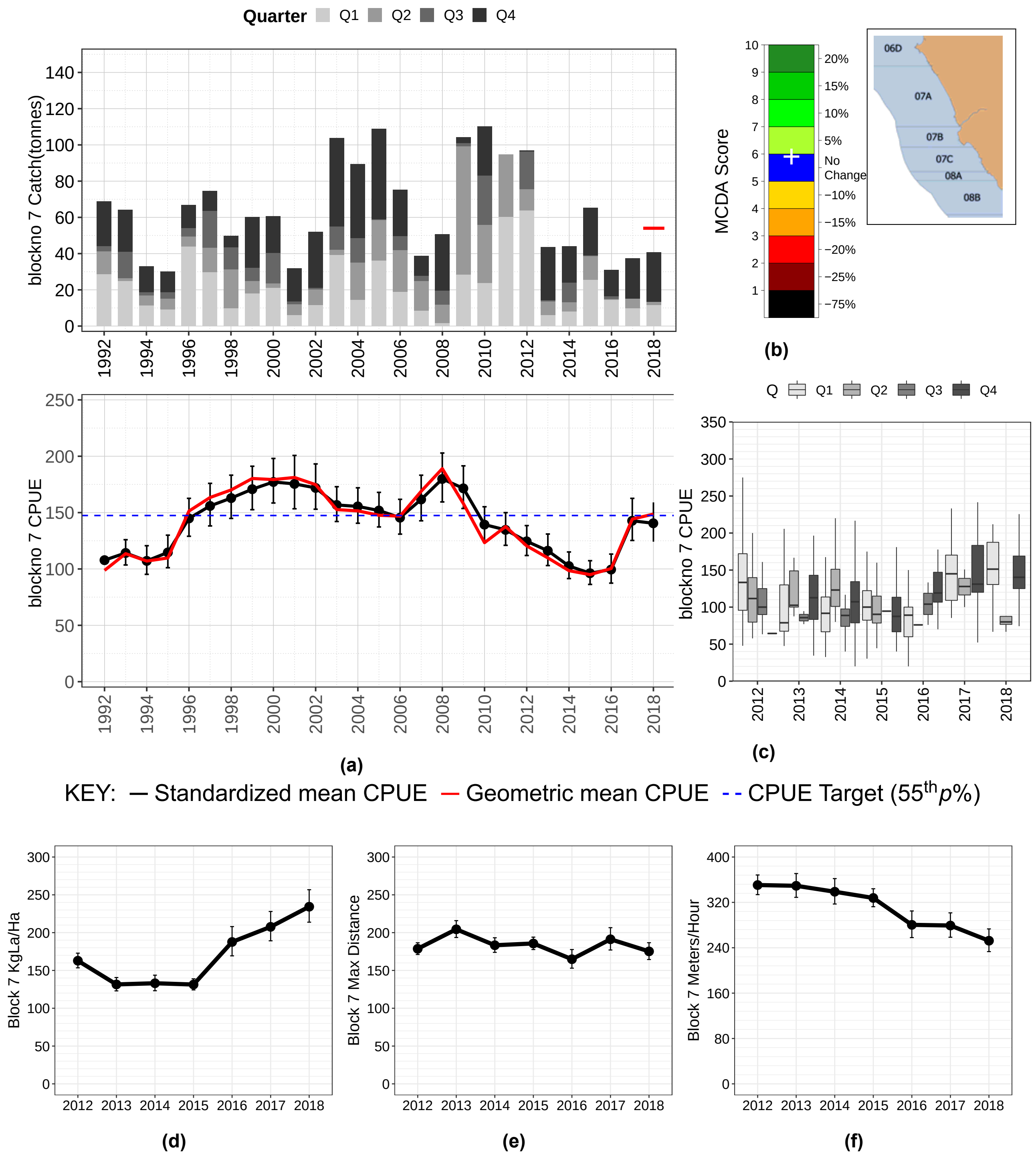


Figure 3.29: *Block 7 WZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 8 - Granville Harbour to Ocean Beach

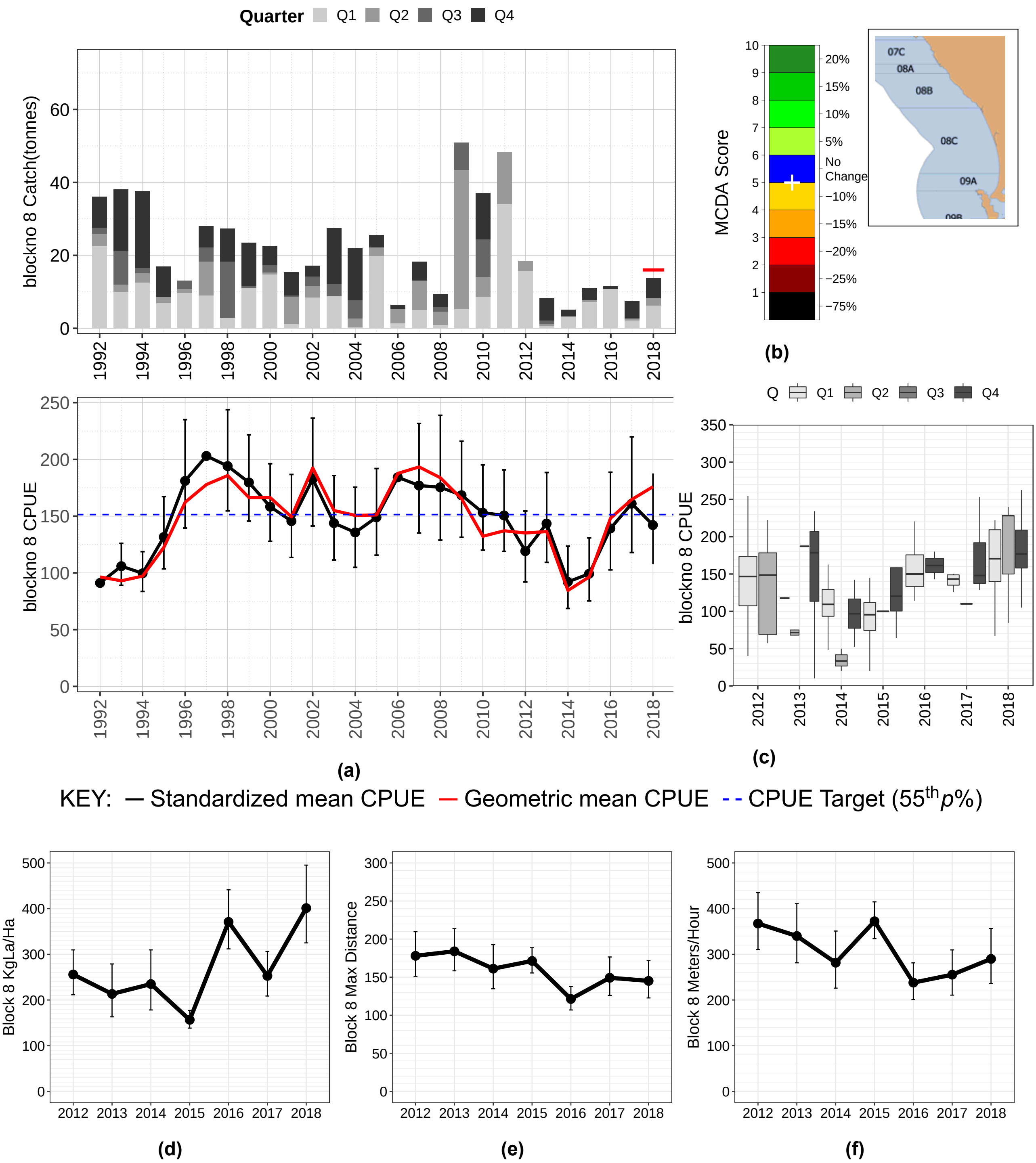


Figure 3.30: *Block 8 WZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 9 - Ocean Beach to Meerim Beach

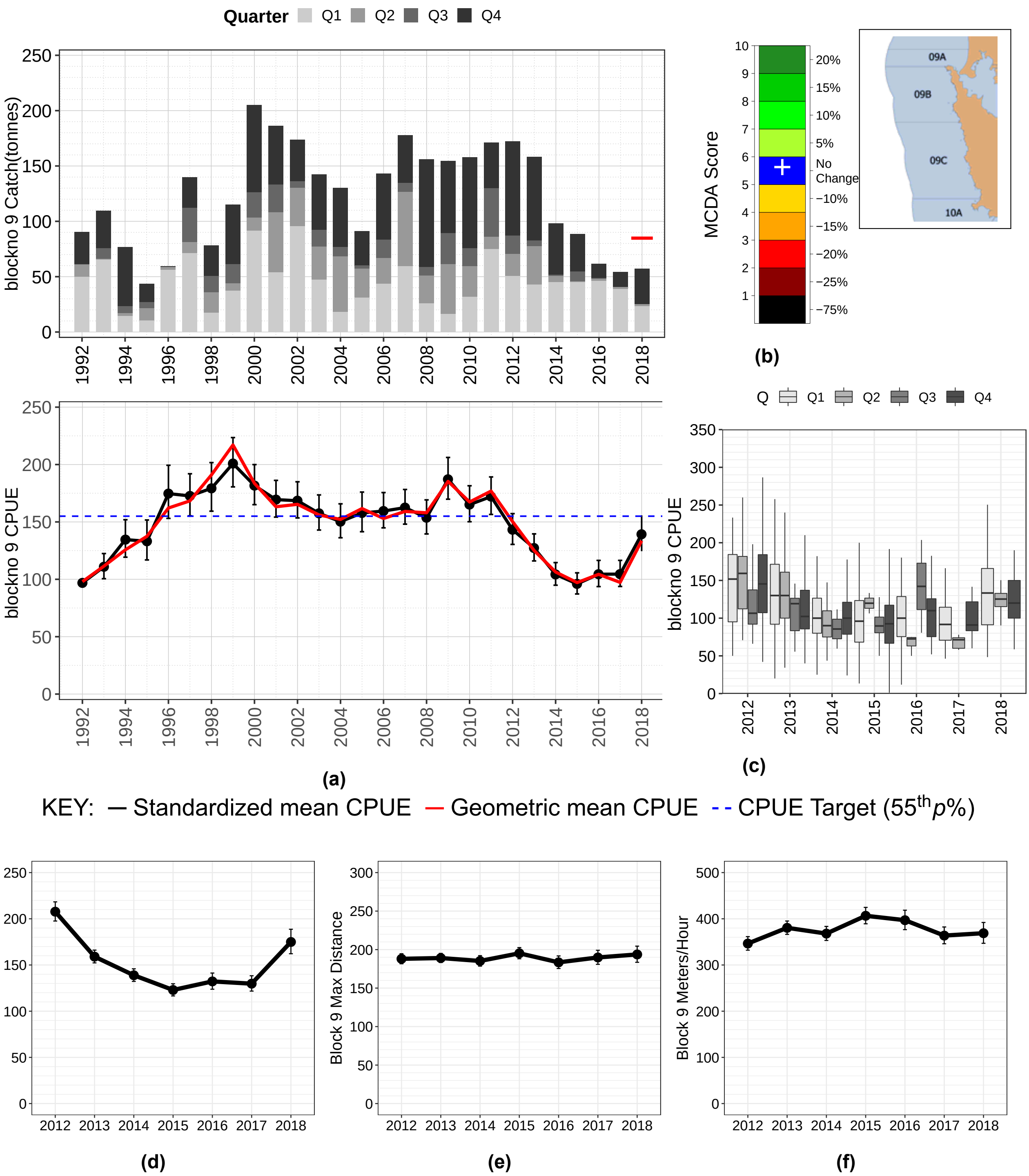


Figure 3.31: *Block 9 WZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 10 - Meerim Beach to Low Rocky Point

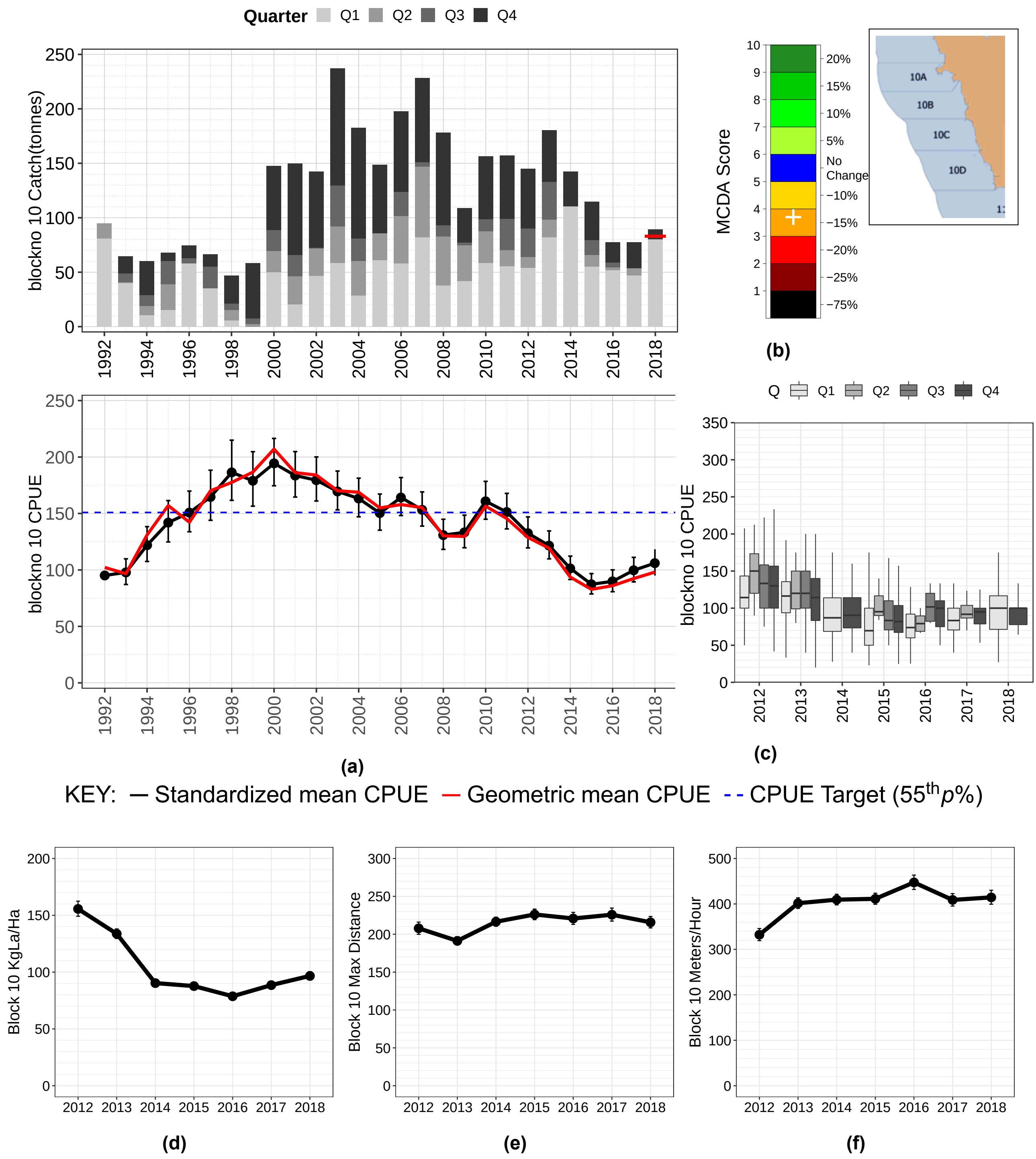


Figure 3.32: *Block 10 WZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 11 - Low Rocky Point to Faults Bay

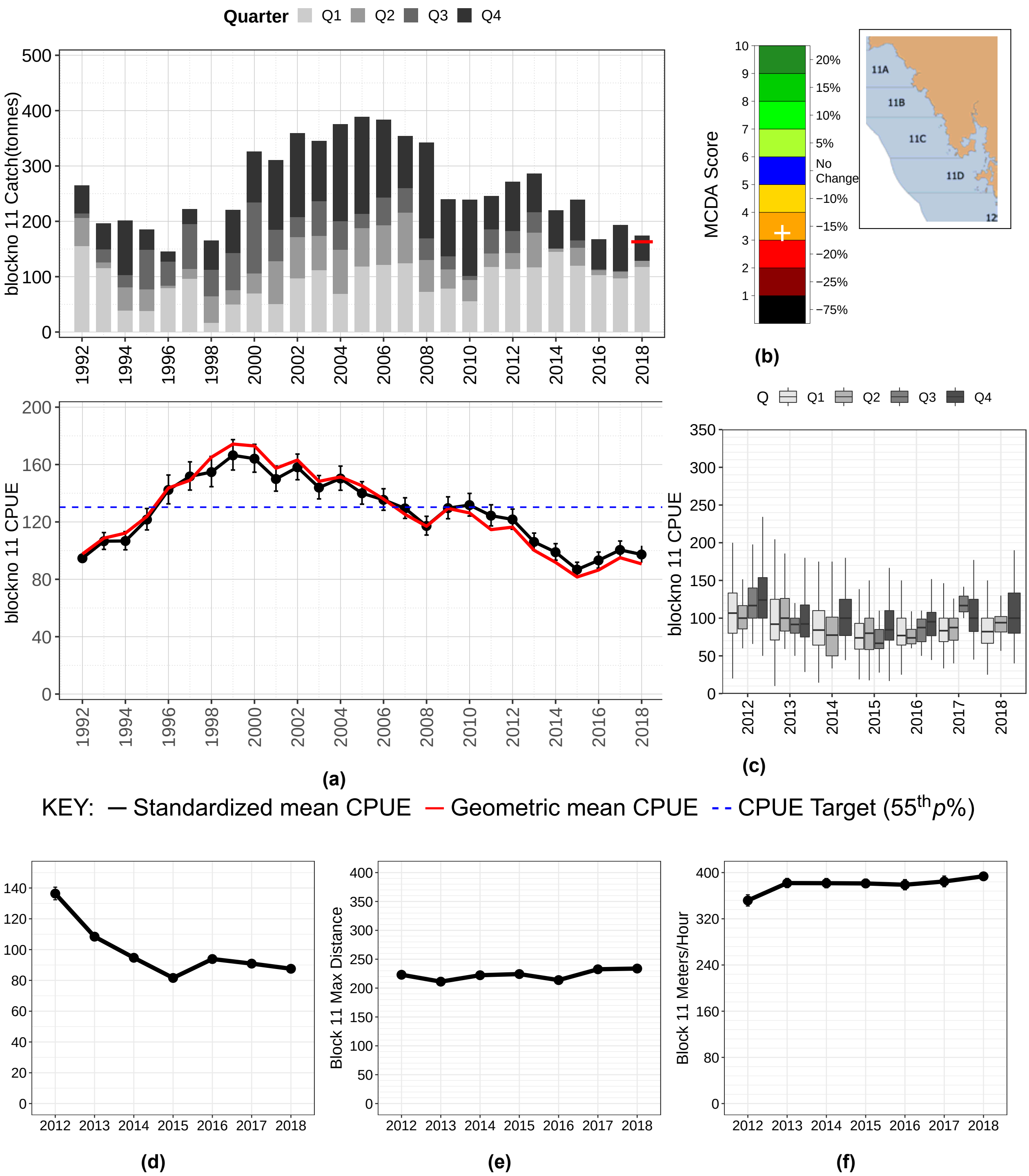


Figure 3.33: *Block 11 WZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 12 - Faults Bay to Prion Beach

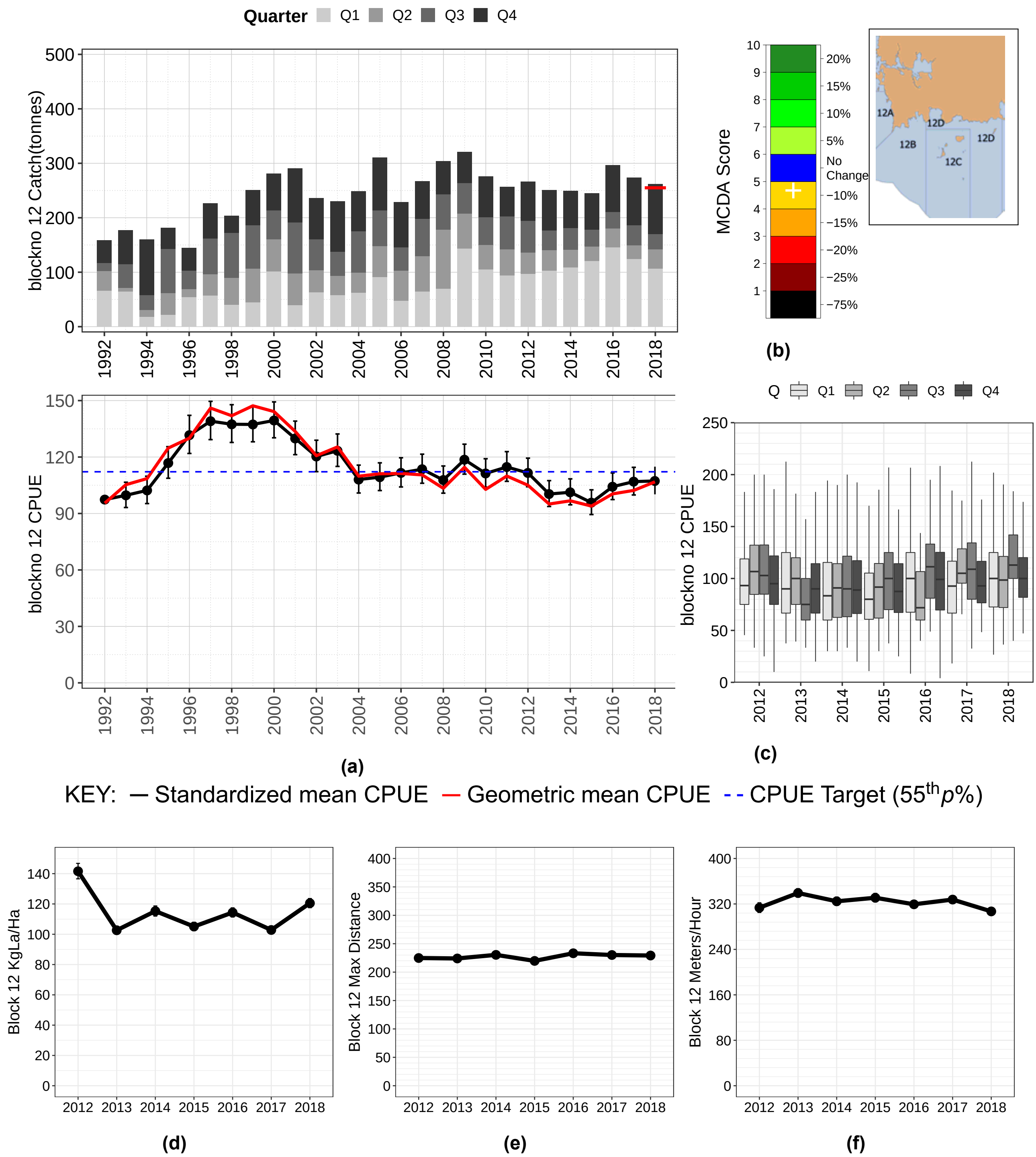


Figure 3.34: *Block 12 WZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 13A and B - Prion Beach to Whale Head

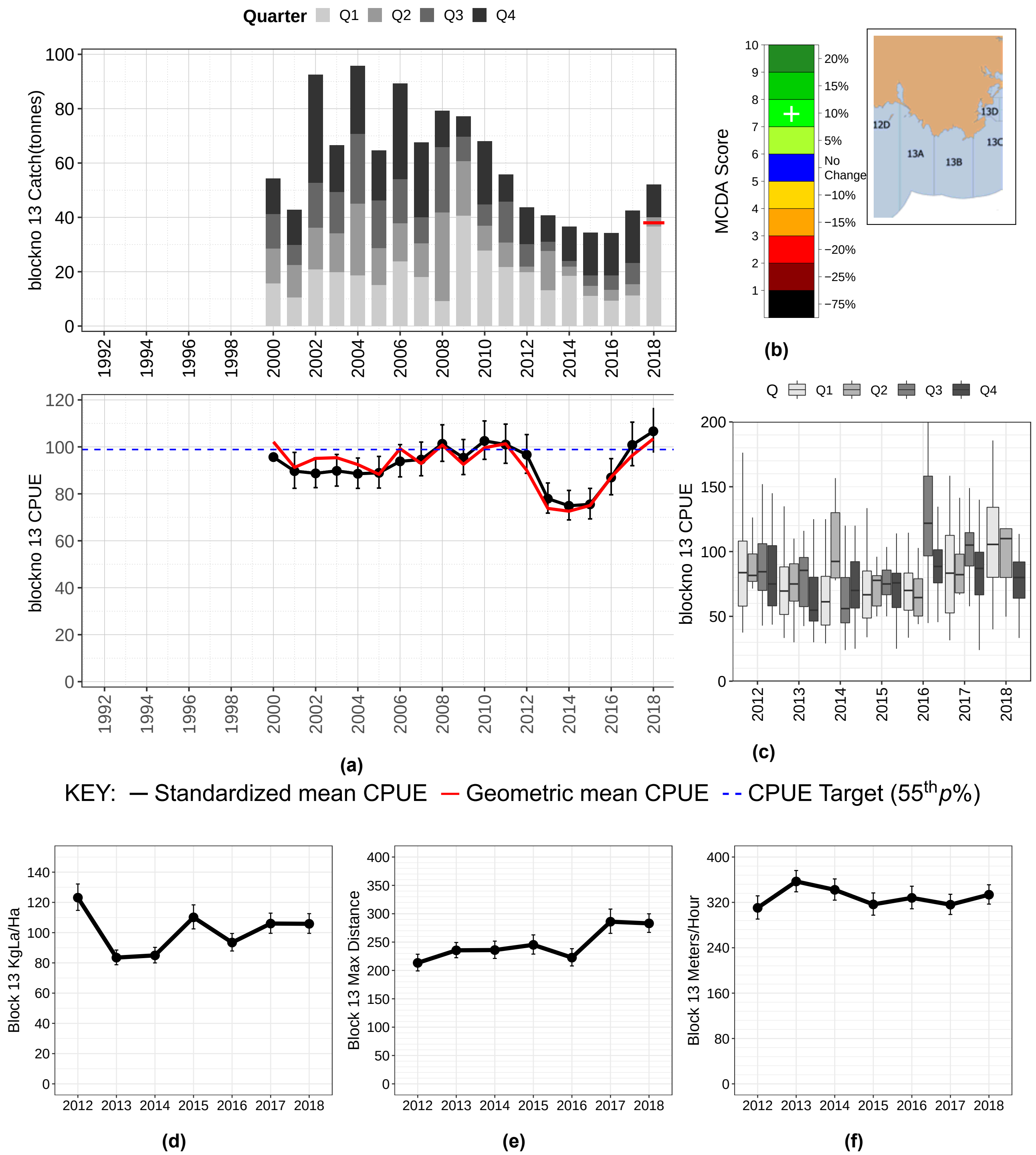
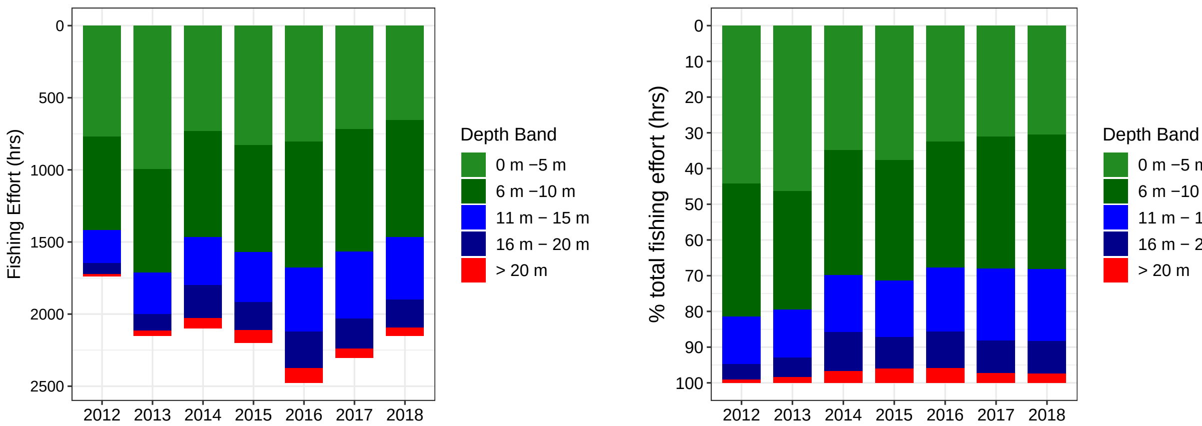


Figure 3.35: *Block 13A/B WZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

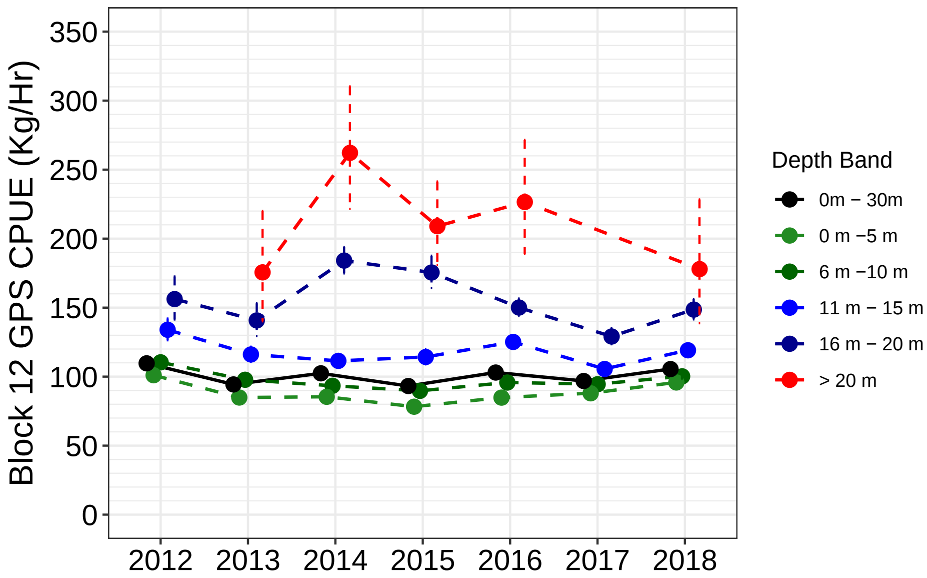
Effect on CPUE of increasing effort on deep reefs

Historically, several reefs greater than 10m were fished intensively and in recent years fishers are increasingly returning to a number of these deep fishing grounds. The primary deep reef fishing grounds are found around offshore islands and rock stacks particular along the south coast, but also the west coast and King Island. While concern was expressed by several divers about the extent of deep fishing in block 12, the proportion of effort in 5m depth bands has been stable for the past 4 years. Overall effort increased in block 12 between 2012 and 2016, although decreased slightly in 2017, and was stable in 2018. The proportion of effort deeper than 10 m increased sharply in 2014 and has remained stable through to 2018. (fig. 3.36). Average catch rates (Kg/Hr) on these deep reefs can be up to double the average catch rate shallower than 10 m (fig. 3.37). Catch rates in the 11 m to 15 m and 16 m to 20 m bands in block 12 has been declining over the past three years (fig. 3.37).



(a) **(b)**

Figure 3.36: *Fishing effort in Block 12 across five depth bands: a) Total effort in each depth band, pooled across dives; b) effort in each depth band as a percentage of total annual effort.*



(a)

Figure 3.37: *CPUE Kg/Hr in Block 12 across five depth bands. Note: all means are bias corrected geometric means with 95% confidence intervals. Solid black line indicates CPUE across all depths pooled. Coloured dashed lines represent CPUE in each depth band.*

In block 13, the proportion of effort deeper than 15 m has been increasing since 2014. In 2018 effort deeper than 10 m accounted for ≈ 30% of total effort, in contrast to 2012 and 2013 where effort greater than 10m was less than 10% (fig. 3.38). While catch rates > 15 m are almost 50% higher than catch rates below 15 m, the small proportion of catch events at depth are unlikely to have a major effect on the overall catch rate trend (fig. 3.39).

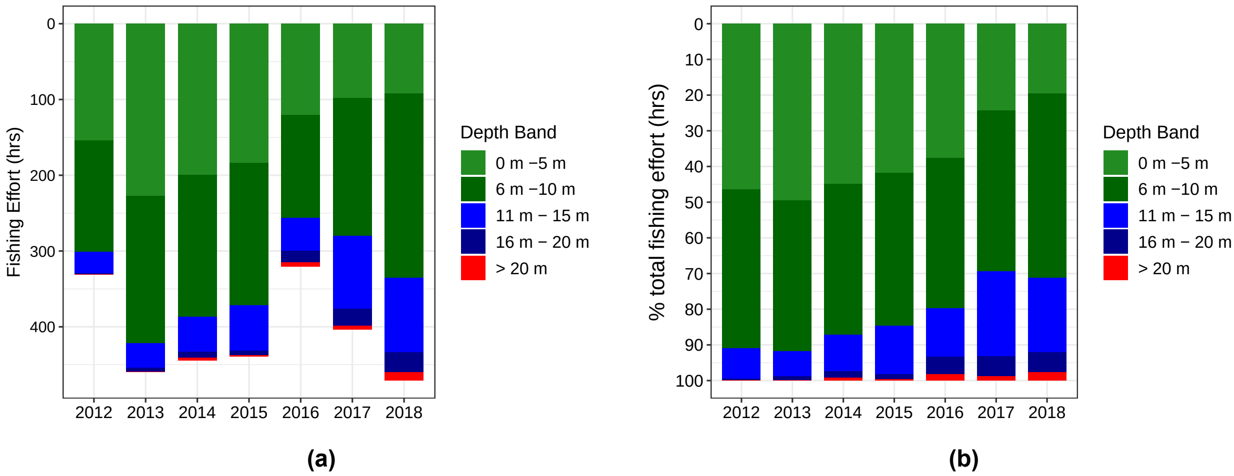


Figure 3.38: *Fishing effort in Block 13 across five depth bands: a) Total effort in each depth band, pooled across dives; b) effort in each depth band as a percentage of total annual effort.*

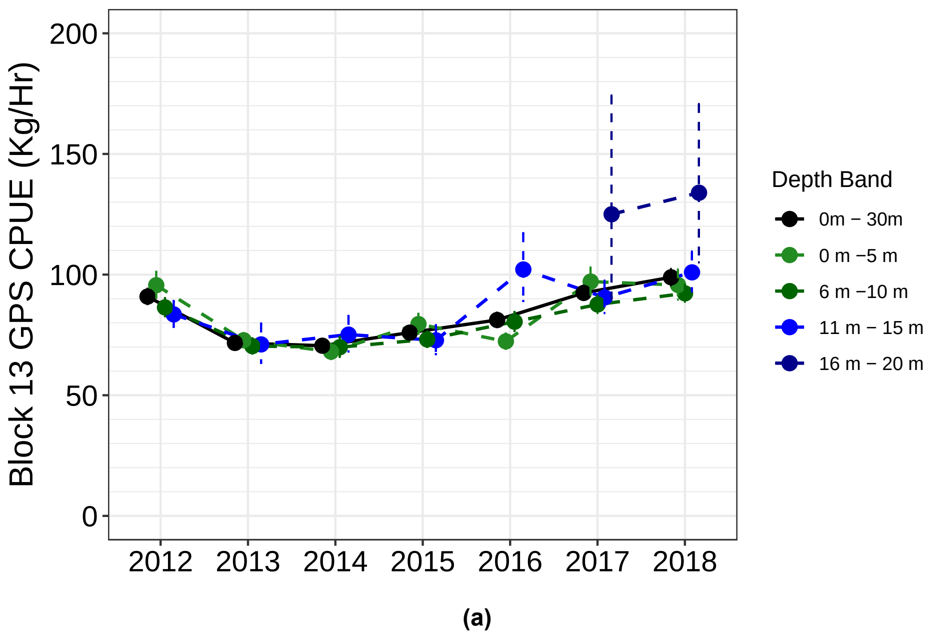


Figure 3.39: *CPUE Kg/Hr in Block 13 across five depth bands. Note: all means are bias corrected geometric means with 95% confidence intervals. Solid black line indicates CPUE across all depths pooled. Coloured dashed lines represent CPUE in each depth band.*

IMAS Summary Notes to FRAG –Western Zone

- CPUE in blocks 6, 9, 10, and 13 increasing.
  Calm weather enabled access to difficult to fish locations in block 9?
- CPUE in blocks 7, 8, and 12 stable.
- CPUE in block 11 declining.
- Fishing at depth in Western Zone Block 13 is increasing, with $\approx$ 30% of effort deeper than 11m in 2018.
  Has there been significant recruitment of abalone deeper than normal?
  Is there sign of multiple year-classes at depth?

Table 3.2: *Western Zone Catch, CPUE, Harvest Strategy scores and projected TACC for 2018. CPUE Targets are based on the 55th percentile of standardised annual mean CPUE, with a weighting of 65:25:10 on CPUE, Gradient 4 and Gradient 1 performance measures respectively*

Block No	**Catch 2017**	**Catch Targ**	**Catch YTD**	**CPUE YTD**	**Score CPUE**	**Score Grad4**	**Score Grad1**	**Score**	**HS adj**	**IM adj**	**MCDA 2019**	**IMAS 2019**	**FRAG 2019**
6	11.7	23.0	11.1	104.1	3.4	7.0	6.6	4.6	0.90	1.00	20.7	23.0	
7	37.3	54.0	40.7	140.6	4.5	9.0	4.7	5.6	1.00	1.00	54.0	54.0	
8	7.4	16.0	13.8	142.2	4.4	7.2	3.7	5.0	0.90	1.00	14.4	16.0	
9	55.7	84.8	57.3	139.2	3.8	8.4	8.4	5.4	1.00	1.00	84.8	84.8	
10	77.8	83.0	89.2	106.0	2.0	8.3	6.3	4.0	0.90	1.00	74.7	83.0	
11	194.6	163.0	174.1	97.3	1.9	8.9	4.0	3.8	0.85	0.85	138.5	138.5	
12	273.9	255.0	261.7	107.3	3.8	8.7	5.1	5.1	1.00	1.00	255.0	255.0	
13	42.5	38.0	52.2	106.6	7.3	8.8	6.5	7.6	1.10	1.15	41.8	43.7	
Total	701.0		700.0								683.9	698.0	0.0

3.2.3 Western Zone Summary

The zone-wide mean $SCPUE_{cw}$ has continued to improve over 2017 and at the end of 2018 had increased approximately 2 Kg/Hr to 109.6 Kg/Hr. Increasing catch rates were observed in blocks 6, 9, 10, 13. Catch rates in blocks 7 and 12 were stable, while blocks 8 and 11 declined. The proportion of effort on deeper reefs in Blocks 12 and 13 was similar to that observed in 2017.

The Simple Spatial Indicators (SSI) largely supported the observed CPUE trends, but with some notable exceptions. SSI trends suggest abundance in block 7 continued to increase in 2018 whereas CPUE appeared to be stable. SSI trends were mixed in Block 8 with two indicators (Kg/Ha and MaxDist) improving in 2018, whereas the swim rate (Lm/Hr) increased, suggesting a decline in abundance. The sharp increase in CPUE (Kg/Hr) in block 9 was matched by CPUA (Kg/Ha), whereas MaxDist and the SwimRate were stable. These contradictory trends suggest the rapid increase in abundance indicated by CPUE may not be accurate. SSI in Block 12 were also contradictory, with CPUA and SwimRate suggestive of improving abundance, whereas MaxDist and CPUE remained stable. None of the SSI trends in Block 13 reflected the increase observed in CPUE.

The zone-wide proxy for abundance is 3.3, while the proxy for fishing mortality has declined from 2017 and is now 2.0, but remains above the TRP for sustainability (fig. 3.25).

3.3 Northern Zone

3.3.1 Zone Overview

In 2018, several major changes to zone boundaries were made in order to partition zones into areas with similar size limits and where market price was largely equal. The first change was to extend the southern boundary of the Northern Zone on the West coast to include Sub Blocks 6A, 6B and 6C, and abolish Central West Zone. The second change was to Extend the western boundary of the Bass Strait Zone further west to incorporate Block 48 and Sub Blocks 49A, 49B and 49C (Hunter, Three Hummock and Robbins Islands). Albatross Islands and other offshore islands west of Hunter Island were retained in the Northern Zone. The Legal Minimum Length was increased in Block 5 and 49D from 127 mm to 132 mm in 2018. This change reduced the overall geographic variation in dynamics within the Tasmanian Northern Zone, reflected by only two Legal Minimum Lengths (LML) –129 mm and 132 mm. Regional catch and catch rates have varied between 2000 and 2018 (fig. 3.40) as a function of changing market preference and adaptive management including effort redistribution and changes in LML. The majority of abalone landed from this zone are traditionally unsuited to the live market, and are processed for canned or frozen markets.

In 2008, the first of two industry driven experimental fisheries to improve fish quality commenced in Block 5 with a reduction in LML from 132mm –127 mm and a 50 t increase in catch, and a second industry driven experimental fishery commenced in Block 49 in 2011, pushing the Northern Zone TACC to a peak of 402.5 t. These two blocks, along with block 3 on King Island produce the majority of blacklip abalone for the Northern Zone (fig. 3.42). This experimental depletion initiative was not successful, and has had longer term negative impacts on biomass. Standardised CPUE (SCPUE) varies across different geographic regions within the Northern Zone, but $SCPUE_{cw}$ for the zone has fallen in all the key fishing grounds targeted in the industry program over the past five years despite TACC reductions in every year from 2012 to 2018 (chapter C).

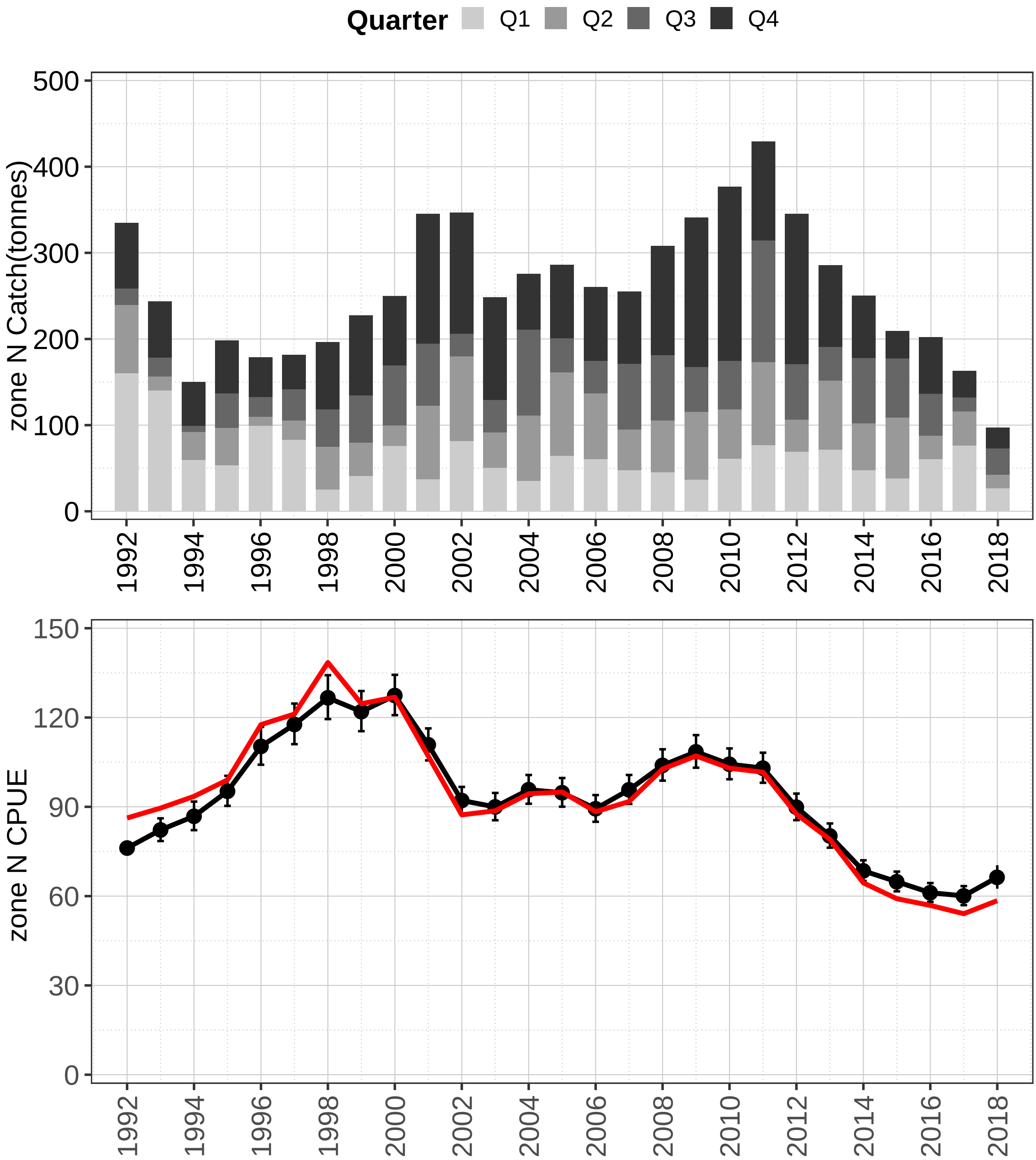


Figure 3.40: *Zone-wide catch and catch rate for Northern Zone blacklip abalone, 1992–2018. Upper plot: catch (t) by quarter pooled across blocks currently classified as Northern Zone. Lower Plot: standardised CPUE (black line) and geometric mean CPUE (red line).*

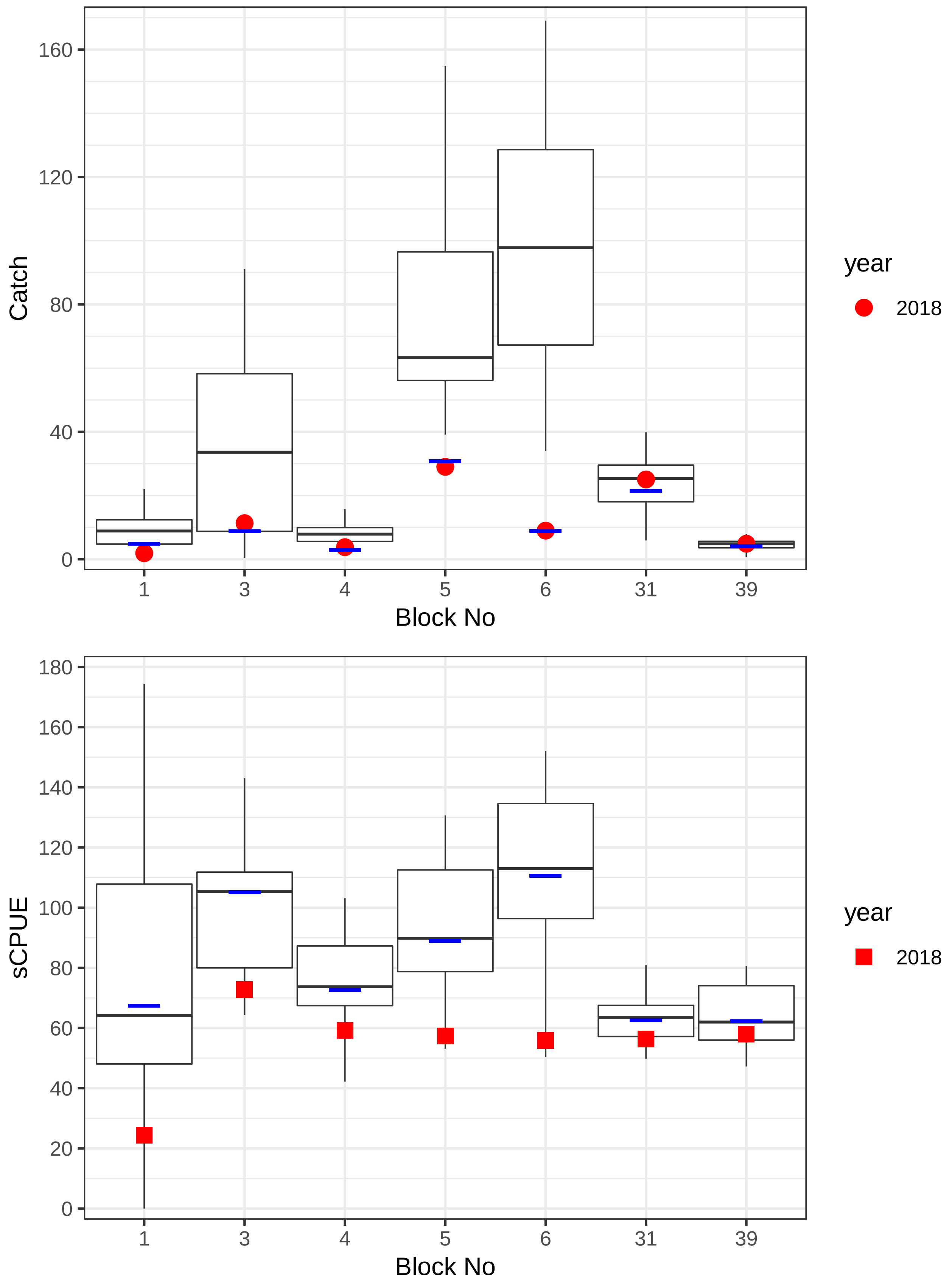


Figure 3.41: *Boxplot of catch and standardised CPUE by statistical block for the Northern Zone blacklip abalone fishery.* ***Upper Panel****: Boxplot of annual catch. Blue line indicates catch target allocated for 2018. Red dot indicates catch taken in 2018.* ***Lower Panel****: Boxplot of annual standardised CPUE. Blue line indicates the CPUE target reference point. Red square indicates sCPUE in 2018.*

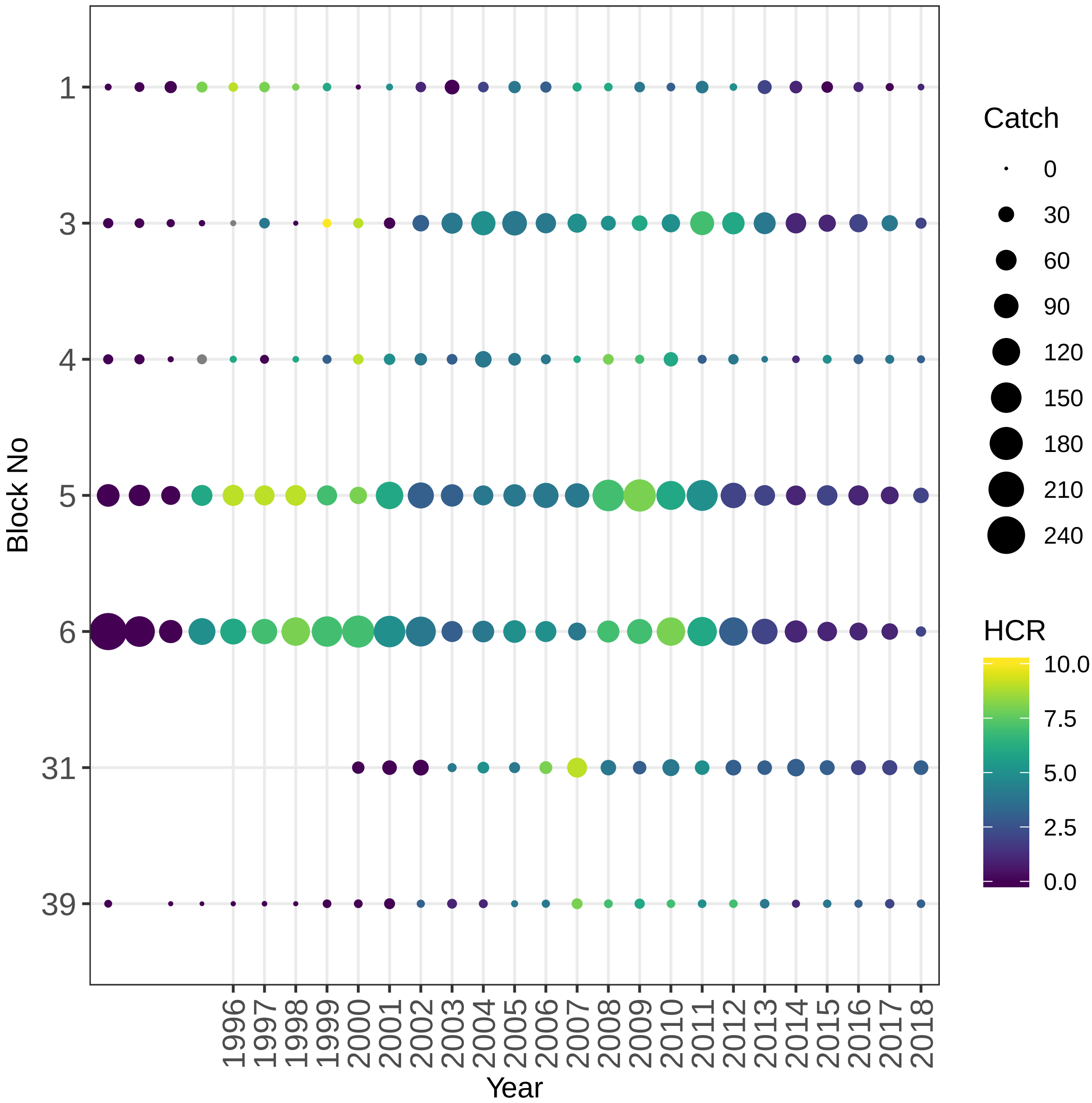


Figure 3.42: *Bubble plot of harvest strategy combined score (bubble colour) and catch (bubble size) for Northern Zone blacklip abalone. Block 31 catch prior to 2000 included in Eastern Zone*

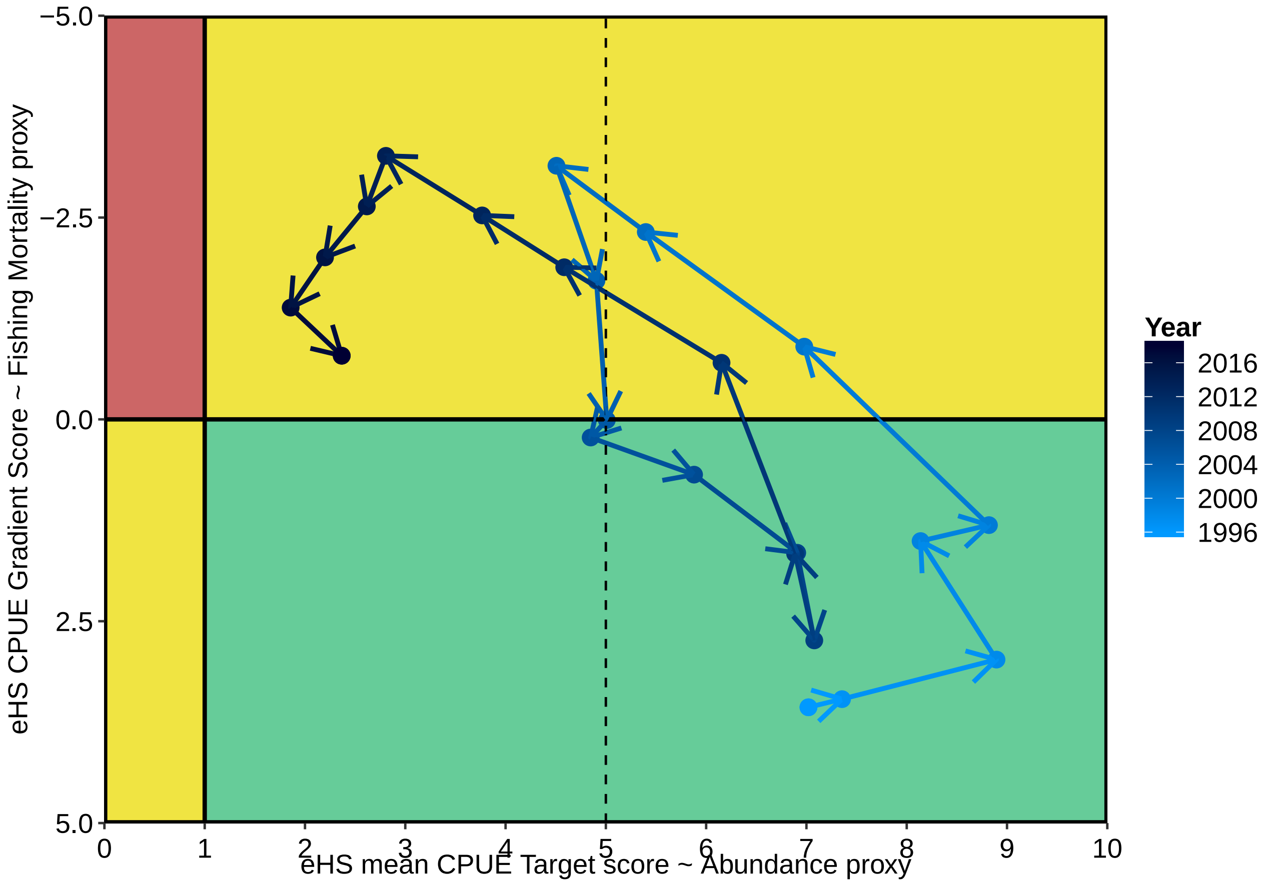


Figure 3.43: *Phase plot of fishing mortality and abundance proxies for Northern Zone blacklip abalone , 1996–2018. The Gradient 4 PM (y-axis) is used as a proxy for fishing mortality, and the Target CPUE PM is used as a proxy for abundance. Zone score is calculated as a catch-weighted mean of individual block scores.*

