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TASMANIAN ABALONE FISHERY - 2010

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Abalone Fishery Assessment: 2010

Executive summary

A total of 2659.5 tonnes of abalone were landed in 2010, up 57 tonnes from the previous year. This was almost the entire Total Allowable Commercial Catch (TACC – 2660t) and comprised 2526.8 tonnes of blacklip (*Haliotis rubra*) and 132.