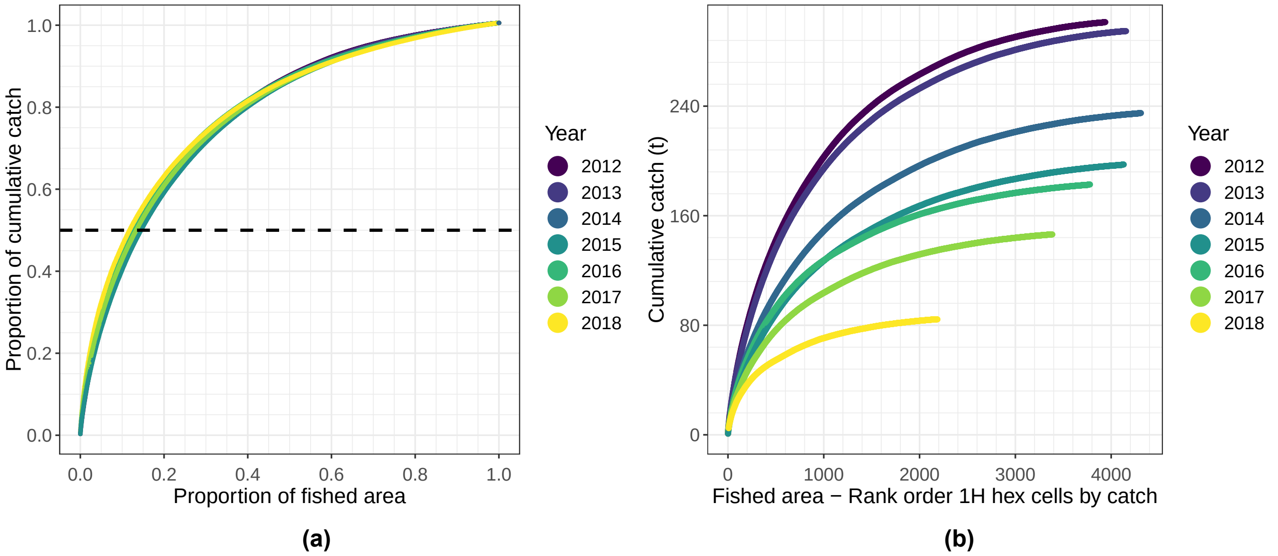


Figure 3.44: *Concentration area curves for catch in the Northern Zone: a) Proportion of catch (y axis) against proportion of reef utilised (x axis). Hashed line represents 50% of catch; b) cumulative catch (y axis) against rank order of hex cells, descending from highest to smallest catch. Data filtered to exclude hex cells where less than 5 minutes of effort observed.*

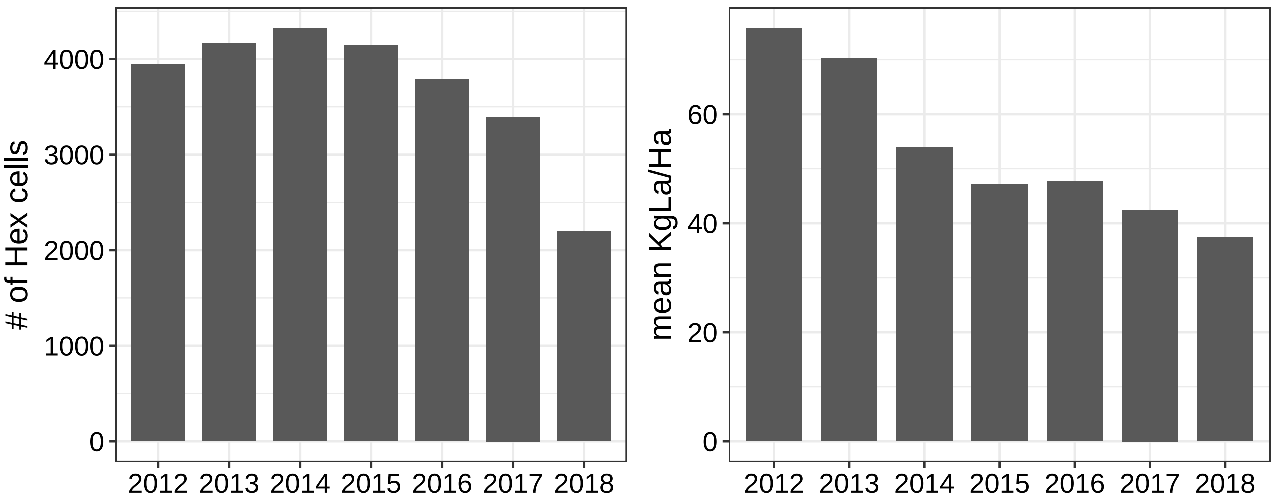
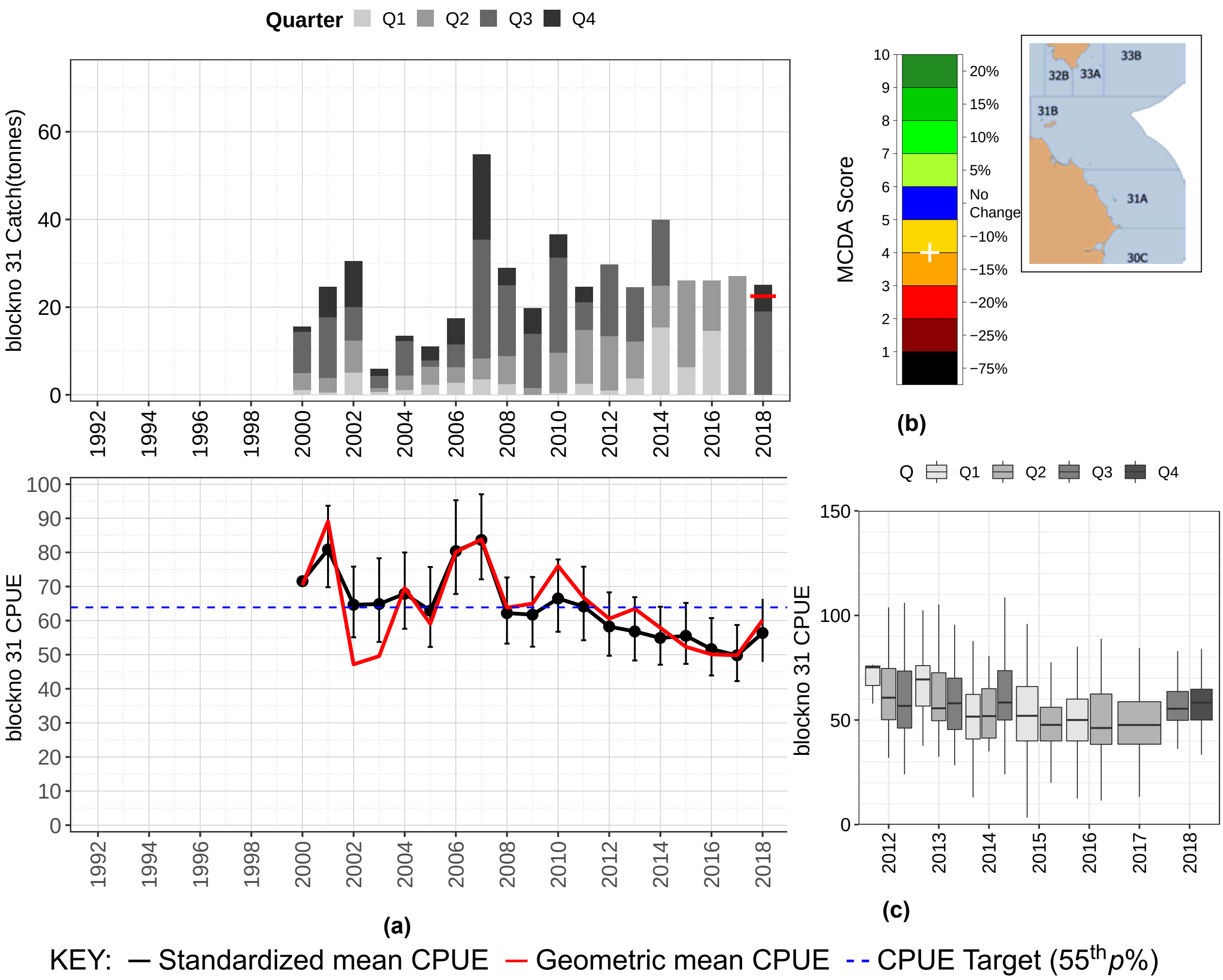


Figure 3.45: *Number of 1 Hectare grid cells where at least 5 minutes of fishing was observed for Northern Zone blacklip abalone, and the total catch landed divided by the number of hex cells visited as the mean catch landed per hex cell.*

3.3.2 Fishery Trends by Statistical Block

Blacklip: Block 31B - Cape Naturaliste to Little Musselroe Bay



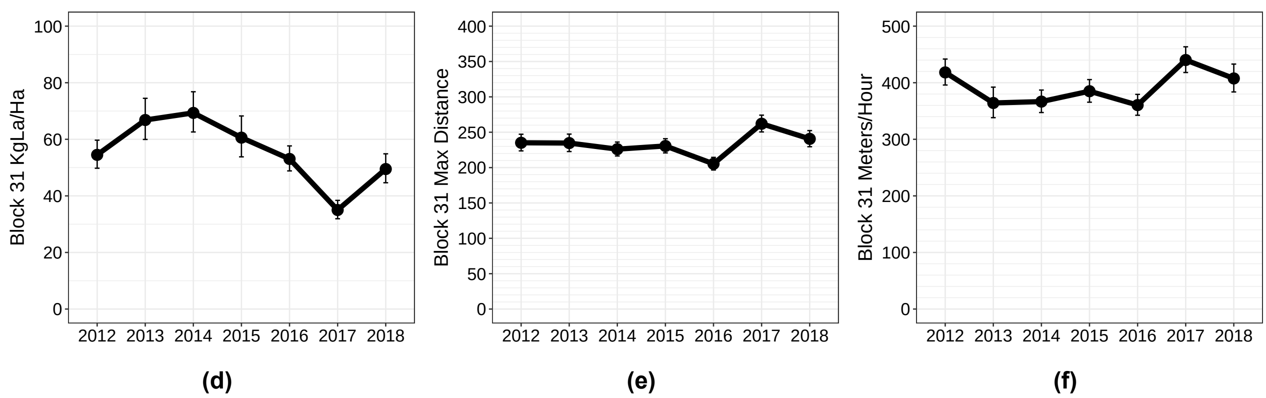


Figure 3.46: *Block 31B NZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 39 - Little Musselrose Bay to Tomahawk Beach

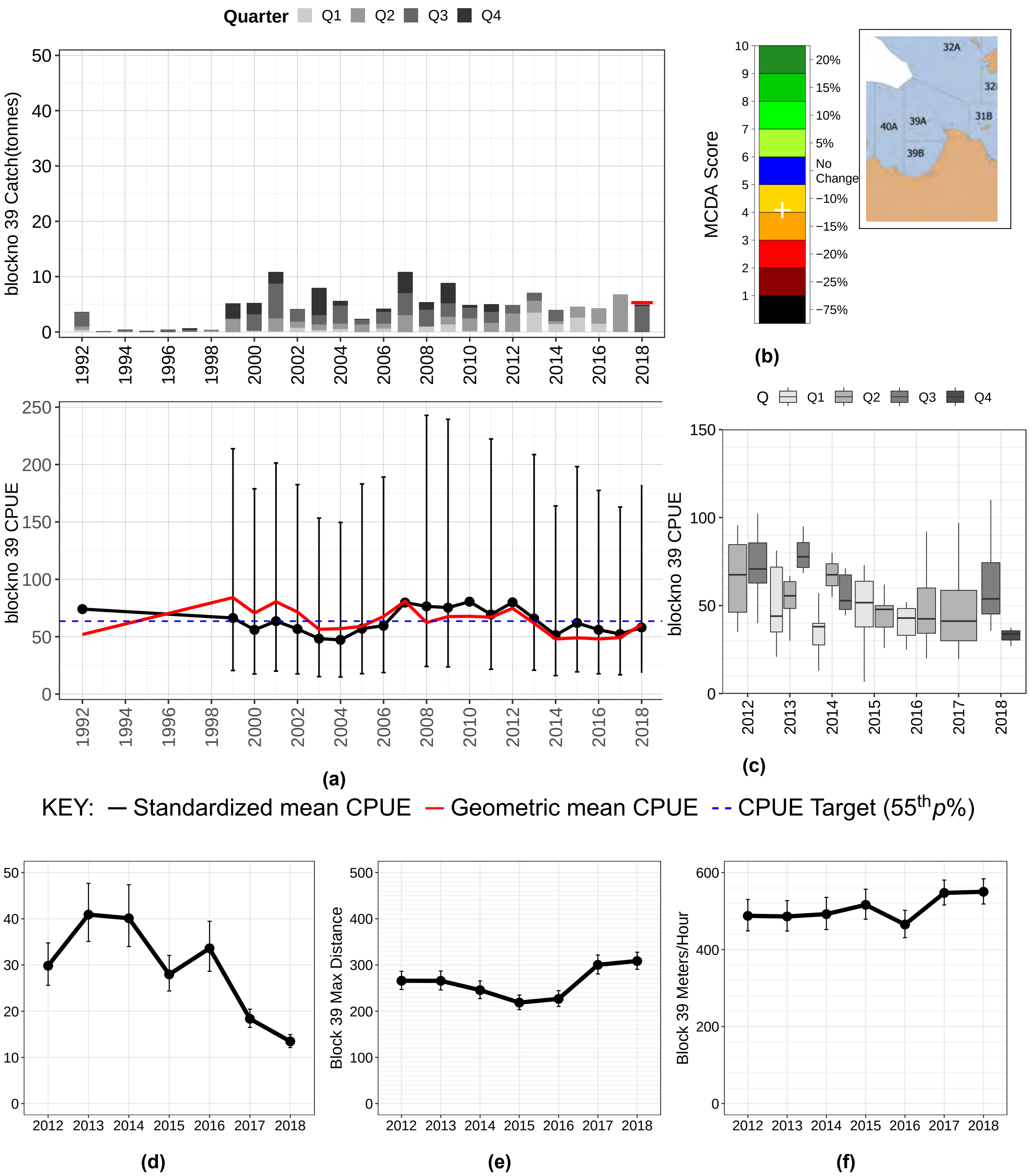


Figure 3.47: *Block 39 NZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 49D - Albatross Island

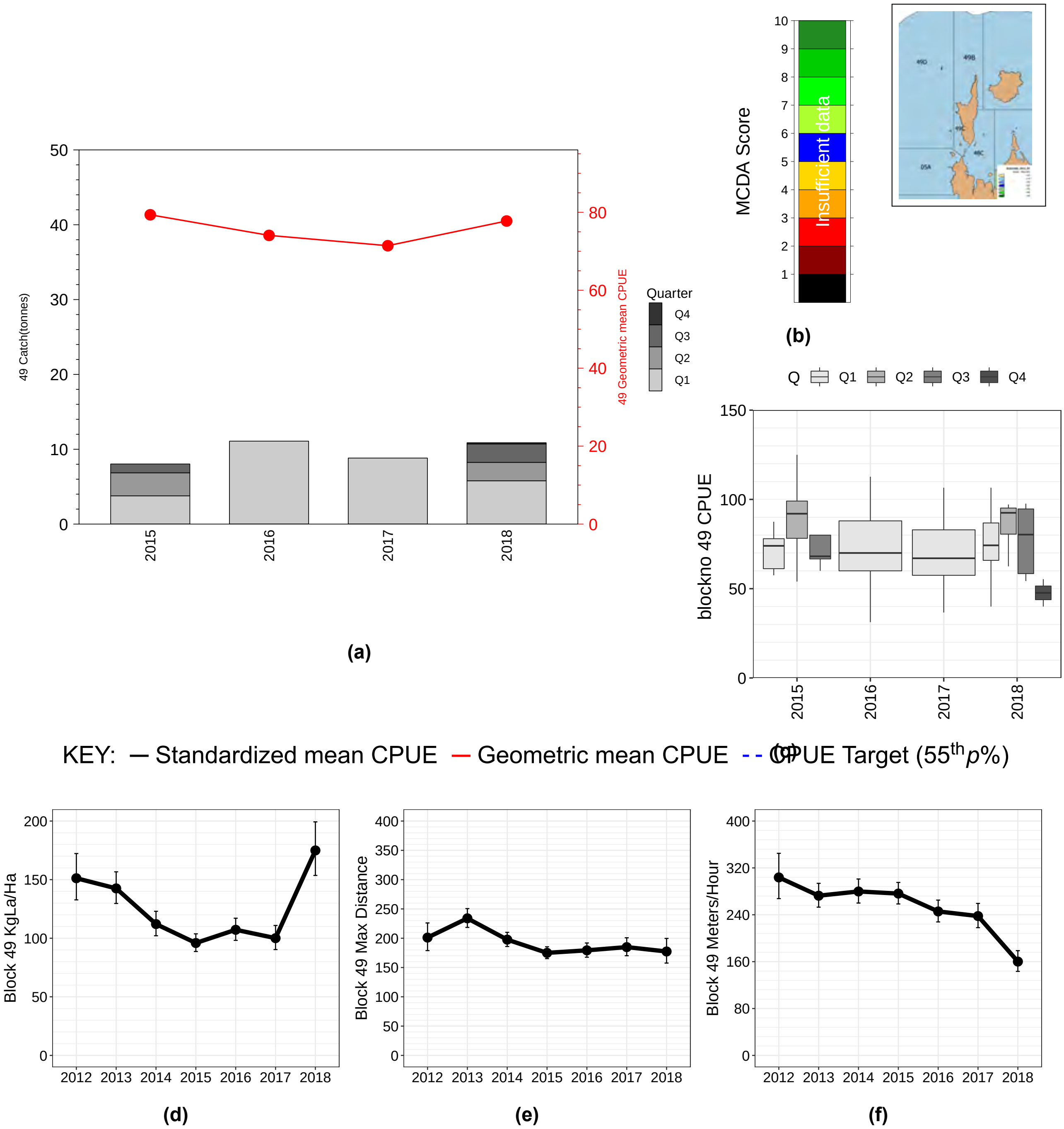


Figure 3.48: *Block 49 NZ: a) Catch per quarter (bars), bias corrected geometric mean CPUE; b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 5A-C - Woolnorth to Arthur River

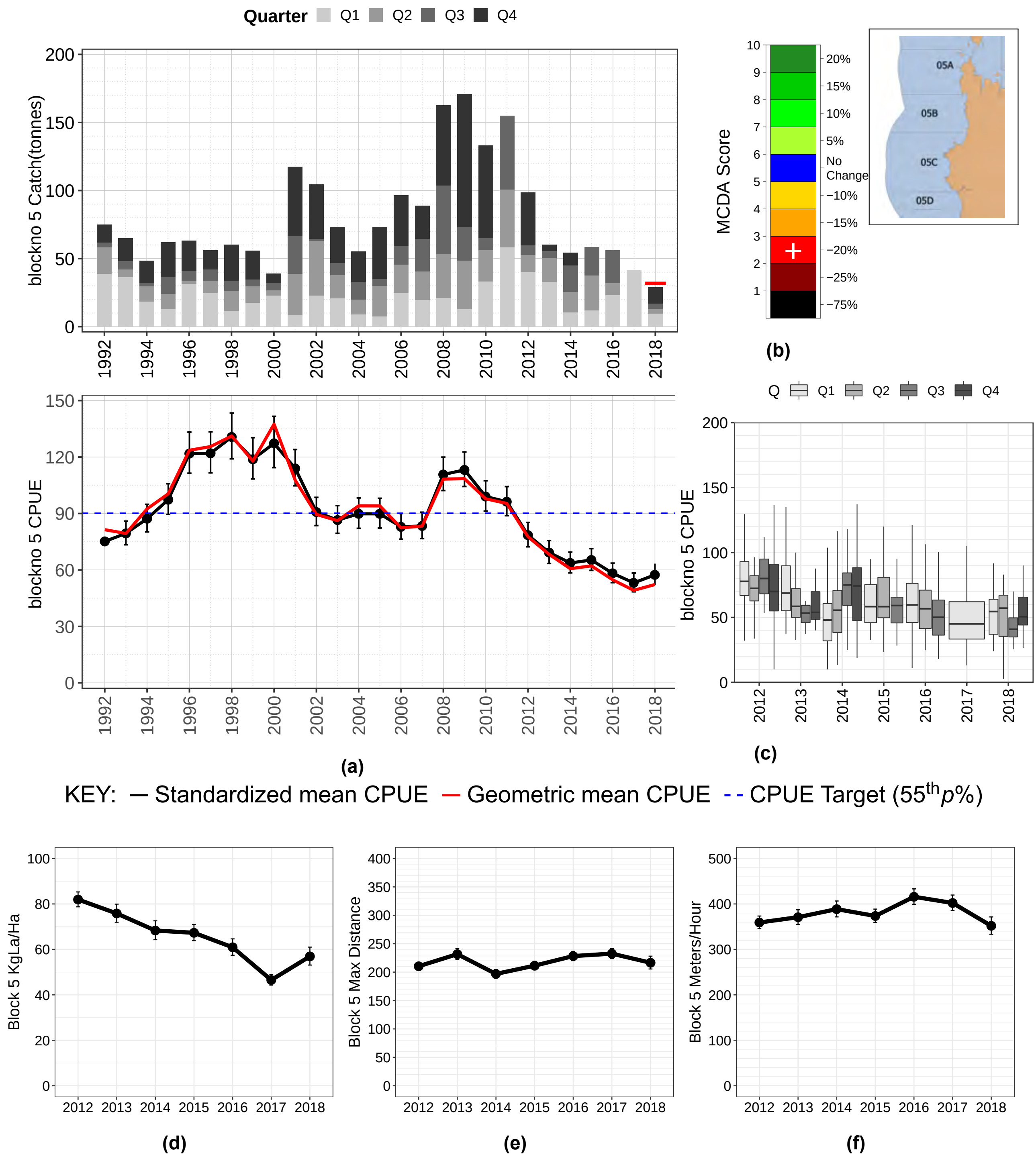


Figure 3.49: *Block 5 NZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 6A-C - Sundown Point to Wild Wave River

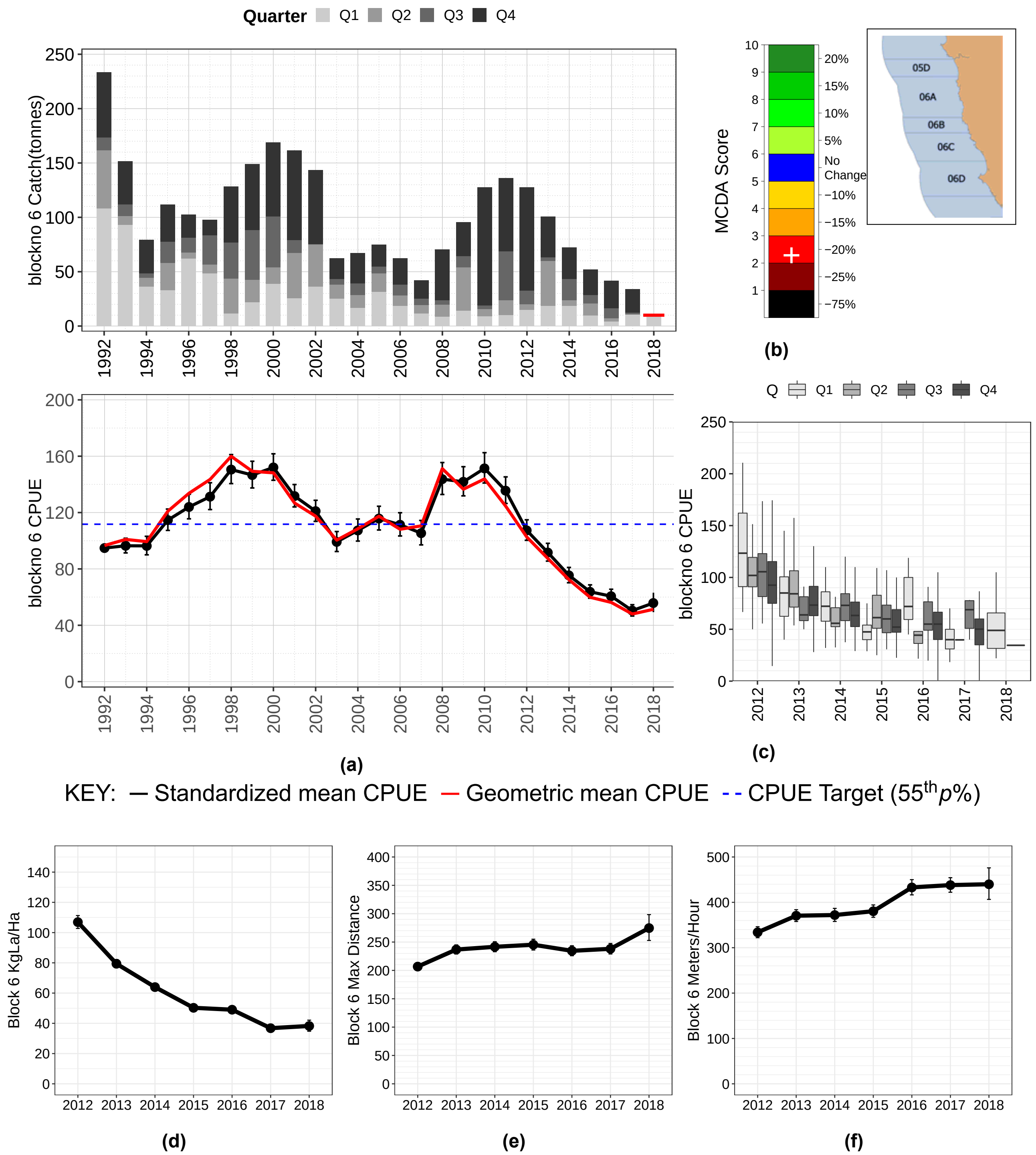


Figure 3.50: *Block 6A/C NZ: a) Catch per quarter and standardised CPUE (black with 95% CL) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 1 - Cape Wickham to KI airport

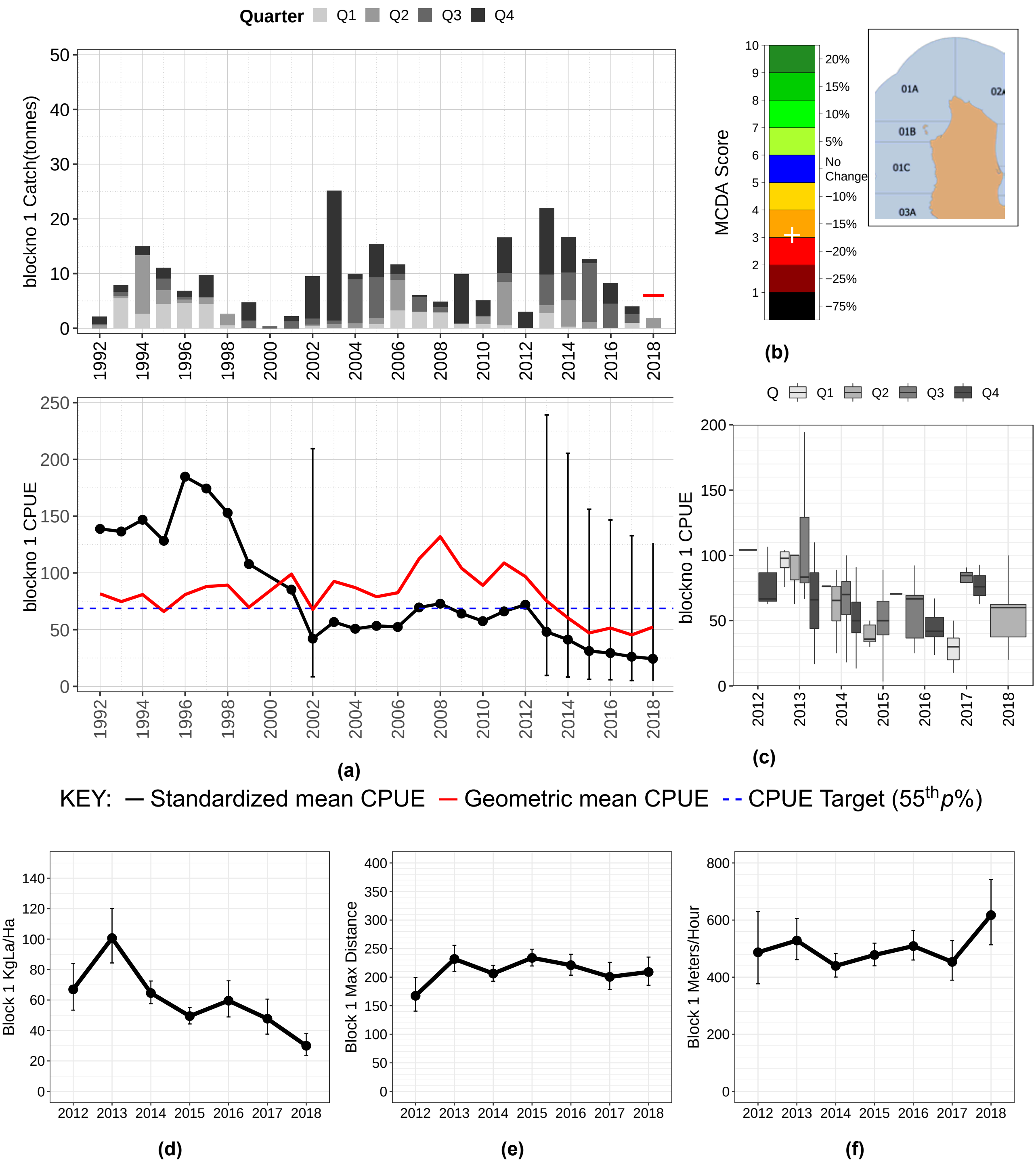


Figure 3.51: *Block 1 NZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 2 - Cape Wickham to Sea Elephant Bay

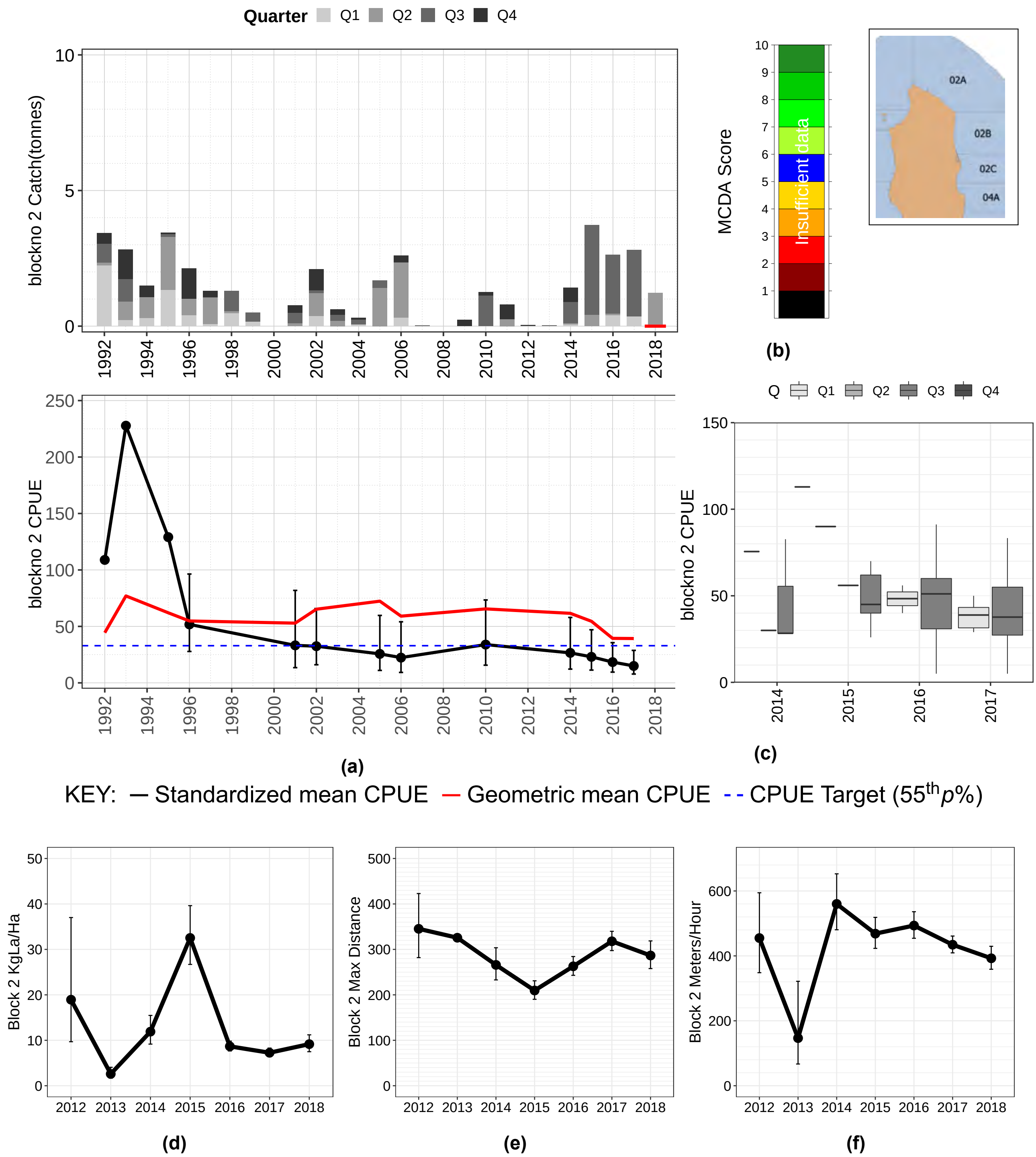


Figure 3.52: *Block 2 NZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 3 - KI airport to Middle Point

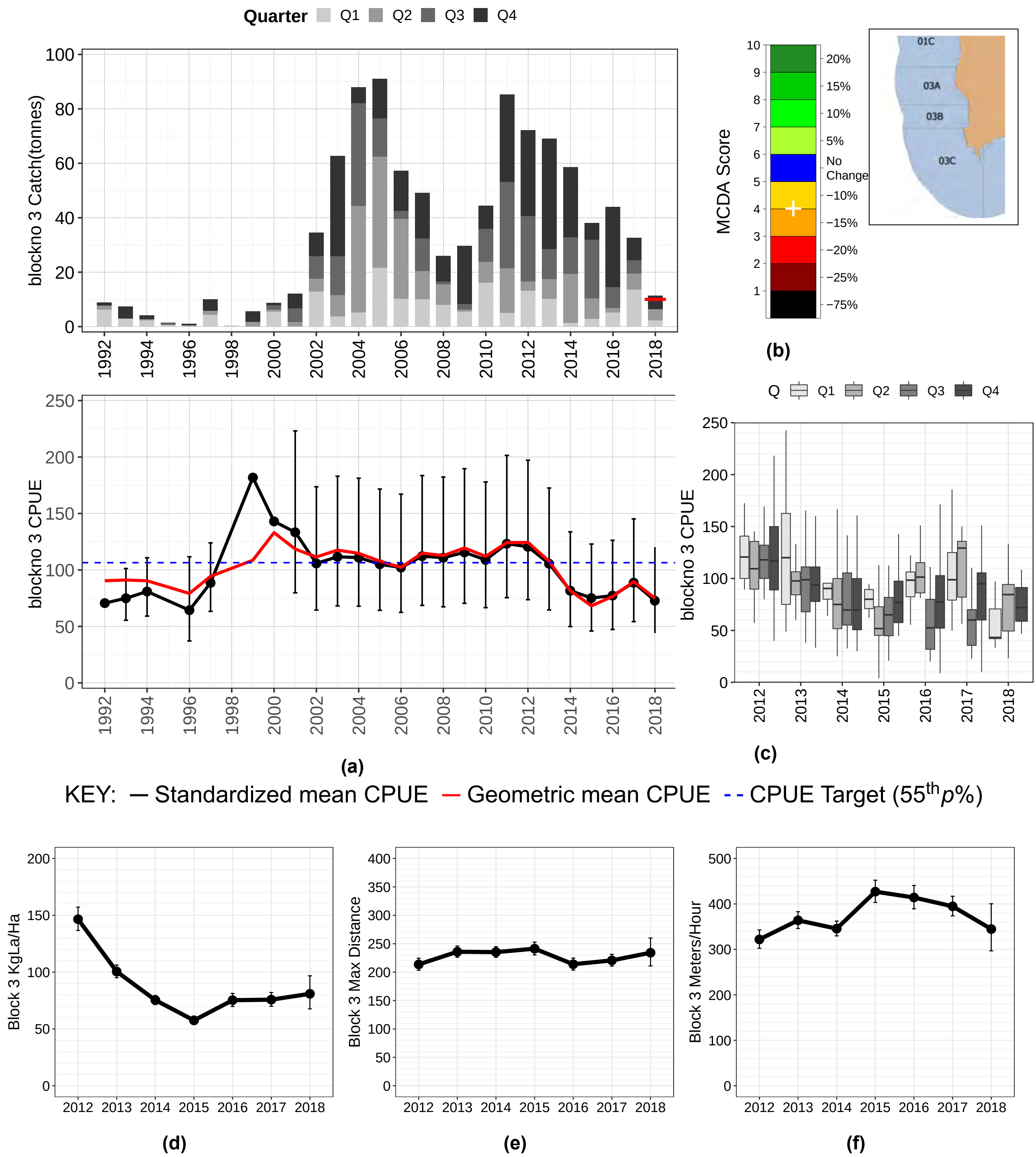


Figure 3.53: *Block 3 NZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and un-standardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 4 - Middle Point to Sea Elephant Bay

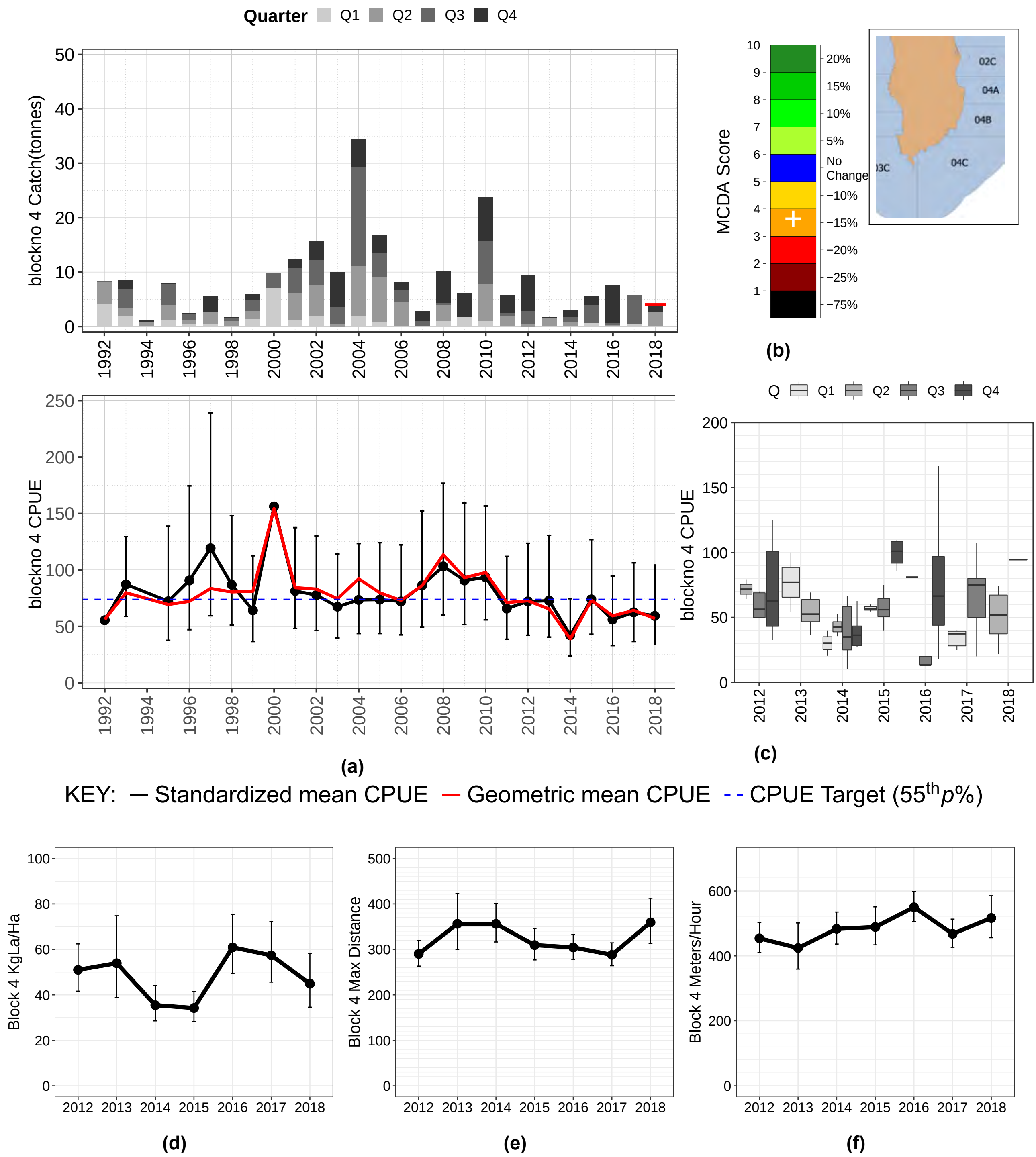


Figure 3.54: *Block 4 NZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

IMAS Summary Notes to FRAG –Northern Zone

- Block 5 - CPUE stable with $\approx$ 17 t caught. Expect very low levels of recruitment over the next 6 to 8 years given decreasing catch and decreasing CPUE over the past 8 years.

  Note: 10 t decrease in catch and 2 mm LML increase to 129 mm. Absence of recovery can't be assigned wholly to LML increase.
- Block 6 CPUE increasing slightly with $\approx$ 9 t caught.
- King Island Block 3 CPUE down sharply from 2017.

  $\approx$ 35% of fishing effort in 2017 in Block 3 deeper than 15 m.

Table 3.3: *Northern Zone Catch, CPUE, Harvest Strategy scores and projected TACC for 2018. CPUE Targets are based on the 55th percentile of standardised annual mean CPUE, with a weighting of 65:25:10 on CPUE, Gradient 4 and Gradient 1 performance measures respectively*

Block No	Catch 2017	Catch Targ	Catch YTD	CPUE YTD	Score CPUE	Score Grad4	Score Grad1	Score	HS adj	IM adj	MCDA 2019	IMAS 2019	FRAG 2019
1	4.0	6.0	1.9	24.4	0.0	3.3	4.1	1.2	0.75	1.00	4.5	6.0	
2	2.9	0.0	1.2							1.00		0.0	
3	32.6	10.0	11.3	72.8	0.9	5.5	1.7	2.1	0.80	0.80	8.0	8.0	
4	5.8	4.0	3.8	59.2	3.2	3.7	4.5	3.5	0.85	0.85	3.4	3.4	
5	41.3	31.9	29.0	57.4	1.2	3.4	6.0	2.2	0.80	1.00	25.5	31.9	
6	34.0	10.0	9.0	55.8	1.1	3.5	6.2	2.2	0.80	1.00	8.0	10.0	
31	27.3	22.5	25.1	56.4	3.1	5.1	6.8	4.0	0.85	1.00	19.1	22.5	
39	6.8	5.3	4.9	58.0	3.6	4.0	6.3	4.0	0.85	1.00	4.5	5.3	
40		0.0	0.1							1.00		0.0	
49	8.8	10.0	10.9							1.00		10.0	
Total	163.4		97.3								73.0	97.1	0.0

3.3.3 Northern Zone Summary

The changes in the zone boundaries require trends to be considered with some caution. Re-assigning the current 2018 zone boundaries to the historic catch and effort data provides some context. The mean $SCPUE_{cw}$ in 2007 prior to the industry experiments was 93.0 Kg/hr at a TACC of 243 t, compared with a mean $SCPUE_{cw}$ of 58.4 Kg/Hr in 2018 at a TACC of 98 t. The rate of decline in SCPUE since 2012 has been sharp despite consecutive TACC reductions, although SCPUE improved slightly in 2018 (fig. 3.40).

A secondary indicator of the extent of depletion in the Northern Zone is the relative change in overall area of reef fished in contrast to the TACC reduction. Between 2012 and 2018, catch in the Blocks that make up the current Northern Zone was reduced by 72%, whereas the overall area utilised by the fishery has declined by only 43%. The Northern Zone fishery is reliant on a relative small area of productive reef, with less than 18% of the reef area fished supporting 50% of the catch in most years (fig. 3.44). Two (blocks 5 and 6) of the four primary fishing blocks in the Northern Zone were subject to the industry fish-down initiative commencing in 2008. The loss of productivity associated with the fish-down initiative has been the primary driver for substantial reductions in average harvest per hectare (fig. 3.45), with the longer-term consequences for recovery of that fishdown not yet understood.

Trends in Simple Spatial Indicators (SSI) diverged from CPUE trends in Block 39, where variation in standardised CPUE is very high, and CPUE appeared to be stable. In contrast, CPUA dropped sharply, while MaxDist and SwimRate were gradually increasing, although stable between 2017 and 2018. SSI and CPUE trends were divergent in Block 3, which may indicate search practices departed from normal. Catch in Block 3 has seen an 8 fold reduction in catch in the past 8 years.

In 2018, the zone-wide proxy for abundance was 2.3 and above the LRP, while the proxy for fishing mortality was -0.84, which is below the TRP for sustainability.

3.4 Bass Strait Zone

3.4.1 Zone Overview

The Bass Strait Zone was created in 2003 to enable access to abalone populations across the Bass Strait Islands and areas of the Furneaux group where the Legal Minimum Length of 127mm was over-protective of slowing growing populations. Since the creation of this zone in 2003, catch and standardised CPUE (SCPUE) have been relatively stable (fig. 3.55). The Bass Strait Zone was closed in 2007 due to concerns around the possible risk of transferring AVG from Victoria to Tasmania, and re-opened in 2008. In 2016, the TACC for the Bass Strait Zone was increased from 70 t to 77 t based on an industry argument that the Bass Strait Islands had been lightly fished for the previous few years. In 2018, the western boundary of the Bass Strait Zone was extended further west to incorporate Block 48 and Sub Blocks 49A, 49B and 49C (Hunter, Three Hummock and Robbins Islands). Catch rate and Catch allocated for 2018 was acceptable for the productive blocks of 33 and 38, but at or below the 25th percentile for blocks 48 and 49 (fig. 3.56).

The Bass Strait Zone fishery is reliant on a relative small area of productive reef, with less than 15% of the reef area fished supporting 50% of the catch in most years (fig. 3.59). The distribution of catch has shifted over the past ten years, largely associated with the reduction in LML commencing in 2010 in blocks 38 (Babel Island) and 33 (Clarke Island) (fig. 3.57). The approximately four-fold increases in annual catch in blocks 33 and 38 associated with the Legal Minimum Length (LML) reduction must be assumed to be reducing stock levels, and consequently average recruitment to the fishery would be expected to decline. As it takes around 7 to 8 years to grow into the fishery from biological recruitment, we expect pre-LML reduction based recruits to continue to enter the fishery until around 2018. From 2018, recruitment into the fishery will be largely reliant on spawning stock levels post LML change, with a clear expectation that abundance will decline along with an increasingly smaller population size structure. In addition to the expected decline in recruitment, destructive grazing by the long-spined sea urchin was first reported to the FRAG in 2017 and appears to be extending into shallower depths in 2018.

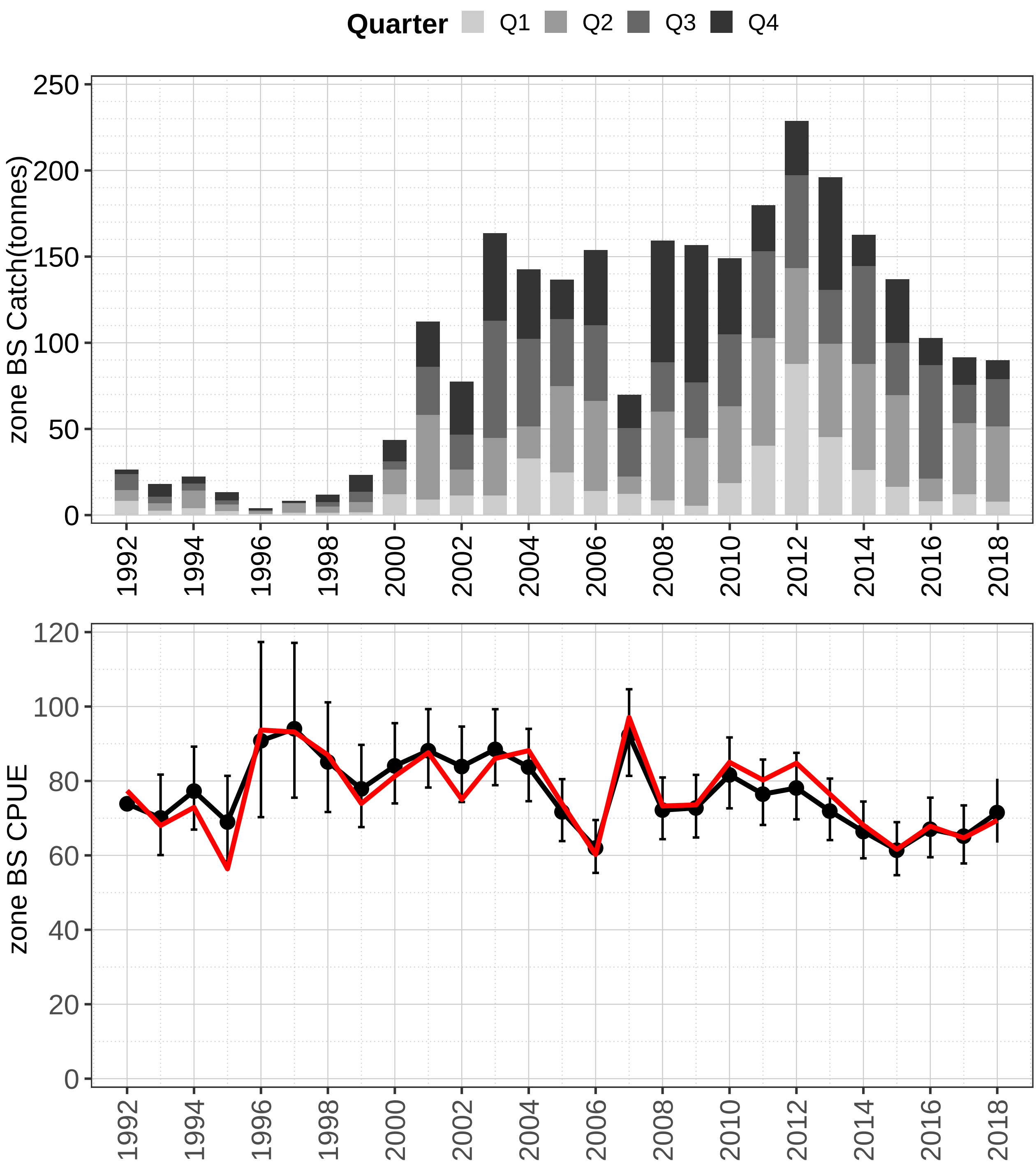
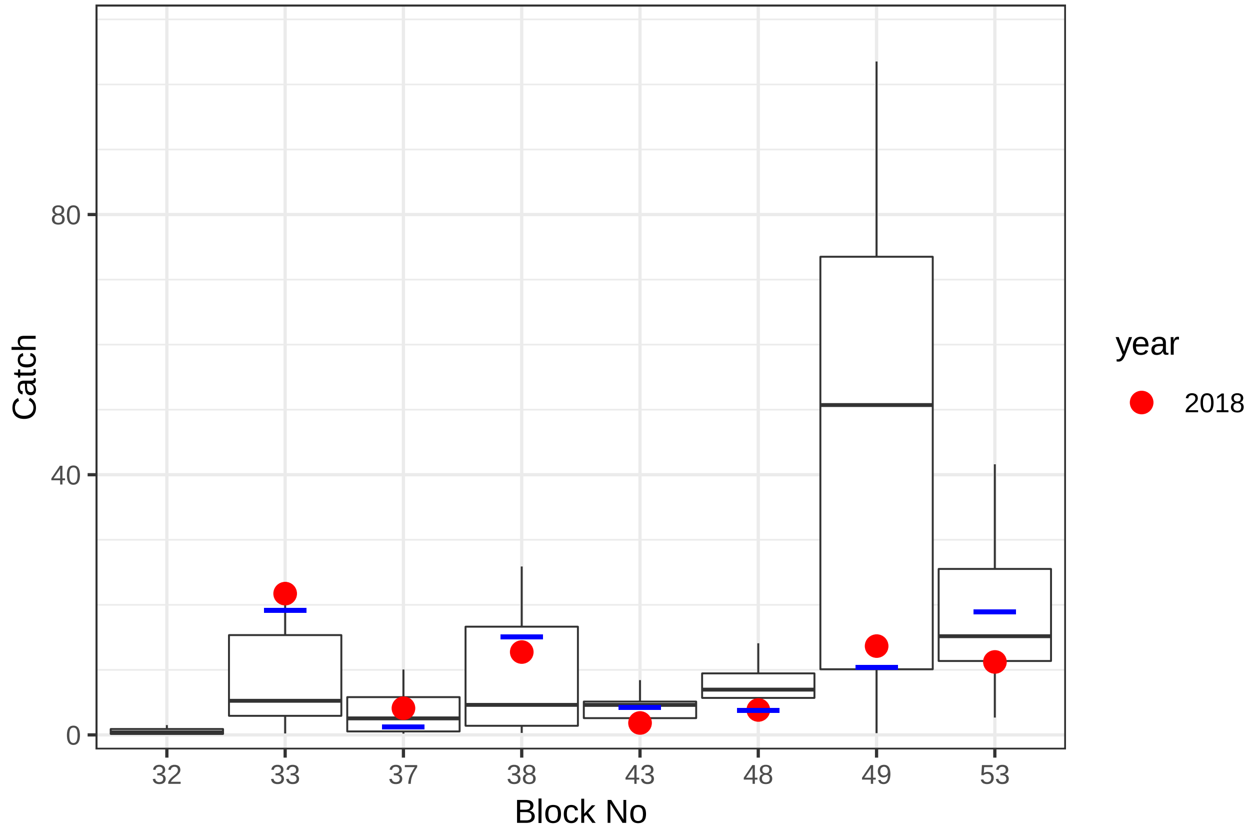


Figure 3.55: *Zone-wide catch and catch rate for Bass Strait Zone blacklip abalone, 1992–2018. Upper plot: catch (t) by quarter pooled across blocks currently classified as Bass Strait Zone. Lower Plot: standardised CPUE (black line) and geometric mean CPUE (red line).*



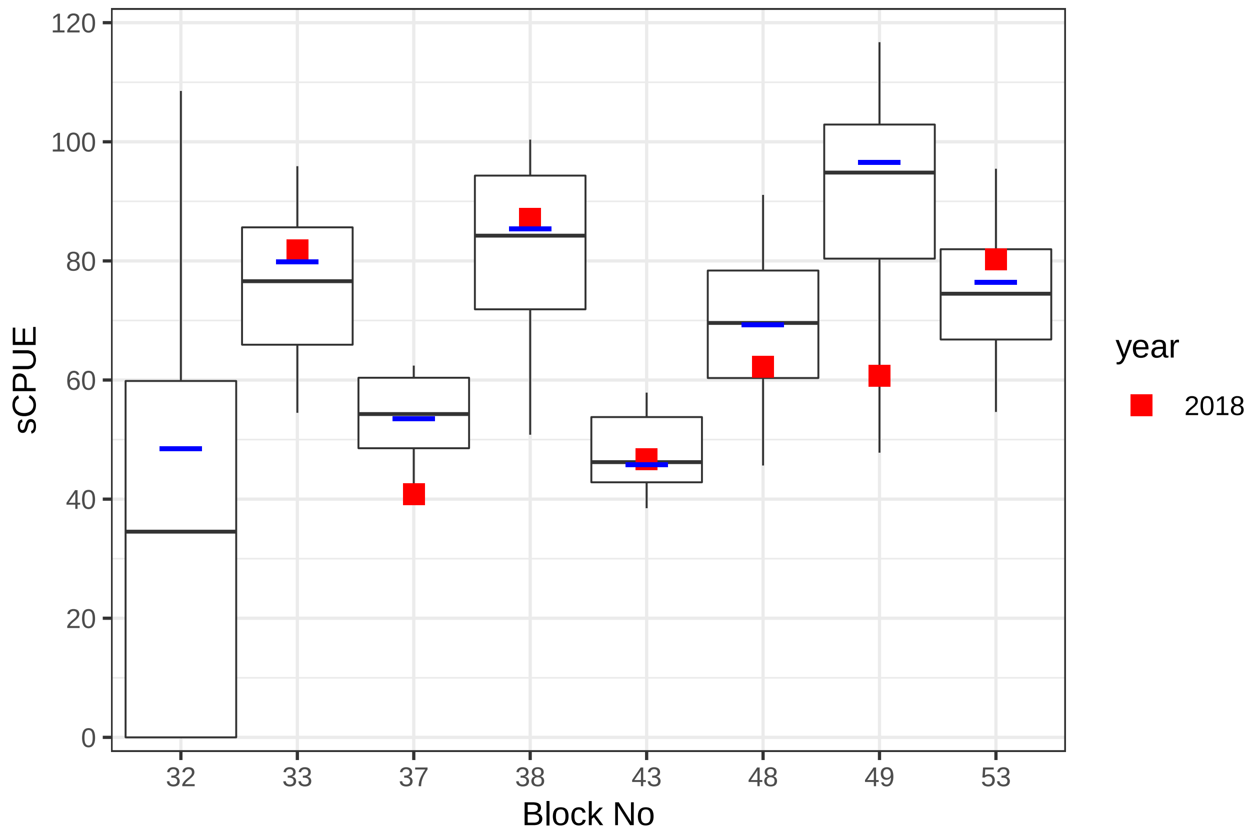


Figure 3.56: *Boxplot of catch and standardised CPUE by statistical block for the Bass Strait Zone blacklip abalone fishery.* ***Upper Panel****: Boxplot of annual catch. Blue line indicates catch target allocated for 2018. Red dot indicates catch taken in 2018.* ***Lower Panel****: Boxplot of annual standardised CPUE. Blue line indicates the CPUE target reference point. Red square indicates sCPUE in 2018.*

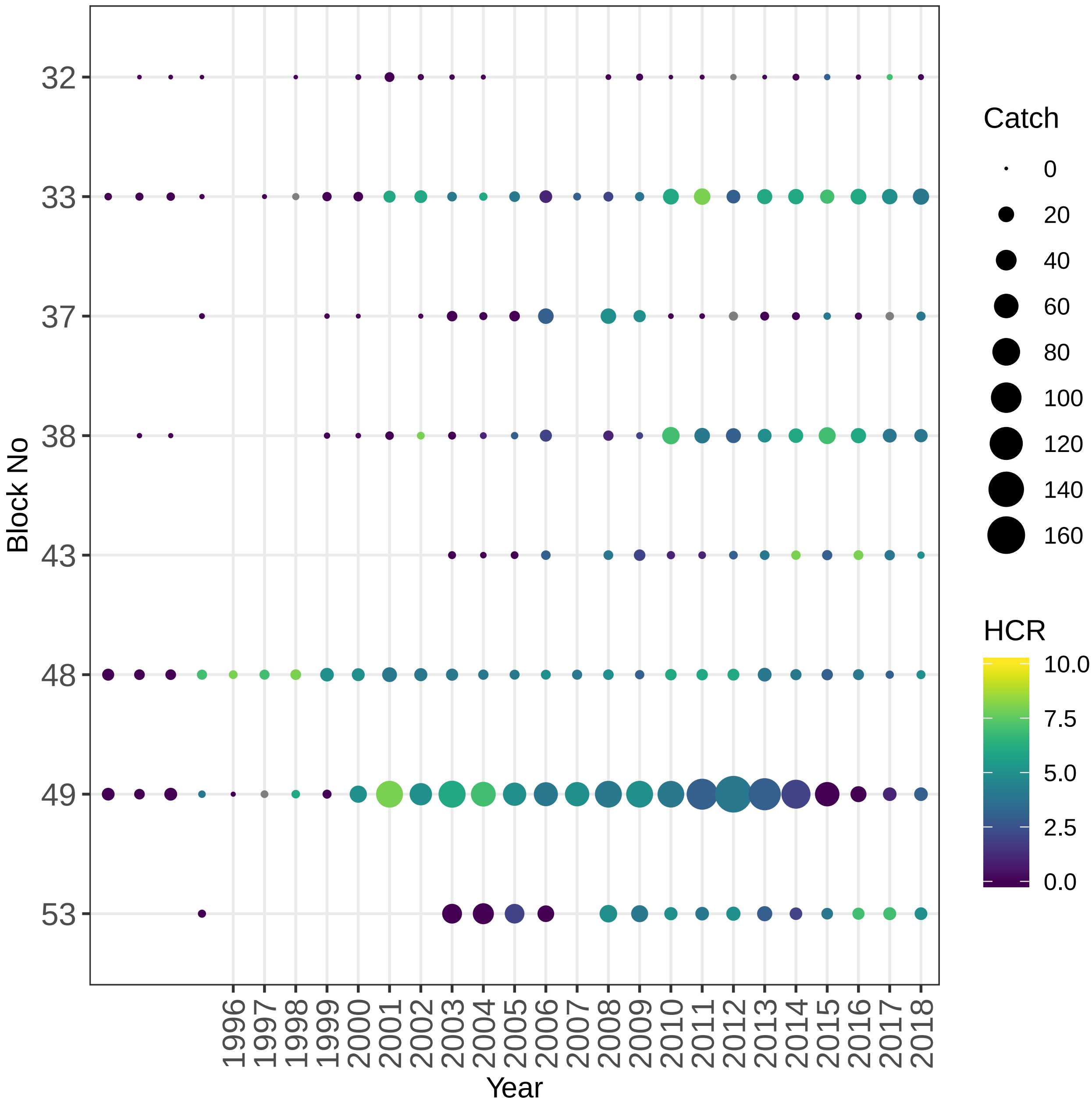


Figure 3.57: *Bubble plot of harvest strategy combined score (bubble colour) and catch (bubble size) for Bass Strait Zone blacklip abalone.*

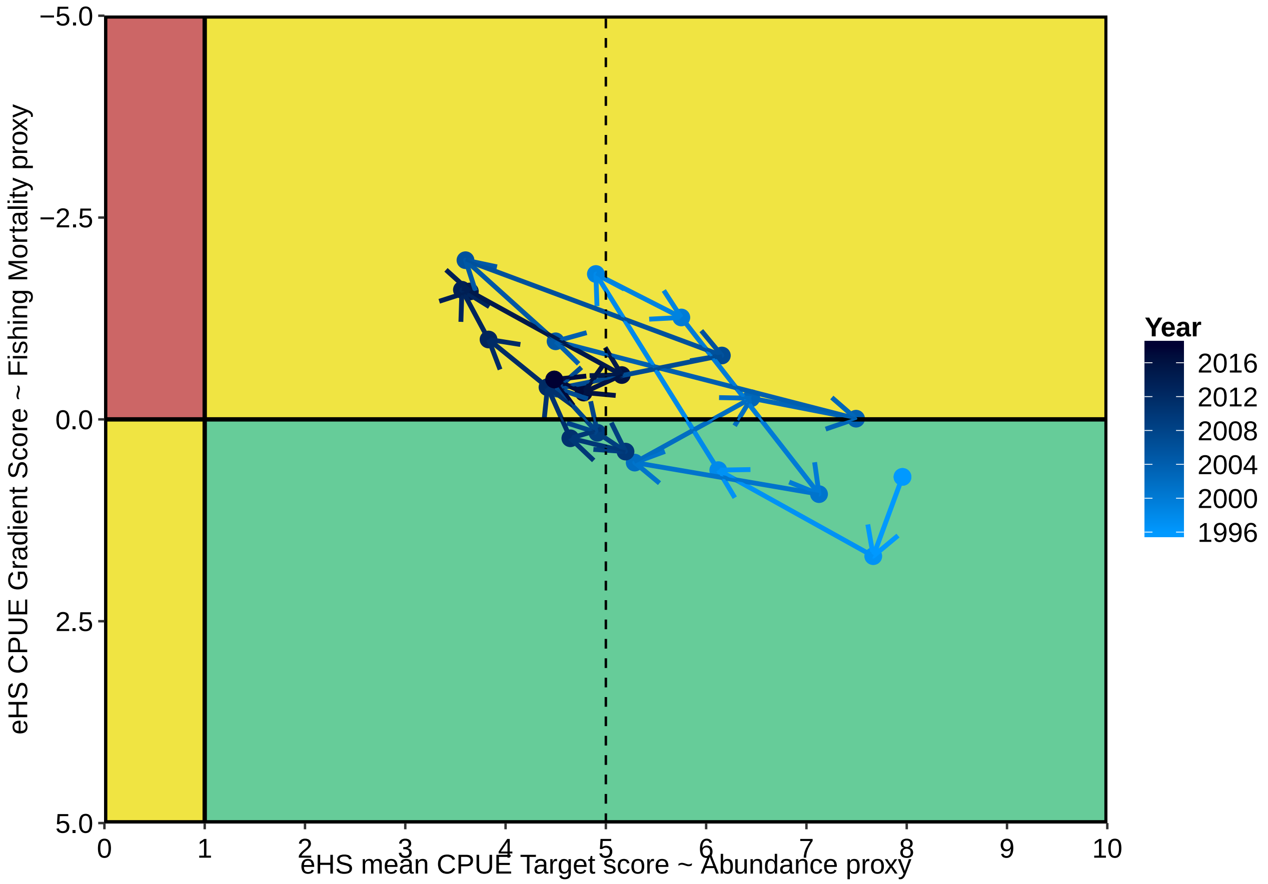
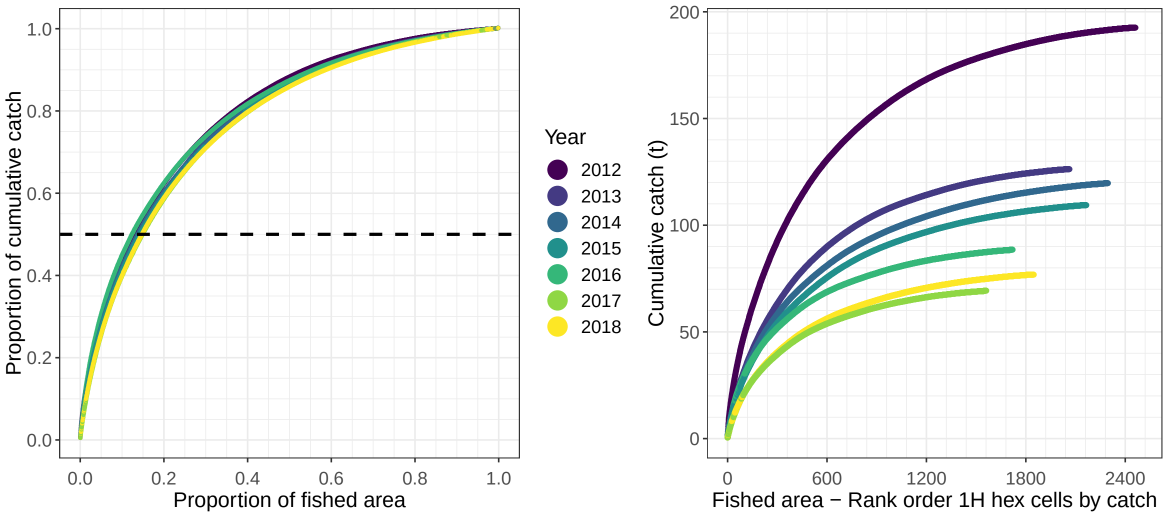


Figure 3.58: *Phase plot of fishing mortality and abundance proxies for Bass Strait Zone blacklip abalone , 1996–2018. The Gradient 4 PM (y-axis) is used as a proxy for fishing mortality, and the Target CPUE PM is used as a proxy for abundance. Zone score is calculated as a catch-weighted mean of individual block scores.*



(a) **(b)**

Figure 3.59: *Concentration area curves for catch in the Bass Strait Zone: a) Proportion of catch (y axis) against proportion of reef utilised (x axis). Hashed line represents 50% of catch; b) cumulative catch (y axis) against rank order of hex cells, descending from highest to smallest catch. Data filtered to exclude hex cells where less than 5 minutes of effort observed.*

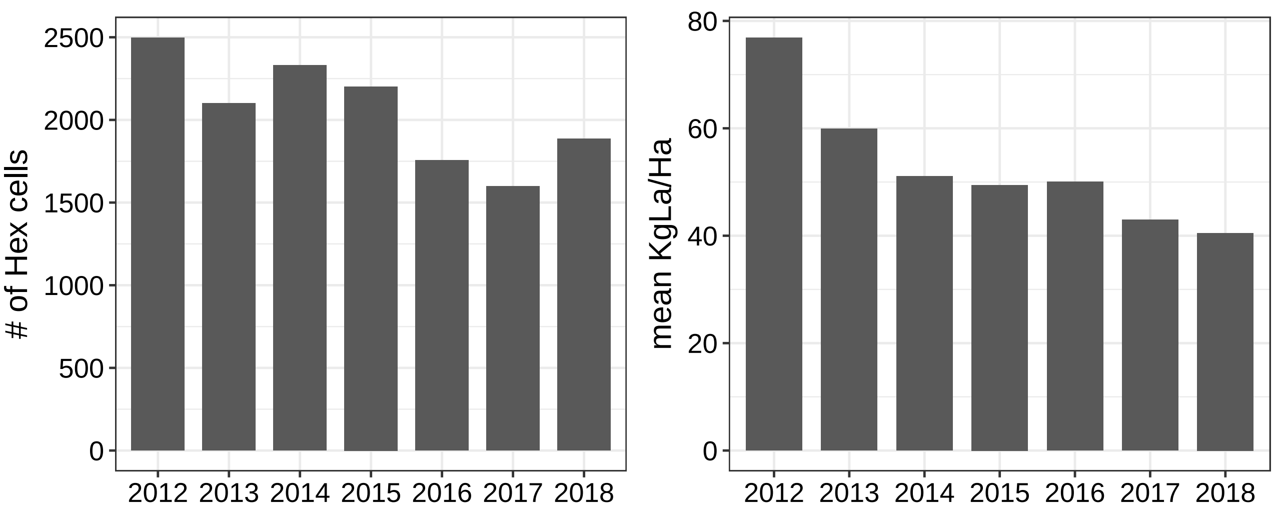


Figure 3.60: *Number of 1 Hectare grid cells where at least 5 minutes of fishing was observed for Bass Strait Zone blacklip abalone, and the total catch landed divided by the number of hex cells visited as the mean catch landed per hex cell.*

3.4.2 Fishery Trends by Statistical Block

Blacklip: Block 48 - Kingston Point to Woolnorth

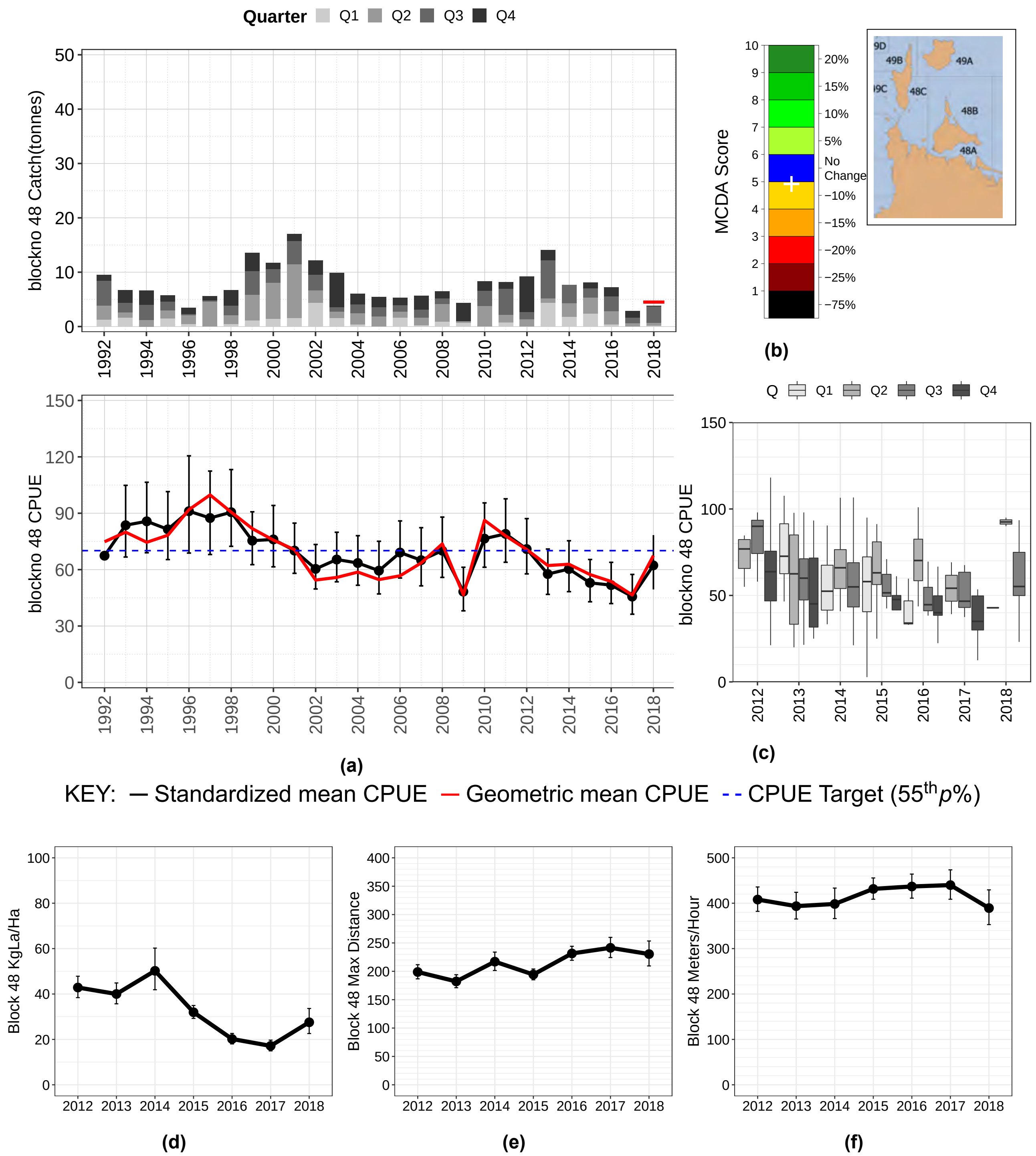


Figure 3.61: *Block 48 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 49 - Hunter Island

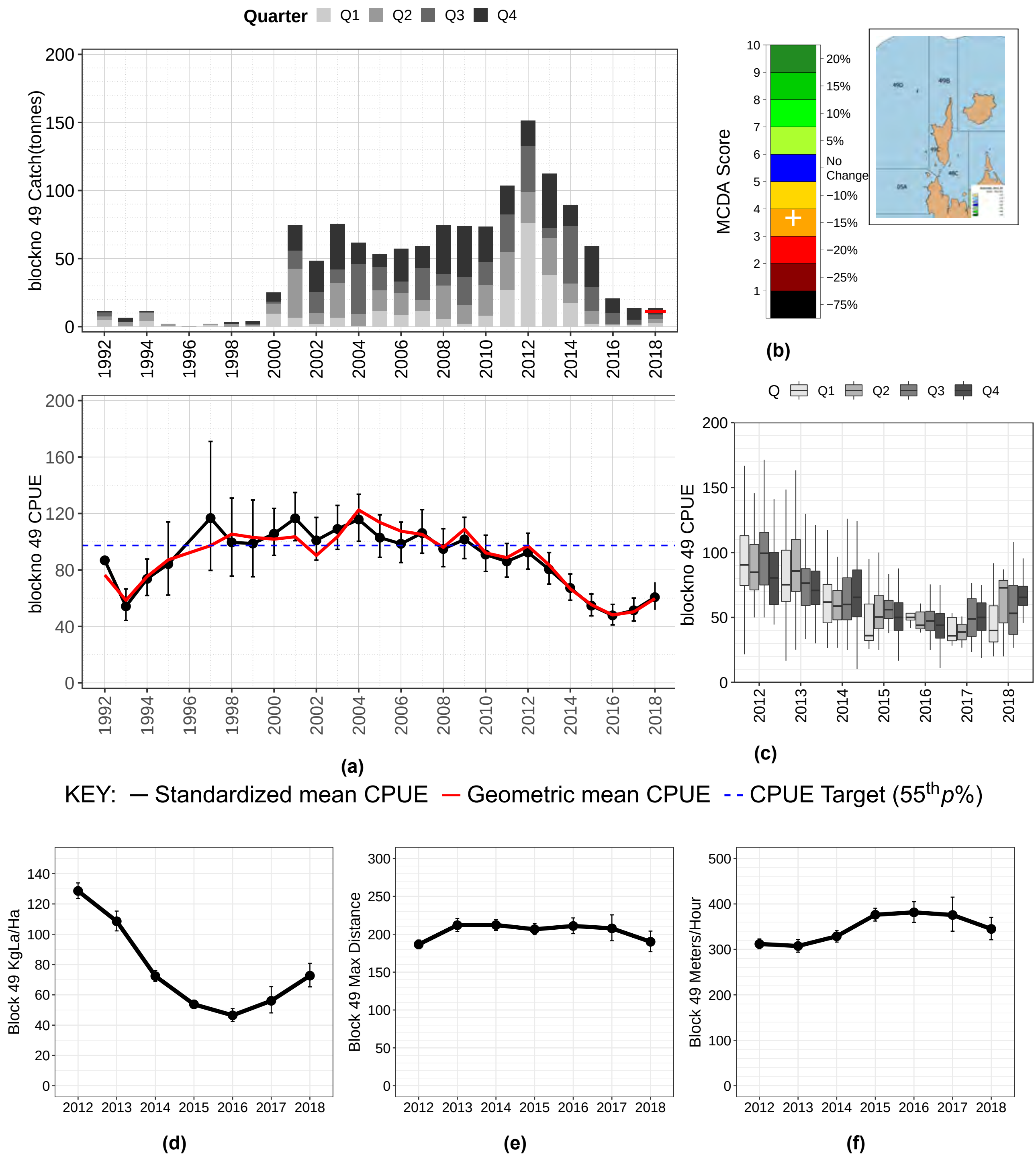


Figure 3.62: *Block 49 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 32 - Western Clarke Island and Armstrong Passage

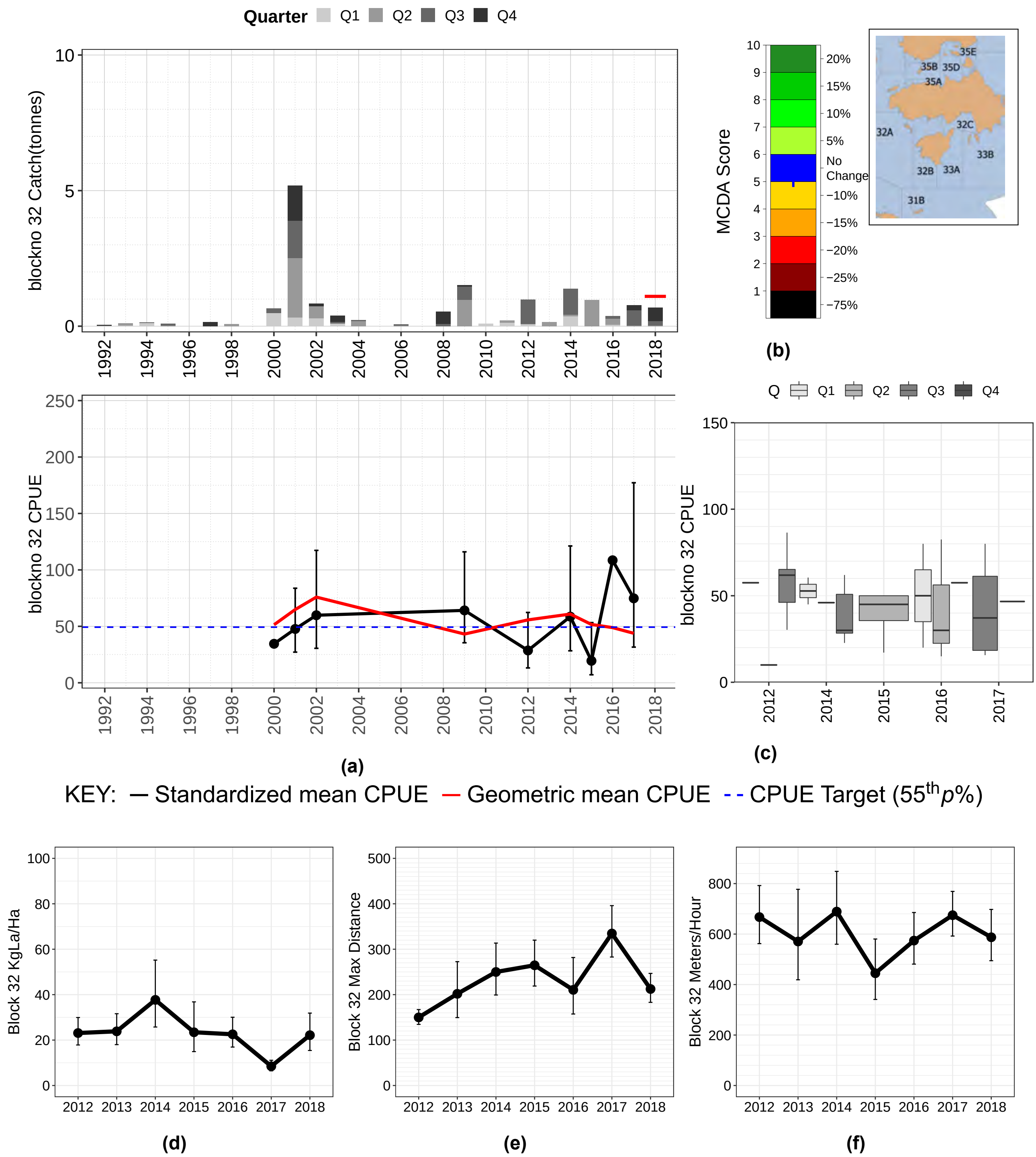


Figure 3.63: *Block 32 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 33 - SE Clarke Island and Cape Barren Islands

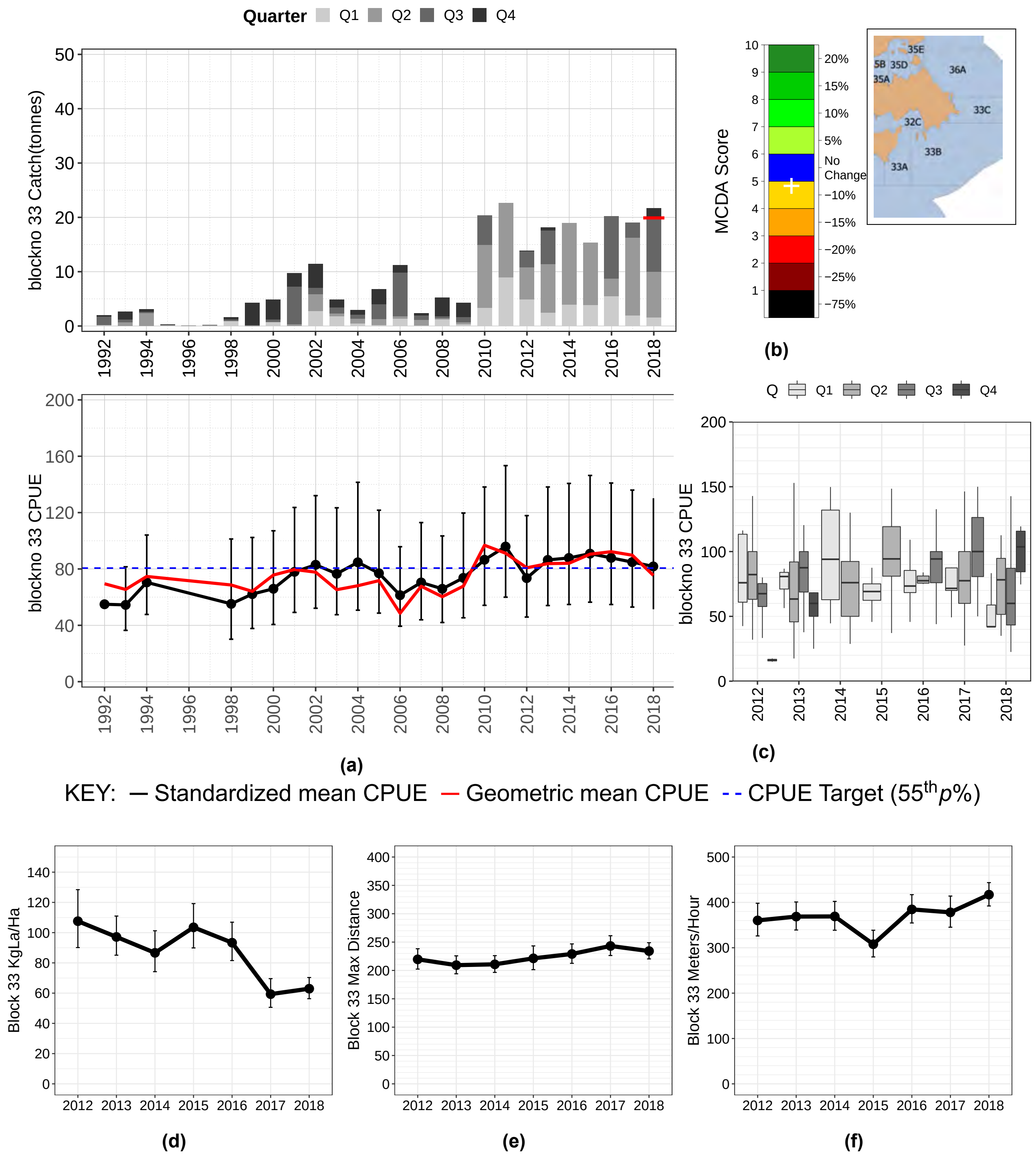


Figure 3.64: *Block 33 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 37 - NW Flinders Island

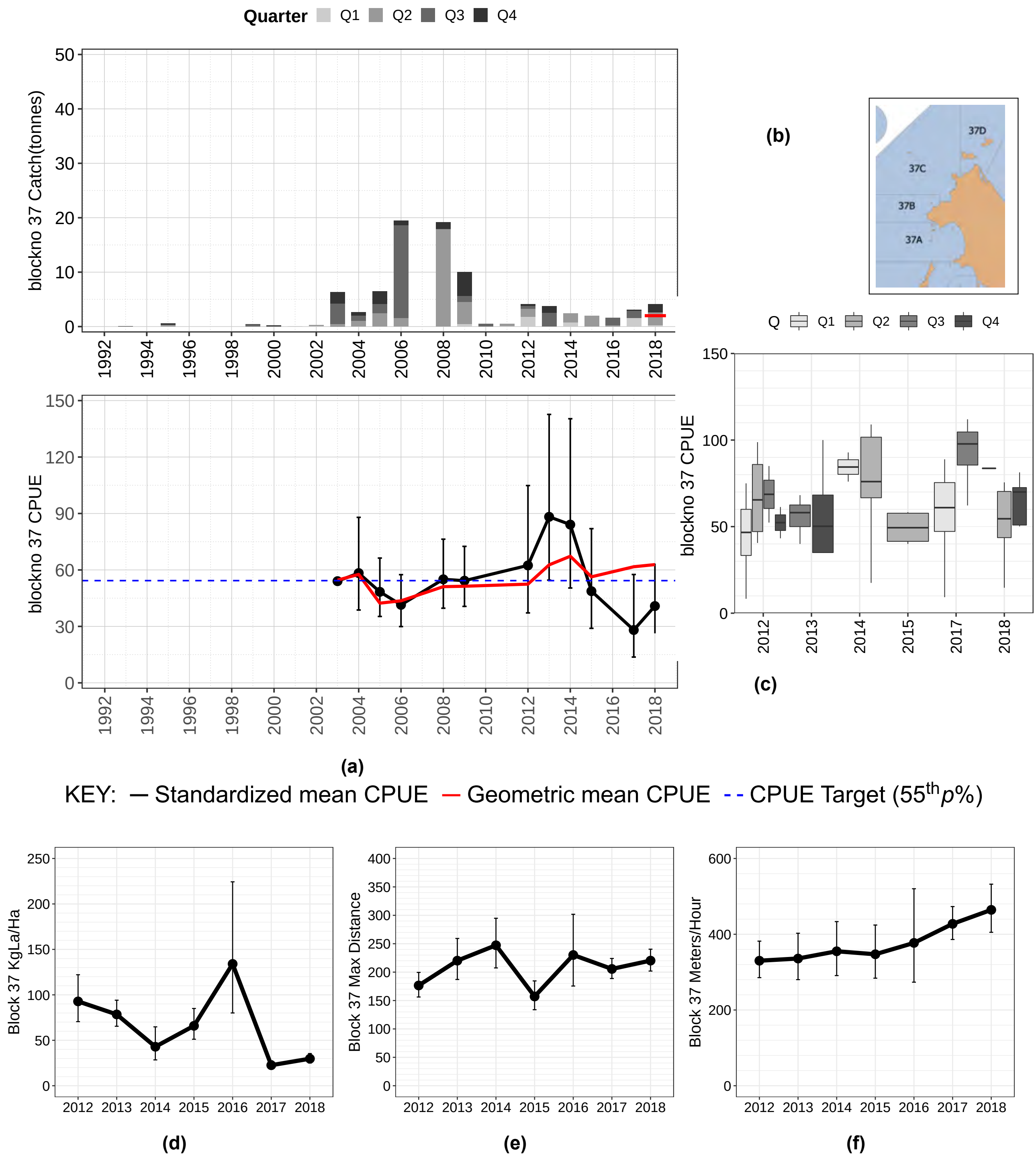


Figure 3.65: *Block 37 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 38 - NE Flinders Island inc. Babel Island

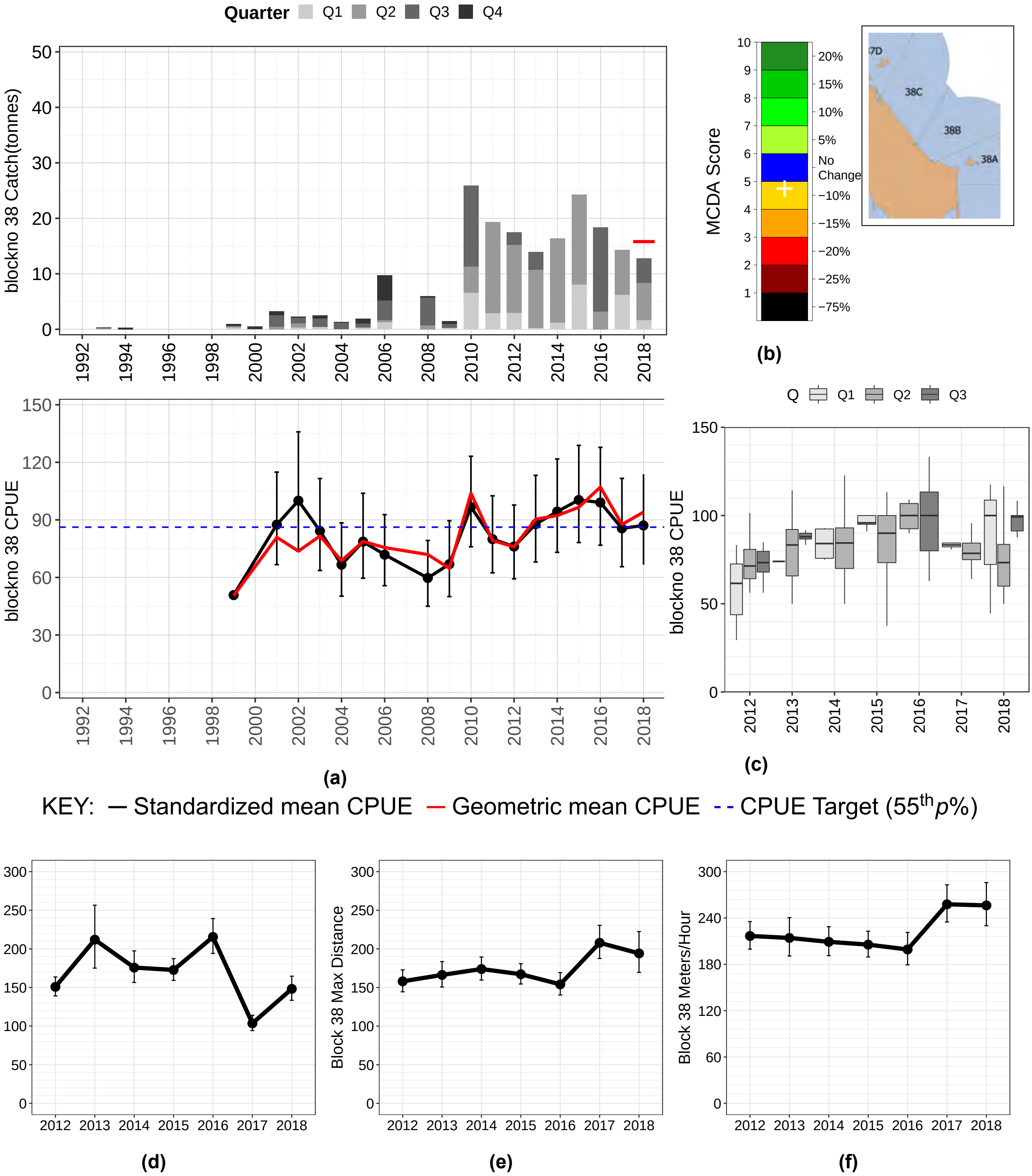


Figure 3.66: *Block 38 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 41 - Waterhouse Beach to Fanny's Bay

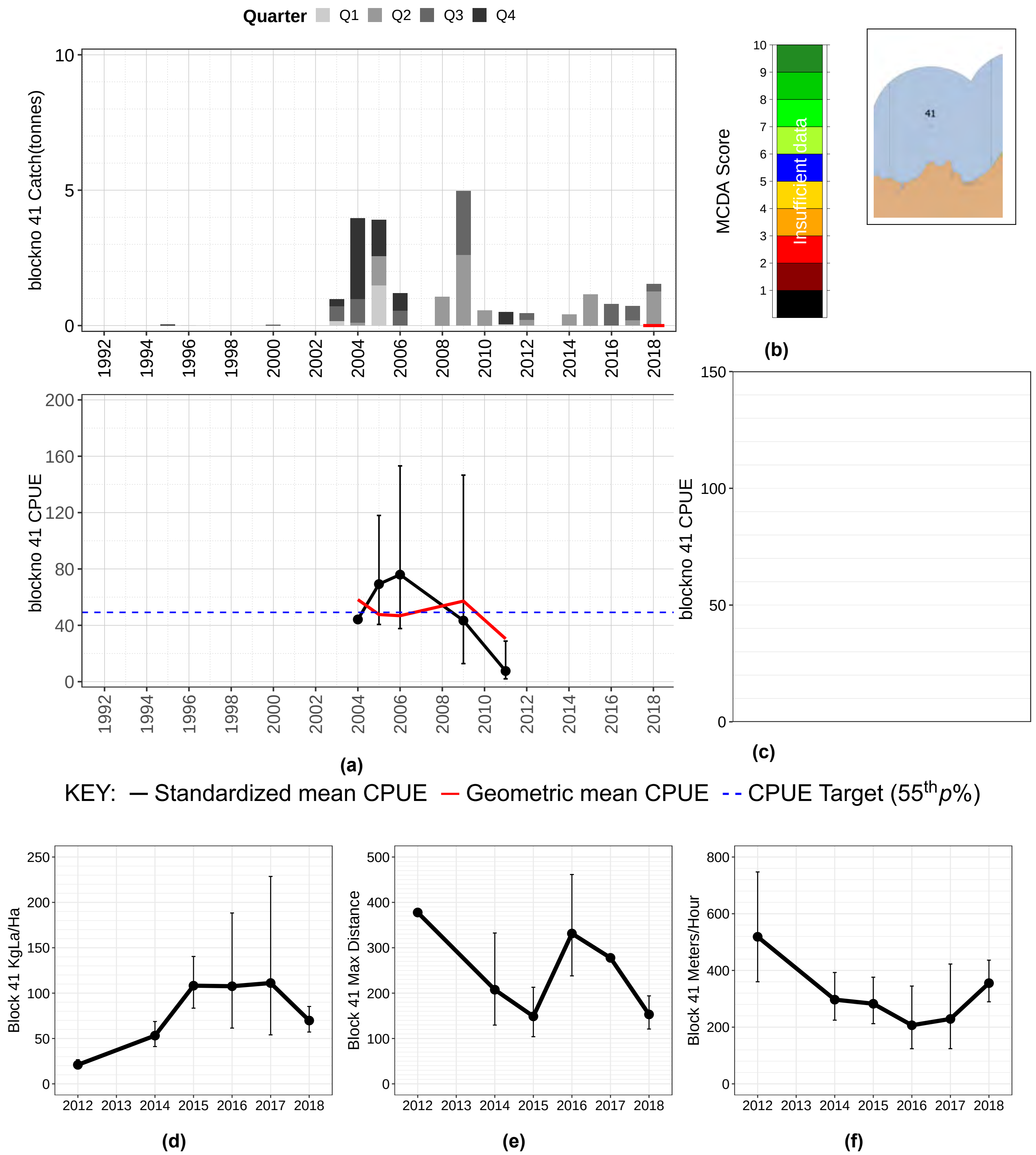


Figure 3.67: *Block 41 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 43 - Three Mile Bluff to Northdown Beach

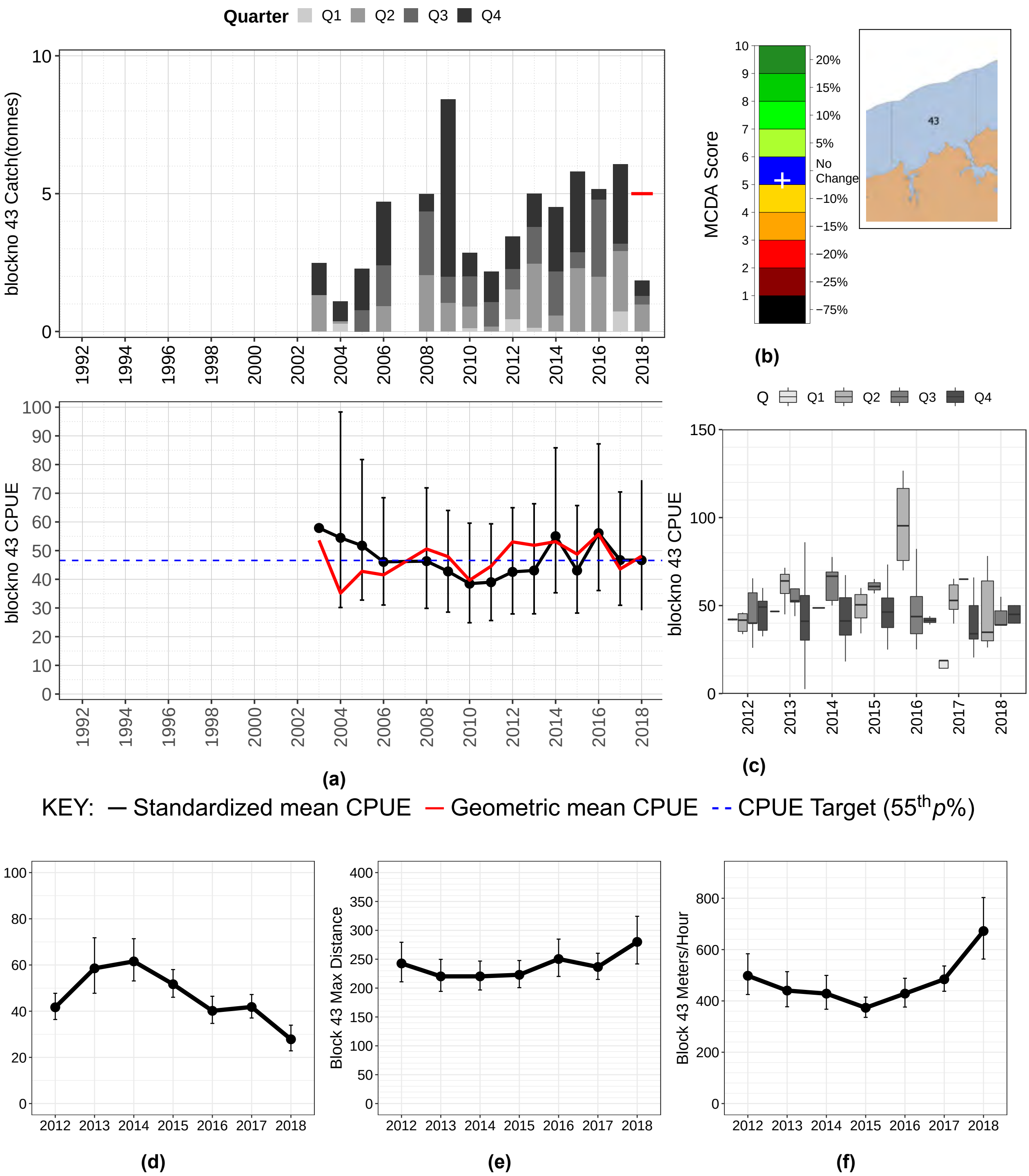


Figure 3.68: *Block 43 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 45 - Heybridge to Chambers Bay

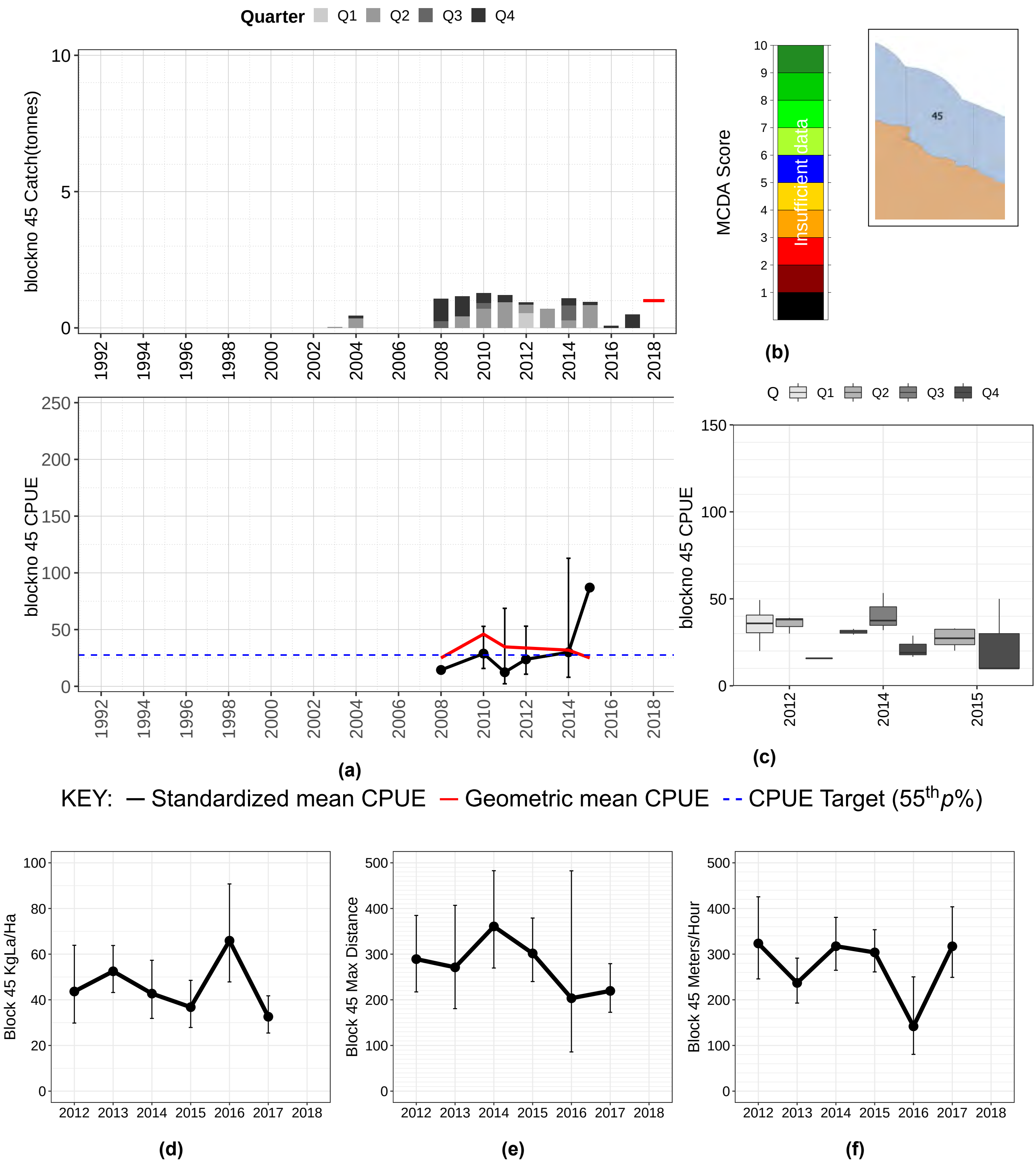


Figure 3.69: *Block 45 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 51 - Kent Group

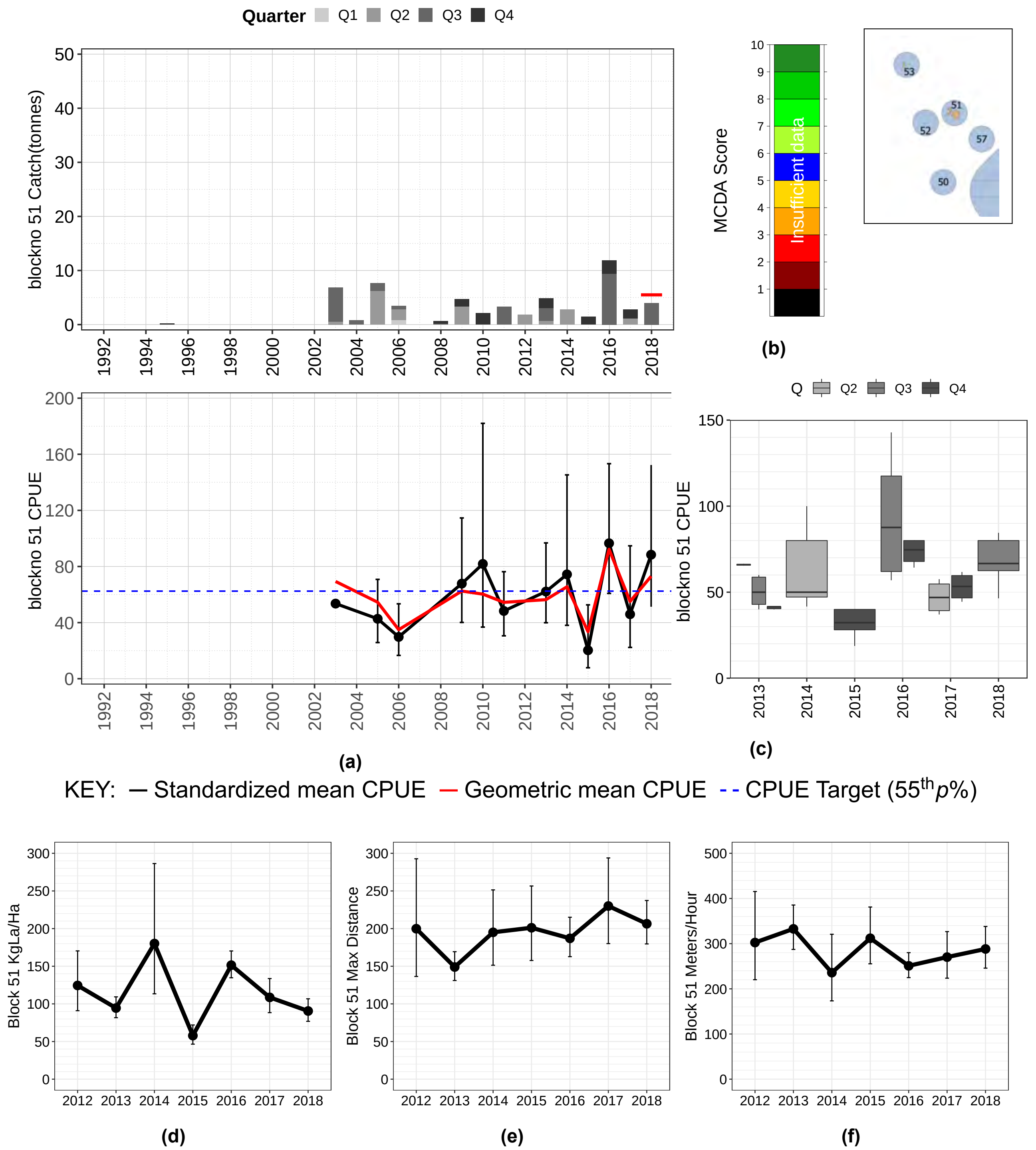


Figure 3.70: *Block 51 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 53 - Hogan Group

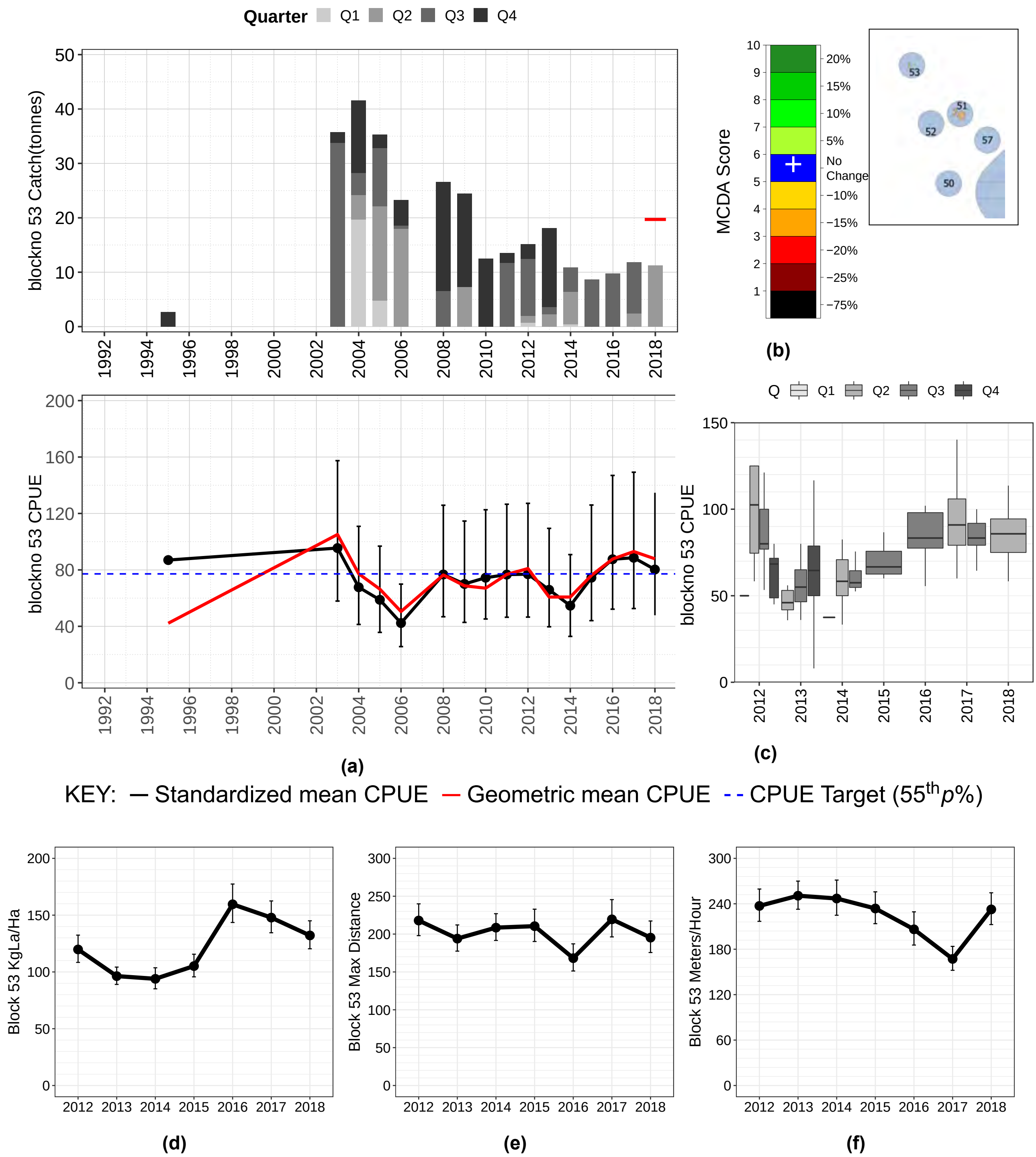


Figure 3.71: *Block 53 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Blacklip: Block 54 - East Moncoeur Island

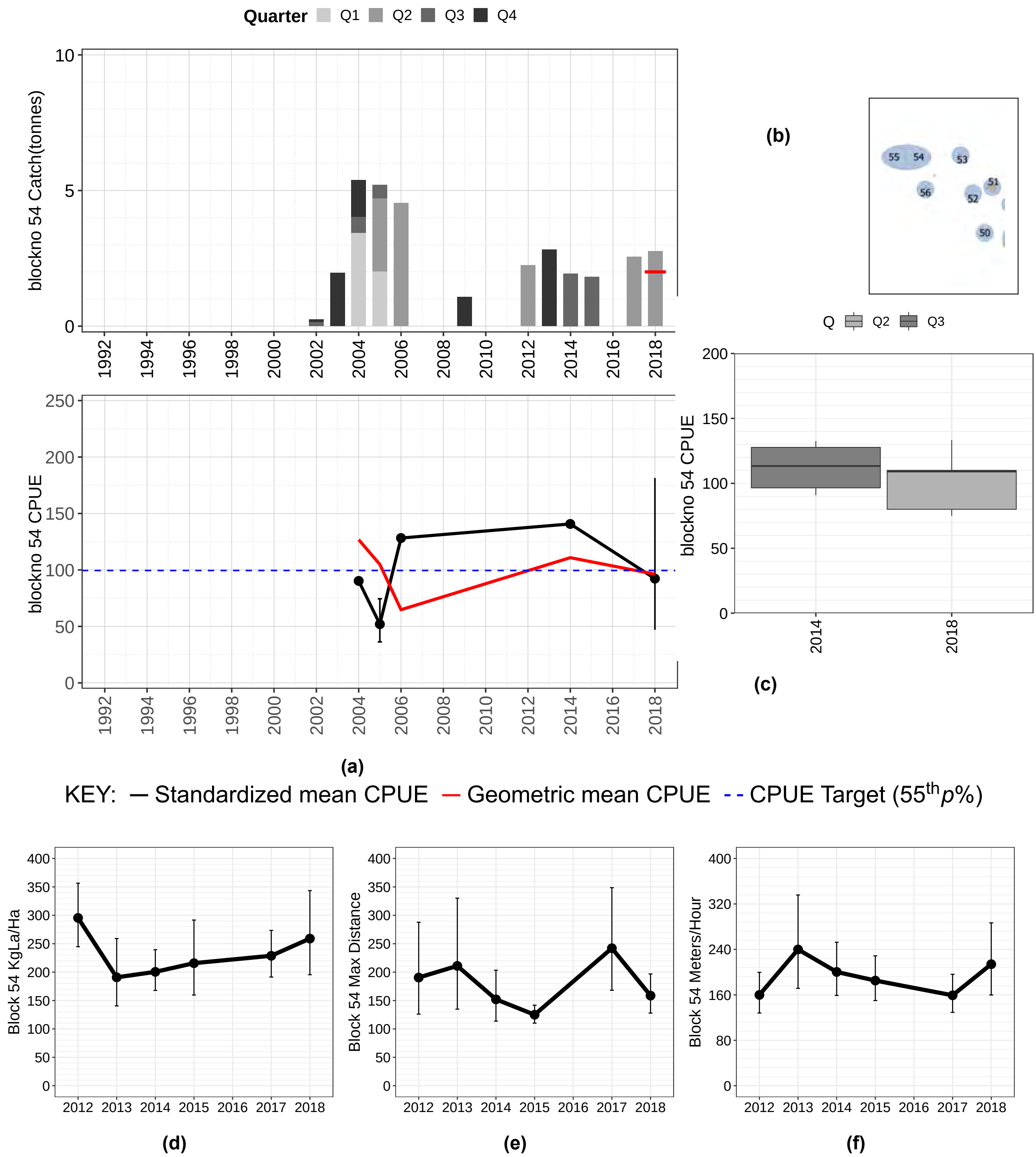


Figure 3.72: *Block 54 BSZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

IMAS Summary Notes to FRAG –Bass Strait Zone

- Consider reviewing 1 t catch allocation to each of Blocks 32, 34 - 37, 44, 45, 51.
  5 year average catch (t) is 0.7, 0.5, 0.4, 2.9, 2.6, 0.7, 0.6, 4.6 respectively.
- CPUE in block 33 trending down, and stable at CPUE target in block 38.
- Expect CPUE to fall in 33 and 38 after 8 years of catches at the new low LML of 114mm. Reduced recruitment from lower biomass following LML change will begin to influence the fishery (based on 7 to 8 years from biological recruitment to entering the fishery).
- CPUE in Hunter and Three Hummock improving during 2018.

Table 3.4: *Bass Strait Zone Catch, CPUE, Harvest Strategy scores and projected TACC for 2018. CPUE Targets are based on the 55th percentile of standardised annual mean CPUE, with a weighting of 65:25:10 on CPUE, Gradient 4 and Gradient 1 performance measures respectively*

Block No	Catch 2017	Catch Targ	Catch YTD	CPUE YTD	Score CPUE	Score Grad4	Score Grad1	Score	HS adj	IM adj	MCDA 2019	IMAS 2019	FRAG 2019
32	0.8	1.1	0.7					0.0		1.00		1.1	
33	19.1	19.9	21.7	81.8	5.3	3.5	4.4	4.8	0.90	0.90	17.9	17.9	
34	0.7	1.0	0.7							1.00		1.0	
35	0.3	1.0	1.8							1.00		1.0	
36	6.7	2.0	4.1							1.00		2.0	
37	3.1	2.0	4.1	40.8	3.9	3.9	9.3	4.4	0.90	1.00	1.8	2.0	
38	14.3	15.8	12.7	87.1	5.2	3.1	5.2	4.7	0.90	0.90	14.2	14.2	
41	0.7	0.0	1.5							1.00		0.0	
42	0.8	0.0	0.6							1.00		0.0	
43	6.1	5.0	1.8	46.7	5.0	5.1	5.0	5.1	1.00	0.90	5.0	4.5	
44	0.7	1.0								1.00		1.0	
45	0.5	1.0								1.00		1.0	
46	0.1	0.0								1.00		0.0	
48	2.9	4.5	3.9	62.3	4.5	6.2	8.3	5.3	1.00	1.00	4.5	4.5	
49	13.6	11.1	13.7	60.7	1.7	7.5	10.0	4.0	0.85	1.00	9.4	11.1	
51	2.8	5.5	4.0							1.00		5.5	
53	11.8	19.7	11.2	80.3	5.8	5.5	3.8	5.5	1.00	1.00	19.7	19.7	
54	2.6	2.0	2.8							1.00		2.0	
55		0.0	1.6							1.00		0.0	
56	4.2	0.0	3.0							1.00		0.0	
Total	91.7		89.9								72.6	88.5	0.0

3.4.3 Bass Strait Zone Summary

The zone-wide catch weighted block mean $SCPUE_{cw}$ increased slightly from 71.46 Kg/Hr in 2017 to 73.2 Kg/Hr in 2018, compared with 88.2 Kg/Hr when the Legal Minimum Length was reduced for blocks 33 and 38 in 2010 (chapter C). While catch increased slightly in 2018 and the area of reef also increased, the mean KgLa/Ha declined (fig. 3.60). Of the major catch areas in this fishery Simple Spatial Indicators (SSI) were consistent with CPUE trends in Blocks 38, 48 and 49. However in Block 33 all three SSIs suggested abundance declined between 2012 and 2018, contrasting strongly with CPUE trends which suggests abundance was stable. Similarly, CPUE trends in Block 43 appeared stable over the past 7 years, whereas all three SSIs suggested abundance was declining rapidly.

Blocks 48 and 49 are showing early signs of recovery following the industry driven fishdowns commencing in 2010. Catch in Block 49 has been reduced from 150 t in 2012 to 10 t in 2017 and 2018. This trend is mirrored in trends of the SSIs.

The zone-wide proxy for abundance has declined from 6.6 in 2017 to 4.3 in 2018 and remains well above the TRP of 1.0. The zone-wide proxy for fishing mortality decreased slightly from 0.75 in 2017 to -0.75 in 2018 and is now below the TRP for sustainability (fig. 3.58).

3.5 Greenlip Zone

3.5.1 Zone Overview

Prior to the introduction of separate greenlip and blacklip zones in 2000, the greenlip catch escalated quickly. The TACC for the Tasmanian greenlip abalone fishery has been stable at around 140 t since 2000 (fig. 3.73), with only minor variation in the proportion of the TACC harvested from each of the four primary regions (King Island, North West, North East and Furneaux) (fig. 3.75). However, $SCPUE_{cw}$ has declined since 2010 with limited management action, to a large part due to the difficulty in calculating CPUE in mixed blacklip and greenlip fishing areas. Commencing in 2014 there were sharp changes in the seasonality of greenlip fishing, with higher levels of catch taken in the warm summer months of January - March, when condition of greenlip abalone is considered to be poor. A range of measures were attempted to control the timing and concentration of effort, including a reverse-cap in 2018. While management action has been successful in re-directing effort to the cooler months, significant pulse fishing has occurred in he North-East greenlip catch region, with the 20 t area cap reached in four days, with up to 48 divers contributing to the catch in that short period.

The zone-wide catch-weighted block mean $SCPUE_{cw}$ declined from 59.2 Kg/Hr in 2017 to 52.1 Kg/Hr in 2018.

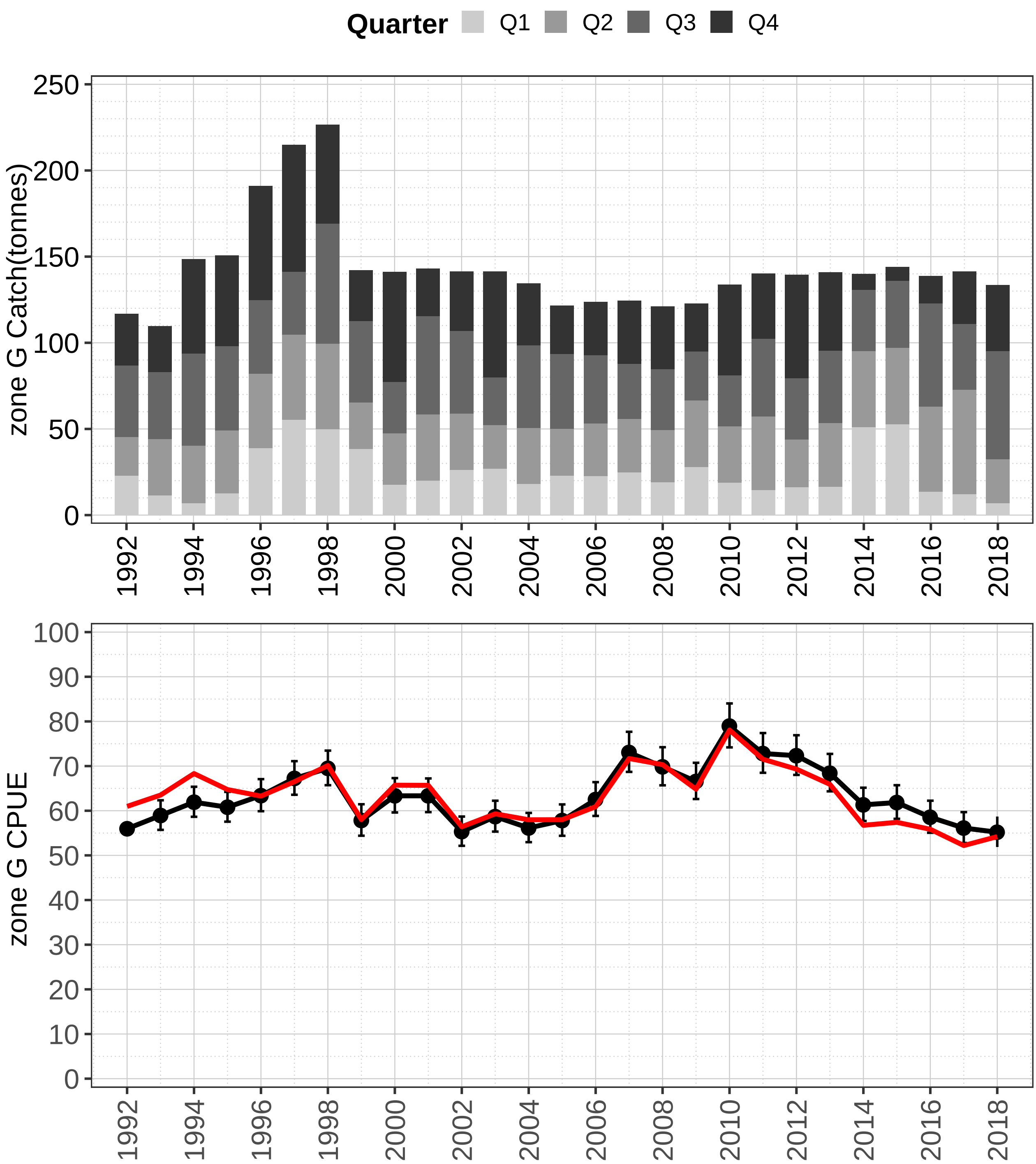


Figure 3.73: *Zone-wide catch and catch rate for greenlip abalone, 1992–2018. Upper plot: catch (t) by quarter pooled across blocks. Lower Plot: standardised CPUE (black line) and geometric mean CPUE (red line).*

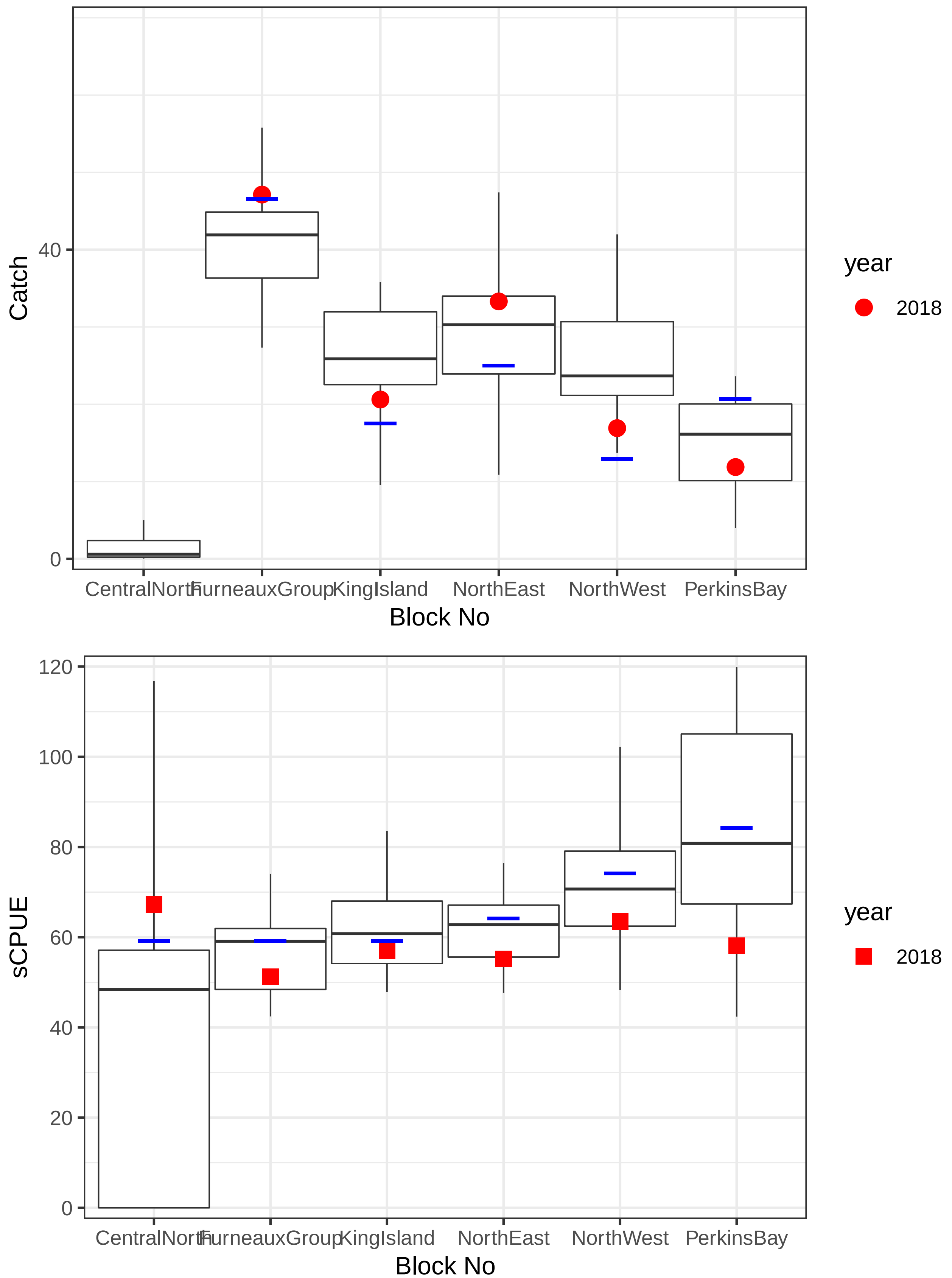


Figure 3.74: *Boxplot of catch and standardised CPUE by statistical block for the Greenlip Zone abalone fishery.* ***Upper Panel****: Boxplot of annual catch. Blue line indicates catch target allocated for 2018. Red dot indicates catch taken in 2018.* ***Lower Panel****: Boxplot of annual standardised CPUE. Blue line indicates the CPUE target reference point. Red square indicates sCPUE in 2018.*

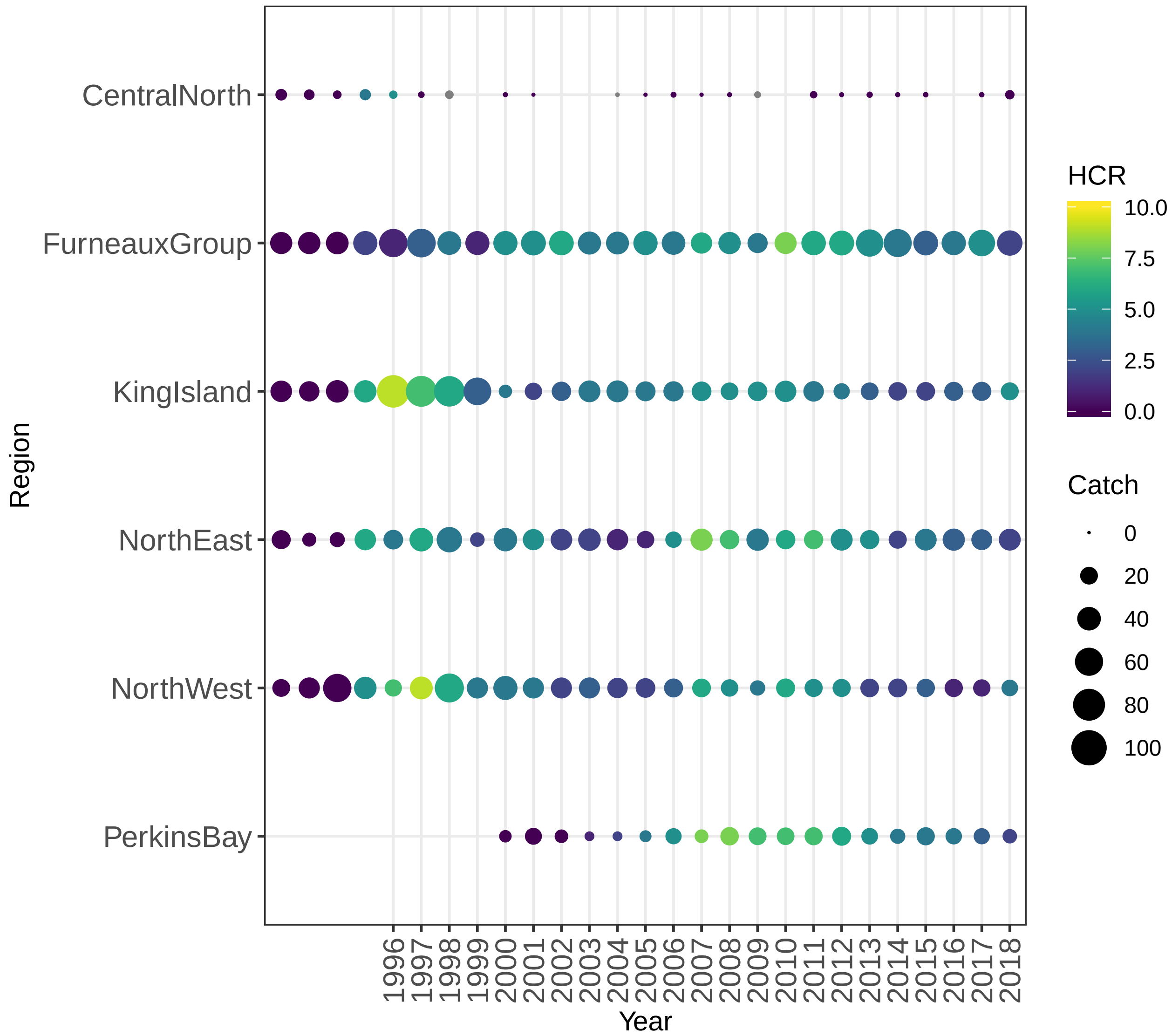


Figure 3.75: *Bubble plot of harvest strategy combined score (bubble colour) and catch (bubble size) for greenlip abalone.*

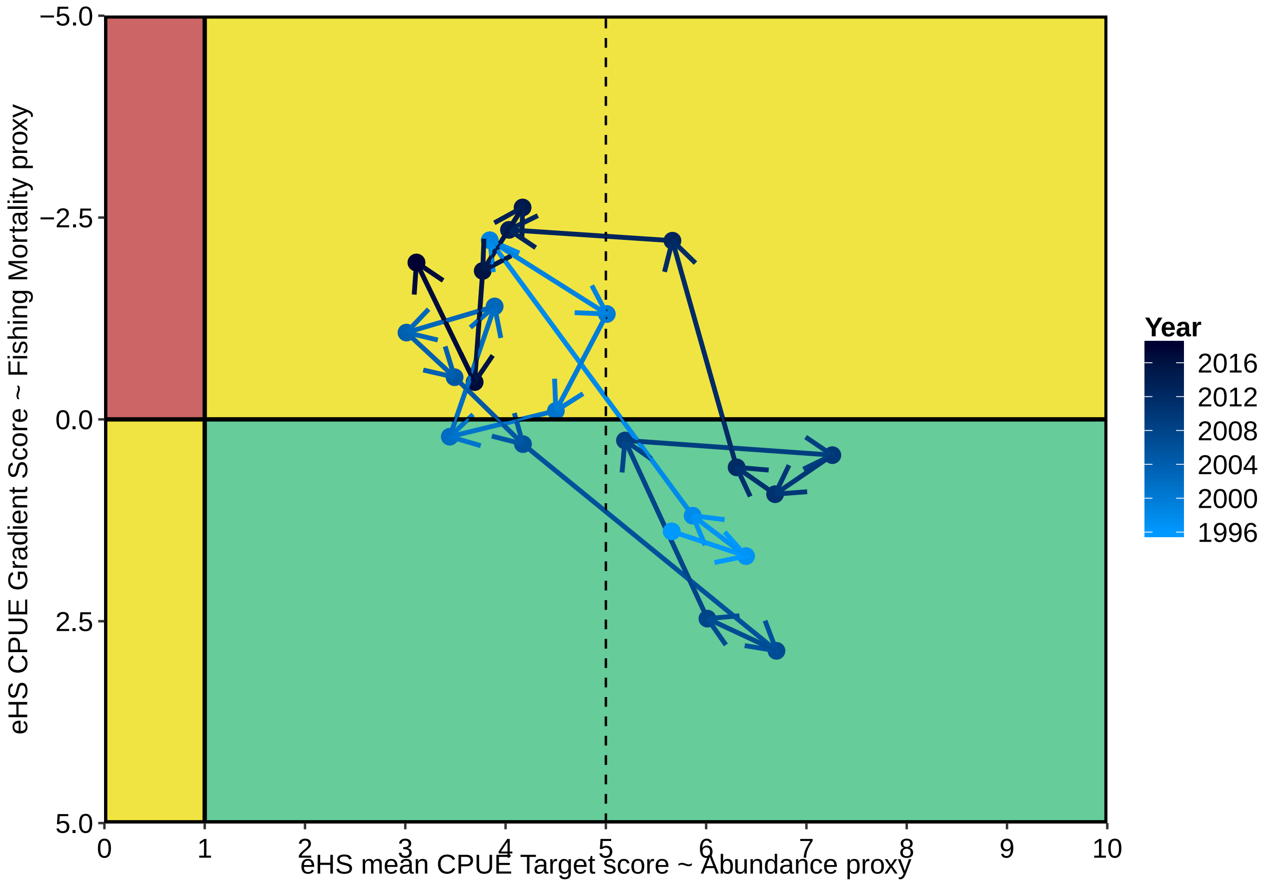
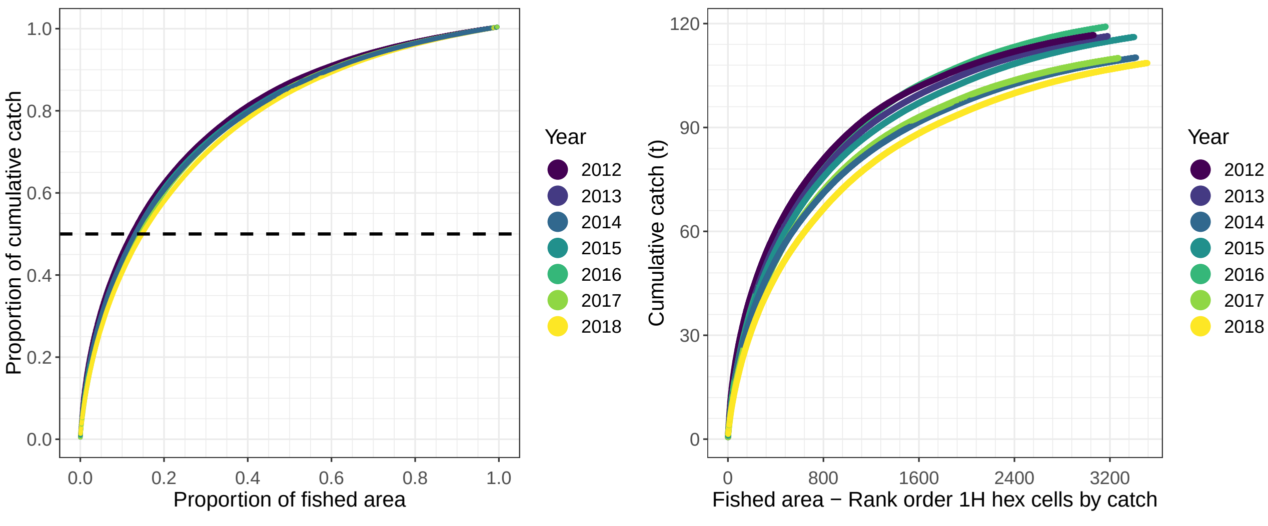


Figure 3.76: *Phase plot of fishing mortality and abundance proxies for greenlip abalone, 1996–2018. The Gradient 4 PM (y-axis) is used as a proxy for fishing mortality, and the Target CPUE PM is used as a proxy for abundance. Zone score is calculated as a catch-weighted mean of individual regional scores.*



(a) **(b)**

Figure 3.77: *Concentration area curves for catch in the Greenlip Zone: a) Proportion of catch (y axis) against proportion of reef utilised (x axis). Hashed line represents 50% of catch; b) cumulative catch (y axis) against rank order of hex cells, descending from highest to smallest catch. Data filtered to exclude hex cells where less than 5 minutes of effort observed.*

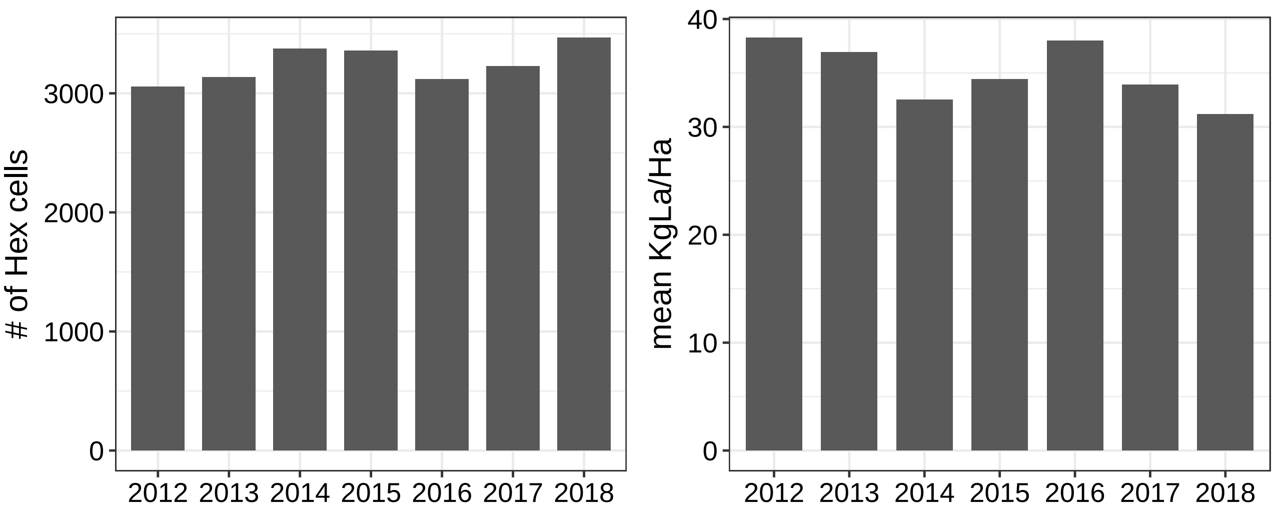


Figure 3.78: *Number of 1 Hectare grid cells where at least 5 minutes of fishing was observed for greenlip abalone, and the total catch landed divided by the number of hex cells visited as the mean catch landed per hex cell.*

3.5.2 Fishery Trends by Region

Greenlip: King Island

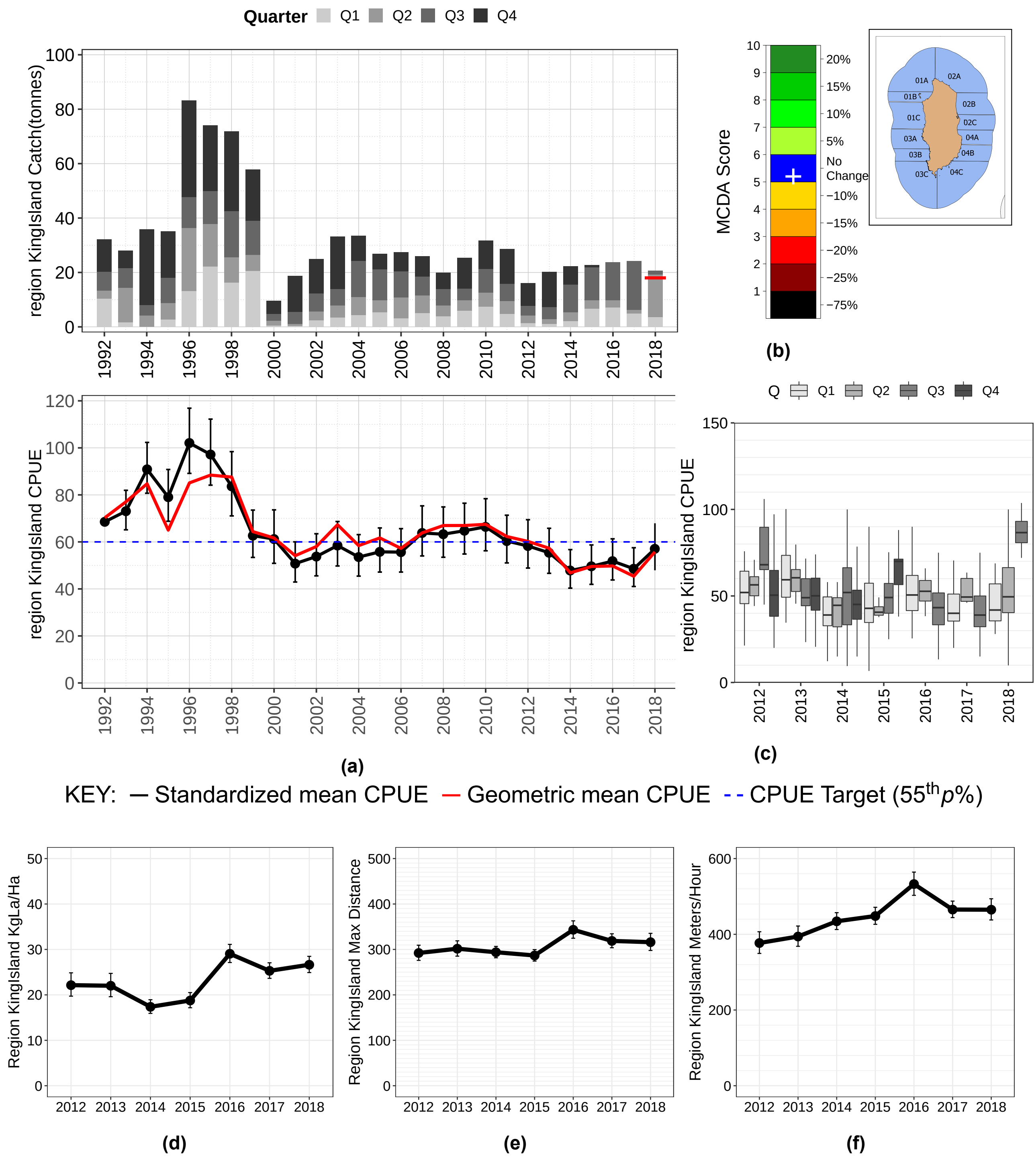


Figure 3.79: *King Island GZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Greenlip: North West

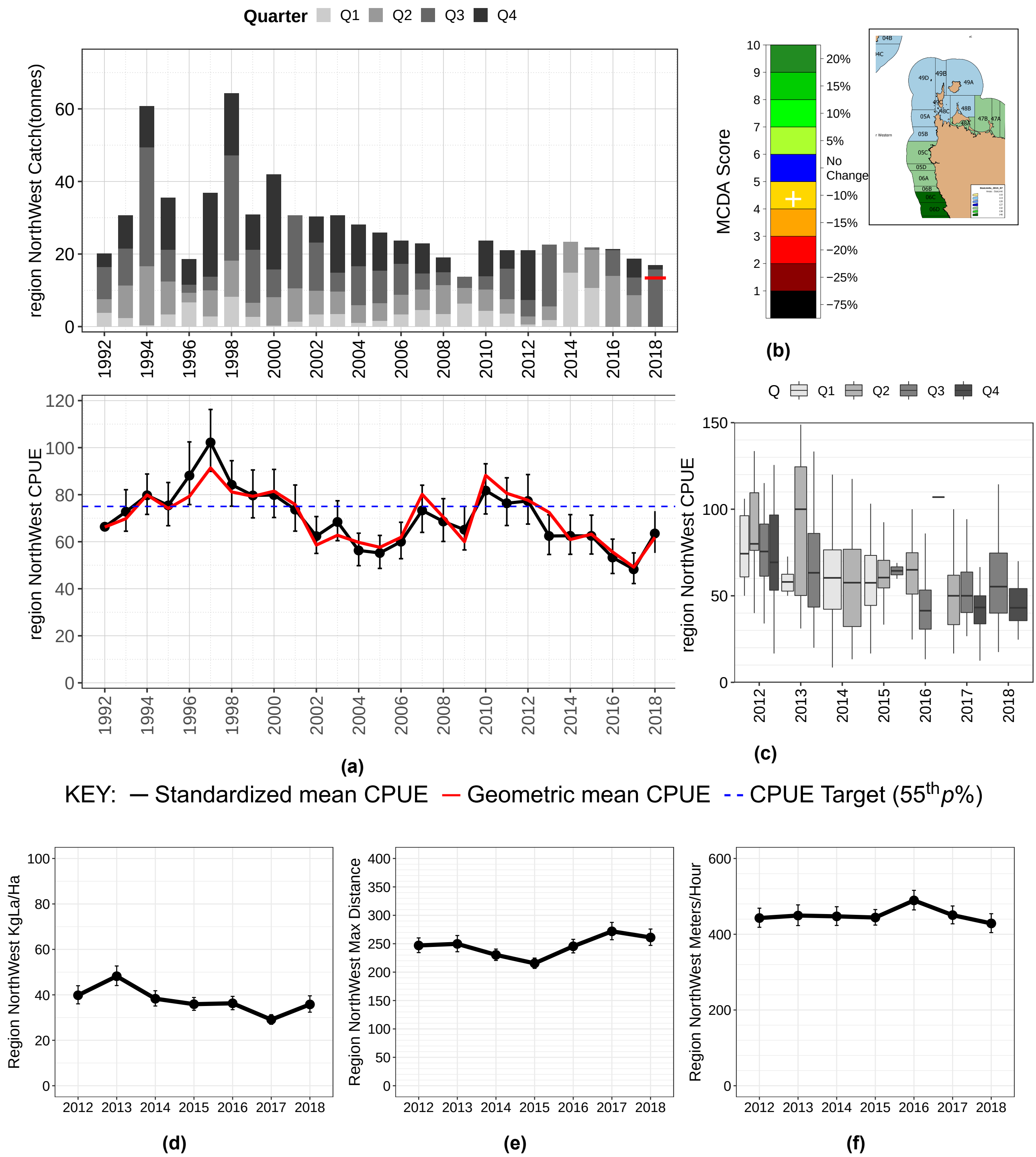


Figure 3.80: *North West GZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Greenlip: Perkins Bay

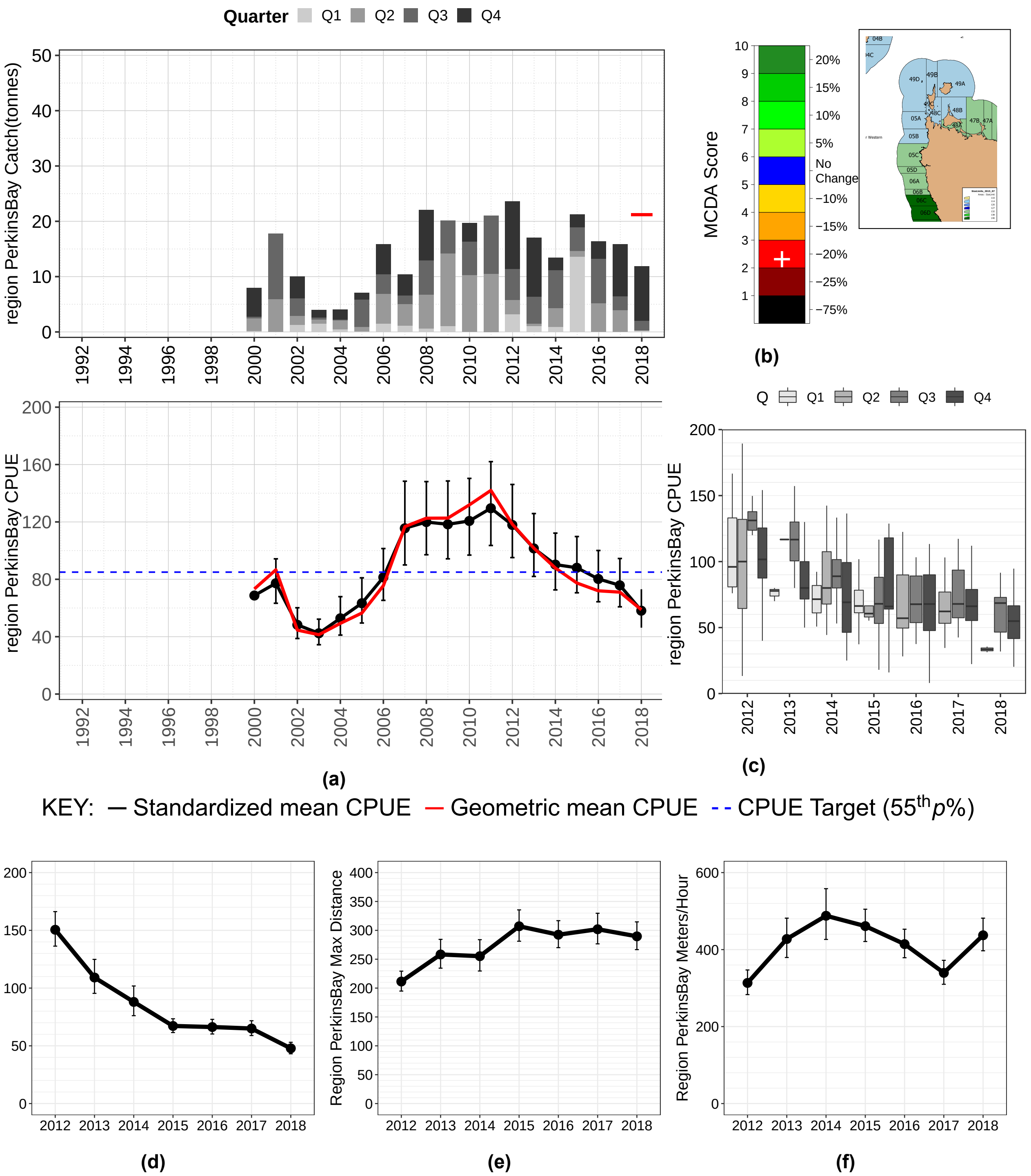


Figure 3.81: *Perkins Bay GZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and un-standardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Greenlip: Central North Coast

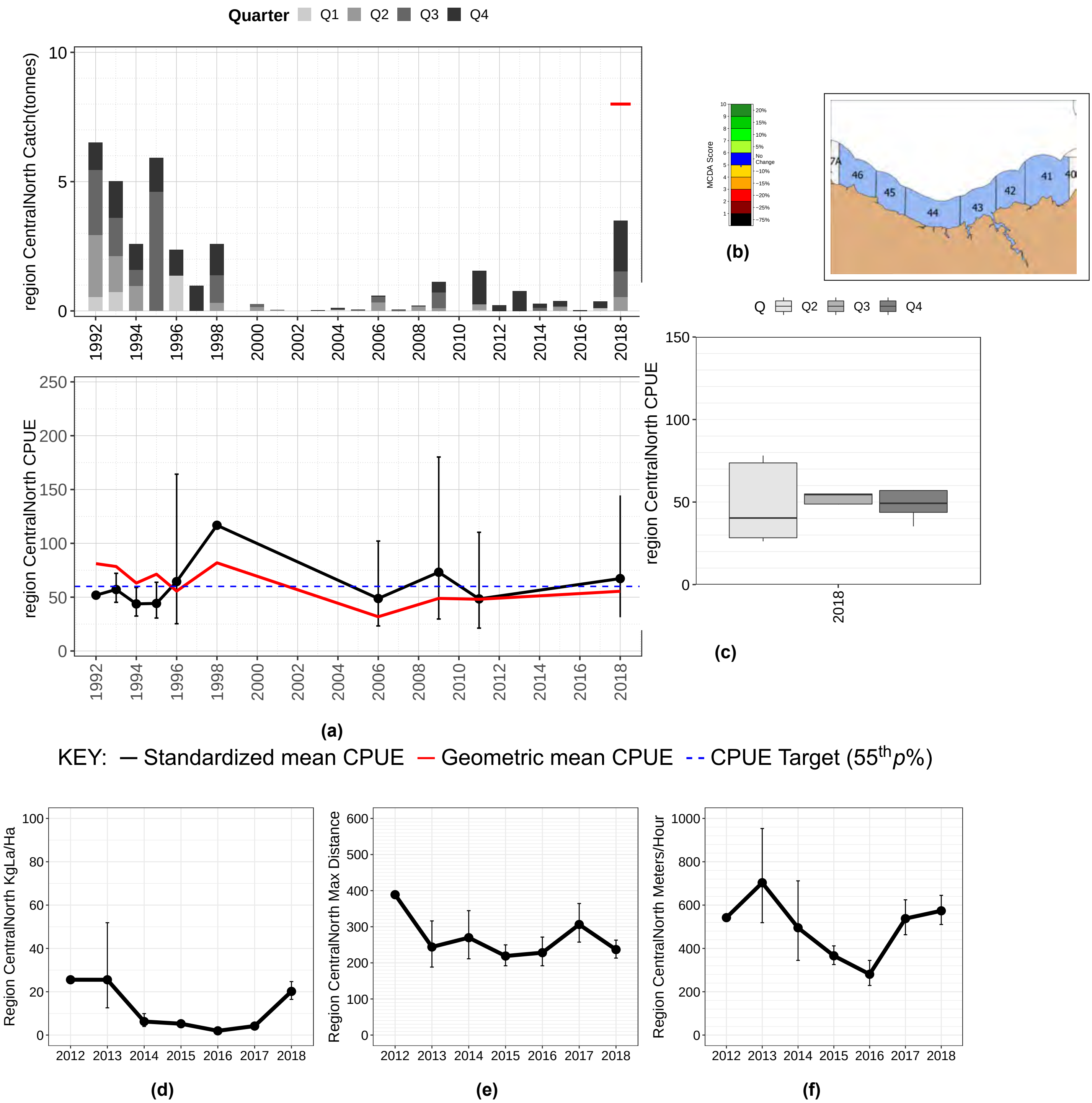


Figure 3.82: *Central North GZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Greenlip: North East

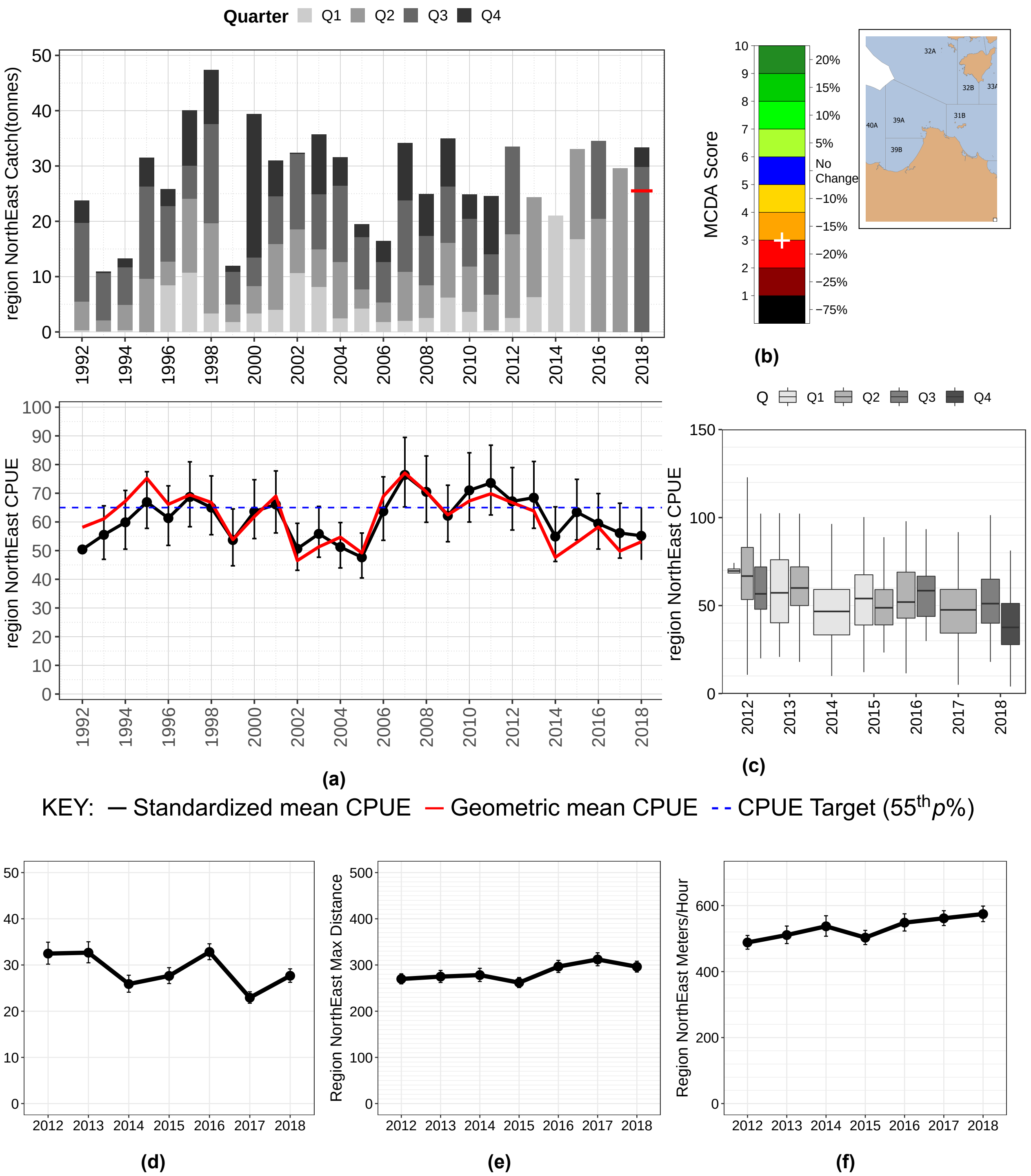


Figure 3.83: *North East GZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and unstandardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

Greenlip: Furneaux Group

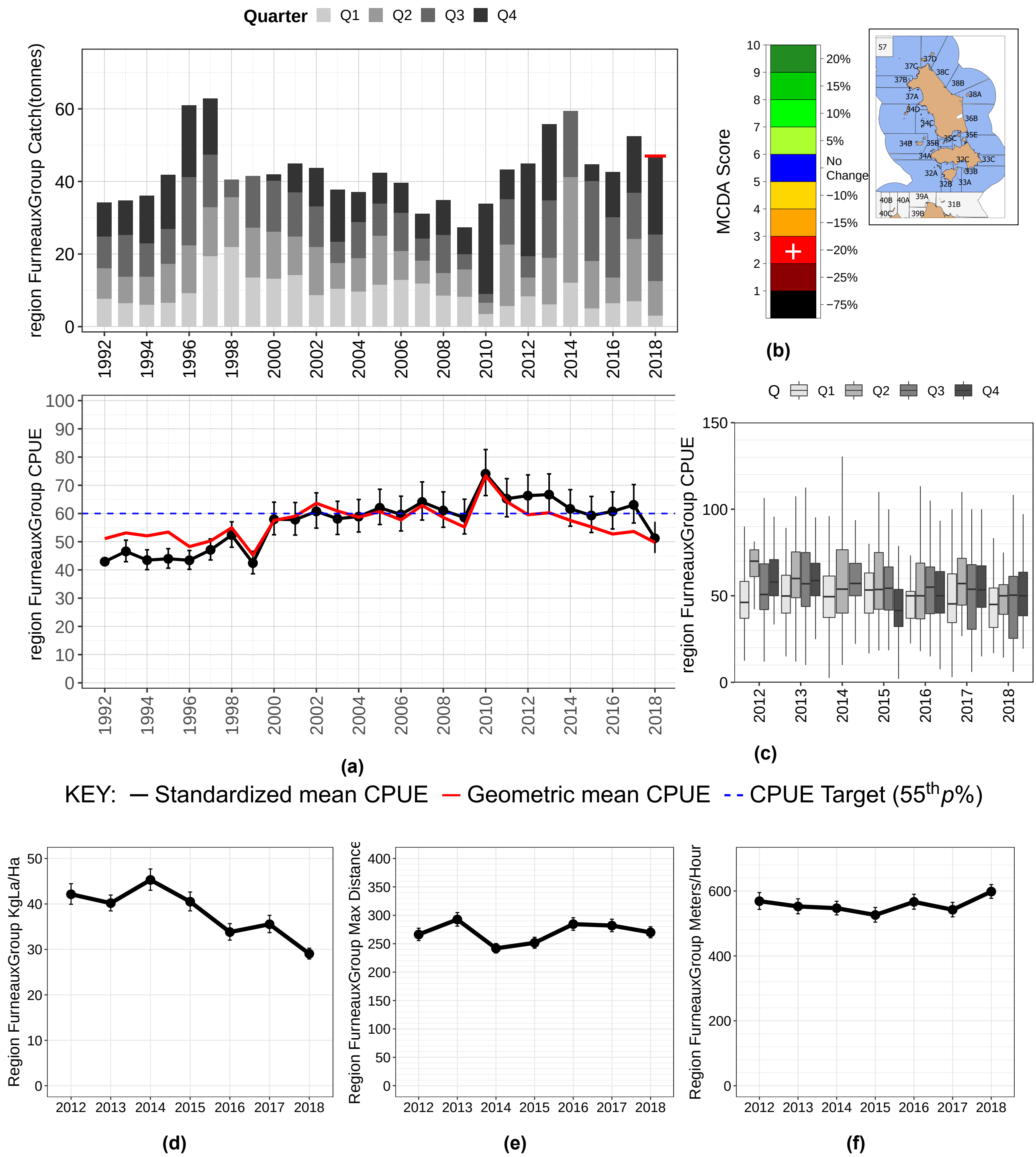


Figure 3.84: *Furneaux Group GZ: a) Catch per quarter (bars) standardised CPUE (black with SE bars) and un-standardised CPUE (red); b) HCR outcome; c) CPUE boxplot by quarter; d) mean KgLa/Ha based on dive vessel footprint from kernel density analysis; e) mean maximum length of dive; f) mean swim rate in metres of coast per hour. Note: all means are bias corrected geometric means.*

IMAS Summary Notes to FRAG –Greenlip Zone

- Reverse cap in place for 2018 - North East catch allocation reached in 4 fishing days for the second consecutive year.
- CPUE on King Island and North West improving.
- Central North - 1.5 of 8 tonnes taken YTD. Catch allocation for this area to be set to zero for 2019.
- Perkins Bay open but negligible catch YTD, and CPUE still falling.
  Catch allocation to be reduced, and spread across central North.
  Perkins Bay is subject to selective fishing, distorting CPUE trends and status.
  IMAS will adopt precautionary approach and following Harvest Strategy outcome.
- Sharp decline in Furneaux Group CPUE.
- Decline in CPUE in North East. Precautionary approach taken and reduction is recommended.

Table 3.5: *Greenlip Zone Catch, CPUE, Harvest Strategy scores and projected TACC for 2018. CPUE Targets are based on the 55th percentile of standardised annual mean CPUE, with a weighting of 65:25:10 on CPUE, Gradient 4 and Gradient 1 performance measures respectively*

Region	Catch 2017	Catch Targ	Catch YTD	CPUE YTD	Score CPUE	Score Grad4	Score Grad1	Score	HS adj	IM adj	MCDA 2019	IMAS 2019	FRAG 2019
KI	24.1	18.0	20.6	57.1	4.2	6.4	7.5	5.1	1.00	1.00	18.0	18.0	
NW	18.8	13.4	16.9	63.5	3.2	4.9	10.0	4.3	0.90	1.00	12.1	13.4	
PB	15.9	21.2	11.9	58.1	2.5	2.5	0.0	2.2	0.80	0.80	17.0	17.0	
CN	0.4	8.0	3.5	67.3	5.3			0.0		0.00		0.0	
NE	29.9	25.5	33.3	55.2	2.6	2.9	4.6	2.9	0.80	0.85	20.4	21.7	
FG	52.5	47.0	47.1	51.2	2.9	1.2	1.2	2.3	0.80	0.80	37.6	37.6	
BS	0.0	0.0	0.1										
Total	141.5		133.4								105.0	107.6	0.0

3.5.3 Greenlip Zone Summary

The regional SCPUE is now below the target CPUE in all five major regions. In 2018, the King Island and North West regions (excluding Perkins Bay) SCPUE improved and are approaching the CPUE target. Mean SCPUE in the Perkins Bay capped area in 2017 was 75.5 Kg/Hr and dropped sharply in 2018 to 58.1 Kg/Hr with only 50% of the catch allocation of 21.2 t taken. Some industry members argued that selective fishing for larger animals in Perkins Bay was responsible for the CPUE declines, but this seems to be secondary to the long-term depletion associated with an over-optimistic catch target. Changes from a winter to late-summer (lower weight/length) fishing season in recent years and increased selective fishing are thought to have had more influence over the SCPUE trend and HS outcomes than actual changes in biomass. However, until these factors are included in the CPUE standardisation, as a precautionary approach this stock is considered to be declining from a sustainable position.

Trends in the three spatial indicators of KgLa/Hr, MaxDist, and M/hr swim rate provide support that selective fishing was occurring but also suggest abundance was declining regardless. Typically KgLa/Ha mirrors trends in CPUE (Kg/Hr), whereas swim rate trends are inverse to CPUE. For Perkins Bay, CPUE and KgLa/Ha declined over the period 2012 - 2017, whereas swim rate increased between 2012 and 2014 consistent with declining stocks, but then declined from 2015 to 2017. In 2018, CPUE and all Simple Spatial Indicators (SSI) suggested there was a sharp reduction in abundance. Collectively, the numerical evidence suggests declining CPUE in Perkins Bay is a response to both declining stocks and a change in fishing pattern associated with selective fishing for larger abalone. The Greenlip fishery is reliant on a relative small area of productive reef, with less than 20% of the reef area fished supporting 50% of the catch in most years fig. 3.77.

The zone-wide proxy for abundance was 3.8 in 2018 and remains above the LRP. The zone-wide proxy for F declined further to -1.7, and remains below the TRP for sustainability (fig. 3.76).

3.6 Commercial Catch Length-frequency

3.6.1 Eastern Zone

Catch sampling has traditionally been well represented in the Eastern Zone. Overall catches in the Eastern Zone have typically been dominated by abalone <150 mm and near the LML. Up until 2010, catches tended to comprise abalone near to the LML, with a pattern of increasing size structure moving from southern to northern regions of the eastern zone. However, in 2015 catches across all regions were generally comprised of larger abalone centred around 150 mm, with smaller abalone being poorly represented particularly in the southern regions where catches have traditionally been dominated by abalone near to the LML. Notwithstanding market preferences, the absence of small abalone and a shift towards larger abalone provides further evidence of a fishery suffering recruitment stress and a reliance on pre-existing older and larger abalone across most eastern zone regions.

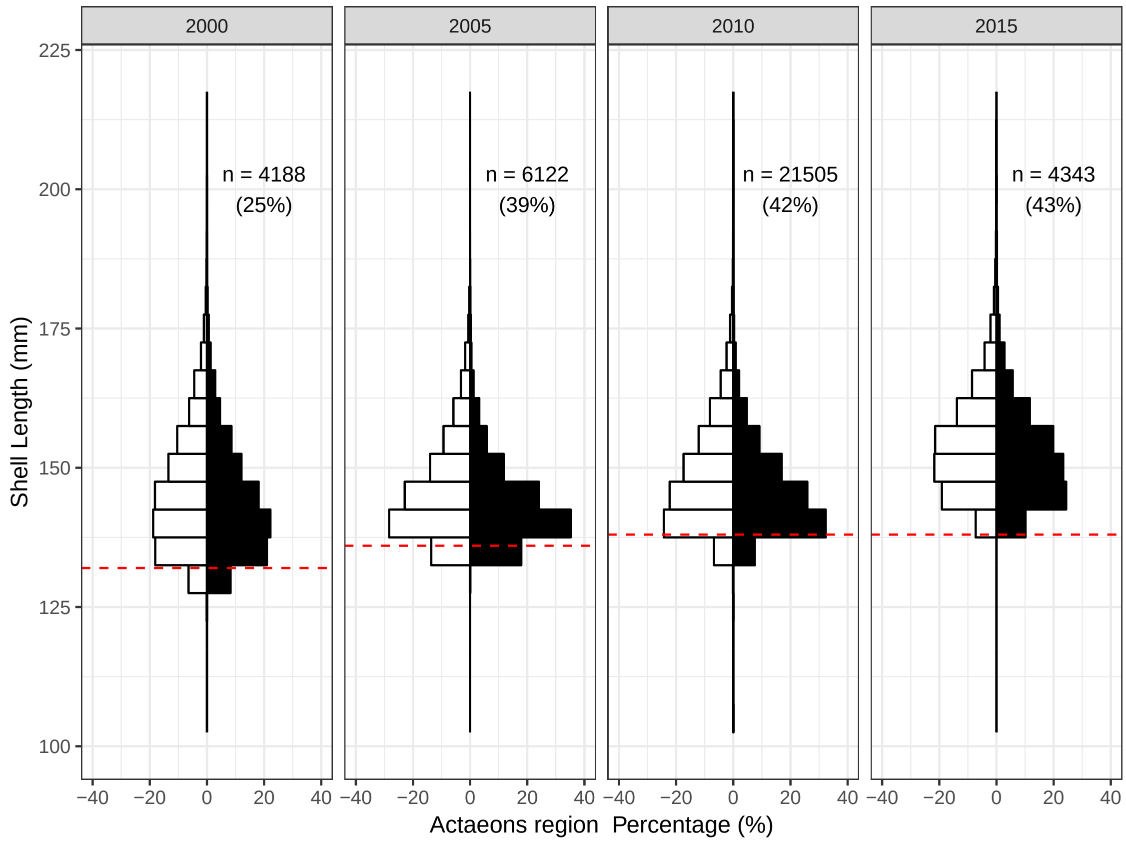


Figure 3.85: *Length frequency distributions for the Actaeons (East) region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Eastern Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

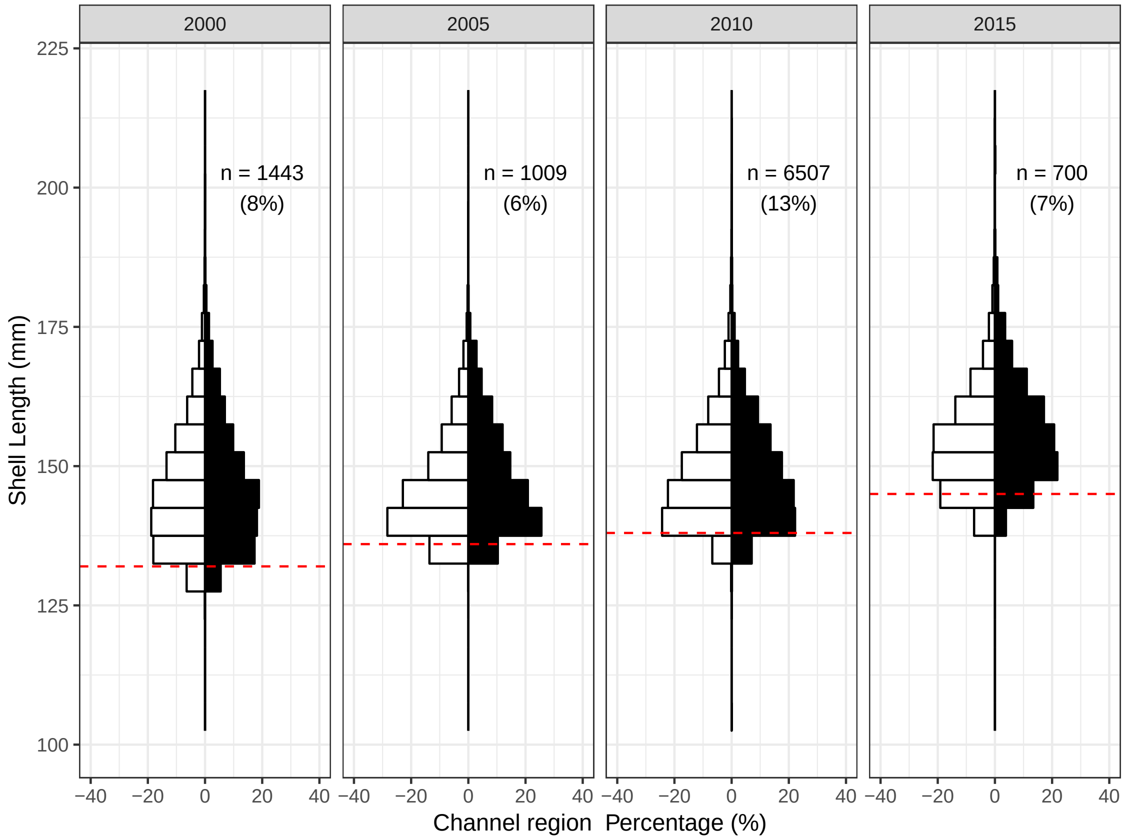


Figure 3.86: *Length frequency distributions for the Channel region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Eastern Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

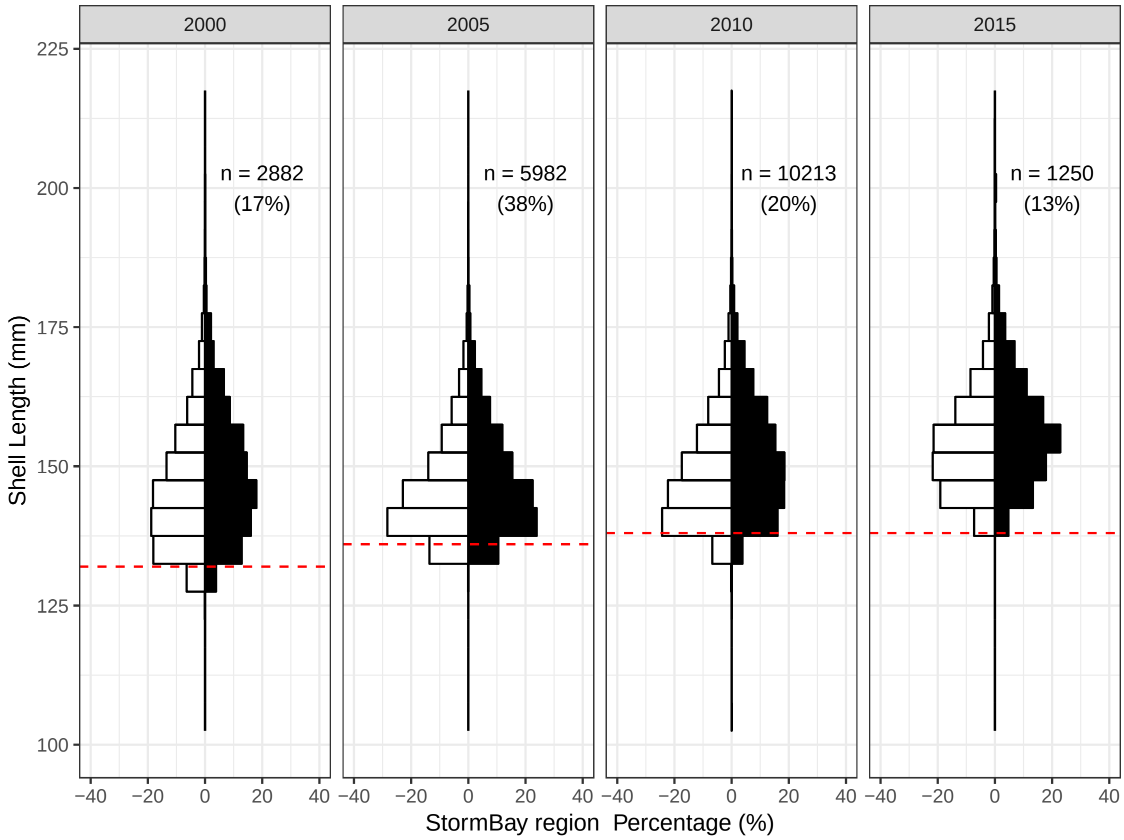


Figure 3.87: *Length frequency distributions for the Storm Bay region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Eastern Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

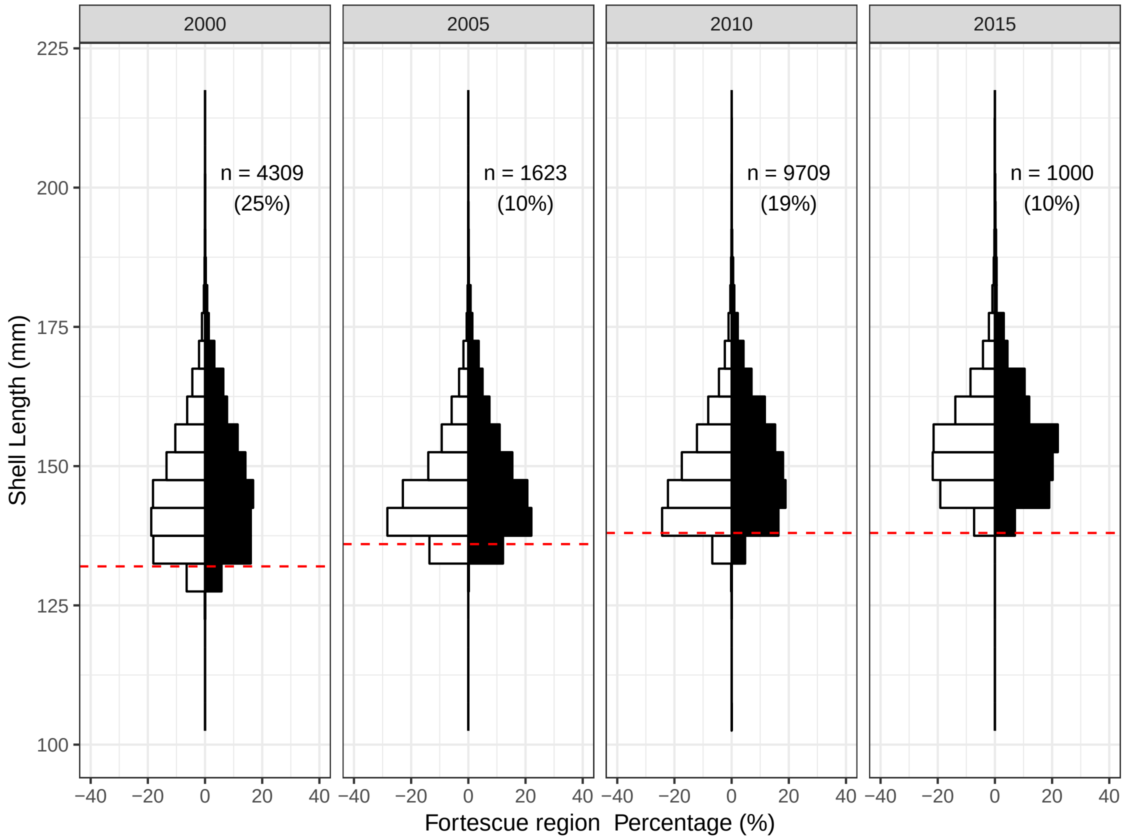


Figure 3.88: *Length frequency distributions for the Fortescue region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Eastern Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

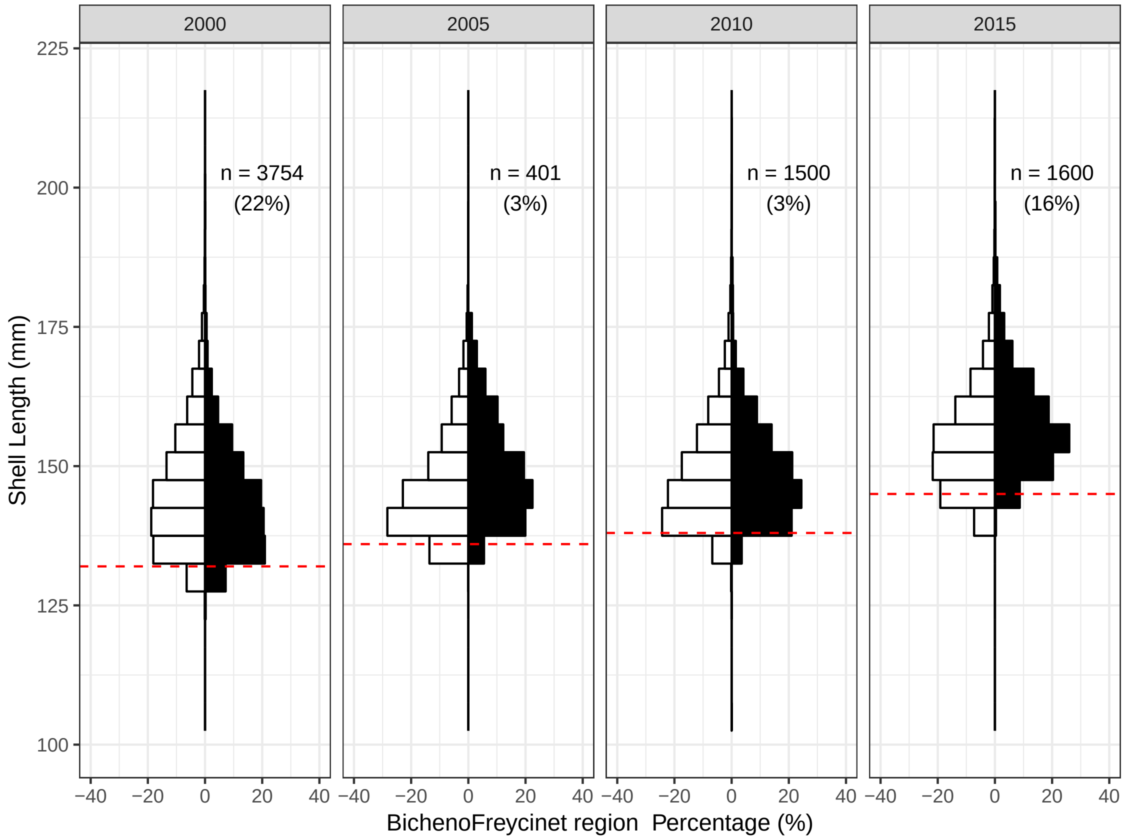


Figure 3.89: *Length frequency distributions for the Bicheno-Freycinet region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Eastern Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

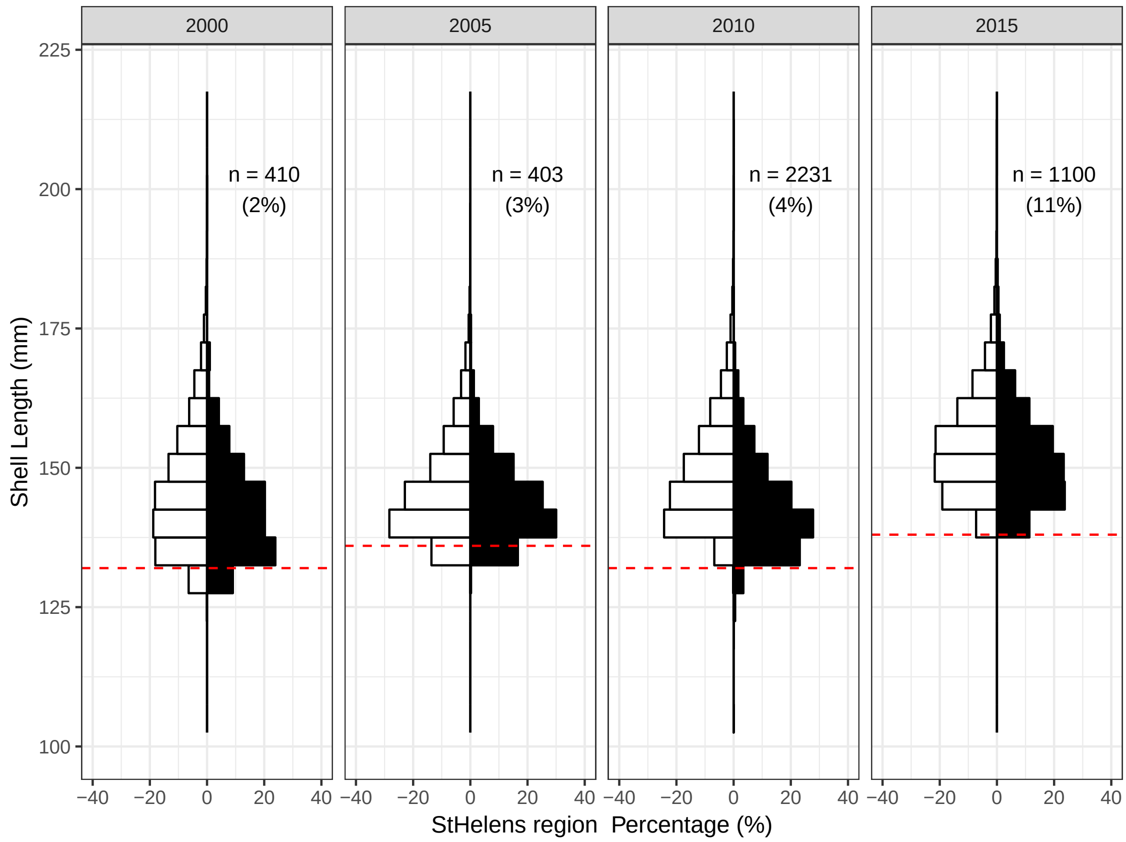


Figure 3.90: *Length frequency distributions for the St Helens region at five-year intervals between 2000 and 2015 for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

3.6.2 Western Zone

Western Zone catches have typically been dominated by some of the largest abalone measured from market measuring, trending towards slightly smaller animals at the southern and northern regions of the zone. Up until 2010, catches were consistently centred around 150 mm, with approx. 50% of individuals larger than 150 mm across all regions within the zone. Post 2010 catches were dominated by larger individuals with a mode centred closer to 160 mm and fewer small abalone occurring in catches particularly from the South Coast to Strahan regions.

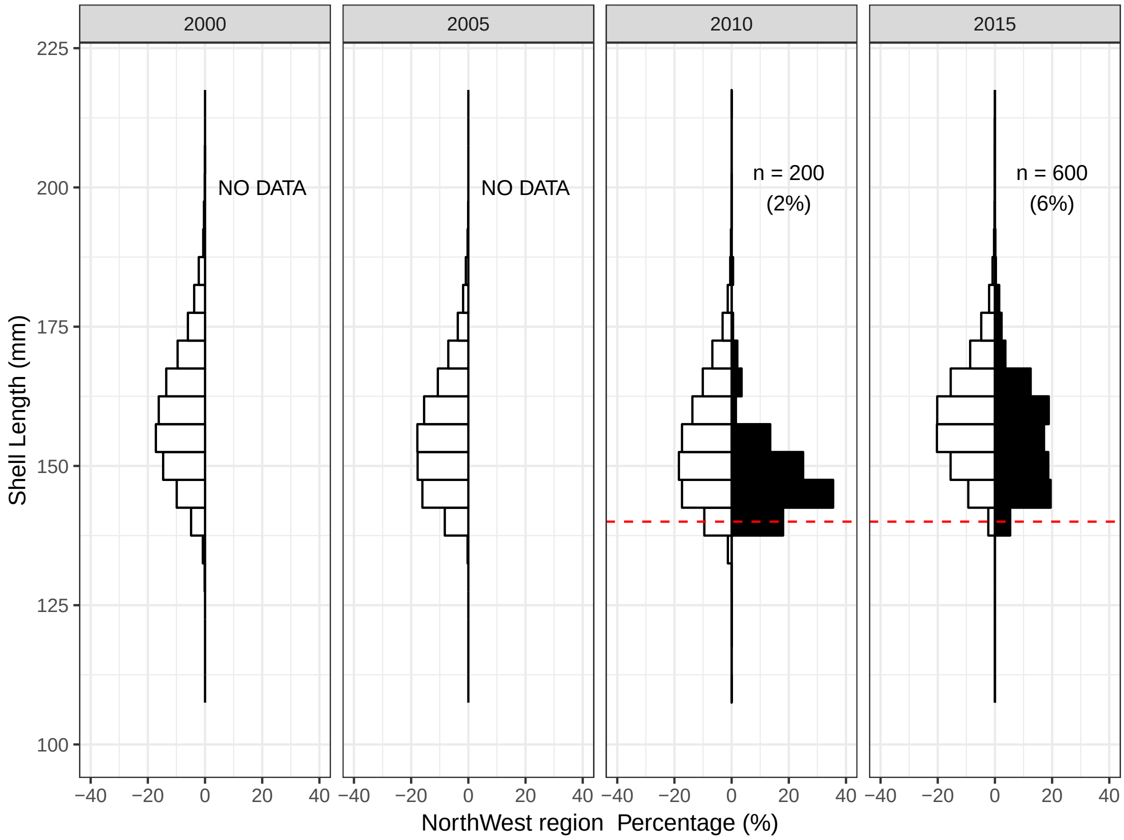


Figure 3.91: *Length frequency distributions for the North West region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Western Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

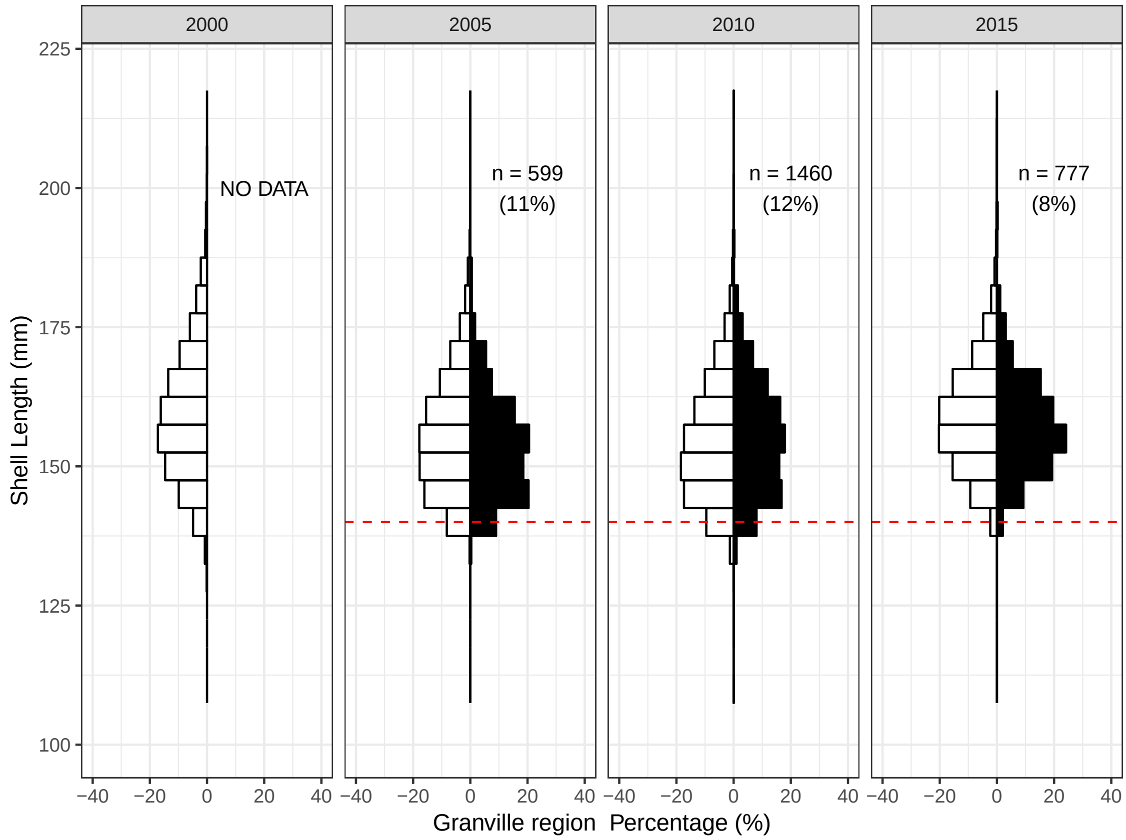


Figure 3.92: *Length frequency distributions for the Granville region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Western Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

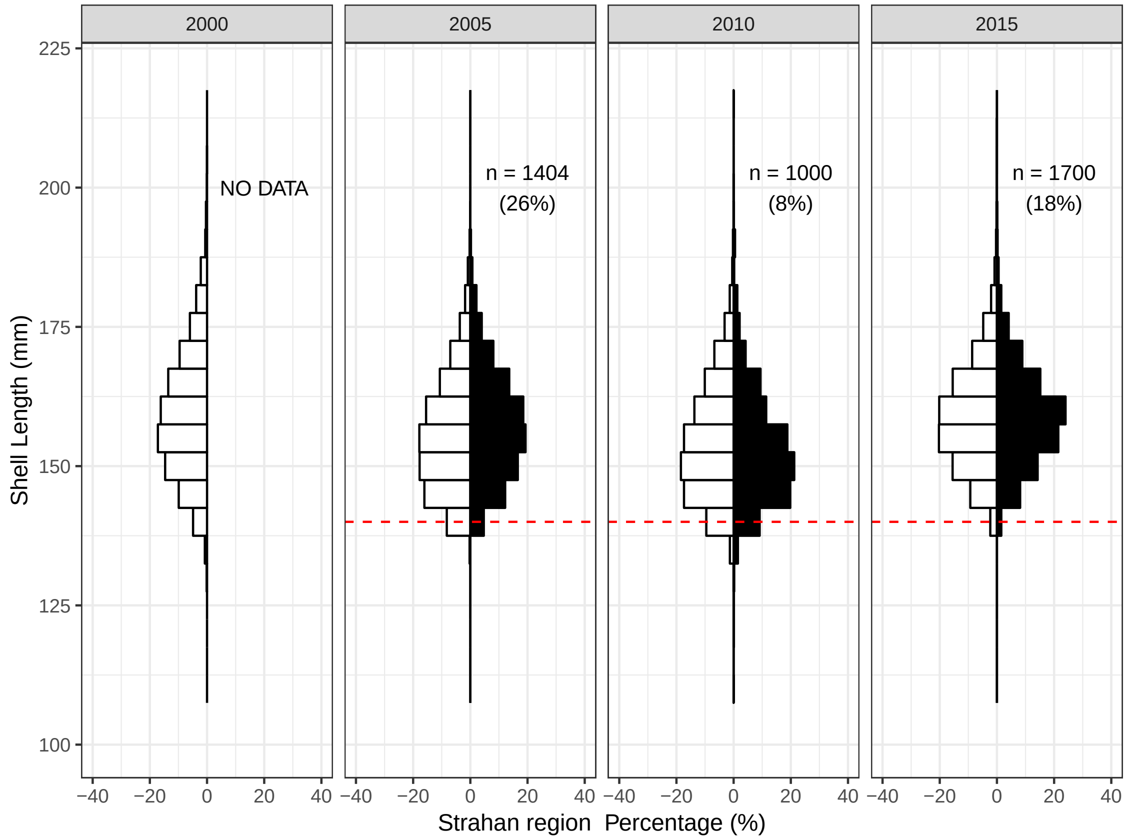


Figure 3.93: *Length frequency distributions for the Strahan region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Western Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

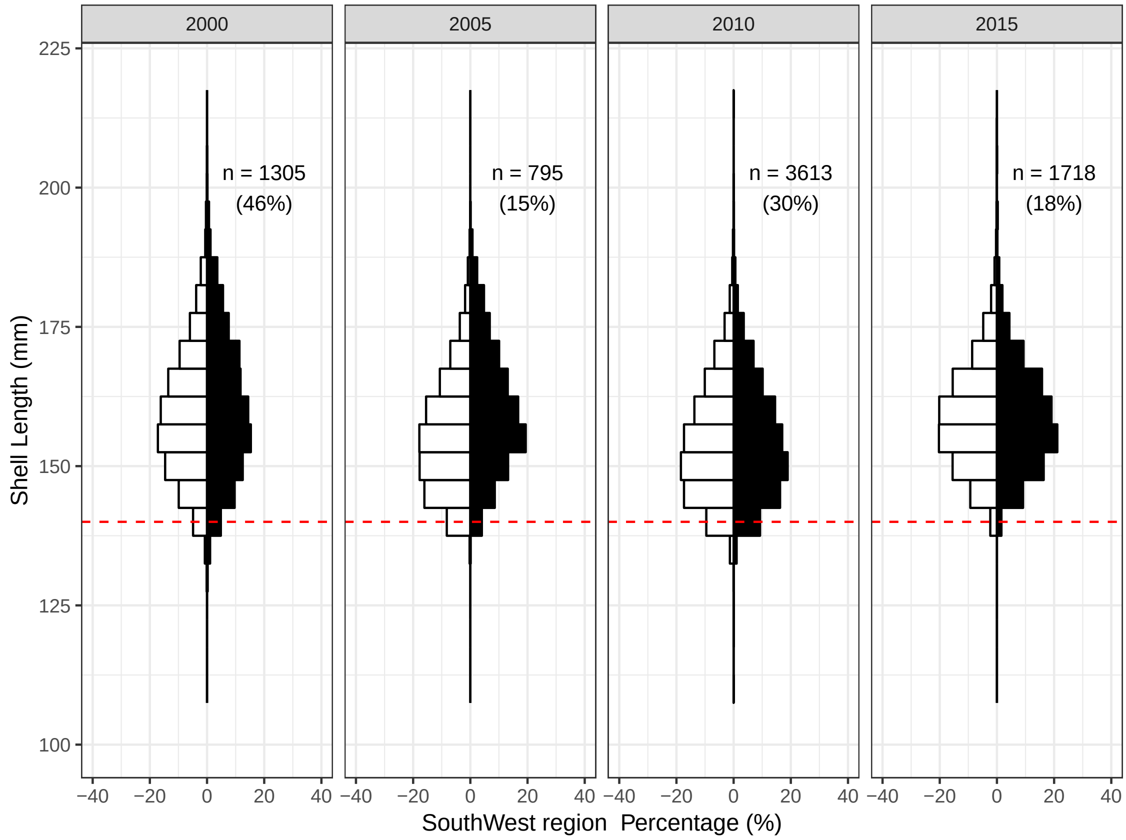


Figure 3.94: *Length frequency distributions for the South West region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Western Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

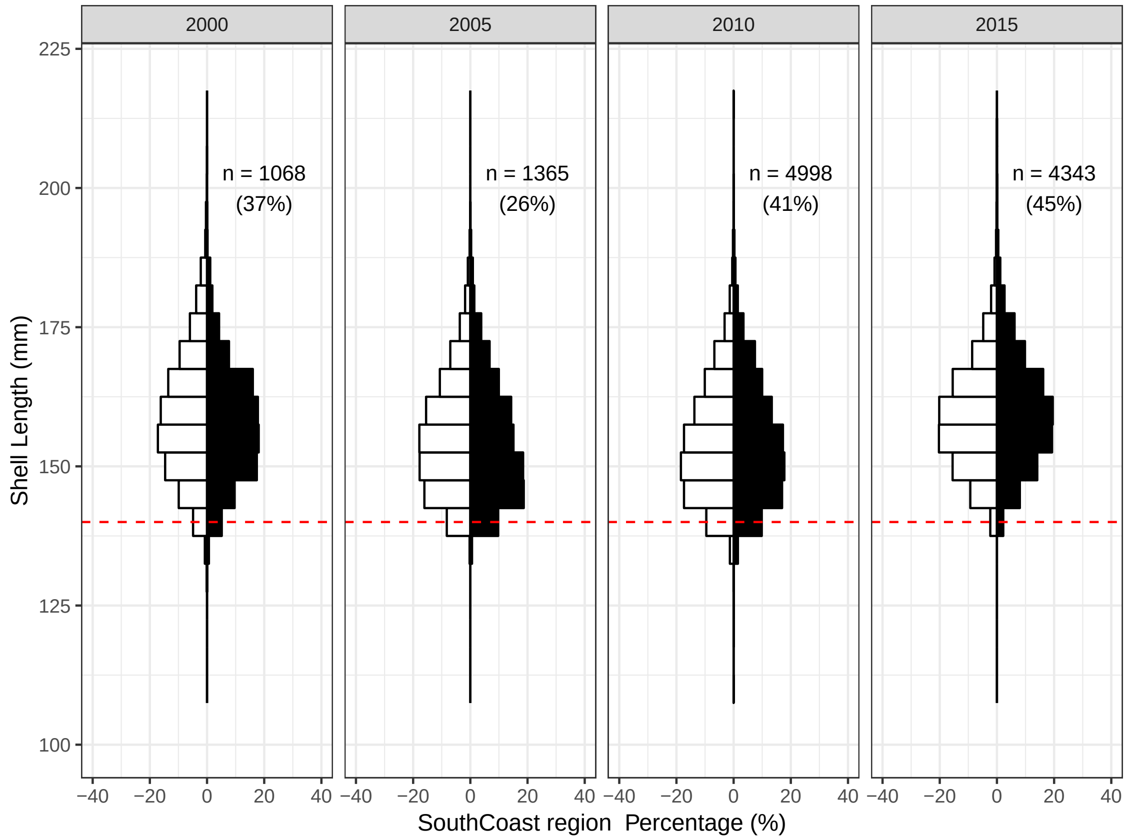


Figure 3.95: *Length frequency distributions for the South Coast region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Western Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

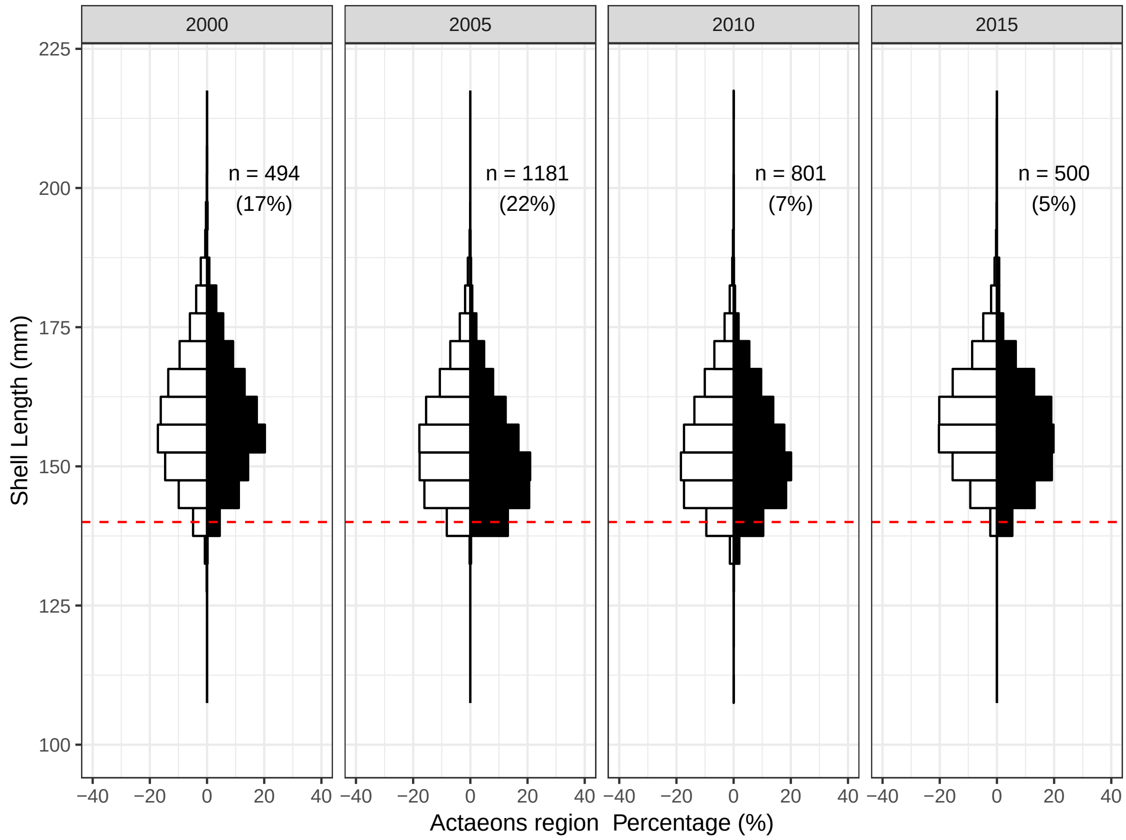


Figure 3.96: *Length frequency distributions for the Actaeons (West) region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Western Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

3.6.3 Northern Zone

Relatively few samples were taken from the Northern Zone, reflecting the landing and processing location of catch from this zone and the difficulty of sampling catches from remote regions. Prior to the creation of the northern zone in 2001, catches were generally dominated by abalone around 140 mm to 150 mm shell length, particularly at the eastern and western extremities of the zone. Since 2000, the size composition of catches has fluctuated between regions, largely driven by changes in market preferences and management. In the North West and Hunter Island regions catches have typically trended towards reductions in the LML through experimental fishing which commenced in 2008 and were dominated by mostly smaller abalone centred around 130 mm in 2010, compared to larger animals centred around 140 mm in the early 2000's. Limited sampling in 2015 however, indicated a marked increase in larger abalone centred around 150 mm in the Hunter Island region, with abalone < 130 mm being rare (section 3.6.3). Catch sampling in the North East region have been limited with size structure remaining relatively stable between 2010 and 2015, dominated by mostly larger abalone compared to the rest of the zone between the LML of 127 mm to around 135 mm.

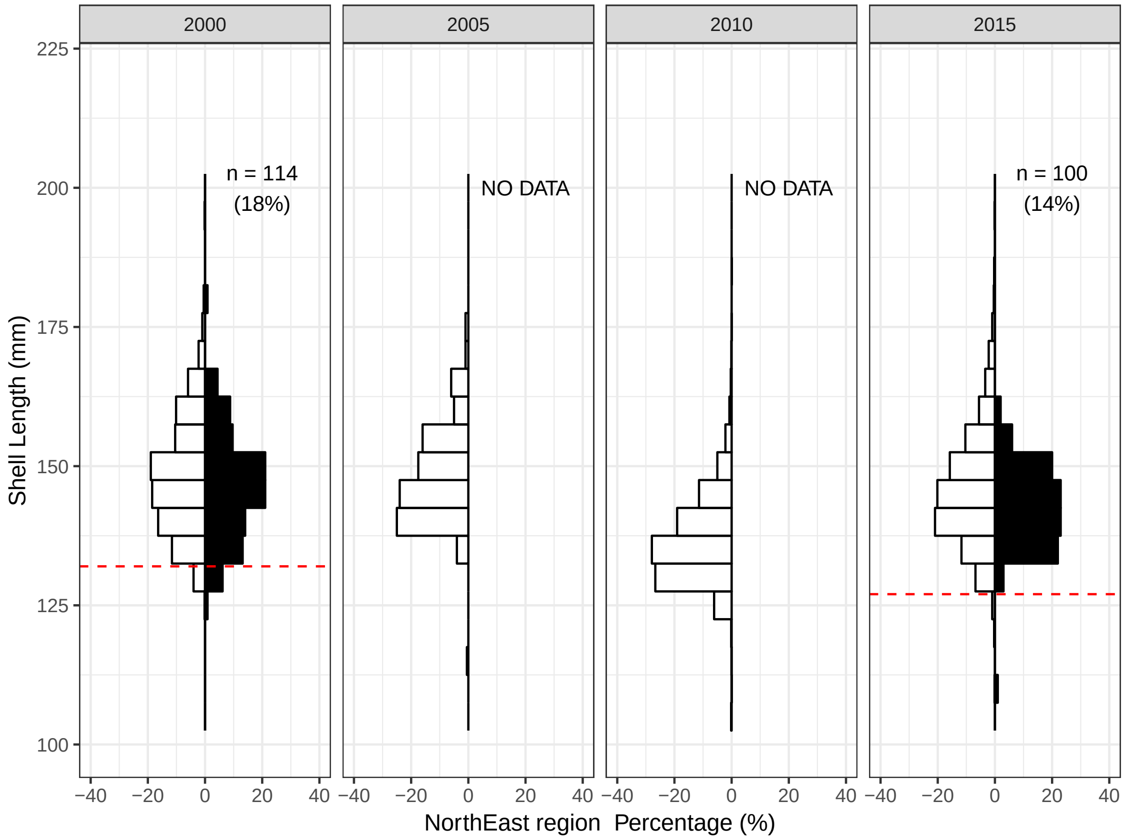


Figure 3.97: *Length frequency distributions for the North-east region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Northern Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

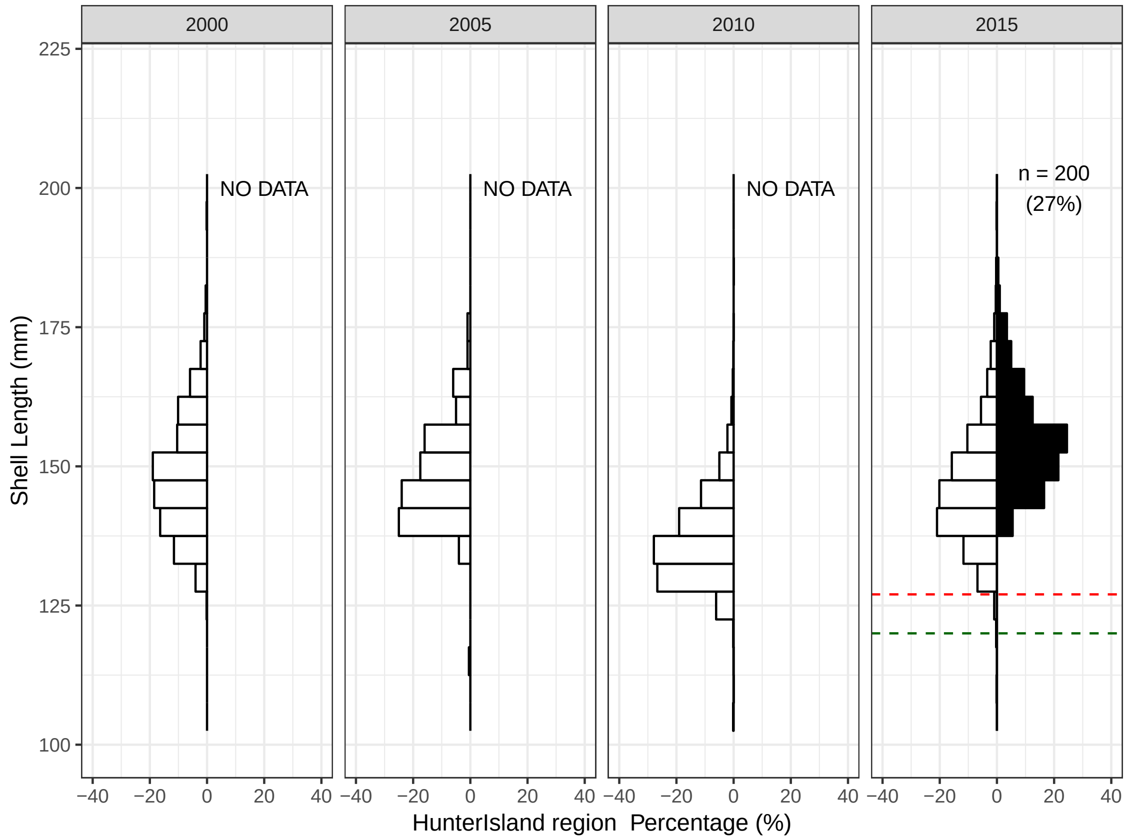


Figure 3.98: *Length frequency distributions for the Hunter Island region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Northern Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

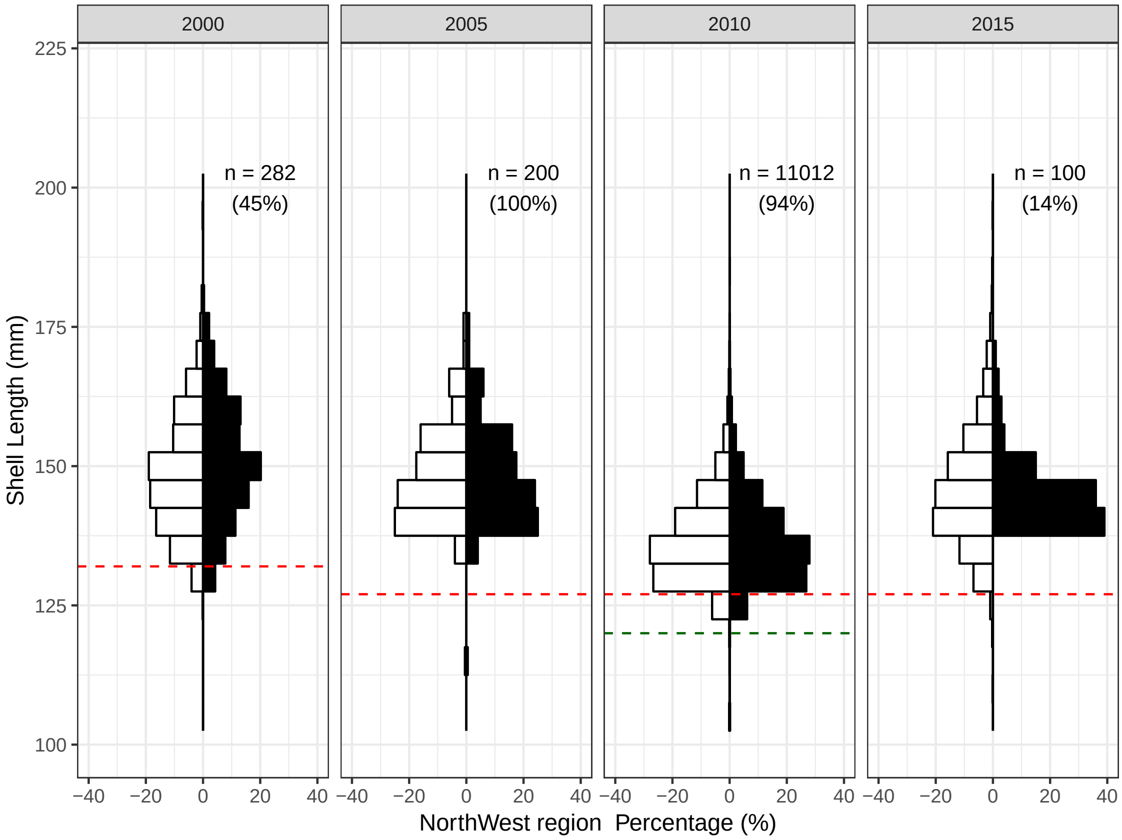


Figure 3.99: *Length frequency distributions for the North-west (Northern) region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Northern Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

3.6.4 Bass Strait Zone

Catch sampling from the Bass Strait zone has been rare. Prior to the creation of the zone in 2003, catches were comprised of mostly larger animals centred around 135 mm from the Hunter Island region and 150 mm from the Furneaux Group. Reductions in the LML in the Furneaux Group in 2010 also resulted in reduced size compositions from 2010, with catches dominated by abalone centred around 125 mm and almost no abalone larger than 150 mm. Limited catch sampling from the Bass Strait Island region in 2010 indicated that catches are typically dominated by smaller abalone, similar in size structure to the Furneaux Group, centred around 125 mm. Observations from limited catch sampling in the Central North region in 2010 suggest abalone are typically much smaller than the remainder of the zone with catch compositions centred around 115 mm.

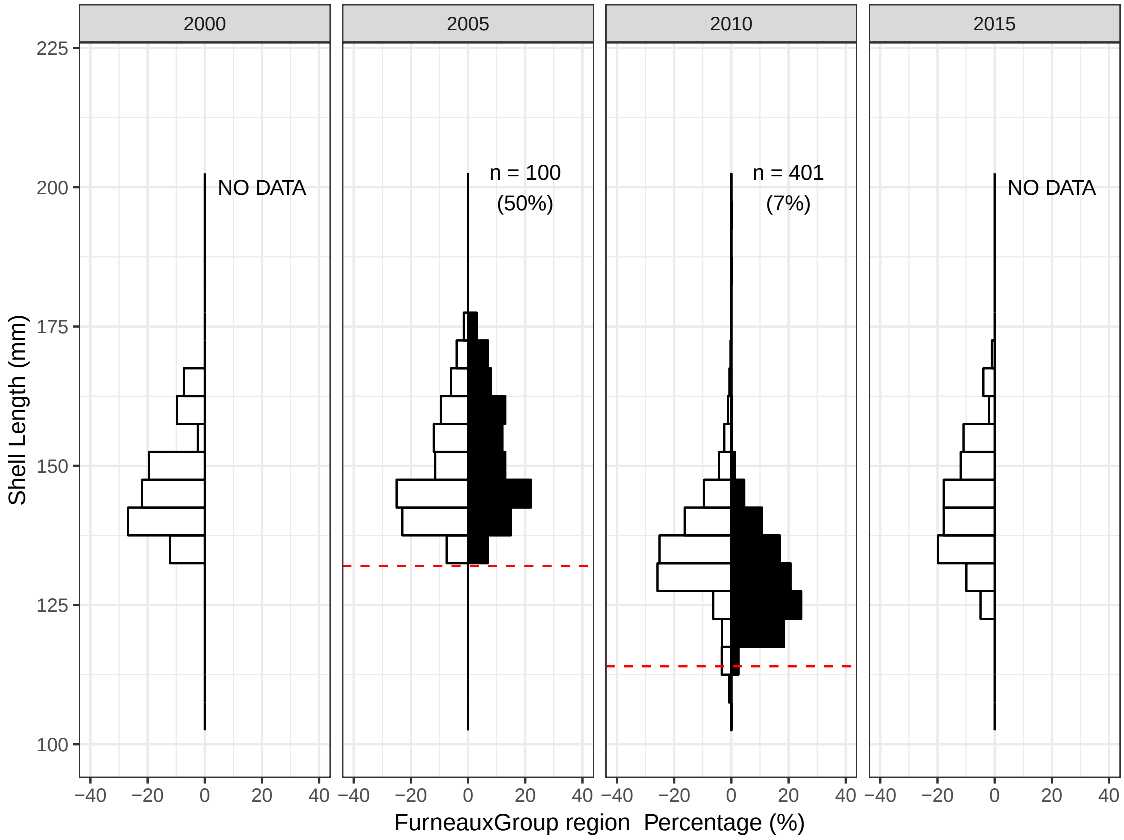


Figure 3.100: *Length frequency distributions for the Central-north region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Bass Strait Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

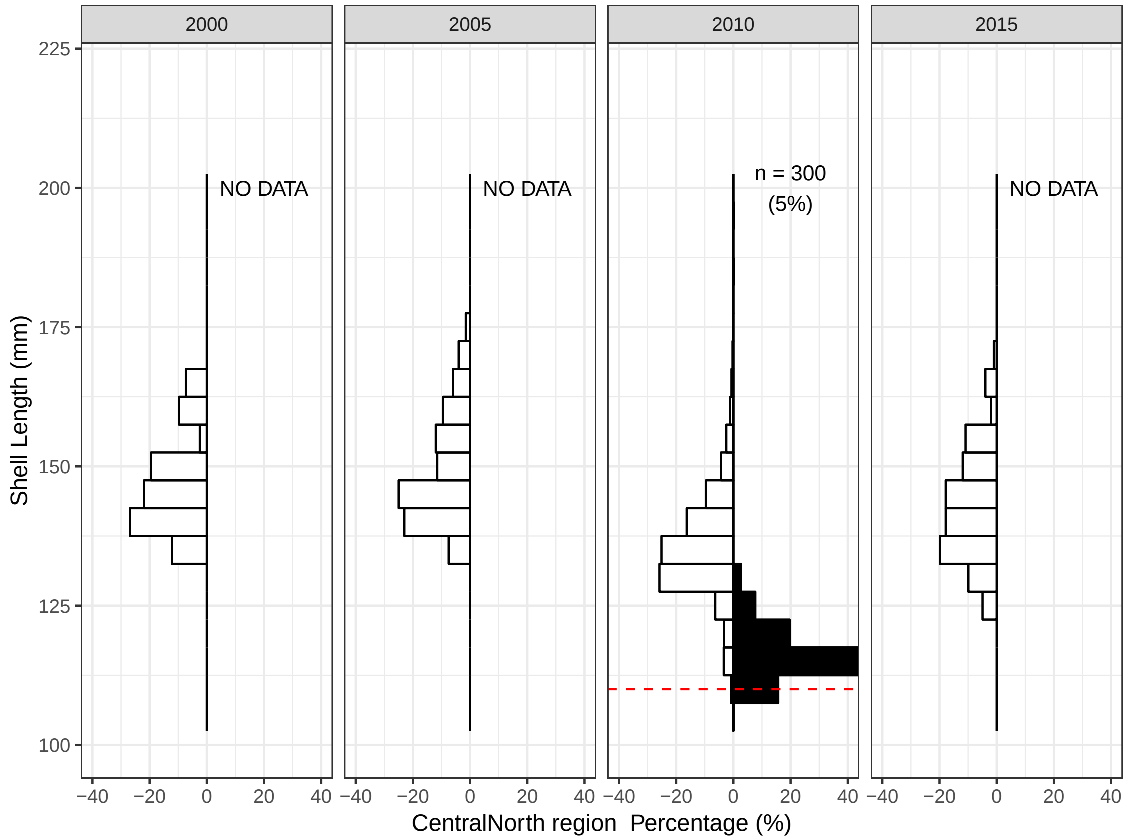


Figure 3.101: *Length frequency distributions for the Central-north region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Bass Strait Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

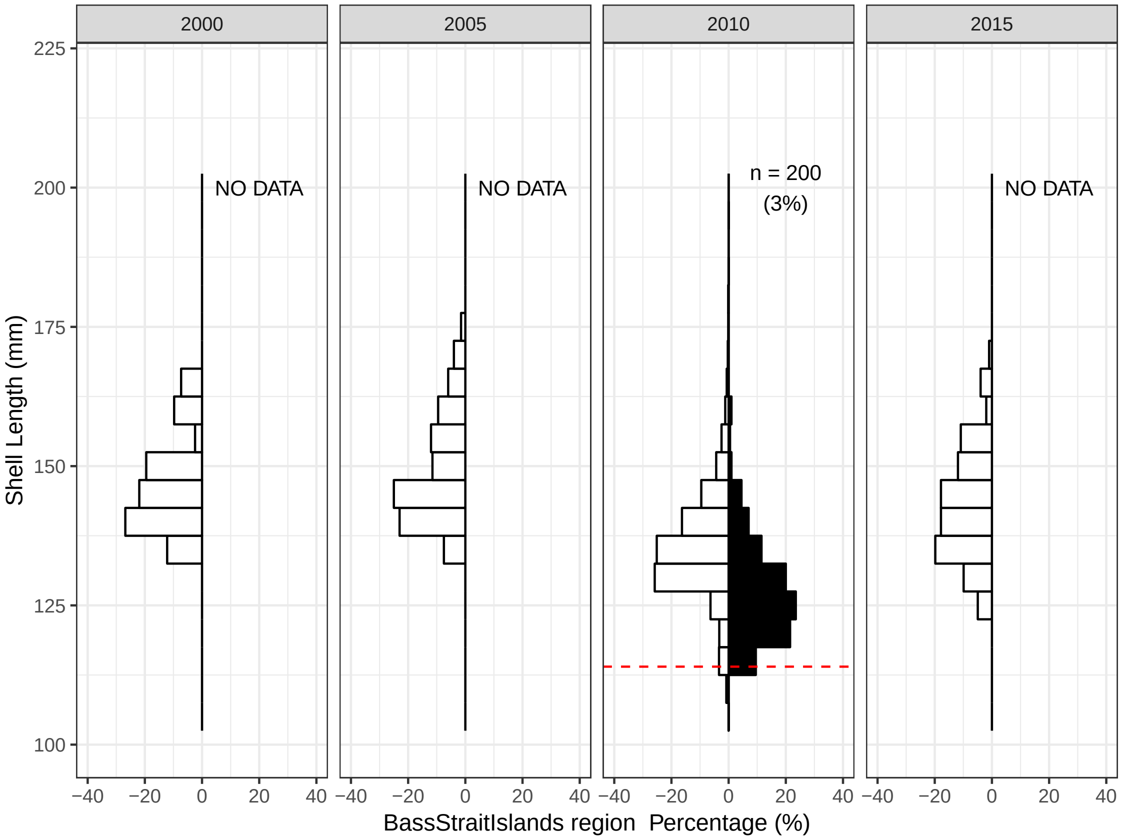


Figure 3.102: *Length frequency distributions for the Bass Strait Islands region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Bass Strait Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

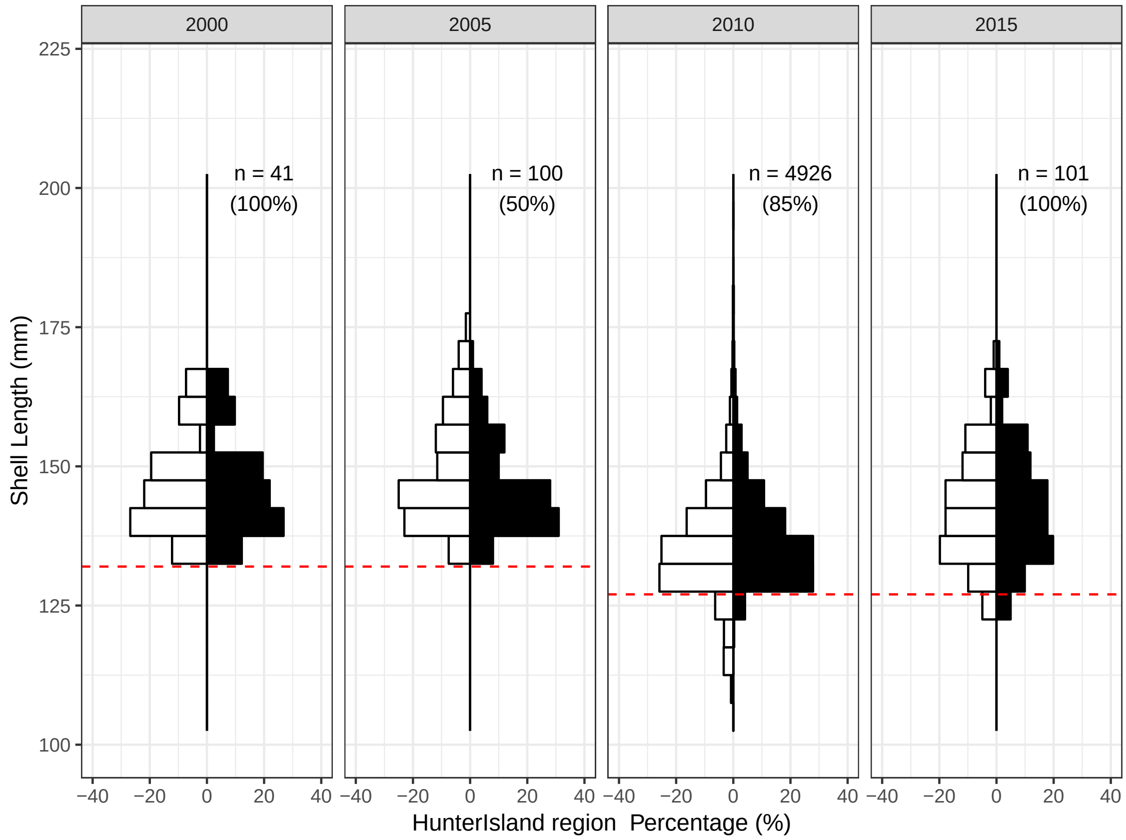


Figure 3.103: *Length frequency distributions for the Hunter Island region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Bass Strait Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

3.6.5 Greenlip Zone

Catch sampling of the Greenlip zone during the early 2000s was uncommon. Following a reduction in the LML at Perkins Bay in 2006, the overall size structure of greenlip measured in 2010 was dominated by smaller abalone centred around 140 mm. Greenlip catch from the North East region (section 3.6.5) have typically comprised larger abalone centred around 160 mm. Since 2010, overall greenlip catch compositions have progressively increased in size, most likely reflecting more selective fishing and market preference for larger individuals, particularly from the North East and Furneaux region where most catches are centred around 150-160 mm.

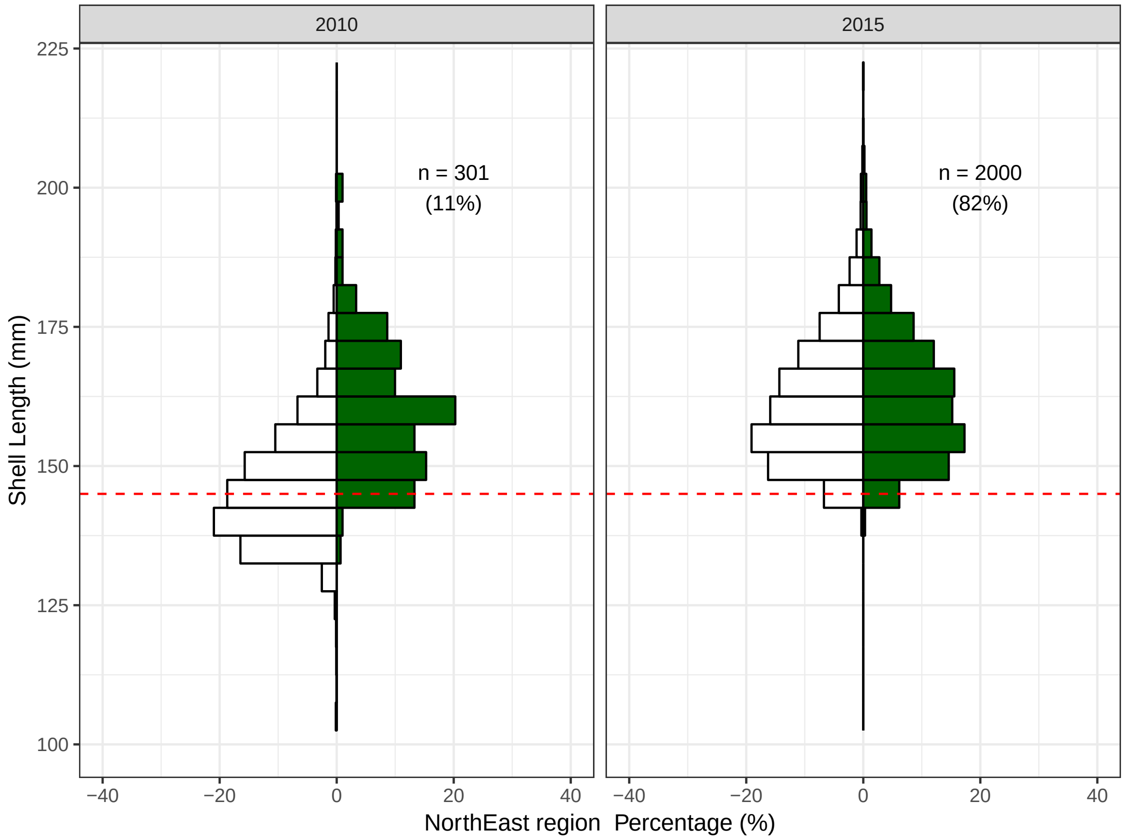


Figure 3.104: *Length frequency distributions for the Greenlip Zone North-east region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Greenlip Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

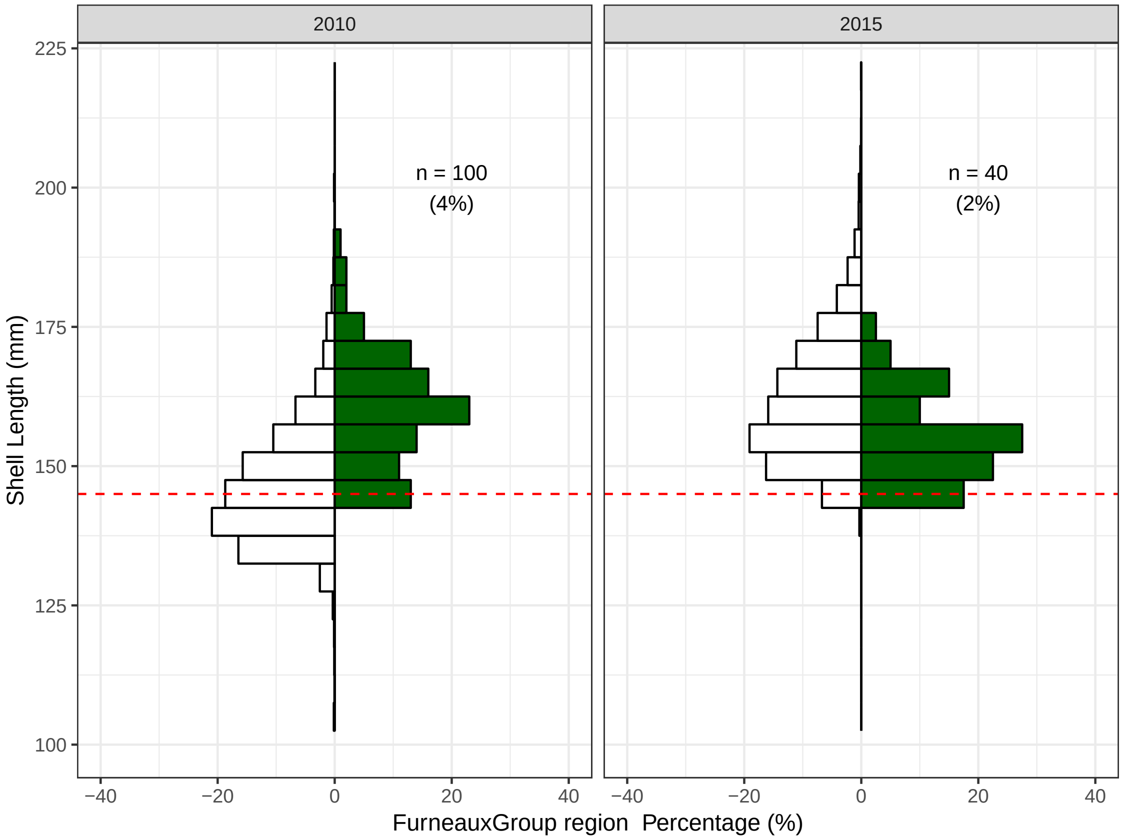


Figure 3.105: *Length frequency distributions for the Greenlip Zone Furneaux region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Greenlip Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

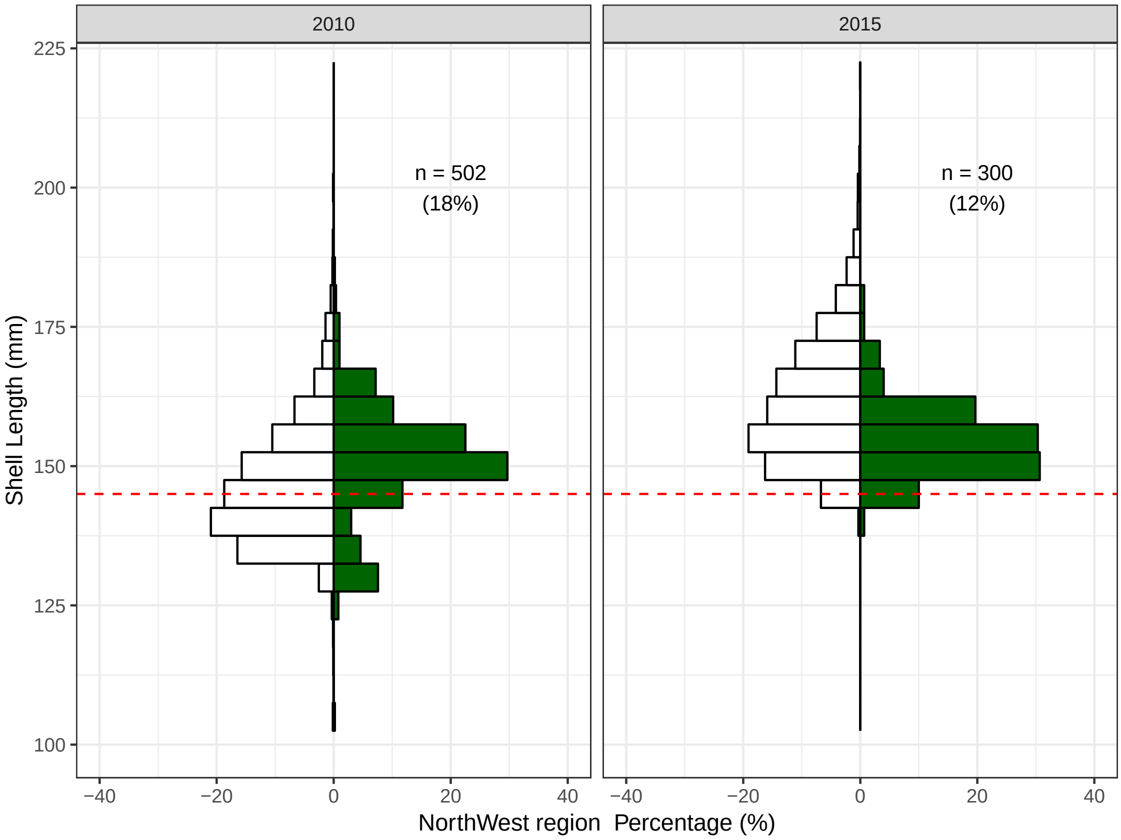


Figure 3.106: *Length frequency distributions for the Greenlip Zone North-West region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Greenlip Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

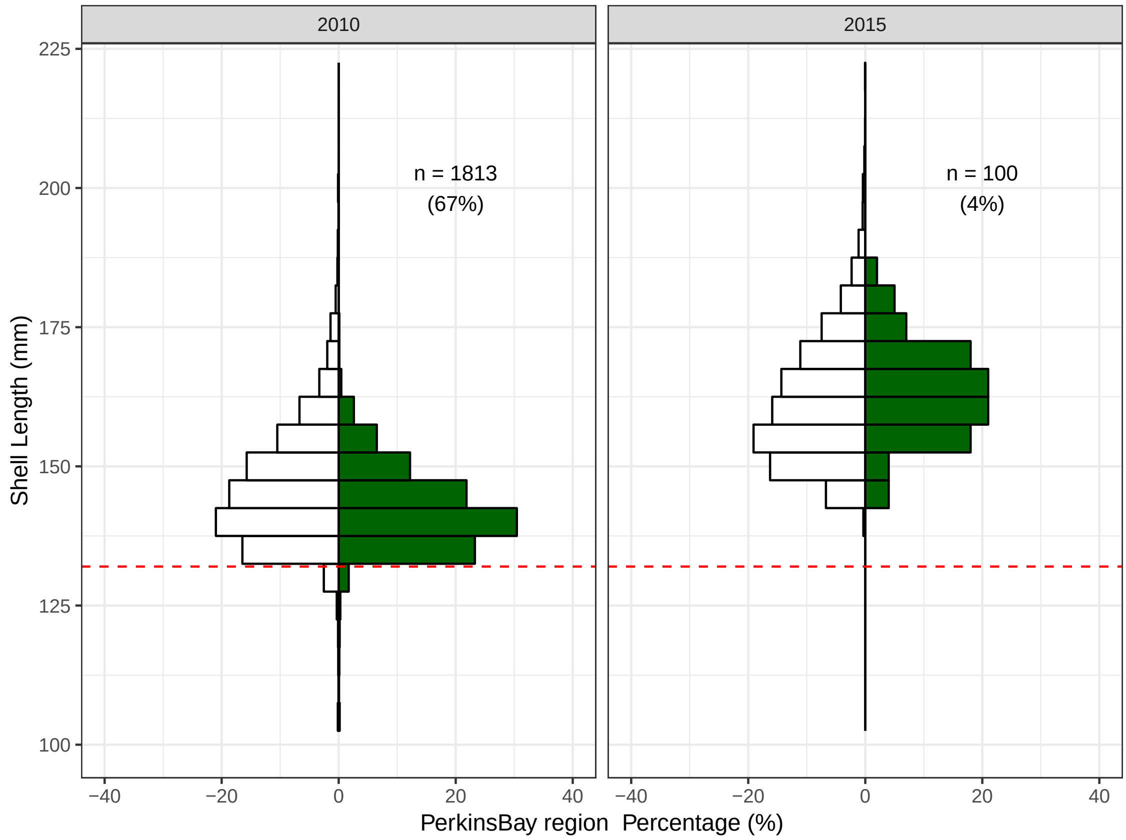


Figure 3.107: *Length frequency distributions for the Greenlip Zone Perkins Bay region at five-year intervals between 2000 and 2015. Filled black bars indicate size structure for this region. Open bars represent the entire Greenlip Zone for that year. Hashed red line represents the LML for that year. Region sample size and percentage of the total number of samples measured for the entire zone in that year is also given.*

Chapter 4

Fishery Independent Research Results

4.1 Fishery-independant ARM and LEG surveys

4.1.1 Black Reef - boulder site (Block 14A)

Adult abundance recorded from visual belt transect surveys (LEGs) has remained stable between at 1-2 abalone m^2 with a similar pattern observed between strings across the sampling period (fig. 4.1). Juvenile recruitment steadily increased at a similar rate on both strings to around 20 abalone m^2 by winter 2017 and has since stabilised around 20-30 abalone m^2 at string one (fig. 4.1). However, juvenile recruitment at string two has been declining steadily since winter 2017 to below 10 abalone m^2.

LEGs have been dominated by a single cohort of mostly sub-legal abalone between 120-130 mm SL with legal size abalone comprising only 15% of surveys across all years (fig. 4.2). The high level of fishing pressure at this site is clearly evident from the absence of larger legal sized abalone in the surveys. ARMs have typically been dominated by abalone 50-60 mm across seasons with very few abalone greater than 100 mm SL (fig. 4.2). Recent settlement of abalone recruits evidenced by the presence of very small abalone <20 mm SL have also been observed across most seasons.

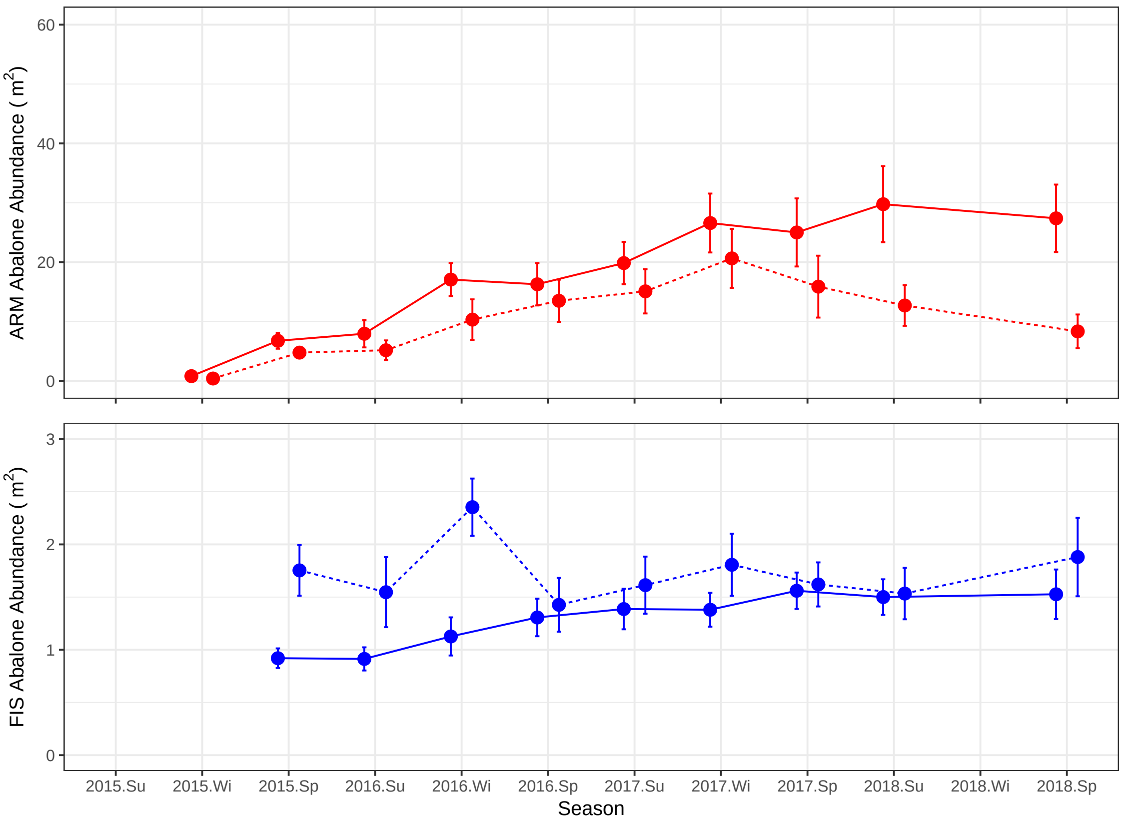


Figure 4.1: *Mean density (m^2) of abalone (+- SE) underneath ARMs (red) and recorded from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at Black Reef boulder site (Block 14A). Each ARM has a planar surface area of 0.126m^2. Replicate strings (sub-sites) are denoted by line type. Note the difference in density scale between the ARM and LEG results.*

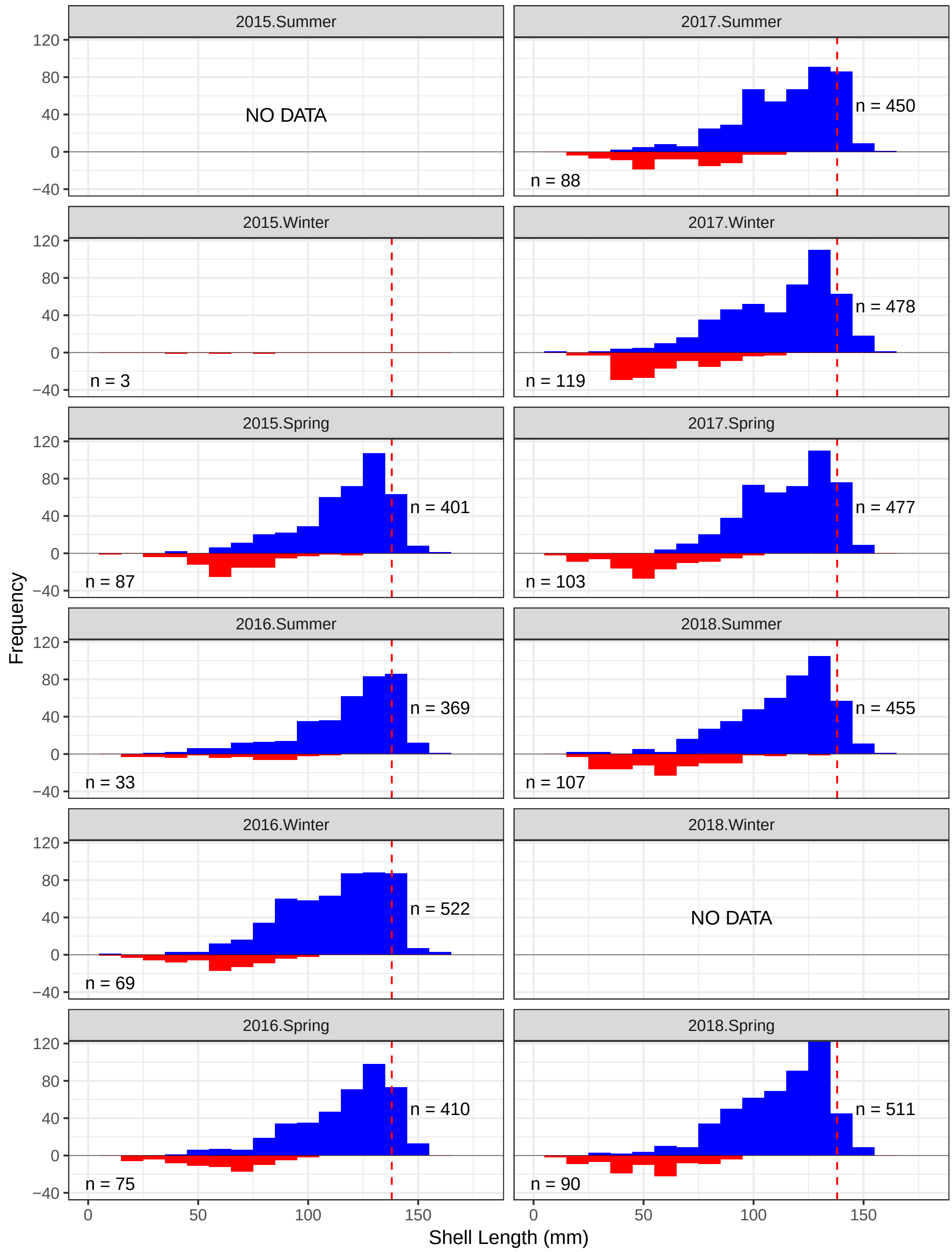


Figure 4.2: *Size frequency of abalone recorded underneath ARMs (red) and from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at Black Reef Boulder (Block 14A). Hashed red line represents the LML for that year. Total number of abalone measured for ARMs (lower) and LEG (upper) during each sampling period are also given.*

4.1.2 Black Reef - slab site (Block 14A)

Adult abundance recorded from LEGs has remained stable between at 1-2 abalone m^2 and similar between strings across the sampling period (fig. 4.3). Juvenile recruitment increased rapidly in the first year of deployment on both strings reaching up to 50 abalone m^2 at string one by winter 2016 (fig. 4.3). Recruitment on string one declined sharply in spring 2016 but has progressively increased to around 40 abalone m^2, reaching over 50 abalone m^2 in spring 2018, the highest recorded density across all sites. Recruitment on string two has remained stable around 30 abalone m^2 since winter 2016.

During 2016 LEGs were dominated by two cohorts centred around 100 and 130 mm, respectively, but has since been dominated by a single large cohort of sub-legal abalone between 120-138 mm (fig. 4.4). Legal sized abalone have typically comprised around 10% of LEGs across all season. ARMs have typically been dominated by abalone 40 - 60 mm across seasons with no abalone greater than 100 mm SL (fig. 4.4). Recent settlement of abalone recruits evidenced by the presence of very small abalone < 20 mm SL have also been observed and in some seasons have been quite abundant.

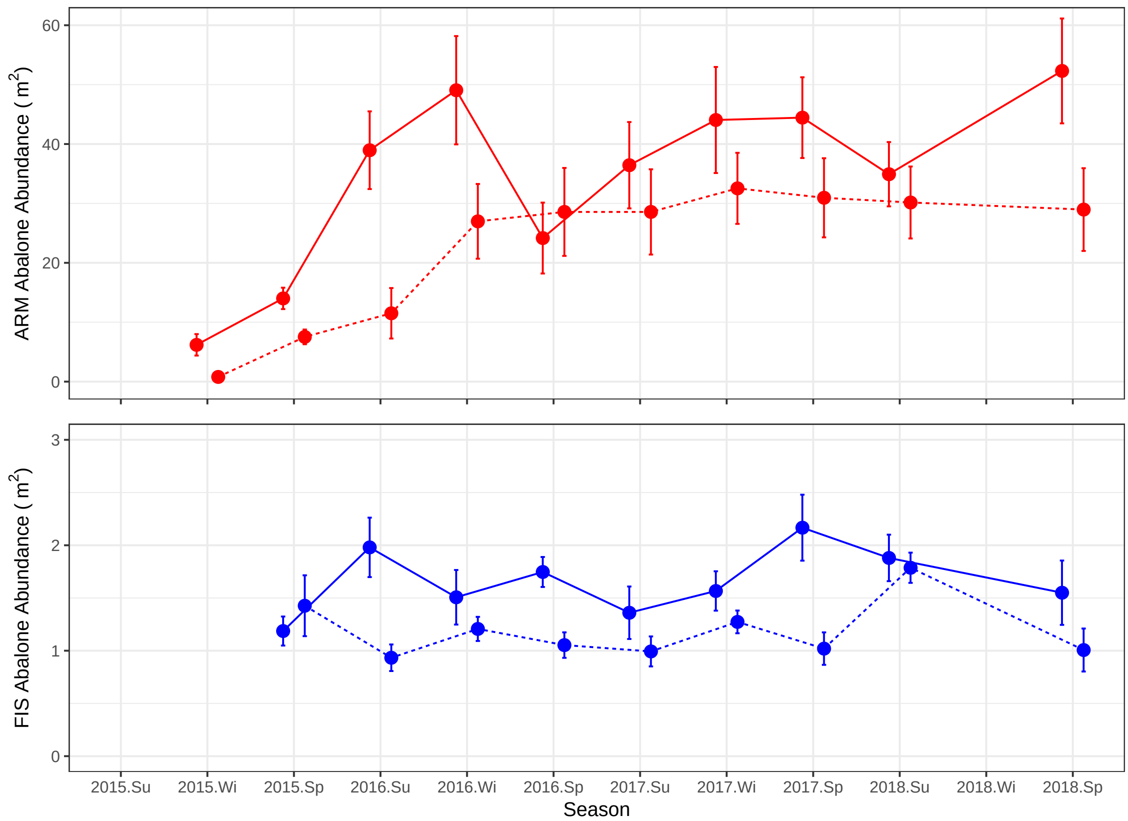


Figure 4.3: *Mean density (m^2) of abalone (+- SE) underneath ARMs (red) and recorded from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at Black Reef Slab site (Block 14A). Each ARM has a planar surface area of 0.126m^2. Replicate strings (sub-sites) are denoted by line type. Note the difference in density scale between the ARM and LEG results.*

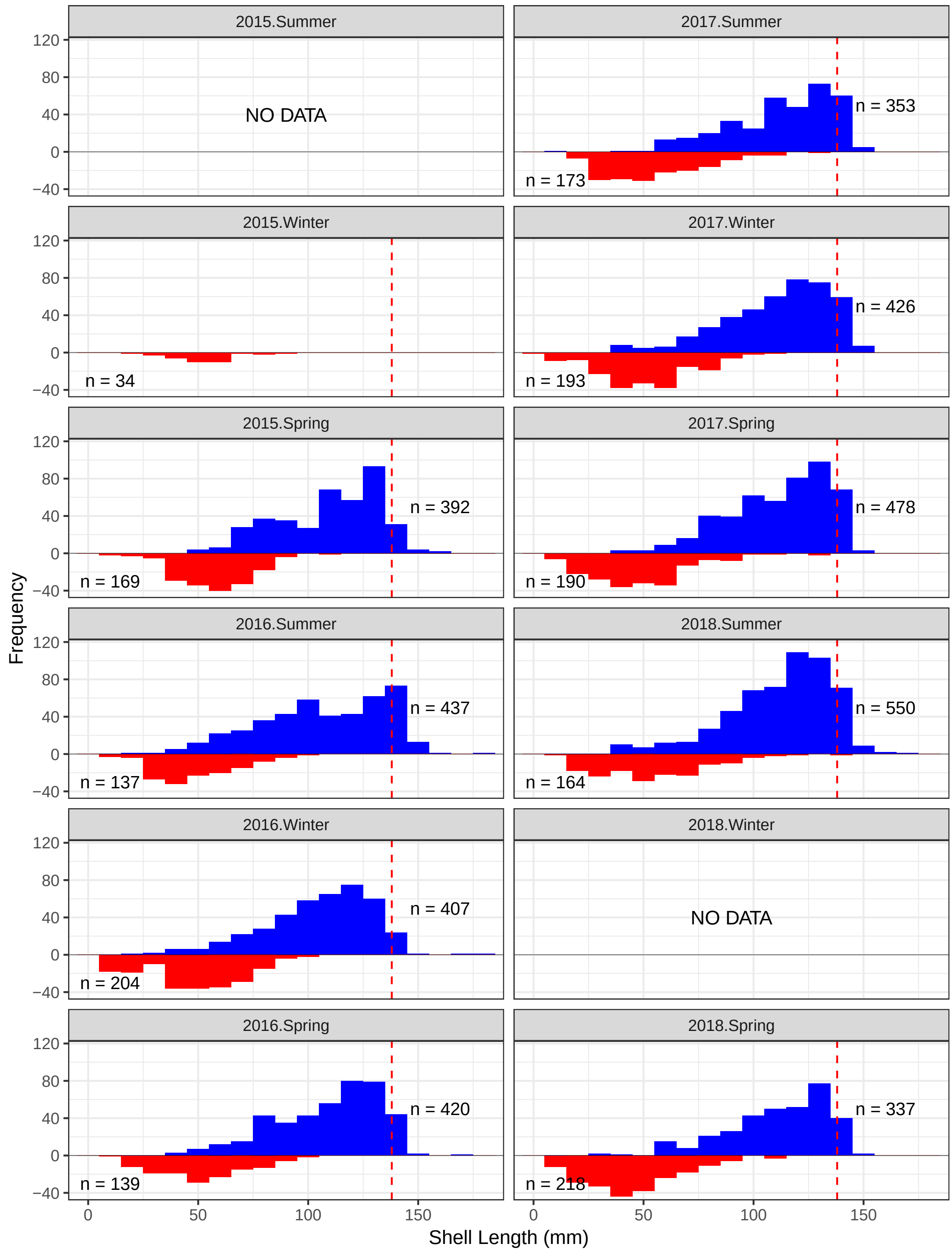


Figure 4.4: *Size frequency of abalone recorded underneath ARMs (red) and from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at Black Reef Slab (Block 14A). Hashed red line represents the LML for that year. Total number of abalone measured for ARMs (lower) and LEG (upper) during each sampling period are also given.*

4.1.3 George III Rock

Adult abundance recorded from LEGs have typically been quite low and remained below 1 abalone m^2 across seasons (fig. 4.5). Abundance between strings appears to have followed an inverse relationship across years with string one typically having higher abundances during summer and lower abundances in winter. Juvenile recruitment steadily increased to around 20-30 abalone m^2 by winter 2016 and remained stable up until spring 2017 however has since declined to around 20 abalone m^2 across both strings (fig. 4.5). Interestingly, juvenile abundance (ARMs) at George III rock are similar to the two nearby Black Reef sites, despite an sub-adult and adult density of around half that observed at Black Reef.

LEGs have typically been dominated by a single cohort of larger abalone centred around 130 mm SL (fig. 4.6). Legal sized abalone have typically comprised around 20-30% of LEGs across seasons, however is somewhat surprising given this area is closed to recreational and commercial abalone fishing and greater numbers of larger individuals would be expected. Juvenile abalone between 40-50 mm SL have generally dominated ARMs (fig. 4.6).

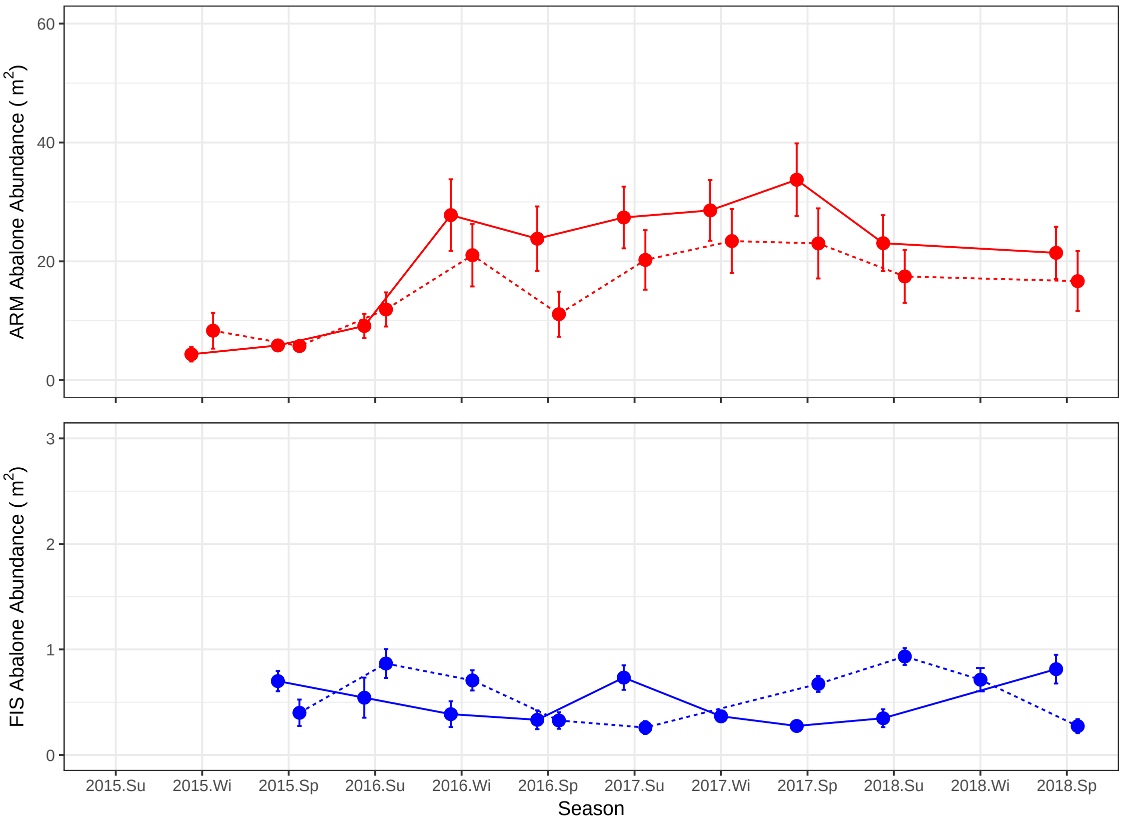


Figure 4.5: *Mean density (m^2) of abalone (+- SE) underneath ARMs (red) and recorded from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at George III Rock. Each ARM has a planar surface area of 0.126m^2. Replicate strings (sub-sites) are denoted by line type. Note the difference in density scale between the ARM and LEG results.*

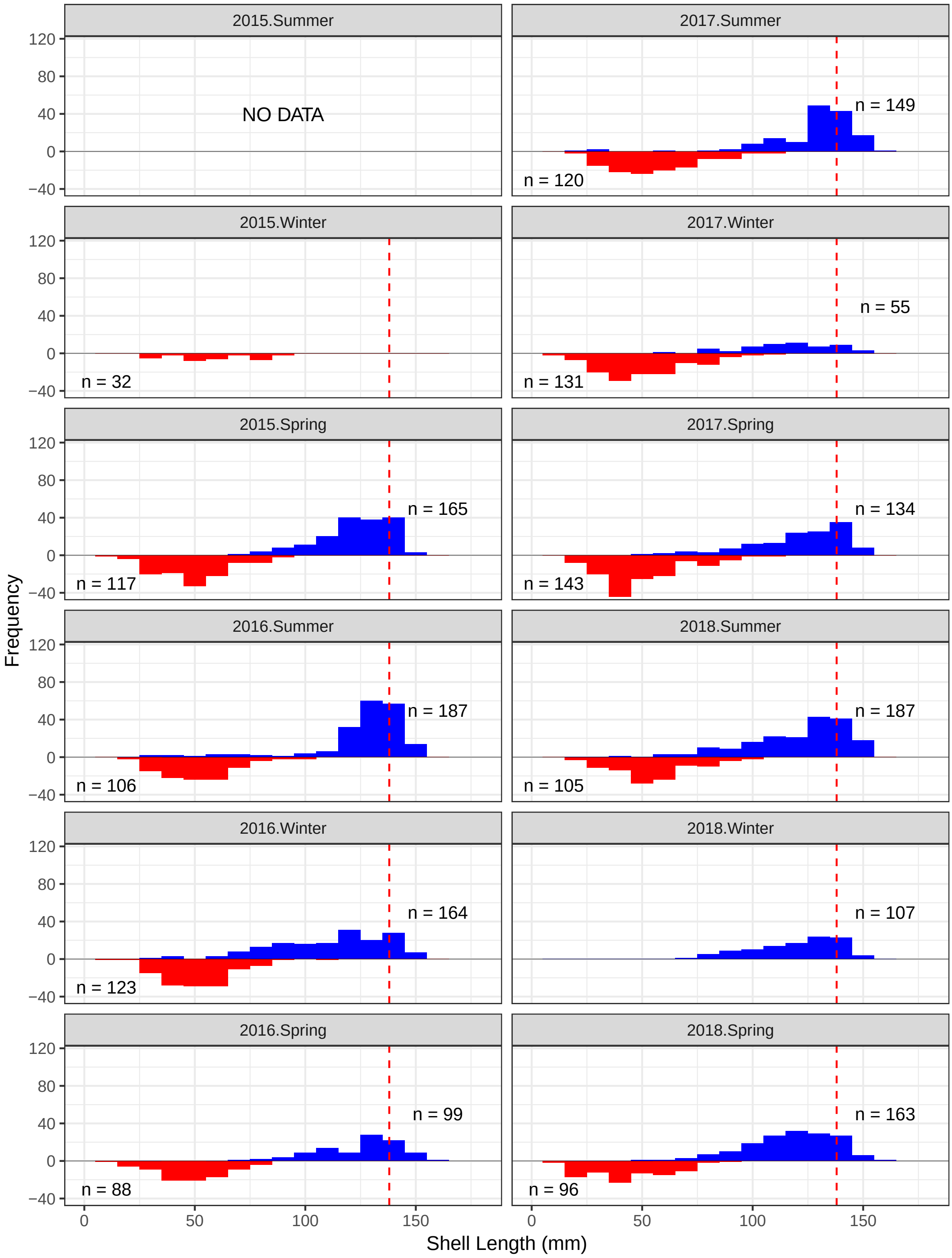


Figure 4.6: *Size frequency of abalone recorded underneath ARMs (red) and from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at George III Rock. Hashed red line represents the LML for that year. Total number of abalone measured for ARMs (lower) and LEG (upper) during each sampling period are also given.*

4.1.4 Betsey Island (Block 17A)

Betsy Island was the first site established and has the longest continuous time-series over the sampling period. Adult abundance from LEGs have remained consistently below 0.5 abalone m^2 across all seasons and the lowest of all sites monitored (fig. 4.7). Juvenile recruitment has generally remained stable for much of the sampling period around 5-10 abalone m^2, however since spring 2017 has been steadily increasing at string two reaching 20 abalone m^2 in spring 2018 (fig. 4.7).

LEGs have typically been dominated by larger abalone between 120-140 mm comprising around 30% of legal sized abalone, the highest of all sites, across seasons (fig. 4.8). The consistency of data collection at Betsy Island provides a clear bi-modal progression of juvenile abalone observed from ARMs through the seasons. Typically, juveniles centred around 25 mm SL have started to appear around spring together with a larger cohort of around 50-60 mm, both persisting in resurveys for at least two years before appearing to transition and be observed in LEG surveys at around 100 mm SL (fig. 4.8).

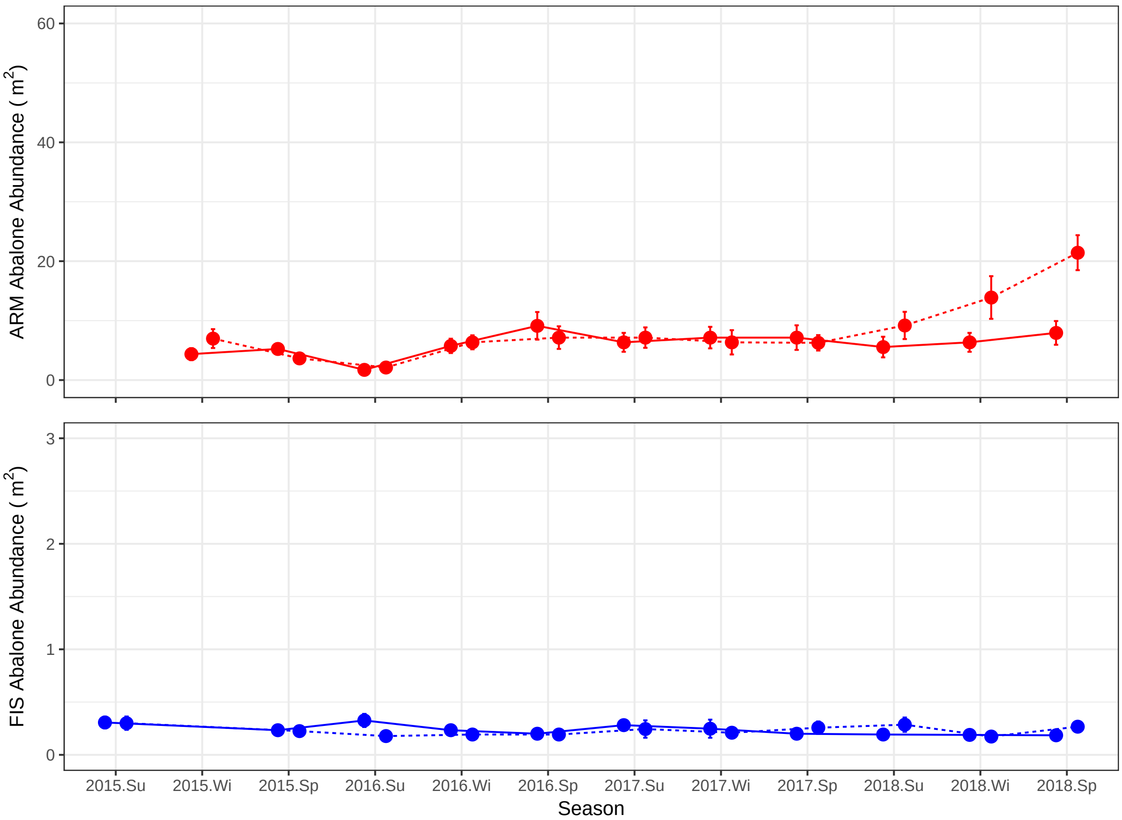


Figure 4.7: *Mean density (m^2) of abalone (+- SE) underneath ARMs (red) and recorded from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at Betsey Island (Block 17A). Each ARM has a planar surface area of 0.126m^2. Replicate strings (sub-sites) are denoted by line type. Note the difference in density scale between the ARM and LEG results.*

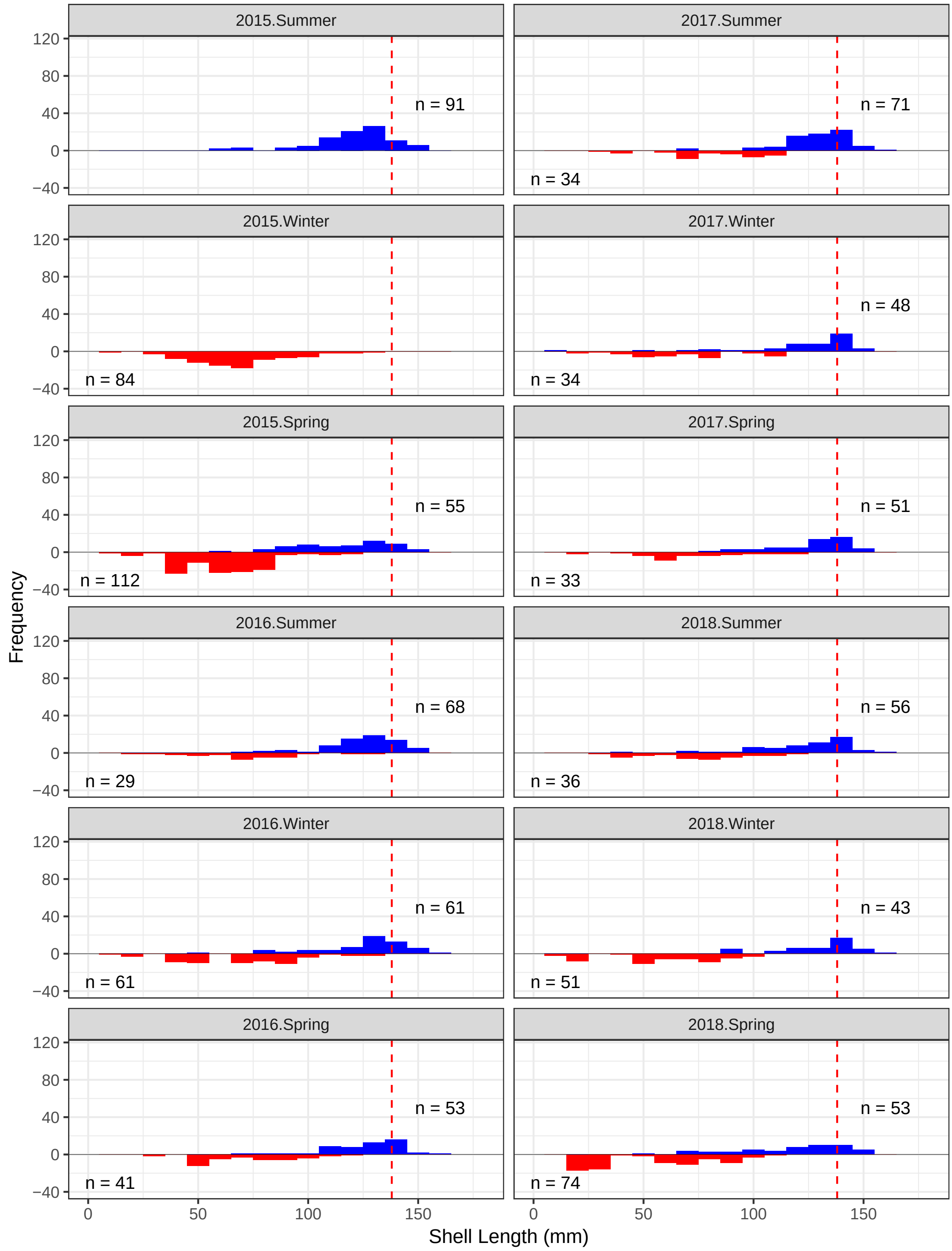


Figure 4.8: *Size frequency of abalone recorded underneath ARMs (red) and from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at Betsey Island (Block 17A). Hashed red line represents the LML for that year. Total number of abalone measured for ARMs (lower) and LEG (upper) during each sampling period are also given.*

4.1.5 Seymour Point (Block 29)

Adult abundance from LEGs has remained reasonably stable on string two at around 0.5 abalone m^2 (fig. 4.9). In contrast, string one abundance has gradually declined from around 1.3 abalone m^2 in spring 2015 to around 0.5 abalone m^2 in winter 2018. During the first twelve months of ARM deployment juveniles were rare and abundances were consistently the lowest recorded across all sites at < 5 abalone m^2 (fig. 4.9). Coincidently, this period overlaps with a significant storm event in June 2016 which caused damage to the surrounding reef and our ARM infrastructure. These low abundances possibly reflect the damage to the ARMs from the 2016 storm event given juvenile abundances have slowly increased and remained relatively stable at around 5-8 abalone m^2 since spring 2016. The habitat at Seymour Point is also characterised by large boulders surrounding the ARMs. The persistently low abundances at this site when compared to others is potentially a consequence of the high availability of more complex natural habitat preferred by juvenile abalone.

LEGs have largely been dominated by sub-legal abalone centred around 100 to 120 mm SL (fig. 4.10). Legal sized abalone comprised around 10% samples up until summer 2016 but have since declined below 7% of samples. ARMs have typically been dominated by a single cohort of smaller abalone around 30-50 mm SL with very few abalone between 50-100 mm SL when compared to other sites (fig. 4.10). If natural habitats are preferred by larger juveniles in these more complex sites, then it is plausible that the presence of mostly smaller individuals at SP is the result of settlers persisting under the ARMs as opposed to juveniles seeking refuge from nearby natural habitat.

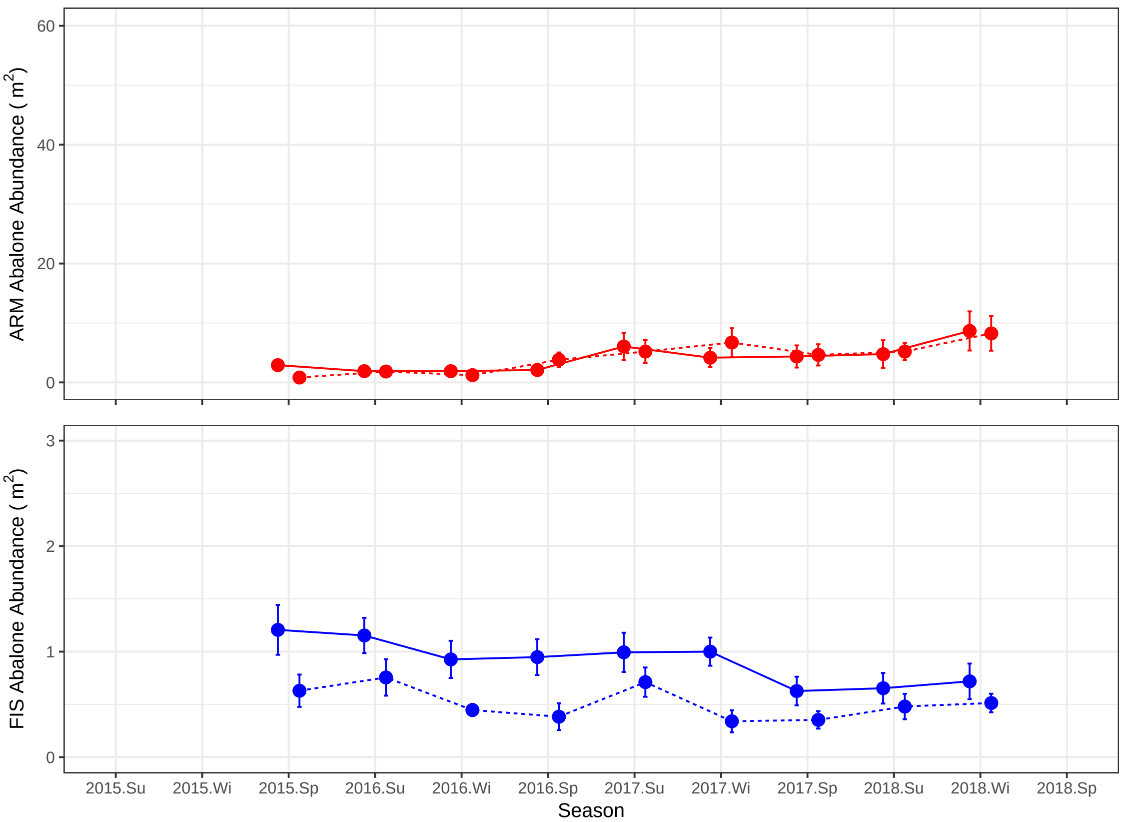


Figure 4.9: *Mean density (m^2) of abalone (+- SE) underneath ARMs (red) and recorded from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at Seymour Point (Block 29). Each ARM has a planar surface area of 0.126m^2. Replicate strings (sub-sites) are denoted by line type. Note the difference in density scale between the ARM and LEG results.*

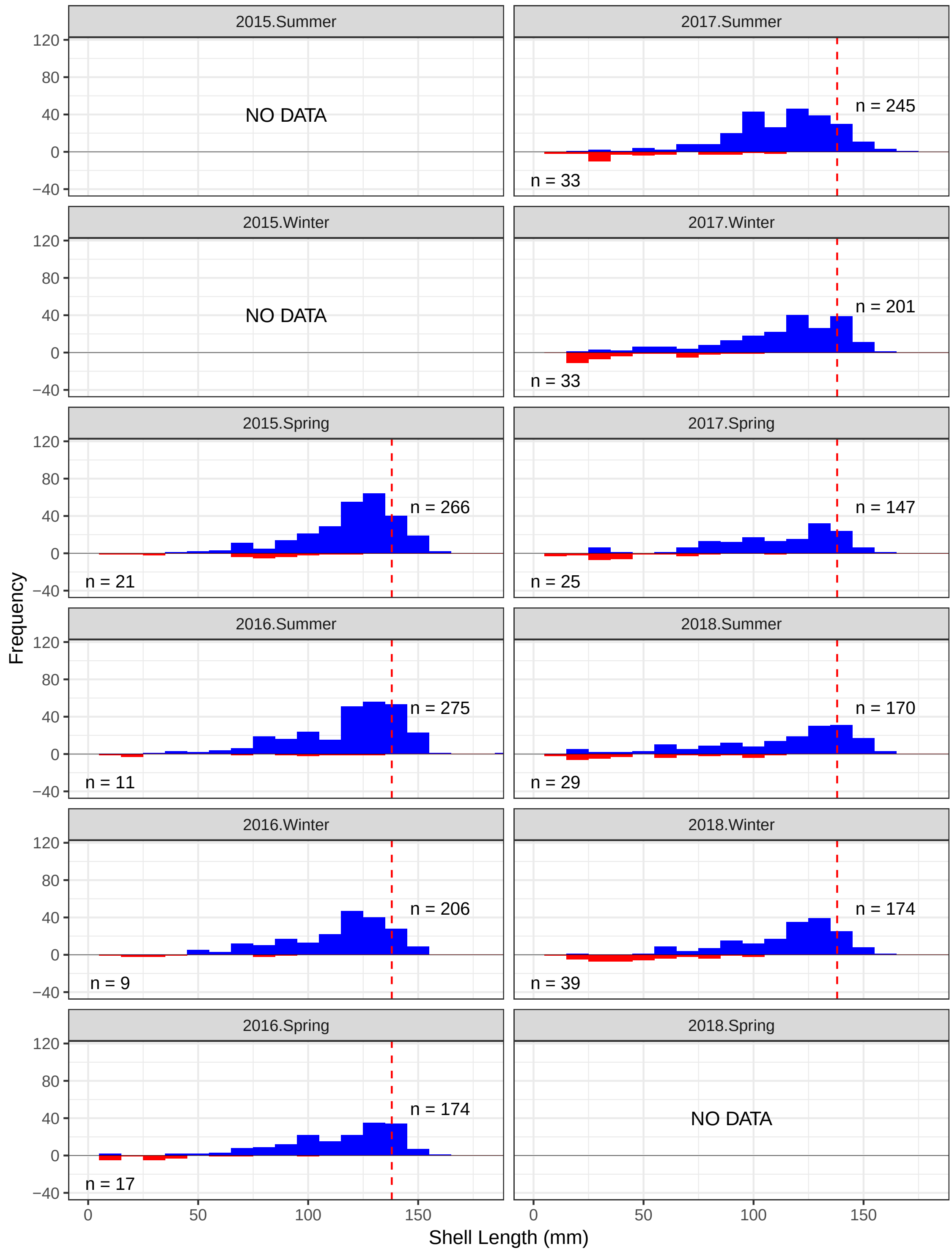


Figure 4.10: *Size frequency of abalone recorded underneath ARMs (red) and from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at Seymour Point (Block 29). Hashed red line represents the LML for that year. Total number of abalone measured for ARMs (lower) and LEG (upper) during each sampling period are also given.*

4.1.6 The Gardens (Block 30)

Adult abundance from LEGs have remained relatively stable across both strings across the sampling period. However, abundance has been higher on string one ranging between 0.5-1.2 abalone m^2 compared to string two where abundance has typically been < 0.5 abalone m^2 (fig. 4.11). Juvenile abundance gradually increased across both strings reaching a peak of 15 abalone m^2 on string two in winter 2016 and 10 abalone m^2 on string one in winter 2017 (fig. 4.11). Juvenile abundance has since remained relatively stable on string two at around 10 abalone m^2 however has declined on string one to around 5 abalone m^2 in spring 2018.

LEGs have largely been dominated by sub-legal abalone representing a bimodal distribution centred around 80 and 125 mm SL (fig. 4.12). Smaller abalone <100 mm SL have typically comprised a large proportion of LEGs across all seasons. Legal size abalone abundance comprised between 17-30% of LEGs during the first three sampling seasons but has declined significantly since summer 2016 and remains below 8%. ARMs have also typically been dominated by a single larger cohort of juvenile abalone centred around 50 -75 mm SL (fig. 4.12). With the exception of winter 2016, very small abalone <20 mm SL have been rarely been observed.

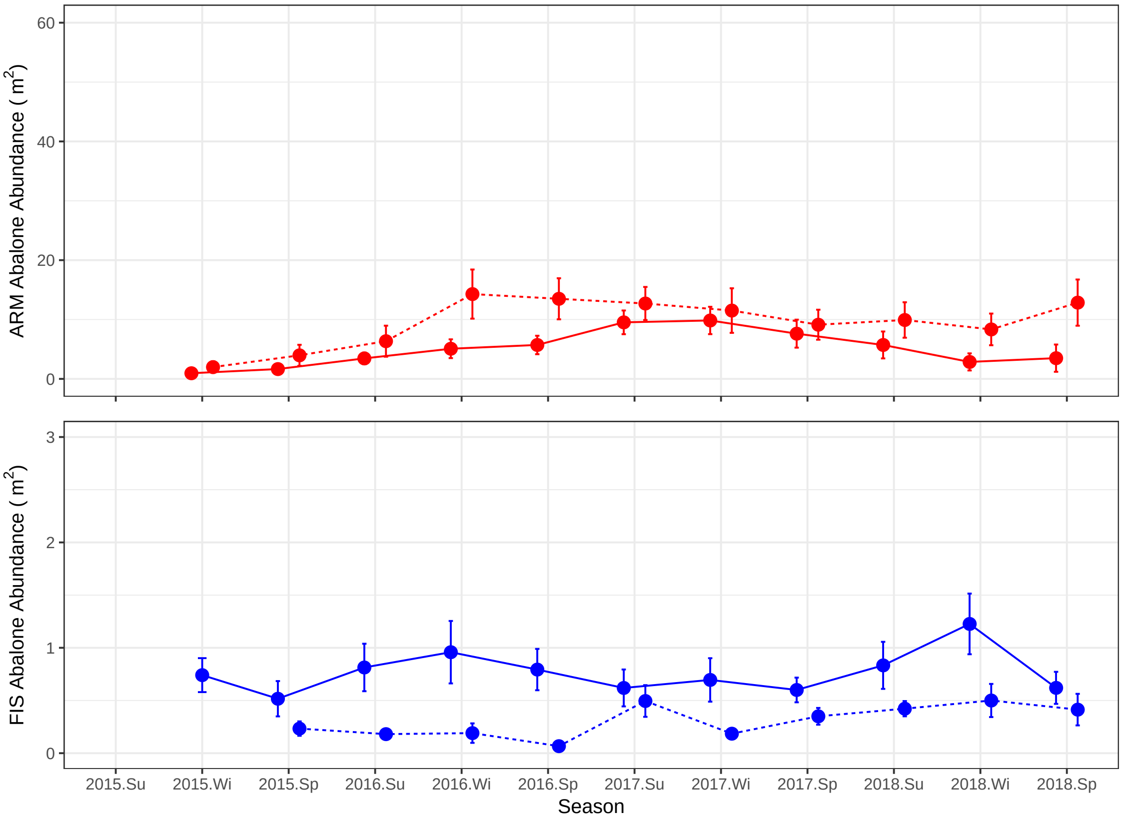


Figure 4.11: *Mean density (m^2) of abalone (+- SE) underneath ARMs (red) and recorded from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at The Gardens (Block 30). Each ARM has a planar surface area of 0.126m^2. Replicate strings (sub-sites) are denoted by line type. Note the difference in density scale between the ARM and LEG results.*

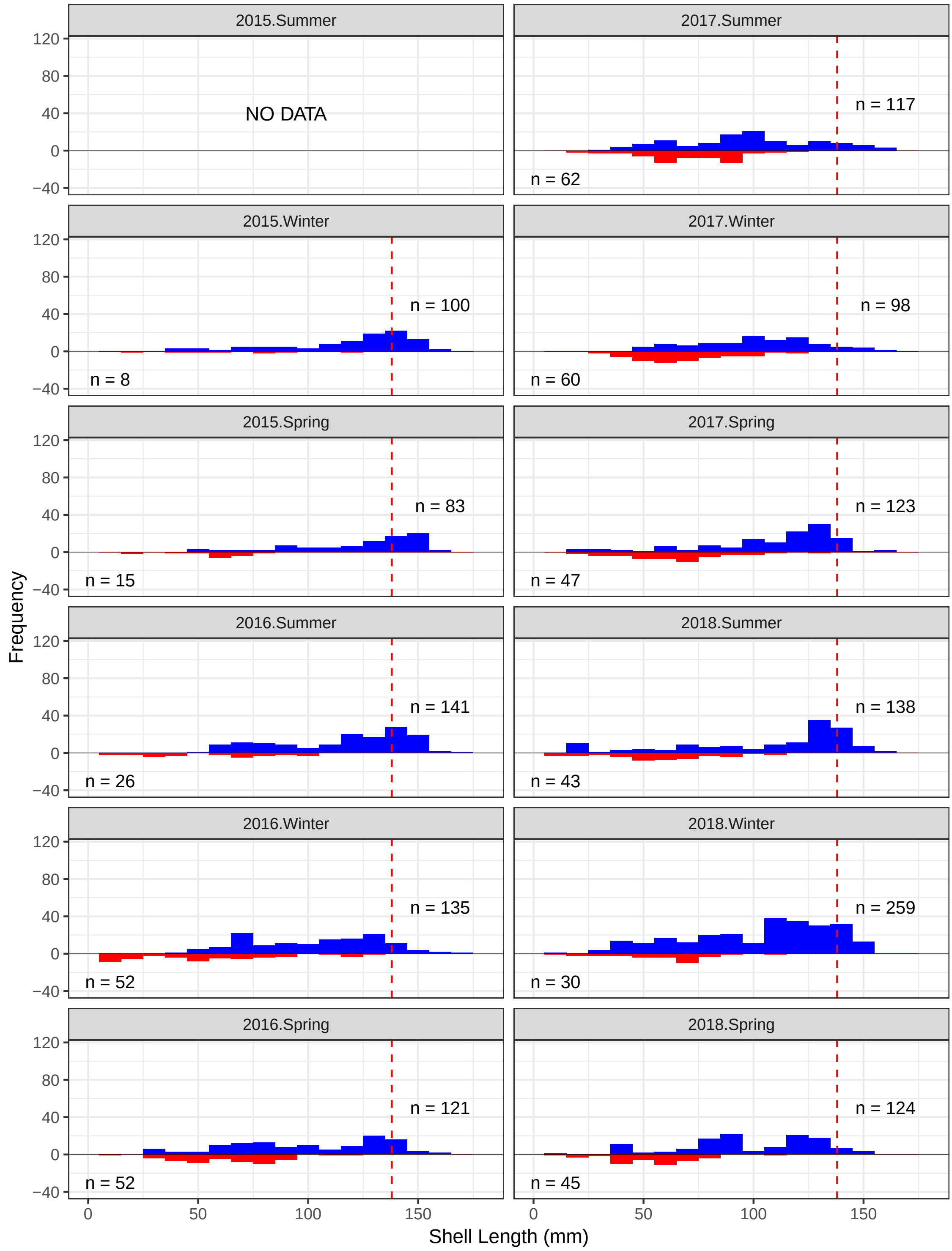


Figure 4.12: *Size frequency of abalone recorded underneath ARMs (red) and from LEG (blue) across the sampling period Summer 2015 to Spring 2018 at The Gardens (Block 30). Hashed red line represents the LML for that year. Total number of abalone measured for ARMs (lower) and LEG (upper) during each sampling period are also given.*

4.2 Summary - Fishery-independent data

- ARM abundances have progressively increased since their deployment in 2015 and appear to have peaked and stabilised across all sites.
- LEG abundance has remained relatively stable across all sites since the first surveys were undertaken in 2015.
- ARM and LEG sites at Black Reef (Block 14A) have recorded the highest abundance of legal and sub-legal abalone across all sites and seasons.
- There appears to be a general transition of juvenile abalone from ARM to LEG surveys at around 60 mm SL across all sites.
- Legal-sized abalone have been uncommon across all sites during LEG surveys.
- In 2019 ARM and LEG surveys will be focussed on maintaining regular seasonal sampling of sites in southern Tasmania (Black Reef, George III Rock and Betsey Island), with annual sampling at remaining sites.

Chapter 5

Discussion

The status of Tasmanian abalone stocks in 2018 varied substantially across zones. The Western Zone continues to improve with the exception of Block 9, while all other zones including Greenlip have declined. The origins of the improvement in the Western Zone CPUE are unknown, and may have different origins across the zone, with improvements in the south underpinned by a strong year class, and improvements in the northern blocks of the Western Zone by a reduction in exploitation rate. The Central Western zone blocks (Subblocks 6 a–c) were re-assigned to the Northern Zone in 2018 and the Central Western Zone abolished. Multiple factors are thought to be responsible for the decline in the Eastern Zone, and include long-term impacts of excessive fishing in the late 1990's, shrinking fishing grounds due to destructive grazing of *Centrostephanus rodgersi*, and collective impacts of multiple MHW events over the past decade (Oliver et al., 2017a, 2018). The Bass Strait blacklip fishery remains stable, but with evidence catch levels in the two key fishing blocks of 33 and 38 may be too high. The key fishing blocks in the Northern Zone (Blocks 3, 5, and 6) are all in decline, although minor improvements in CPUE were observed in blocks 5 and 6 through 2018 after several years of substantial TAC reductions. The greenlip fishery remains healthy although some reductions are likely in the ensuing years for the two western regions (King Island and North West). Catch reductions were recommended and adopted for the Eastern, Central Western and Northern Zones, while Western and Greenlip Zones remain unchanged. The TACC for the Bass Strait Zone was increased by 10% to 77 t, on condition the additional 7 t was taken from the Bass Strait Islands.

Greater than anticipated declines in catch rates in the Eastern Zone demanded flexibility in the implementation of Catch Targets, with catch overruns permitted in blocks 13 and 14 again during 2018 in order to reduce fishing in areas north of Cape Pillar and also areas in Storm Bay affected by the 2016 MHW. Two consecutive years of catch overruns in Block 13 may diminish the benefits of what appears to be stronger than normal year classes arriving in the fishery over the past two years. Northern and Central Western zone blocks that were the target of industry initiated experimental fishing programs continue to decline despite five consecutive TACC reductions.

The challenge with the introduction of a Harvest Strategy is reconciling the lag in response of the fishery to management change with the operation of the HS, and whether action should be taken every year or every second year. An initial set of meta- rules or 'break out' rules for the Harvest Strategy have been developed, but these require more discussion and more evaluation to ensure the HS is effective. In particular, there is a need to formalise alteration of the Recommended Biological Catch (RBC), where the RBC involves a small TACC reduction (i.e. no action if the Zone TACC reduction is less than 5%), and holding the TACC when the fishery is improving, but still below the target reference point.

5.1 Benefits of spatial indicators

Review of the 2018 spatial indicator trends highlight the potential value of the GPS and Depth data-logger program to flag hyper-stability in classic catch rate indicators (Kg/hr). The spatial indicators also provided evidence of selective fishing in the Perkins Bay Greenlip fishery, although it remains unclear as to whether the effects of selective fishing can be separated from stock decline. Regardless, the ability to identify unusual patterns in spatial indicators relative to CPUE trends as a flag for changes in divers fishing strategy will increase certainty over appropriate management action. Collectively these trends highlight the potential application of spatial indicators to improve our understanding of stock levels, and mitigate the effect of hyper-stability confounding or confusing CPUE trends.

5.2 Future developments

5.2.1 CPUE standardisation

Use of statistical standardisation of CPUE has been in place since 2017. Currently that includes month, diver and doubling up as key factors. Where mixed species fishing has occurred on the same day, the assessed species as a proportion of the total daily catch is also included in the standardisation. Climate effects (temperature, swell) are also being explored in order to better estimate inter-annual variation in seasonal conditions, for example early commencement of autumnal winds or extended periods of warm sea temperatures.

Improvement of the Harvest Strategy remains a priority, and in particular resolving the complications of using catch rates on mixed species fishing days for greenlip and blacklip. There also remains scope to identify true mixed species reefs from reefs where one species is always a minor component of the daily catch (bycatch).

5.2.2 Development of fleet based spatial indicators

The initial focus of the spatial indictor program has been on evaluating simple spatial indicators (KgLa/Ha, Lm/Hr, MaxDist). Quantifying the proportion of the known fishable reef utilised in any one year, the reliance on key areas of the fishery, and the level of overlap in reef use among divers provide further opportunity to understand the inter-annual spatial and temporal dynamics of the fishery. As with all indicators used to determine the TACC, the time line of the decision process necessitates decisions based on partial year trends (i.e. decisions must be made in October prior to the end of the fishing year in December). An important characteristic of fleet based indicators is the capacity to be informative prior to the completion of the fishing year.

5.2.3 Empirical Harvest Strategy

With increasing application of our MCDA based empirical Harvest Strategy (currently two years - 2017 and 2018), our understanding of the strengths and limitations will improve. It is already apparent that the Control Rule component of the EHS is suitable for maintaining a fishery in a stable phase, but lacks capacity to rebuild stocks when substantial rebuilding is required. The meta-rules also need review with consideration of the consequences of not taking action, even when action is recommend however minor. In the presence of effective within quota-year spatial management as implemented in Tasmania, a more precautionary approach would be to adopt HS outcomes, however minor.

Formal inclusion of spatial indicators in the empirical Harvest Strategy is the next significant challenge for the Tasmanian fishery assessment process. As of 2018, the time-series of simple spatial indicators (KgLa/Ha, Lm/Hr, MaxDist) extends to seven years. A key constraint with such a short reference period is identifying appropriate target and limit reference points. Three options are available for inclusion of spatial information in the assessment process are;

- Used as a secondary informal indicator

- Included as a factor in CPUE standardisation
- Apply gradient based scoring functions for use in the Harvest Strategy

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Appendix A

Interpreting trends in catch and catch rate, and the size composition of the commercial catch

A.1 The use of catch and catch rates to infer changes in abundance

This assessment is primarily based upon the interpretation of information produced from fishery catch data; both catch distribution and catch rates. It relies upon the assumption that trends in catch-rates reflect changes in abundance of the fishable stock, although no assumptions are made about the structure of that relationship (linear, precision). Despite CPUE being much discredited as an index of abalone abundance (e.g. (Breen, 1992; Prince and Shepherd, 1992; Shephard and Rodda, 2001) it has been used with some success for many years in the Tasmanian fishery. There are several factors that adversely affect the relationship between CPUE and abalone abundance: biological (abalone behaviour and movement), environmental (sea conditions, habitat complexity) and fleet (skill of fishing team, experience, local knowledge). In particular the ability of fishers to maintain catch rates by changing their fishing patterns (more drops, swim further, swim faster) can lead to hyper-stability in catch rates, masking an underlying decline in stock abundance. If the effects of the above factors are understood and can be minimized then the reliability of CPUE as an index of abundance can be improved.

Abalone tend to aggregate in favourable habitat (e.g. gutters, sand-edges, shallow margins, ledges, boulder junctions), and a large proportion of abalone may be found in only a small area of each reef (Prince and Shepherd, 1992). When these aggregations are fished, the remaining abalone may over several weeks encounter vacated sites, renewing the aggregated structure. Thus reefs may become depleted while catch rates are maintained (McShane, 1995; Officer et al., 2001), and by the time catch rates start to decline rapidly abalone abundance will already have been greatly reduced (Prince and Shepherd, 1992).

Where abalone abundance is high and abalone are locally aggregated, catch rates are primarily a function of handling time (the time taken to detach abalone from the reef and transfer them to the boat). As abalone abundance decreases, and aggregations become smaller and further apart, search time increases, and fishers have to cover more reef area to harvest the same number of abalone. This is one of the key behavioural changes targeted with the geo-referenced effort data captured with the data logger program.

Serial depletion of reefs occurs when divers progressively reduce stock abundance on individual reefs, and maintain stable catch rates by moving between reefs (Prince and Shepherd, 1992). Identifying and detecting serial depletion is problematic as most divers adopt a strategy of returning to known sites in a given frequency, which may be once or twice per year, or once every few years. Serial depletion in effect is a departure from the normal cycle of visitation, with either increasing frequency of visits, or abandoned sites when they become unviable for commercial fishing. These behavioural changes can only be detected with long term data on fishing activity at fine-spatial scales.

A.2 Change in fishing efficiency

The detection and avoidance of difficulties associated with improvement in fishing efficiency, or effort creep is a continuing problem when catch rates are used as an index of stock biomass or abundance when assessing fisheries. Catch rates (CPUE) and the stock biomass are assumed to be related: CPUE $= q$B, where q is the catchability coefficient and B is the exploitable biomass. If q increases through time in an unknown manner, through diving operations becoming more efficient, then the relationship between CPUE and biomass becomes altered to an unknown degree and the interpretation of CPUE as a measure of biomass becomes biased high.

One of the features of commercial fisheries is that fishermen almost always find ways to make their operations more efficient, and the abalone fishery has been no exception. Thus if stock levels are unchanged, efficiency gains allow more abalone to be collected per unit time now than in the past i.e. catchability increases. This leads to a rise in reported catch rates without an associated increase in abalone abundance, or alternatively it can lead to catch rates appearing to be stable while the stock abundance is declining. Two broad categories of causes of change in fishing efficiency have been identified in the Tasmanian abalone fishery – technological and behavioural.

Technological causes of change in fishing efficiency are usually easy to detect. For example, early in the history of the Tasmanian abalone fishery, divers anchored their boats, and often worked without a deckhand. Later, during the 1970's, the boats carried a deckhand who drove the boat and followed the diver, thus eliminating time spent swimming the catch from the reef to the anchored boat. It was estimated that the catching efficiency of divers doubled between the start of the fishery in the 1960's and 1982 (Harrison, 1983).

Possibly the greatest single improvement occurred during the late 1980's when divers widely adopted the practise of attaching their collecting nets to ropes lowered to them by their deckhands (droplines) and they no longer had to surface every time they filled their nets. This increased efficiency because:

- time spent ascending to the boat, unloading the catch and descending back to the reef was eliminated,
- the diver maintained his position on the productive part of the reef,
- catch bags could be reduced in size, which meant that divers could swim more easily and with less effort.

More recent technological changes to fishing operations include the increased use of GPS navigation systems, Nitrox breathing gases and diver propulsion vehicles (DPV). The extent of the usage of GPS navigators and associated plotting equipment by abalone divers is unknown, but it apparently has become much more widespread over the last five years. Nitrox gas mixing plants are currently used by only a few divers, but these divers are responsible for landing a large proportion of the catch in the regions where they work. DPVs are also not yet in common usage, but can help divers move more quickly between concentrations of abalone, particularly in deeper water.

Many divers reduce operating costs by teaming up with other divers and work from the same vessel, particularly when quota availability becomes reduced and they have comparatively small orders to fill e.g. following a TACC reduction. Team diving has the effect of reducing diver efficiency and team dive catch rates are generally lower than single diver catch rates, but increasing profitability because of cost-sharing between the divers. A comparison of annual mean catch rates from team divers compared with single divers during the period 2000-2014 found mean differences of 9 kg/hr (range 3-16 kg/hr) (fig. A.1). During this period, the percentage of team dives increased, from 15% in 2000, to 42% in 2011. The net effect of team diving over this period will lead to a reduction in the mean catch rate, independent of changes in stock levels. For this reason, team diving is included as a categorical variable in the statistical standardisation of catch rates.

Since 2007 divers have reported that the availability of improved forecasting of sea conditions was responsible for effort creep through improved catch rates, because they could choose to fish the West Coast when conditions were optimal. Previously they had travelled to the west when they hoped conditions were favourable, but often were not, and faced with the prospect of returning home with no catch, were obliged to fish in less favourable conditions with a greater likelihood of reduced catch rates.

The most recent Tasmanian study into the effects of effort creep on abalone catch rates was made using catch-effort data collected between 1975 and 2000, from Blocks 13 and 14. Using documented estimates of effort creep as guidelines (Buckworth, 1987; Haddon and Hodgson, 2000; Harrison, 1983), a series of plausible effort creep scenarios was constructed. Extrapolation of Harrison's (1983) estimate of effort creep (approximately 5% p.a.) caused an overall reduction in relative CPUE over the study period i.e. by removing the confounding effect caused by improvements in diver efficiency, catch rates were higher in 1975 than they were in 2000 (Tarbath et al., 2001). However, the overall relative trends in catch rate were only slightly altered when using the standardization (fig. A.2).

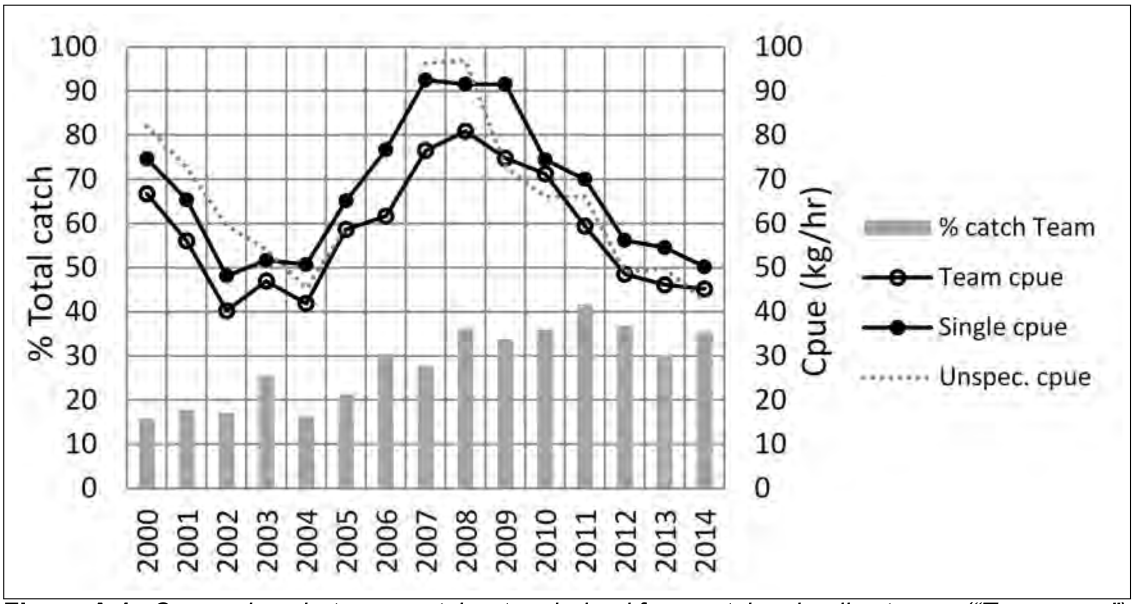


Figure A.1: *Comparison between catch rates derived from catches by dive teams ("Team cpue") and by single divers ("Single cpue"), showing the percentage of the total catch taken by dive teams, from Block 13 (Eastern Zone), between 2000 and 2014. "Unspec.cpue" refers to catch rates where the number of divers could not be determined, which ranged 0-6% pa during the period.*

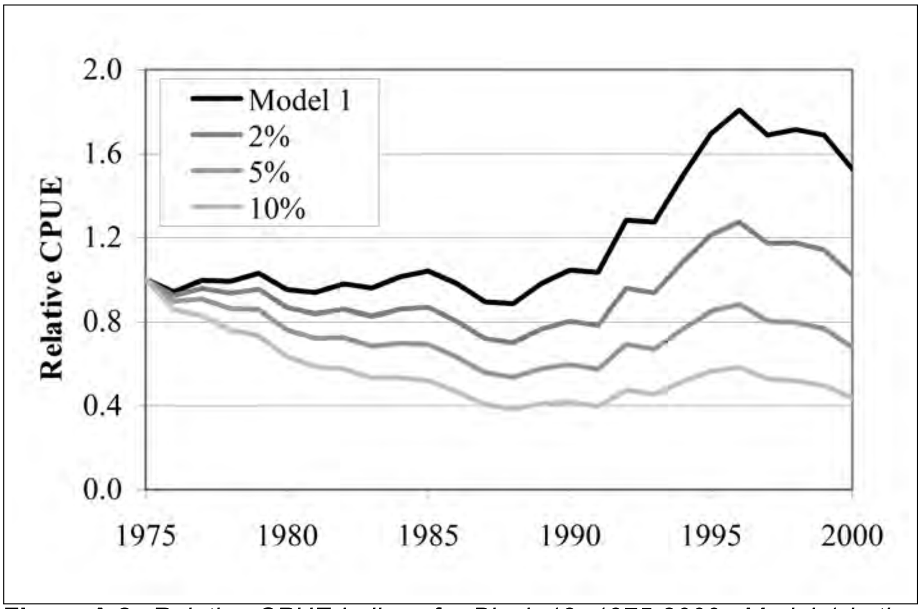


Figure A.2: *Relative CPUE indices for Block 13, 1975-2000. Model 1 is the raw geometric mean of CPUE. The three effort creep scenarios considered are: (i) 2% per annum; (ii) 5% per annum; and (iii) 10% per annum. All values of CPUE are relative to 1975 (Tarbath et al., 2001)*

Appendix B

Early abalone production 1960-1981

Annual tonnages of abalone production from Tasmania have been reproduced from "Summary of Statistics – Tasmania", Abalone Situation Report 10, Demersal Mollusc Research Group, published by CSIRO, 1982. Tasmanian Year Book totals were published each year from 1967 by the Commonwealth Bureau of Census and Statistics (annual totals from 1964 were reported in the 1967 edition). are shown below. All three totals (Diver Returns, Processor Returns, Tasmanian Year Book) were reported by financial year. Abalone catch prior to 1968 was reported by divers in general fish returns as miscellaneous catch, and annual totals are incomplete. Catches are believed to have been substantially under-reported between 1960 and 1981 (i.e. catch totals were higher than shown here). Processor receipts were from Tasmanian processors only: much of the early catch was freighted to interstate processors and is not included amongst these processor receipts. Little or no processing was done in Tasmania prior to 1964. The source of the Tasmanian Year Book totals was not reported.

Year	Diver P[a]P returns	Processor P[b]P returns	Tasmanian Year Book P[c]
1960	*	*	**
1961	*	*	**
1962	*	*	**
1963	*	*	**
1964	*	49	33
1965	*	225	225
1966	412	753	727
1967	1,050	1,722	2,003
1968	1,966	2,354	2,792
1969	1,894	2,139	2,113
1970	2,297	2,613	2,613
1971	2,504	3,488	3,495
1972	2,287	2,971	2,977
1973	1,703	2,174	2,172
1974	1,883	2,106	2,060
1975	1,919	2,108	2,108
1976	2,289	2,429	2,429
1977	2,263	2,368	2,368
1978	2,823	2,524	2,525
1979	2,762	3,100	3,100
1980	3,391	3,204	3,214
1981	3,800	3,621	3,743

* Records unavailable. ** Records not published.

Appendix C

Annual Catches by Zone – 1975 to 2018

Table C.1: *Annual tonnages of blacklip abalone caught within the statistical blocks and sub-blocks comprising the Eastern Zone in 2018. Catches in blocks split by zoning (Blocks 13 and 31) are reported as Eastern Zone because the majority of later catches occurred there. Any discrepancies between totals and sums of component blocks are due to rounding.*

Year	13	14	15	16	17	18	19	20	21	22
1974	163	179	3	40	15		6	5	20	30
1975	247	111	10	47	11	0	0	16	27	49
1976	208	156	0	64	36		1	18	25	45
1977	245	232	2	190	11	0	1	23	35	37
1978	322	218	6	119	24	0	1	32	65	60
1979	374	251	8	148	25	0	2	51	52	43
1980	272	255	7	145	30		1	33	30	42
1981	254	299	18	127	48	1	4	45	69	35
1982	337	218	15	147	24	1	3	36	62	63
1983	252	300	10	189	28		3	43	63	55
1984	318	297	18	166	35	0	5	47	70	73
1985	256	262	4	89	83	0	11	69	80	43
1986	221	262	22	82	93	2	4	65	66	70
1987	224	229	7	47	80	1	1	43	44	32
1988	219	258	6	76	57	1	4	62	44	43
1989	156	172	2	56	43	0	2	61	42	22
1990	133	193	4	76	29	0	3	33	51	40
1991	127	207	2	60	37	3	3	53	50	47
1992	140	106	3	28	20	0	2	51	43	48
1993	257	116	4	100	40	0	1	59	78	48
1994	295	139	10	114	46	1	1	109	80	55
1995	310	247	1	100	35	0	1	95	74	34
1996	391	195	0	78	18		3	71	55	44
1997	471	137	0	64	25	1	2	79	49	47
1998	485	111	1	118	22	2	2	85	66	63
1999	491	66	2	113	35	5	6	102	72	50
2000	381	97	2	71	29		4	62	60	69
2001	324	157	3	108	20	1	2	56	50	40
2002	297	101	1	72	16	0	1	62	58	46
2003	291	116	2	59	17	1	1	88	54	36
2004	221	104	7	50	20		2	92	52	35
2005	181	90	8	56	20		3	116	62	36
2006	183	84	3	67	13	0	2	73	66	71
2007	255	70	0	56	8		6	68	63	61
2008	340	56	1	64	8		0	50	61	56
2009	340	63	1	51	20		1	51	52	90
2010	341	70	1	39	10	0	2	71	59	73
2011	359	15	0	37	8		1	30	47	54
2012	268	22		14	8	0	1	21	23	60
2013	199	22		24	9		1	21	27	56
2014	180	38		27	10		2	38	30	43
2015	227	25		26	11		2	29	45	36
2016	253	64	0	24	23		4	31	18	14
2017	284	53	0	19	6		1	15	19	6
2018	181	31		11	3		1	17	19	2
avg 75-18	273	144	5	77	27	1	2	53	51	47
avg 92-18	294	89	2	59	18	1	2	61	51	47

Table C.1: *Eastern Zone continued*

Year	23	24	25	26	27	28	29	30	31	Total
1974	68	18	10	0	8	103	50	102	35	857
1975	74	15	16	5	44	69	16	44	32	835
1976	56	18	12	9	40	72	9	37	50	857
1977	53	11	10	8	55	90	22	119	54	1197
1978	88	22	13	11	93	87	25	137	105	1431
1979	30	9	23	7	80	52	12	105	60	1332
1980	46	158	34	7	108	91	27	148	105	1538
1981	77	137	19	15	68	154	22	146	52	1586
1982	49	97	20	9	89	100	32	170	48	1520
1983	92	99	31	14	99	103	65	296	90	1831
1984	61	109	10	11	106	112	52	148	76	1715
1985	44	120	20	17	86	71	5	85	171	1516
1986	56	88	12	20	50	58	14	124	164	1475
1987	34	66	12	8	76	45	11	67	54	1083
1988	34	79	10	6	65	52	16	95	97	1225
1989	16	34	7	8	41	31	11	39	27	770
1990	36	61	1	2	61	77	21	54	22	898
1991	31	67	2	9	64	66	12	30	21	893
1992	23	67	1	1	67	44	7	10	13	673
1993	24	73	1	1	86	39	8	15	15	963
1994	16	53		3	103	24	8	11	21	1089
1995	19	38		1	81	18	6	10	26	1097
1996	28	67	3	6	89	39	11	28	20	1147
1997	32	106	1	13	190	32	32	23	33	1336
1998	44	161	2	25	181	77	31	10	15	1502
1999	53	143	0	9	94	60	26	11	39	1377
2000	44	104	1	8	101	16	21	10	74	1154
2001	24	111	1	13	68	9	27	13	66	1093
2002	15	46	0	2	53	7	15	12	43	847
2003	21	51		3	50	8	19	3	28	849
2004	19	51	1	1	44	11	24	6	22	761
2005	18	66		0	43	13	36	7	15	770
2006	23	88	1	1	40	10	41		7	772
2007	14	59		1	55	11	32		4	765
2008	9	68		1	48	6	28		10	805
2009	22	62			50	5	26	2	13	849
2010	20	67		0	38	6	20	3	67	885
2011	17	37	0	1	35	5	16	4	42	709
2012	14	22			14	2	19	5	49	543
2013	38	39			7	8	51	7	15	524
2014	23	38	0		19	1	47	6	19	522
2015	19	22		0	20	4	34	5	19	522
2016	17	20			15	3	17	3	15	520
2017	3	7			5	1	12	2	9	440
2018	1	2			6	0	9	1	7	290
avg 75-18	34	64	9	7	63	42	23	51	44	1008
avg 92-18	22	62	1	5	59	17	23	9	26	845

Table C.2: *Annual tonnages of blacklip abalone caught within the statistical blocks and sub-blocks comprising the Western Zone in 2018 (Sub-Block 6D, Blocks 7 to 12, Sub-blocks 13A, 13B). Pre-zoning (1975-1999) catches from Block 13 are reported in the Eastern Zone. Pre-zoning (1975-1999) catches from Sub-block 6D are reported in the Northern Zone. Any discrepancies between totals and sums of components are due to rounding.*

Year	6	7	8	9	10	11	12	13	Total
1974		1		3	24	82	143		254
1975		36	42	126	130	191	143		668
1976		56	77	252	179	240	153		957
1977		24	22	123	98	153	189		608
1978		13	27	115	258	275	208		894
1979		19	23	172	166	269	325		974
1980		81	63	316	195	338	351		1343
1981		88	87	444	260	417	246		1541
1982		34	34	249	100	303	235		955
1983		102	58	199	175	430	242		1206
1984		78	38	248	284	682	258		1588
1985		99	23	246	140	479	155		1142
1986		97	11	133	127	289	194		851
1987		84	44	251	82	339	195		995
1988		53	27	160	126	276	162		805
1989		49	46	120	109	212	145		682
1990		56	21	95	80	232	125		610
1991		54	30	102	106	219	140		650
1992		69	36	90	95	265	159		714
1993		64	38	110	65	196	177		649
1994		33	38	77	60	201	160		569
1995		30	17	44	68	186	182		526
1996		67	13	59	75	145	145		504
1997		75	28	140	66	222	227		757
1998		50	27	78	47	165	204		571
1999		60	24	115	58	220	251		729
2000	21	61	23	205	148	326	281	54	1119
2001	49	32	15	186	150	311	291	43	1076
2002	31	52	17	174	142	359	236	93	1104
2003	34	104	27	142	237	346	230	67	1188
2004	24	89	22	130	183	375	248	96	1168
2005	26	110	26	92	149	389	311	65	1167
2006	50	75	6	143	198	384	229	89	1175
2007	34	39	18	178	228	354	267	68	1186
2008	35	51	9	156	178	342	304	79	1155
2009	46	104	51	155	109	240	321	77	1102
2010	23	110	37	158	156	239	276	68	1067
2011	17	95	48	171	157	245	257	56	1046
2012	59	97	19	172	146	271	267	44	1074
2013	11	44	8	158	180	286	251	41	981
2014	34	44	5	98	142	220	249	37	830
2015	32	65	11	89	115	240	245	34	831
2016	19	31	12	62	77	168	297	34	699
2017	12	37	7	54	78	193	274	42	698
2018	11	41	14	57	89	174	262	52	700
avg 75-18	30	61	29	148	134	278	227	60	914
avg 92-18	30	64	22	122	126	262	244	60	903

Table C.3: *Annual tonnages of blacklip abalone caught within the statistical blocks and sub-blocks comprising the Northern Zone in 2018 (Blocks 1 to 4, Sub-blocks 5A, 5B, 5C, 31B, Blocks 39 to 40 and Blocks 47 to 49). There are no records for the Northern Zone part of Block 31 prior to the creation of the zone in 2001. Any discrepancies between totals and sums of components are due to rounding*

Year	1	2	3	4	5	6	31	39	40	49	Total
1974	52	3	20	4	13	7		4	1		105
1975	32	1	27	15	38	110		2	1		227
1976	39	0	51	8	46	63		5	0		212
1977	17	1	87	8	51	50		6	2		222
1978	21	3	55	25	65	79		8	2		259
1979	24	2	10	9	85	112		6	1		250
1980	51	3	33	3	92	196		3	1		382
1981	19	8	32	9	120	257		6	2		454
1982	22	9	27	13	121	147		5	2		345
1983	22	2	31	52	228	231		7	4		576
1984	10	1	33	55	312	298		6	3		718
1985	43	0	26	11	319	322		5	1		728
1986	35	4	24	13	267	213		10	5		571
1987	44	62	24	54	198	185		6	1		571
1988	29	17	22	60	168	244		3	1		543
1989	14	7	10	5	88	192		1	1		319
1990	11	10	9	11	82	197		0	0		320
1991	6	7	14	26	97	169		1			321
1992	2	3	9	8	75	233		4			335
1993	8	3	7	9	65	152		0	0		244
1994	15	1	4	1	48	79		0			150
1995	11	3	1	8	62	112		0	0		198
1996	7	2	1	2	63	103		0	0		179
1997	10	1	10	6	56	98		1			181
1998	3	1	0	2	60	129		0	1		196
1999	5	1	6	6	56	149		5	0		227
2000	0		9	10	39	169	16	5	2		250
2001	2	1	12	12	118	162	25	11	3		345
2002	10	2	35	16	104	143	30	4	3		347
2003	25	1	63	10	73	62	6	8	1		248
2004	10	0	88	34	55	67	13	6	1		276
2005	15	2	91	17	73	75	11	2	0		287
2006	12	3	57	8	96	62	17	4	0		260
2007	6	0	49	3	89	42	55	11			255
2008	5		26	10	163	70	29	5			308
2009	10	0	30	6	171	95	20	9	0		341
2010	5	1	44	24	133	128	37	5			377
2011	17	1	85	6	155	136	25	5			429
2012	3	0	72	9	98	128	30	5	0		345
2013	22	0	69	2	60	101	25	7	0		285
2014	17	1	59	3	54	72	40	4			250
2015	13	4	38	6	58	52	26	5		8	209
2016	8	3	44	8	56	42	26	4		11	202
2017	4	3	33	6	41	34	27	7		9	163
2018	2	1	11	4	29	9	25	5	0	11	97
avg 75-18											
avg 92-18											
avg 75-18	16	4	33	14	101	128	25	5	1	10	314
avg 92-18	9	2	35	9	80	100	25	5	1	10	259

Table C.4: *Annual tonnages of blacklip abalone caught within statistical blocks comprising the Bass Strait Zone in 2018 (Blocks 32-38, 41-46, 50-57). The fishery was temporarily closed in 2007. Any discrepancies between totals and sums of components are due to rounding.*

Year	32	33	34	35	36	37	38	41	42	43	44	45	46
1974				3									
1975	1	10	1	7	7		2	0					
1976		5		1	1		0			1			
1977	6	11		0	3	1	2	0					
1978	1	5	2	6	5	0	4			1			
1979	2	9	0	0	2	1	2	0					3
1980	2	6	1	1	2	1	0	1		0			
1981	1	6	1	1	0	2				1			
1982	0	6	1	0	2	1	4						0
1983	0	3	0	1	5	1	3						0
1984	0	7	0	1	2	0	1	0	0	1			3
1985	3	6	1	2	1		0	2	0	2	0		
1986	0	9	2	3	2	1	1	1	0	4		0	1
1987	0	7	0	2	1	2	1	2		8	1		0
1988	0	11	1	1	0	0			0	2	1		1
1989	0	3	0	0	0	0		1	0	0	0	0	1
1990	0	1		0	1	0		0	0				
1991		2		0	0	0	0	0					0
1992	0	2	0	0	0	0					0		
1993	0	3	0	0	0	0	0						0
1994	0	3	0	0		0	0						
1995	0	0	0	0	0	1		0					
1996		0		0				0					
1997	0	0		0									
1998	0	2											
1999	0	4		0	0	0	1						
2000	1	5	0	0	0	0	0	0			0		
2001	5	10	1	0	0	0	3						
2002	1	11	1	0	0	0	2				0		
2003	0	5	0	0	0	6	2	1	2	2	0	0	2
2004	0	3	0	0	0	3	1	4	4	1		0	1
2005		7	0	0	0	6	2	4	1	2			0
2006	0	11	0	0	0	20	10	1	4	5			5
2007		2		3									
2008	1	5	0		0	19	6	1	2	5	1	1	3
2009	2	4	0	1	0	10	1	5	2	8	6	1	1
2010	0	20	0	0	0	1	26	1	0	3	0	1	1
2011	0	23	0	1		1	19	1	0	2	0	1	1
2012	1	14	0	0		4	17	0		3	1	1	1
2013	0	18	1	0	0	4	14			5	1	1	0
2014	1	19	1	1	2	2	16	0		5	1	1	0
2015	1	15	0	0	1	2	24	1	1	6	1	1	0
2016	0	20	0	0	4	2	18	1	2	5	0	0	
2017	1	19	1	0	7	3	14	1	1	6	1	0	0
2018	1	22	1	2	4	4	13	2	1	2			
avg 75-18	1	8	0	1	1	3	6	1	1	3	1	1	1
avg 92-18	1	9	0	0	1	4	9	1	2	4	1	1	1

Table C.4: *Bass Strait Zone continued*

Year	47	48	49	50	51	52	53	54	55	56	57	Total
1974	2	3	9									17
1975	1	12	9									51
1976	1	12	33									55
1977		8	17									48
1978	3	10	11									46
1979		27	7									54
1980		10	1									24
1981	3	33	10									57
1982	1	45	7									68
1983	9	45	19									87
1984	4	80	44									145
1985	4	48	50									120
1986	15	85	97									223
1987	18	58	67									169
1988	18	36	41									112
1989	14	15	24									60
1990	6	14	20									43
1991	8	12	10									33
1992	3	10	11									26
1993	1	7	7	0								18
1994	0	7	12									22
1995	0	6	2	1	0	0	3				0	13
1996		4	0									4
1997		6	2									8
1998		7	3									12
1999		14	4									24
2000		12	25									44
2001		17	74								2	112
2002		12	48					0			0	78
2003	0	10	76		7	2	36	2		7	2	164
2004	0	6	62		1	0	42	5	2	7		143
2005	0	6	54		8	0	35	5	3	3	0	137
2006	0	5	57		3	0	23	5	2	1	1	154
2007	0	6	59									70
2008		7	74	0	1		27			6		159
2009		4	74		5		24	1		4	2	157
2010		8	73		2		13					149
2011		8	104		3		14			2		180
2012	0	9	151		2		15	2		5		229
2013		14	113		5		18	3				196
2014		8	89		3	0	11	2			0	163
2015		8	60		1		9	2		4		138
2016	0	7	21		12		10					103
2017		3	14		3		12	3		4		92
2018		4	14		4		11	3	2	3		90
avg 75-18	4	17	39	0	4	0	19	3	2	4	1	91
avg 92-18	0	8	48	0	4	0	19	3	2	4	1	99

Table C.5: *Annual tonnages of greenlip abalone caught from the Greenlip fishery. Occasionally, small amounts of catch (< 1 t) are taken from Blocks 50-57. Any discrepancies between totals and sums of components are due to rounding.*

Year	1	2	3	4	5	30	31	32	33	34	35	36	37	38	39
1974		2		1	17	1	6	3	9	3	13	5			9
1975		3		1	8	0	7	3	17	14	49	69	14	11	3
1976	0	0	0		14	1	14	1	26	11	55	49	2	10	2
1977	0	0		0	17	3	6	6	23	21	50	24	1	22	8
1978	1	3	0	2	12	0	8	4	12	17	51	38	7	17	1
1979	0	0		0	8	2	11	10	21	8	46	15	4	4	6
1980	0	3			5		4	7	15	3	29	13	4	4	3
1981		12	0	4	9		6	12	17	17	34	10	9	0	4
1982	0	14		2	2	1	27	4	13	14	29	7	9	9	1
1983	0	9	0	5	9	2	23	4	21	8	34	9	4	8	2
1984	0	7	1	5	11	1	50	9	27	15	56	7	6	0	8
1985	0	1	0	1	3	6	53	9	20	15	42	4	7	7	5
1986	1	8		3	5	2	39	4	14	7	36	2	10		8
1987	13	125	5	69	8	1	32	8	20	10	30	8	10	7	12
1988	3	33	2	12	10	1	35	8	23	5	28	13	6		2
1989	1	70	3	10	6	1	22	4	16	2	22	10	3		5
1990	2	49	3	13	11	0	23	4	9	3	25	6	1	3	7
1991	2	29	3	16	12		20	4	7	2	31	6	3	0	6
1992	3	21	0	8	4		15	3	4	1	18	6	2		9
1993	1	17	0	9	2	0	9	1	4	2	16	8	3		2
1994	4	25		7	10		12	3	8	1	17	5	3	0	1
1995	14	9	0	12	8	1	24	2	7	3	15	3	3	9	6
1996	37	33	1	13	3		11	3	13	4	17	2	8	12	13
1997	35	33	0	6	6		17	8	13	1	12	4	11	15	22
1998	33	34	0	5	14		4	5	6	1	23	1	2	2	17
1999	21	25	1	10	10		6	2	17	1	15	1	2	4	2
2000	2	4	1	3	13		12	8	10	2	14	3	2	2	16
2001	8	8	1	2	3		7	15	14	2	9	3	1	0	20
2002	11	6	1	7	7		17	4	16	2	8	2	2	9	13
2003	15	11	3	4	10		18	5	16	1	11	2	1	3	17
2004	15	10	5	4	11		10	4	4	1	13	3	1	11	22
2005	16	5	4	3	12		6	2	12	1	10	3	1	15	13
2006	11	9	2	5	8		3	5	5	1	11	1	4	13	13
2007	10	7	3	6	9		20	3	6	1	13	2	0	5	14
2008	4	10	1	5	5		13	3	6	1	12	4	3	5	12
2009	8	8	3	6	5		13	2	5	1	13	2	2	2	20
2010	11	11	5	6	8		16	5	13	2	10	0	0	4	9
2011	6	9	9	4	5		14	5	5	2	13	4	2	12	11
2012	2	6	3	4	3		20	3	17	3	19	1	1	3	13
2013	2	12	2	4	5		14	8	23	2	17	2	1	4	9
2014	2	14	2	4	7		14	10	18	2	20	3	3	4	7
2015	4	13	1	5	6		24	7	16	2	14	2	2	1	9
2016	3	17	0	4	4		17	6	11	0	21	2	2	1	16
2017	2	19	0	3	4		15	4	13	1	19	3	8	4	14
2018	4	10	2	5	4		15	5	12	2	19	6	3	0	16
avg 75-18	7	17	2	7	8	1	17	5	13	5	24	8	4	6	9
avg 92-18	11	14	2	6	7	1	13	5	11	2	15	3	3	6	12

Table C.5: *Greenlip Zone continued*

Year	40	41	42	43	44	45	46	47	48	49	51	52	53	55	Total
1974	14	9		0				1	8						100
1975	4	2		0					7	2					214
1976	9	2		0					8	6					213
1977	4	1		1	0		0		40	2					228
1978	2			1				1	13	3					193
1979	2	1							11	0					149
1980	5	0		0		0			6						101
1981	2	0		2				3	12	1					155
1982	3							2	7						142
1983							0	14	40	11					203
1984	4	0	0	1			2	52	60	2					324
1985	4	1	0	1			1	12	36	3					231
1986	7	0	0	2		0	1	57	35	14					257
1987	1	1		9	5		1	37	33	3					447
1988	1	1		2		0	7	35	28	5					263
1989	2	5	1	2		0	6	20	27	4					242
1990	0	2					4	21	27	11					223
1991		1		0	0		8	13	32	6					201
1992			1		0		2	3	14	2					117
1993	0					0	2	2	25	3	0		0		110
1994								3	48	3					149
1995	2	1						5	23	5					151
1996	2	0					0	1	15	0					191
1997	1							1	28	3					215
1998	26	0		1				2	43	8	0				227
1999	4								20	1					142
2000	12			0				0	24	13					141
2001	4	0						0	35	10					143
2002	2								27	7					141
2003	1			0					14	10		0	0		141
2004	0			0					15	6					134
2005	1	0		0					19	1	0		0		122
2006	0		0	0			0	0	29	2	0		0		124
2007								0	21	3					124
2008	0	0		0					33	3					121
2009	1	0		0	0		0		26	2			0		123
2010	0								30	6					134
2011	0	1		0	0			0	31	5					140
2012	0	0							36	6			0		140
2013	1			0				0	32	3			0		141
2014				0	0				24	6		0	0		140
2015		0		0	0				32	5					144
2016	2			0				0	32	3	0		0		139
2017	1			0	0			0	26	4	0		0		141
2018	3	0		1				2	21	4	0		0	0	133
avg 75-18	3	1	0	1	1	0	2	10	26	5	0	0	0	0	172
avg 92-18	3	0	1	0	0	0	1	1	27	5	0	0	0	0	143

Table C.6: *Annual tonnages of greenlip abalone caught within the seven management regions comprising the Western Zone in 2018. Any discrepancies between totals and sums of components are due to rounding.*

Year	KI	NW	PB	CN	NE	FG	BS	Total
1974	3	24		10	29	33		1
1975	4	18		2	14	177		0
1976	0	28		2	25	156		1
1977	0	59		2	18	146		3
1978	6	27		2	11	147		0
1979	1	19		1	19	108		2
1980	3	11		1	12	74		
1981	17	22		5	12	99		
1982	17	9		2	30	83		1
1983	15	59		14	24	88		2
1984	14	73		55	61	120		1
1985	3	42		15	62	103		6
1986	13	54		61	54	74		2
1987	212	44		52	45	93		1
1988	51	43		46	39	85		1
1989	84	37		34	28	58		1
1990	68	49		26	30	50		0
1991	50	49		22	26	53		
1992	32	20		7	24	34		
1993	28	31		5	11	35	0	0
1994	36	61		3	13	36		
1995	35	35		6	32	42		1
1996	83	19		2	26	61		
1997	74	37		1	40	63		
1998	72	64		3	47	40	0	
1999	58	31			12	42		
2000	10	42	8	0	39	42		
2001	19	31	18	0	31	45		
2002	25	30	10		32	44		
2003	33	31	4	0	36	38	0	
2004	34	28	4	0	32	37		
2005	27	26	7	0	19	42	0	
2006	27	24	16	1	16	40	0	
2007	26	23	10	0	34	31		
2008	20	19	22	0	25	35		
2009	25	14	20	1	35	27	0	
2010	32	24	20		25	34		
2011	29	21	21	2	25	43		
2012	16	21	24	0	33	45	0	
2013	20	23	17	1	24	56	0	
2014	22	23	13	0	21	59	0	
2015	23	22	21	0	33	45		
2016	24	21	16	0	35	43	0	
2017	24	19	16	0	30	52	0	
2018	21	17	12	3	33	47	0	
avg 75-18	32	32	15	9	29	65	0	1
avg 92-18	32	28	15	1	28	43	0	1

Appendix D

History of Management Changes

This history has been compiled from a number of sources, principal among which has been DPIPWE's Abalone Management Plans.

1962	Legal minimum length (LML) of 5 inches (127 mm) minimum shell diameter introduced.
1964	LML increased to 6 inches (152 mm).
1965	LML reduced to 5 inches. Introduction of commercial abalone diving licenses. All abalone to be landed live (no processing at sea). Skippers of boats engaged in abalone fishing required to lodge monthly fish returns as part of their license conditions.
1966	Abalone processing factories required to record the number of persons from whom abalone were bought.
1967	Abalone divers required to carry a measuring device to measure the abalone before taking them. Special penalty introduced for possession of undersized abalone at $1 per fish. Abalone to be sold in live condition to registered processors only.
1968	Abalone catch returns were introduced. These recorded daily catches and effort by reporting block, and were lodged monthly by the skipper (not necessarily a diver) of an abalone fishing vessel. More than one diver's catch could be reported on a return. These returns replaced the general fish return on which earlier catches were reported.
1969	License limitation introduced. Rapid expansion of the fishery led to this first attempt to control effort. Only divers fishing the previous year were licensed to fish in 1969. This figure (120 divers) was maintained in subsequent years.
1971	Only licensed divers allowed to dive from a boat engaged in abalone fishing. Unusually prolonged calm sea conditions and warm water were associated with a widespread die-off of abalone and rock lobster between the Arthur River and Granville Harbour. Substantial quantities of both species were reported killed.
1972	License transfer from a retiring diver to his nominee allowable on grounds of health problems. Annual license fees calculated as 1.5% of the mean of the previous three years value of annual production. An additional five licenses were issued to divers living in the Furneaux Group. These divers were restricted to fishing the Furneaux Group, but the other 120 divers were not prevented from fishing there. Penalties for breaches of regulations in relation to abalone fishing increased. Permit to transfer licenses between divers revoked.
1974	License transfer from a retiring diver to his nominee permitted. Computerised catch records started from July 1974.
1979	Penalties for breaches of regulations in relation to abalone fishing increased, with special penalties rising to $2 per fish. Identification cards for divers introduced.
1982	Penalties for breaches of regulations in relation to abalone fishing increased, with special penalties rising to $10 per fish. Catch restricted by marketing crisis: processors limit divers to 24 tonnes pa.
1983	Penalties for breaches of regulations in relation to abalone fishing increased. Easing of market difficulties sees lifting of processor applied catch restrictions.

1985	Individual transferable quota (ITQ) and a total allowable catch (TACC) were introduced. Each of the 120 general license divers were allocated 28 units of quota, the Furneaux Group divers 20 units: therefore there were 3460 units. For 1985, the quota unit was set at 1100 kg i.e. the TACC was 3806 tonnes. – This amount was derived from an estimate of average catches, with a 10% bonus granted by the Minister to compensate for any financial difficulties caused by the new system. License fees were increased to 2.5% of the value of the annual landed catch, for each quota unit held. Quota unit transfers between Furneaux divers and non-Furneaux divers were prohibited. The 120 Tasmanian mainland divers were prohibited from diving in the Furneaux group. Divers were required to own at least 16 units, but could accumulate no more than 80. The catch (kg) per quota unit was determined by the Liaison Committee based upon advice from the Government researchers. Catch dockets recording the catch weight landed by individual divers were introduced.
1986	Annual license fees set at 5% of value of annual landed catch. The catch per ITQ was reduced to 1000 kg (9% reduction) i.e. TACC was 3460 tonnes.
1987	LML increased to 132 mm from 127 mm. The catch per ITQ was reduced to 950 kg (5% reduction) i.e. TACC was 3287 tonnes.
1988	The catch per ITQ was reduced to 855 kg (5% reduction) i.e. TACC was 2958.3 tonnes. The minimum legal weight for abalone meats was set at 90 g.
1989	The catch per ITQ was reduced to 600 kg (30% reduction) i.e. TACC was 2076 tonnes. A fishery for abalone in Bass Strait was held in April, with a LML of 110 mm and a maximum size limit of 132 mm. Each diver was limited to 2.4 tonnes, with 198 tonnes caught. The fishery was free of fees, and while only licensed abalone divers could participate, was held to be distinct from the Tasmanian abalone fishery (hence the maximum size limit). The minimum meat weight regulation of 90g was amended to apply only to blacklip abalone.
1990	LML for blacklip abalone on south and west coasts between the Wild Wave River (north of Sandy Cape) and Whale Head increased to 140 mm. LML for greenlip in Furneaux Group waters increased to 140 mm. Furneaux Group boundary removed. The Furneaux Group divers were issued with an extra 8 units each, which could only be fished by the divers themselves and were not transferable. This increased the number of units in the fishery to 3500, and the TACC to 2100 tonnes.
1991	A fishery for abalone in Bass Strait was held in May, with a LML of 118 mm. The TACC was 110 tonnes, with a fee of $1.40 per kg of quota. The license system was restructured: the diving entitlement was uncoupled from the entitlement to hold quota units and the lower and upper limits on the amount of units held was abolished.
1992	Minimum meat weight for greenlip was set at 70 g. Development of DPIF's compliance catch database (SEALSPROD) that enabled auditing of catch from vessel to factory.
1993	A fishery for abalone in Bass Strait was held in May and June, with a LML of 110 mm. The TACC was 100 tonnes, with a fee of $5.00 per kg of quota. Minimum meat weight regulation amended to 90g for all abalone other than greenlip. Penalties reviewed and significantly increased, with the option of prison terms for serious and repeat offenders. Special penalties increased to $50 per fish.
1994	Quota owners were given the choice of continuing with their annual abalone licenses or entering into a Deed of Agreement that applied for 10 years with the right of renewal for perpetuity. 90% of owners chose the Deed of Agreement. The Deed of Agreement set a fee structure that included both management costs and return to the community, based upon an increasing (but non-linear) proportion of beach price. At $6/kg, no fees were payable, at $35/kg fees were 10% at and at $200/kg, fees were 33% of beach price.

1995	A fishery for abalone in Bass Strait was held in May and June, with a LML of 110 mm. Only 12 commercial divers (i.e. non-abalone) participated. While the TACC was 100 tonnes, only 21 tonnes was taken. The fee was $10.00 per kg of quota. Another Bass Strait fishery was held in November, with both abalone and commercial divers participating. The LML was 100 mm, and the TACC was set at 140 tonnes, with a fee of $10/kg. Only 106 tonnes was taken before the fishery was closed. It was maintained by divers that a very high proportion of the fishable biomass had been taken, and that continuing the fishery could affect the sustainability of stocks.
1996	The *Living Marine Resources Management Act 1995* was introduced. Trigger points were introduced by DPIF to initiate a management response if catch and catch rates changed by a pre-determined quantity with respect to those from two earlier reference periods.
1997	The TACC was increased to 2520 tonnes (720 kg per quota unit). Difference in beach price between east coast and west coast blacklip first appears – is initially $2.00.
1998	The first abalone Fishery Management Plan was introduced. Among changes that it introduced were catch monitoring, which included: 1. Pre-fishing reporting by divers. 2. Post-fishing reporting of catch by divers and processors. 3. Processors required to maintain a daily balance of stock in, stock out and stock on hand. 4. Processors to report prior to movement of stock out and on receipt of stock. 5. Reports to be made by telephone, where information was immediately available to Compliance Audit Unit and Tasmania Police. For several years, greenlip abalone had attracted premium beach prices, causing a diversion of effort to that species. To enhance protection, a number of management changes were made: • For management purposes, the greenlip fishery was subdivided into two regions: the Furneaux Group and the remainder (North West, North East and King Island) • LML was raised to 140 mm state-wide (except the North West, which was left at 132 mm), • The annual catch for the Furneaux Group was capped at 42 t based on estimates of sustainable yield. This cap was managed monthly, so that where more than one twelfth of the annual cap (3.5 t) was taken in any month, the Minister could close the fishery until the next month. Within the Furneaux Group, several other rules were introduced to reduce effort: • Divers could only work two days per week. Originally, the days were fixed, but because this forced divers to work in often hazardous conditions, divers were allowed to nominate which two days they could work. • A 200 kg/day bag limit was introduced, as was a 200 kg/day landing limit. This effectively meant that catch was not held on motherships overnight. • These rules were repealed in 1999. • The greenlip catch from the remainder of the State was to be limited to 106 tonnes. • Because the Department was unable to monitor catch closely enough, the monthly Furneaux Group catch usually overran its limit, and the fishery there was closed in August when the regional cap was met. The greenlip cap in the rest of the State was also overrun. Vessels over 10 m landing abalone at Smithton or Stanley had to make a prior report to the CAU reporting service so that Tasmania Police could inspect their catch. Fixed trigger points were abandoned as an assessment strategy as rising catch and catch rates indiscriminately fired triggers. Assessments have since used catch and catch rate trends to monitor stock levels. A new compliance catch database (LMM/QMS) introduced by DPIWE

1999	LML for greenlip raised to 140 mm in North West, and 150 mm for the remainder. This applied to the commercial fishery only, the LML for recreational fishers remaining at 140 mm. The greenlip fishery was divided into east (Furneaux Group and North East) and west (King Island and North Wes t) with quarterly caps of 17 tonnes and 20 tonnes respectively. Overrun of caps led to a closure of the greenlip fishery in October. Within the Furneaux Group, Block 35 was closed to fishing between 1 October and 31 March to protect spawning abalone.
2000	The blacklip fishery was divided into two East and West management zones with boundaries at Whale Head and Port Sorell. The greenlip fishery was managed separately. Eastern blacklip units were set at 340 kg (TACC 1190 t), Western units at 400 kg (1400 t) and greenlip units at 40 kg (140 t), with a TACC for the whole fishery of 2730 tonnes. Size limits for blacklip abalone remained unchanged. The zone boundaries meant that the Western Zone had a size limit of 140 mm from Whale Head to the Wild Wave River and 132 mm from there to Port Sorell. Following egg-per-recruit studies by researchers, LML for King Island greenlip was raised to 155 mm, 140 mm for North West and 145 for both the North East and the Furneaux Group. The Block 35 (Franklin Sound - Furneaux Group) greenlip catch was capped at 20 tonnes. Catch were reported on a smaller spatial scale with the introduction of sub-blocks state-wide. Owners of fishing license (abalone dive) were allowed to hold more than one license and allow others to dive those licenses as supervisors.
2001	The Northern Zone (between Arthur River in the west and Musselroe Point in the east) for blacklip abalone was established, with a LML of 127 mm except between Woolnorth Point and the Arthur River, where 132 mm prevailed. Catch per unit was 80 kg, with a TACC of 280 t. Because the Northern Zone covered coast that was previously included in the two other blacklip zones, catch for those zones was proportionally reduced, with a further allowance for declining Eastern Zone stocks. The TACC for the West was set at 1260 t (360kg/unit), and the East at 1120 t (320 kg/unit). The greenlip TACC remained at 140 tonnes, so production from the entire fishery was 2800 t, or 800 kg/unit. In association with establishment of Northern Zone, research monitoring areas were set aside at the Inner Sister, Swan Island, Waterwitch Reef, and the Doughboys. LML's for recreational divers were changed to 132 mm for blacklip state-wide, and 145 mm for greenlip in all areas except the North West, which remained at 140 mm. The regional catch for the greenlip fishery was limited in three of the main regions. The North West catch was capped at 40 t, the North East at 30 t, while the Furneaux Group catch remained fixed at 42 t. Catch from King Island and the Bass Strait islands (Kent, Curtis, Hogan Groups) was not capped.
2002	Production for the whole fishery was set at 2537.5 t (725 kg/unit). LML for Eastern Zone was increased to 136 mm. LML for greenlip on King Island was reduced to 150 mm. LML for greenlip in the North West was increased to 145 mm. Eastern Zone TACC reduced to 857.5 t (245 kg/unit). Western Zone TACC remained 1260 t (360 kg/unit). Northern Zone TACC remained 280 t (80 kg/unit). Greenlip TACC remained 140 t (40 kg/unit). Catch from the Actaeons (sub-blocks 13C, D and E) was capped at 350 t, managed firstly as a half-yearly cap, then quarterly. The fishery there was closed in September and then mid-October when those caps were reached.

2003	Fishery production was set at 2607.5 t (745 kg/unit) state-wide. Eastern Zone TACC remained 857.5 t (245 kg/unit). Western Zone TACC remained 1260 t (360 kg/unit). Northern Zone TACC remained 280 t (80 kg/unit). Greenlip TACC remained 140 t (40 kg/unit). Bass Strait Zone TACC set at 70 t (20 kg/unit). A Bass Strait blacklip zone (TACC 70 tonnes (20kg/unit), LML of 114 mm) was created within the Northern Zone in central Bass Strait and part of the Furneaux Group. Its purpose was to enable the catching of abalone smaller than allowed by the Northern Zone size limit. The Bass Strait Boundaries were set at Cowrie Point in the west and Anderson Bay in the east. The Flinders Island boundaries were on an unnamed point north of Settlement Point on the western side of the island (40°00'36.32") and Foochow Inlet on the east. Blacklip catch from Block 5 (Northern Zone) was capped at 100 t. LML for Western Zone between the Wild Wave River and Arthur River was increased to 136 mm from 132 mm. Abalone taken from Western Zone subject to upper size limit of 160 mm by canners and live market buyers. Note that this was not rigidly enforced and market sampling showed most samples contained many abalone over this size.
2004	Fishery production was set at 2509.5 t (717 kg/unit) state-wide. Eastern Zone TACC reduced to 770 t (220 kg/unit). Western Zone TACC remained 1260 t (360 kg/unit). Northern Zone TACC remained 280 t (80 kg/unit). Greenlip TACC reduced to 129.5 t (37 kg/unit). Bass Strait Zone TACC remained 70 t (20 kg/unit). The greenlip TACC reduction affected the North West only, where the annual cap was reduced by 10 t to 30 t. October-March closure for Franklin Sound greenlip fishery abolished. Block 35 cap reduced from 20 t to 15 t.
2005	Fishery production was set at 2502.5 t (715 kg/unit) state-wide. Eastern Zone TACC remained 770 t (220 kg/unit). Western Zone TACC remained 1260 t (360 kg/unit). Northern Zone TACC remained 280 t (80 kg/unit). Greenlip TACC reduced to 122.5 t (35 kg/unit). Bass Strait Zone TACC remained 70 t (20 kg/unit). The greenlip TACC reduction affected the North East only, where the annual cap was reduced by 7 t to 23 t. Team diving (sharing catch from one quota unit by two divers) was introduced to legitimise the practise of divers catching abalone for others when they held no quota to which their catch could be assigned. Team dive dockets were submitted by teams, but not computerised. High grading (discarding large abalone in the catch from the deck) prohibited. Caufing of abalone (holding abalone in cages at sea) was prohibited. Introduction of cancellation reports where a prior reported trip is cancelled. Introduction of single (blacklip) zone fishing provisions. Overcatch provisions introduced to cover unintentional underestimation of catch weight. In Victoria in December, ganglioneuritis detected on two land-based (Portland and Port Fairy) and two offshore (Westernport) aquaculture sites.

2006	Fishery production was set at 2502.5 t (715 kg/unit) state-wide. Eastern Zone TACC remained 770 t (220 kg/unit) Western Zone TACC remained 1260 t (360 kg/unit) Northern Zone TACC remained 280 t (80 kg/unit) Greenlip TACC remained 122.5 t (35 kg/unit) Bass Strait Zone TACC remained 70 t (20 kg/unit) On 1 January 2006, interim reduction in LML for Perkins Bay greenlip area (Blocks 47, 48A), from 145 mm to 140 mm. On 20 September 2006, LML for Bass Strait Zone in Blocks 41-46 (North Coast) reduced from 114 mm to 110 mm. On 1 November 2006, LML for Eastern Zone was increased to 138 mm from 136 mm. LML for greenlip abalone in Perkins Bay was reduced to 132 mm from 140 mm. As a temporary measure to facilitate research, Block 30 was entirely closed to commercial abalone fishing and partially closed (except sub-block 30A) to recreational abalone fishing. The bag limit for recreational fishers in sub-block 30A reduced to 5 abalone per day. May 2006: Victorian ganglioneuritis (AVG) outbreaks reported from wild stocks adjacent to land-based aquaculture site at Port Fairey. As a precautionary measure, the Tasmanian wild fishery in Bass Strait closest to the Victorian coast was closed to abalone fishing, from 16 August 2006, initially for three months but then extended to 28 February 2007. The closure was for waters within latitudes 39º12' S and 39 º33' S, and longitudes 146 ºto 147 º35' (Blocks 51 to 56, and part of Block 57, including Wright Rock and Endeavour Reef). The taking of abalone in Tasmanian waters from vessels used in the Victorian fishery was prohibited, and the transfer by sea of abalone from King Island to the Tasmanian mainland was prohibited.
2007	Fishery production was set at 2502.5 t (715 kg/unit) state-wide. Eastern Zone TACC remained 770 t (220 kg/unit) Western Zone TACC remained 1260 t (360 kg/unit) Northern Zone TACC remained 280 t (80 kg/unit) Greenlip TACC remained 122.5 t (35 kg/unit) Bass Strait Zone TACC remained 70 t (20 kg/unit) N.B. it was agreed that the Bass Strait component (70 t) would not be caught due to concerns about disease outbreaks (AVG) in abalone stocks in adjacent Victorian waters. In October 2007, it was agreed that the cap for the southern part of the Actaeons (Sub-blocks 13C, 13D and 13E) would be reduced from 350 t to 266 t, and that a cap of 245 t be implemented for the South Coast (Sub-blocks 12B, 12C, 12D, 13A and 13B).
2008	The total catch state-wide was set at 2,593.5 t, or 741 kg/unit. Eastern Zone TACC increased to 808.5 t (231 kg/unit) Western Zone TACC remained 1260 t (360 kg/unit) Northern Zone TACC increased to 332.5 t (95 kg/unit) Greenlip TACC remained 122.5 t (35 kg/unit) Bass Strait Zone TACC remained 70 t (20 kg/unit) As part of a controlled trial in the North West, size limits in Block 5 and part of Block 6 were reduced for divers meeting defined operating requirements on the basis that there were large stocks of abalone too small to catch at the larger size limit, and that removing these smaller abalone would promote growth among the remaining fish. The LML in the Northern Zone part of Block 5 (5A, 5B and 5C) was reduced from 132 mm to 127 mm, and in sub-blocks 5D, 6A, 6B and 6C, from 136 mm to 132 mm. To promote fishing in the Northern Zone part of Block 5, the cap was increased from 100 t to 152.5 t and the Northern Zone TACC increased to 332.5 t. The remainder of the Northern Zone was capped at 180 t. In Bass Strait, south of 39°33', the Bass Strait Zone was reopened to fishing on 1 January 2008. North of this line, all islands in the Bass Strait Zone remained closed to fishing as part of measures to reduce the spread of AVG from Victoria. The closed area included the Kent, Hogan and Curtis Groups. It was reopened to fishing on 6 July 2008. Fears of an outbreak of AVG resulted in the closure of the Lower Channel (sub-blocks 14A, 14B, 14C and 14D) to abalone fishing between 16 September 2008 and 12 March 2009. The area was reopened after extensive sampling and testing failed to find diseased abalone. Actaeons (Blocks 13C, 13D, 13E) closed to fishing for the remainder of the year from 21 October because the 266 t catch limit had been reached (340 t). South Coast closed to fishing on 29 October because the 245 t catch limit had been reached (332 t).

2009	The total catch state-wide was set at 2,604 t, or 744 kg/unit. Eastern Zone TACC increased to 850.5 t (243 kg/unit) Western Zone TACC reduced to 924 t (264 kg/unit) Central Western Zone TACC established at 304.5 t (87 kg/unit) Northern Zone TACC remained 332.5 t (95 kg/unit) Greenlip TACC remained 122.5 t (35 kg/unit) Bass Strait Zone TACC remained 70 t (20 kg/unit) A new zone was created on the west coast to transfer catch from the South West further north. The Central Western Zone covers Blocks 6, 7 and 8. The Western Zone was correspondingly reduced to Blocks 9, 10, 11, 12, 13A and 13B. Blocks 7 and 8 were closed to fishing on 13 July because the 108 t cap had been reached (155 t). The North West greenlip region (cap 30 t) was closed to fishing on 1 August after the 20 t Perkins Bay cap was reached (20.1 t). The region's catch was 33.9 t. The North East greenlip region was closed to fishing on 19 October because the 23 t cap had been reached (35 t). The Actaeons were closed to fishing on 1 November, because the 340 t cap had been reached (341 t). The South Coast (cap 300 t) was closed to fishing on 1 November with the catch at 321 t. The Block 5 (cap 152 t) was closed to fishing on 5 December with the catch at 172 t. Experimental fishing project with reduced size limits continued in Blocks 5 and 6, where the LML was reduced under permit from 132 mm to 127 mm (Block 5) and 136 mm to 132 mm (Block 6), provided GPS data loggers were used.
2010	The total catch state-wide was set at 2,660 t, or 760 kg/unit. Eastern Zone TACC increased to 896 t (256 kg/unit). Western Zone TACC remained 924 t (264 kg/unit). Central Western Zone TACC remained 304.5 t (87 kg/unit). Northern Zone TACC remained 332.5 t (95 kg/unit). Greenlip TACC increased to 133 t (38 kg/unit). Bass Strait Zone TACC remained 70 t (20 kg/unit). Experimental fishing project with reduced size limits continued in Blocks 5 and 6, where the LML was reduced under permit from 132 mm to 127 mm (Block 5) and 136 mm to 132 mm (Block 6), provided GPS data loggers were used. In September 2010, the size limit for greenlip caught between Andersons Bay (Block 41) and Cowrie Point (Block 46) was reduced from 145 mm to 132 mm, in line with Blocks 47 and 48A (Perkins Bay/Black Reef). The Furneaux Group was brought into the Bass Strait Zone 114 mm size limit area. The size limit for Eastern Zone blacklip caught in Block 31A north of Cod Bay and Georges Rocks (latitude 40º54'53"S) was reduced from 138 mm to 132 mm while fishing under permit. This was a temporary measure between July and October to encourage fishing there. Block 31A was closed to fishing on 4 October after 50 t of abalone had been caught, but was subsequently reopened in December 2010 (at 138 mm) to ease pressure across the remainder of the fishery. Furneaux Group blacklip closed 9 August, capped at 35 t (49 t caught). The Actaeons closed 13 September capped at 340 t cap (342 t). Block 22 closed 13 October when the 60 t cap was almost reached (55 t). It was reopened in December to ease pressure on the reminder of the fishery. Blocks 7, 8 and 6D closed 20 October capped at 150 t (171 t). North East greenlip closed 1 November, capped at 23 t (25 t). North West greenlip closed 13 November, capped at 18 t (23t). Perkins Bay greenlip closed 13 November, capped at 20 t (20t). All the Northern Zone except Block 5 closed 22 November capped at 180 t (191 t caught). South Coast closed 13 December capped at 300 t (311 t). King Island greenlip closed on 13 December, cap 30 t (32 t).

2011	The total catch state-wide was set at 2,565.5 t, or 733 kg/unit. Eastern Zone TACC decreased to 721 t (206 kg/unit). Western Zone TACC remained 924 t (264 kg/unit). Central Western Zone TACC remained 304.5 t (87 kg/unit). Northern Zone TACC increased to 402.5 t (115 kg/unit). Greenlip TACC increased to 143.5 t (41 kg/unit). Bass Strait Zone TACC remained 70 t (20 kg/unit). Experimental fishing project with reduced size limits continued in Blocks 5 and 6, where the LML was reduced under permit from 132 mm to 127 mm (Block 5) and 136 mm to 132 mm (Block 6), provided GPS data loggers were used. The remainder of the 40 units issued to the five Furneaux Group divers in 1990 were transferred back to the Government. The Eastern Zone was closed to fishing in all parts except Block 31 between 1 January and 31 March. Actaeons (Sub-blocks 13C, 13D and 13E) closed 29 October capped at 341 t (359 t caught). Lower Channel (sub-blocks 14A, 14B) closed 5 December cap 10 t (12.5 t caught). Block 22 closed 12 September, reopened 18 December cap 40 t (54 t caught). Blocks 23, 24 closed 12 November cap 50 t (54 t caught). Freycinet/Bicheno (Blocks 25-28, 29A) closed 5 December cap 40 t (47.5 t caught). Block 5 Northern Zone closed 29 August cap 142.5 t (155 t caught). Remainder NW Northern Zone (Blocks 47, 48, 49) closed 29 October cap 100 t (112 t caught). North East Northern Zone (Block 39, 40, 31B) closed 5 December cap 30 t (29 t caught). Granville Harbour/Sandy Cape (Blocks 7, 8, 6D) closed 23 May cap 160 t (159.5 t caught). Furneaux Group Bass Strait Zone closed 20 June cap 35 t (44 t caught). North West greenlip closed 29 October cap 18 t (21 t caught). Perkins Bay greenlip closed 1 October cap 20 t (21 t caught). North East greenlip closed 5 December cap 23 t (23.5 t caught). Furneaux Group greenlip closed 28 November cap 42 t (44.5 t caught). Telephone reporting requirements were suspended on 16 November when the company operating the call centre unexpectedly ceased trading. Following the discovery of AVG-affected greenlip in NSW in November 2011, all imports of live abalone into that state from Tasmania and Victoria have been subject to restrictions. This measure has since greatly reduced the size of the domestic live greenlip market causing a collapse in high-grade greenlip beach prices. LML in the Northern blacklip fishery in Blocks 47, 48 and 49 reduced from 127 mm to 125 mm, provided GPS loggers used.
2012	The total catch state-wide was set at 2,366 t, or 676 kg/unit. Eastern Zone TACC decreased to 549.5 t (157 kg/unit). Western Zone TACC remained 924 t (264 kg/unit). Central Western Zone TACC remained 304.5 t (87 kg/unit). Northern Zone TACC decreased to 378 t (108 kg/unit). Greenlip TACC decreased to 140 t (40 kg/unit). Bass Strait Zone TACC remained 70 t (20 kg/unit). No caps were implemented in the Eastern Zone. The Eastern Zone was closed to fishing in all parts except Block 31 between 1 January and 31 March. East Furneaux Bass Strait Zone (sub-blocks 33B, 33C, Blocks 36, 38) closed 13 August, cap 35 t (36.4 t caught). Eastern Zone sub-block 30A closed 13 August, cap 4 t (4.5 t caught). North East greenlip closed 27 August cap 23 t (32.7 t caught). North East Northern Zone closed 27 August cap 30 t (35 t caught). Granville Harbour/Sandy Cape (Blocks 7, 8, 6D) closed 15 October cap 154.5 t (174 t caught). Blocks 47, 48, 49 Northern Zone (Hunter &Three Hummock Islands) closed 15 October, cap 130 t (156 t caught). Sub-block 48A, Block 47 (Black Reef greenlip) closed 12 November cap 20 t (26 t caught). Remainder North West greenlip closed 19 November, cap 18 t (18.5 t caught). Telephone reporting requirements reinstated with a new operator on 27 February. GPS and depth loggers made mandatory throughout the fishery from 1 January 2012. LML at Block 49 (Hunter Island & Three Hummock Island but not Albatross Island) was reduced from 125 mm to 120 mm. The LML at Albatross Is. was increased to 127 mm from 125 mm.

2013	The total catch state-wide was set at 2,149 t, or 614 kg/unit. Eastern Zone TACC decreased to 528.5 t (151 kg/unit). Western Zone TACC increased to 1001 t (286 kg/unit). Central Western Zone TACC decreased to 101.5 t (29 kg/unit). Northern Zone TACC decreased to 308 t (88 kg/unit). Greenlip TACC remained 140 t (40 kg/unit). Bass Strait Zone TACC remained 70 t (20 kg/unit). The Central Western Zone/Western Zone boundary was moved north to the Wild Wave River between 6D and 6C, meaning that Blocks 7 and 8, and sub-block 6D reverted to the Western Zone, and that the Central Western Zone comprised 5D, 6A, 6B and 6C. The Eastern Zone was closed to fishing in all parts except Block 31 between 1 January and 31 March. North East greenlip closed 3 June, cap 23 t (24 t caught). Bass Strait Zone east coast Furneaux Group closed 19 August, cap 30 t (27 t caught). Annual catch from waters around the Freycinet Peninsula and northward, (including sub-blocks 26B, 26C, 26D, 27A, 27B, 27C, 27D, 27E, 28A & 28B) was capped at 5 t, and the LML increased to 145 mm, these measures to restore populations in the area. It was closed 26 August, 11 t caught. North West greenlip closed 23 September, cap 18.5 t (23 t caught). Block 30A blacklip closed 23 September, cap 4 t (4.5 t caught). North East blacklip closed 7 October, cap 30 t (32 t caught). Blocks 47, 48, 49 Northern Zone (Hunter &Three Hummock Islands) closed 15 October, cap 100 t (126 t caught). Blocks 5 closed 11 November, cap 60 t (60 t caught). Furneaux Group greenlip closed 25 November, cap 47 t (55 t caught). South West Western Zone closed 2 December, cap 405 t (528 t caught).
2014	The total catch state-wide was set at 1,932 t, or 552 kg/unit. Eastern Zone TACC remained 528.5 t (151 kg/unit). Western Zone TACC decreased to 840 t (240 kg/unit). Central Western Zone TACC decreased to 73.5 t (21 kg/unit). Northern Zone TACC decreased to 280 t (80 kg/unit). Greenlip TACC remained 140 t (40 kg/unit). Bass Strait Zone TACC remained 70 t (20 kg/unit). Number of Fishing Licenses (Abalone Dive) or FLAD, changed from 125 to 121. Catch from part of the Freycinet-Bicheno region (26B-28B) was capped at 10 t at LML 145 mm and closed to fishing on 4 June 2014. It was reopened again at 145 LML on 24 September to spread fishing effort, with a further 10 t cap. South West Western Zone closed 28 April, cap 350 t (287 t caught). South West Western Zone re-opened 26 November (108 t caught). North East greenlip closed 20 March, cap 25.5 t (21 t caught). North West greenlip closed 1 June 2014, cap 21 t (23 t caught). Sub-block 30A closed 1 June 2014, cap 4 t (4 t caught). East Furneaux Bass Strait Zone closed 30 June 2014, cap 30 t (37 t caught). Furneaux Group greenlip closed 23 July, cap 47 t (59 t caught). North East Northern Zone closed 23 July, cap 30 t (44 t caught). Remainder Furneaux Bass Strait Zone closed 8 August, no cap (6 t caught). Block 5 Northern Zone closed 12 November, cap 50 t (54 t caught).
2015	The total catch state-wide was set at 1,855 t, or 530 kg/unit. Eastern Zone TACC remained at 528.5 t (151 kg/unit). Western Zone TACC remained at 840 t (240 kg/unit). Central Western Zone TACC decreased to 52.5 t (15 kg/unit). Northern Zone TACC decreased to 224 t (64 kg/unit). Greenlip TACC remained at 140 t (40 kg/unit). Bass Strait Zone TACC remained at 70 t (20 kg/unit). Number of Fishing Licenses (Abalone Dive) or FLAD, remained at 121. The LML of 145 mm for the Freycinet-Bicheno region (26B-28B) was retained for 2015. North-East greenlip closed 6 May, 25.5 t cap (30.6 t caught). North-East blacklip closed 10 May, 30 t cap (30.4 t caught). Furneaux Group blacklip closed 17 June, 30 t cap (44.1 t caught). Block 30A closed 24 June, 4 t cap (4.6 t caught). North-West greenlip (except Perkins Bay) closed 24 June, 21 t cap (21.6 t caught). Freycinet blacklip closed 15 July, 20 t cap (22.4 t caught). Albatross Island (49D) closed 5 August, 10 t cap (8 t caught). Central North blacklip closed 5 August, 5 t cap, reopened 7 December (6.5 t caught). Block 5 (5A-C) Northern Zone closed 3 September, 50 t cap (58.4 t caught). Blocks 14, 15, 16 blacklip (excl. 14B) closed 10 October, 50 t cap (51.4 t caught). Blocks 23 and 24 blacklip closed 4 November, (41.3 t caught).

2016	The total catch state-wide was set at 1,694 t, or 484 kg/unit. Eastern Zone TACC remained at 528.5 t (151 kg/unit). Western Zone TACC decreased to 717.5 t (205 kg/unit). Central Western Zone TACC decreased to 42 t (12 kg/unit). Northern Zone TACC decreased to 189 t (54 kg/unit). Greenlip TACC remained 140 t (40 kg/unit). Bass Strait Zone TACC increased to 77 t (22 kg/unit). Number of Fishing Licenses (Abalone Dive) or FLAD, remained at 121. The LML of 145 mm for the Freycinet-Bicheno region (26B-28B) was retained for 2016. Albatross Island (49D) closed 19 February, 10 t cap (10.8 t caught). North-east blacklip closed 15 June, 30 t cap (30.2 t caught). Furneaux Group blacklip closed 19 August, 30 t cap (45.7 t caught). North-west greenlip (except Perkins Bay) closed 31 August, 21 t cap (21.6 t caught). North-east greenlip closed 19 August, 21 t cap (34.5 t caught). King Island greenlip closed 14 September, 20 t cap (23.5 t caught). Block 5 blacklip closed 5 October, 50 t cap (53.2 t caught).
2017	The total catch state-wide was set at 1,561 t, or 446 kg/unit. Eastern Zone TACC decreased to 444.5 t (127 kg/unit). Western Zone TACC remained at 717.5 t (205 kg/unit). Central Western Zone TACC decreased to 35 t (10 kg/unit). Northern Zone TACC decreased to 147 t (42 kg/unit). Bass Strait Zone TACC remained at 77 t (22 kg/unit). Greenlip TACC remained at 140 t (40 kg/unit). Number of Fishing Licenses (Abalone Dive) or FLAD, remained at 121. The LML of 145 mm for the Freycinet-Bicheno region (26B-28B) was retained for 2017. Albatross Island (49D) 10 t cap (8.8 t caught) and Block 5 Northern closed 29 March, 42.5 t cap (41.3 t caught). North-east greenlip closed 10 May, 25.5 t cap (29.6 t caught). North-east blacklip closed 16 June, 27.8 t cap (33.9 t caught). Furneaux Group (east) blacklip closed 19 July, 39.5 t cap (40.1 t caught). King Island greenlip closed 04 September, 20.0 t cap (24.1 t caught). North-west greenlip (except Perkins Bay) 17.8 t cap (18.8 t caught) and Furneaux Group greenlip closed 29 November, 47 t cap (52.5 t caught).
2018	The total catch state-wide was set at 1,333.5 t, or 381 kg/unit. Eastern Zone TACC decreased to 294 t (84 kg/unit). Western Zone TACC remained at 717.5 t (205 kg/unit). Northern Zone TACC decreased to 98 t (28 kg/unit), in part due to assigning Central West Zone blocks (6A, 6B, 6C) to the Northern Zone, and assigning Northern Zone Blocks 49A, 49B, 49C, 48 and 47 into the Bass Strait Zone. Bass Strait Zone TACC increased to 91 t (26 kg/unit) in part through inclusion of Blocks 49A, 49B, 49C, 48 and 47 from Northern Zone. Greenlip TACC decreased to 133 t (38 kg/unit). Number of Fishing Licenses (Abalone Dive) or FLAD, remained at 121. The LML of 145 mm for the Freycinet-Bicheno region (26B-28B) was retained for 2018. North-west Sub-blocks 5D, 6A, 6B, 6C and south coast sub-blocks 13A, 13B closed for blacklip 25 April. Block 40 opened for blacklip 30 July. Blocks 28C and 29 closed for blacklip 6 August. Block 49D closed for blacklip 3 September. All Blocks 22 to 31 closed to blacklip 21 September. Blocks 31B and 39 closed to blacklip 12 October. Blocks 10, 11 and 33 closed to blacklip 31 October. Blocks 10, 11, 13A, 13B opened to blacklip 4 December. Blocks 2A, 2B, 2C, 4A closed to greenlip 28 May. Blocks 32 and 33 opened to greenlip 26 June. Blocks 48B, 48C, 49, 5, 40 opened to greenlip 30 July. Blocks 1, 3, 4B and 4C closed to greenlip 3 September. Blocks 31 and 39 opened for greenlip 10 September, and closed 22 September. Block 48B, 48C, 49 and 5 closed to greenlip 27 September. Blocks 32 and 33 closed to greenlip 31 October. Blocks 31, 39, 48B, 48C, 49 and 5 opened to greenlip 17 December.

Appendix E

Maps of Reporting Blocks

It is not intended that these maps be used for any purpose other than identifying the position of sub-blocks mentioned in this report.

Figure E.1: *Map of King Island blocks*

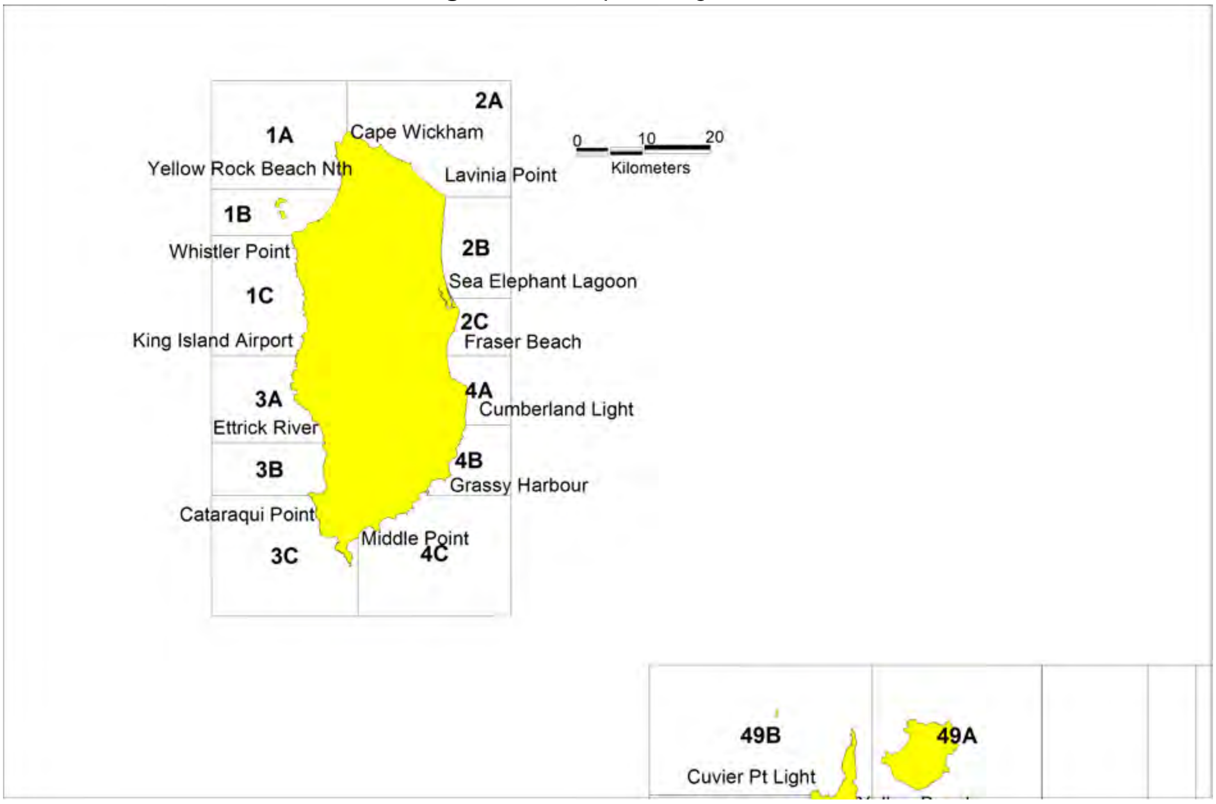


Figure E.2: *Map of North West blocks*

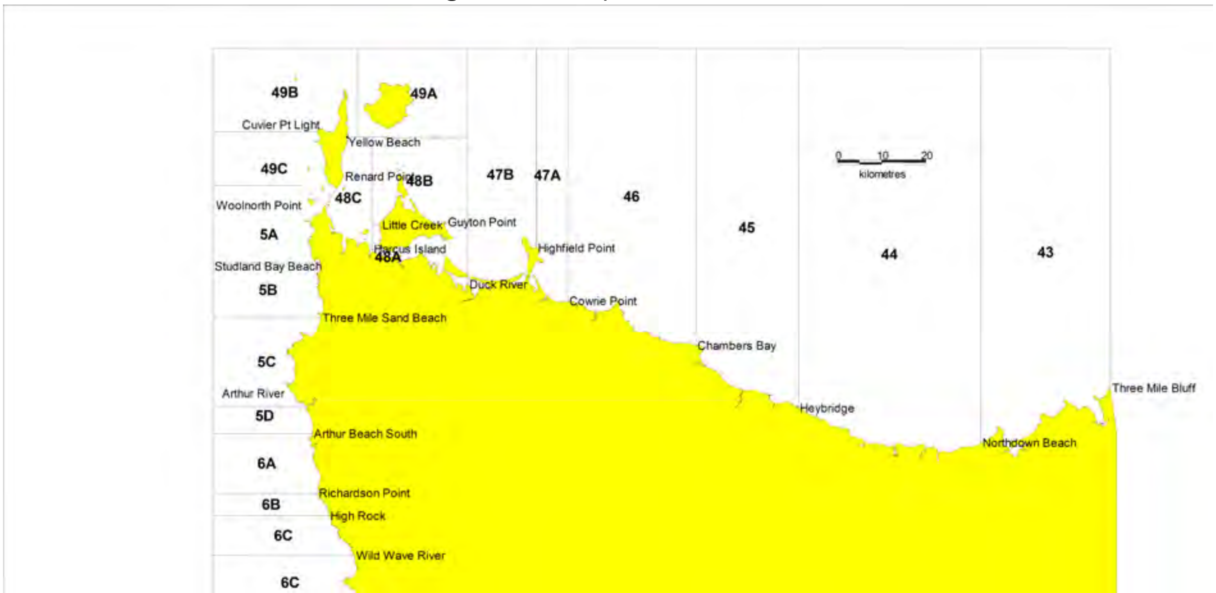


Figure E.3: *Map of Central West Coast (north) blocks*

Figure E.4: *Map of Central West Coast (south) blocks*

Figure E.5: *Map of South West blocks*

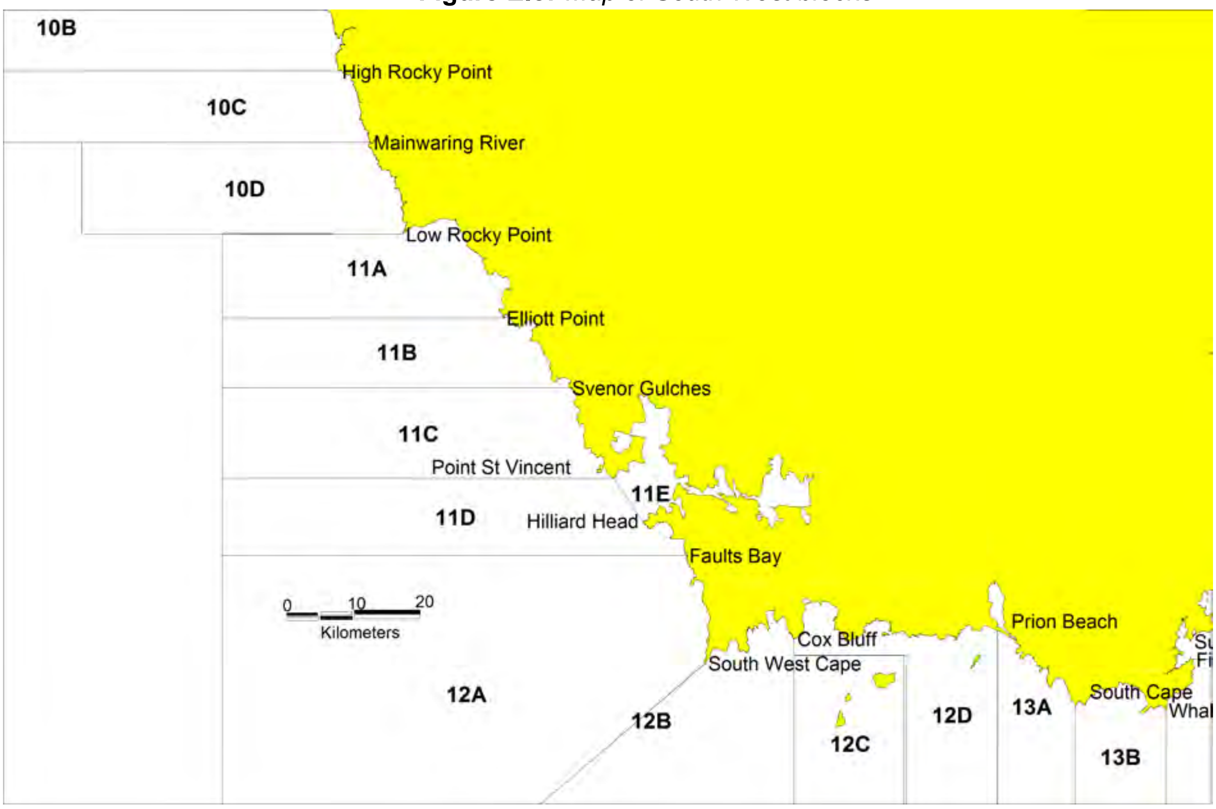


Figure E.6: *Map of South East Tasmania blocks*

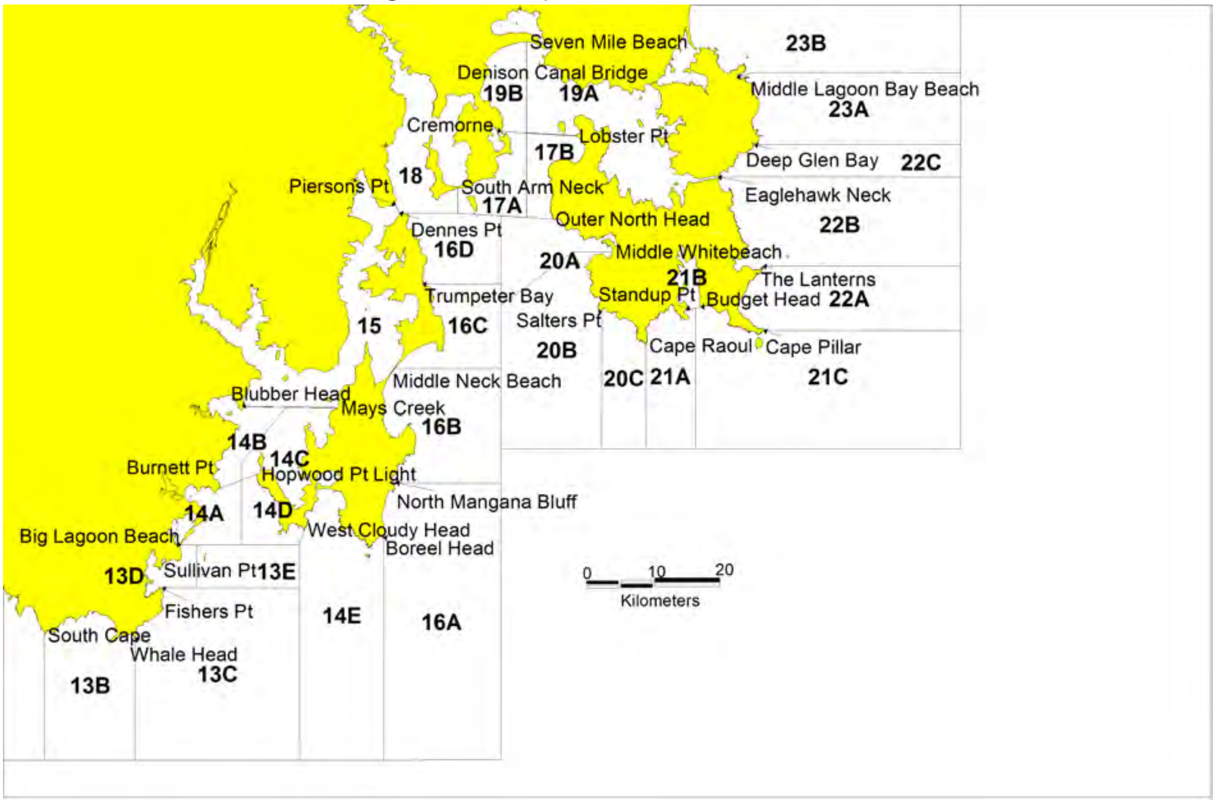


Figure E.7: *Map of Lower East Coast blocks*

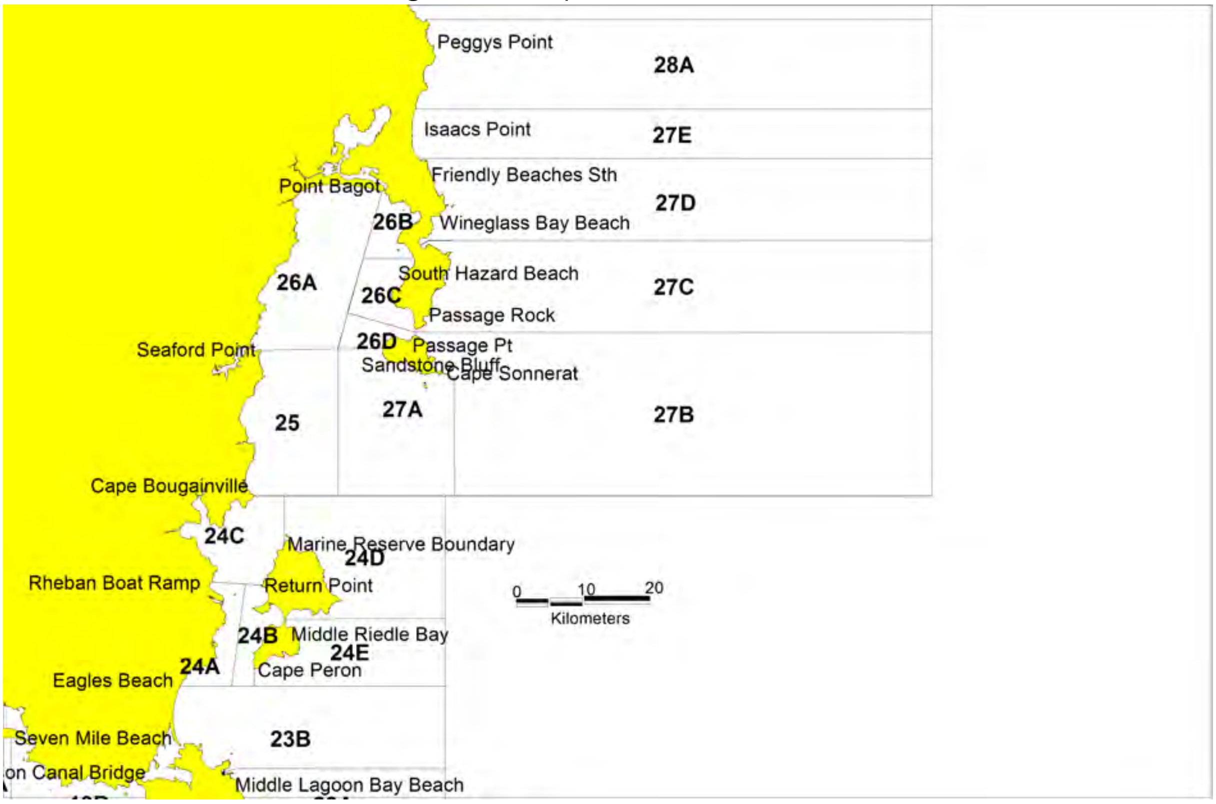


Figure E.8: *Map of Upper East Coast blocks*

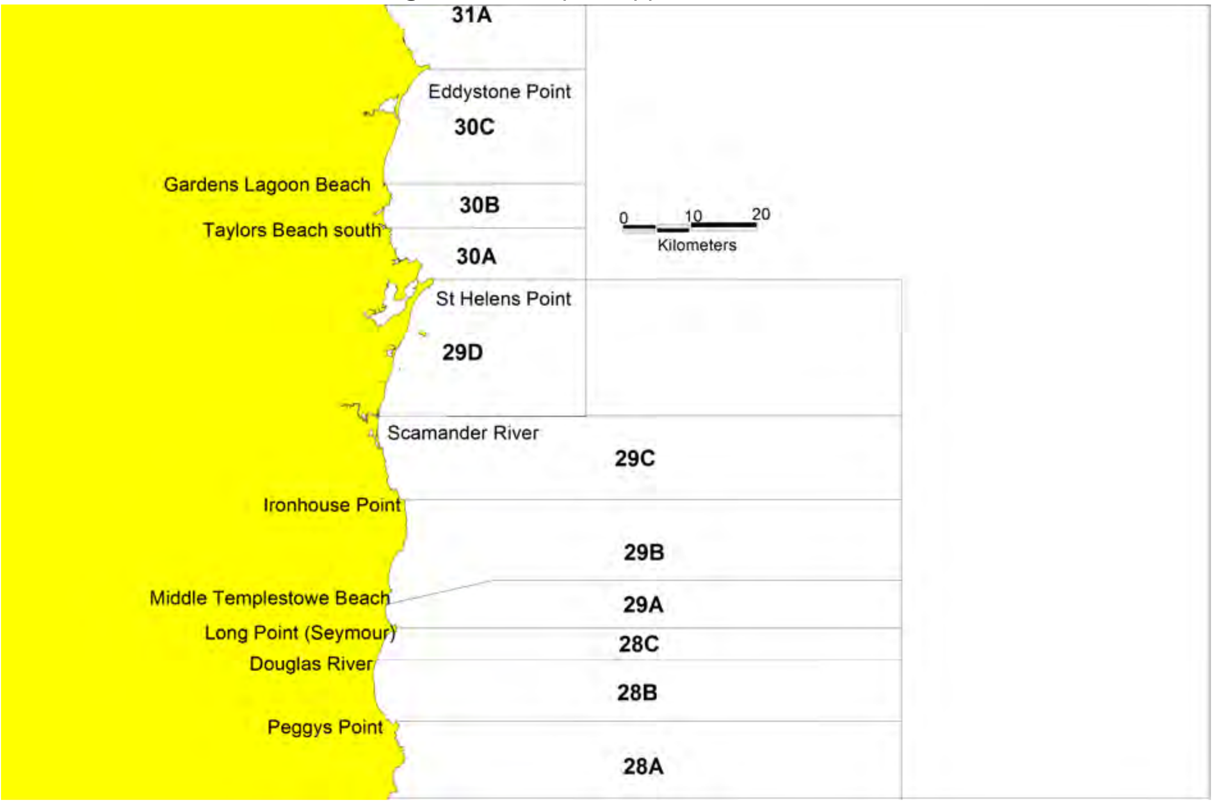


Figure E.9: *Map of North East blocks*

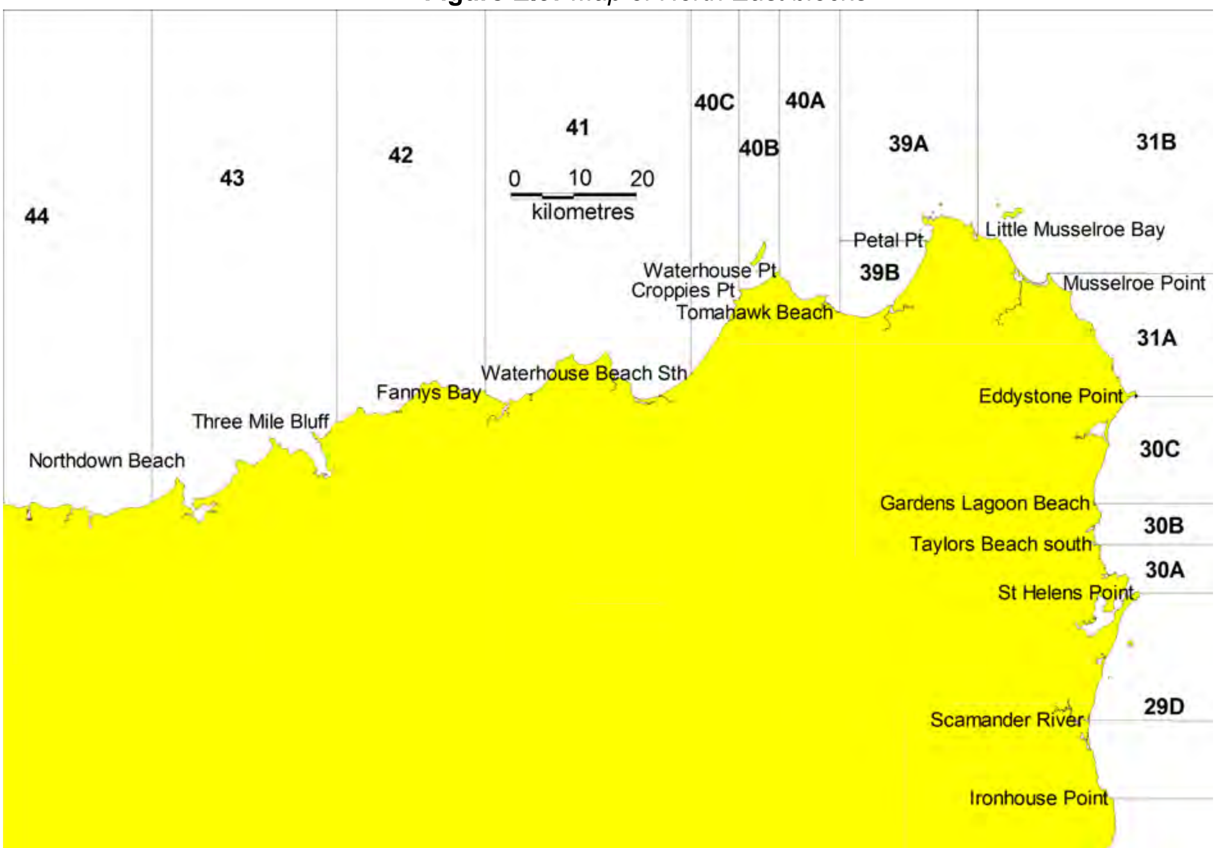


Figure E.10: *Map of Furneaux Group blocks*

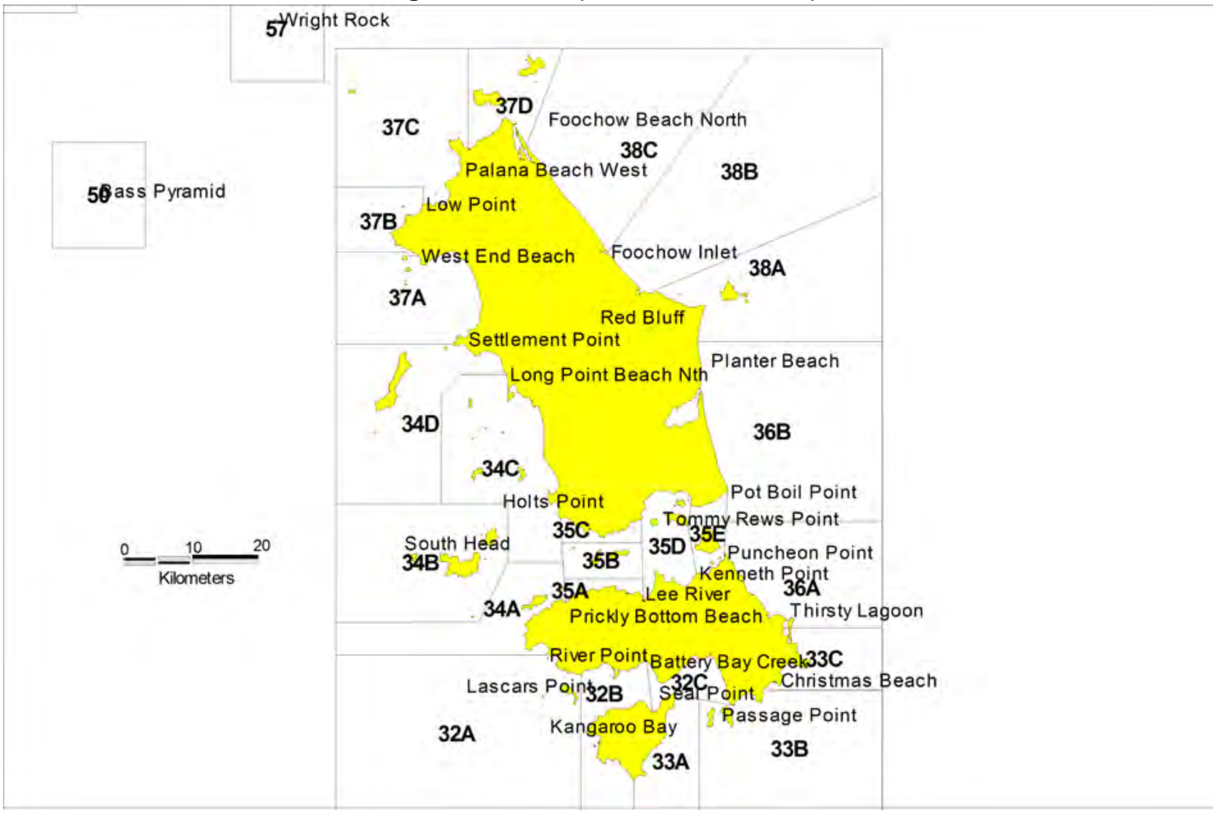
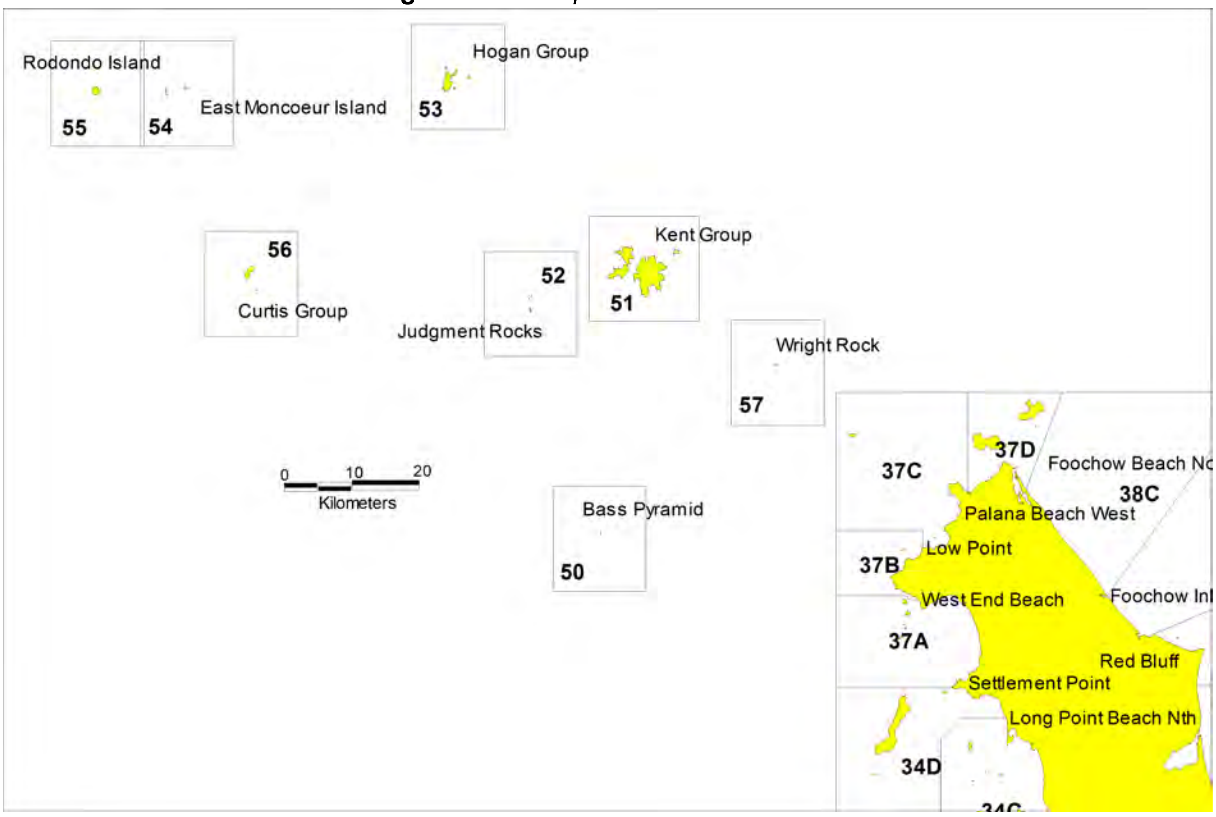


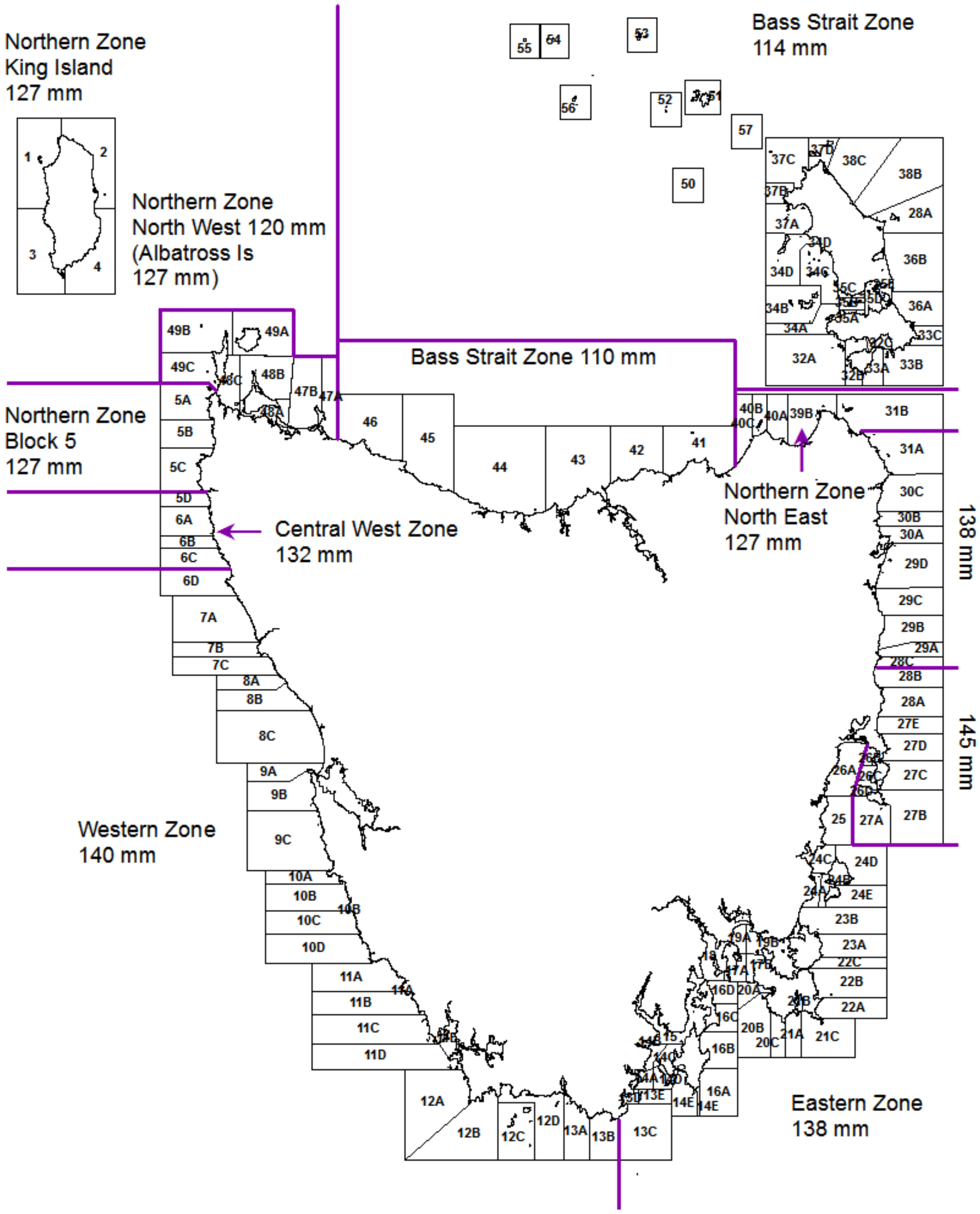
Figure E.11: *Map of Bass Strait Island blocks*

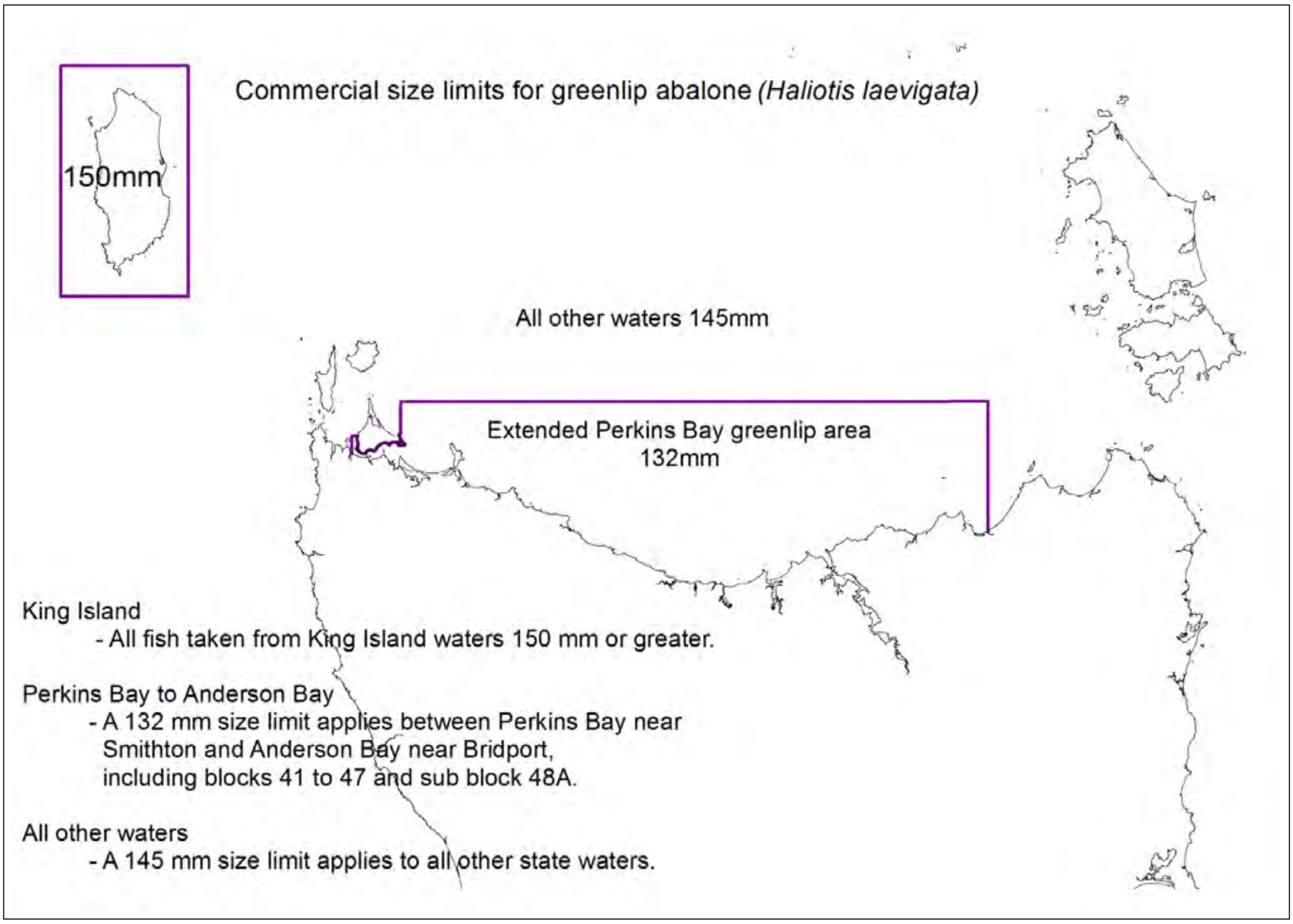


Appendix F

Commercial size limits for blacklip and greenlip abalone, 2018

Commercial size limits and zones for blacklip abalone





Commercial size limits for greenlip abalone *(Haliotis laevigata)*
150mm
All other waters 145mm
Extended Perkins Bay greenlip area
132mm
King Island
- All fish taken from King Island waters 150 mm or greater.
Perkins Bay to Anderson Bay
- A 132 mm size limit applies between Perkins Bay near Smithton and Anderson Bay near Bridport, including blocks 41 to 47 and sub block 48A.
All other waters
- A 145 mm size limit applies to all other state waters.

The Institute for Marine and Antarctic Studies (IMAS), established in 2010, comprises the University of Tasmania's internationally recognised expertise across the full spectrum of temperate marine, Southern Ocean and Antarctic research and education.

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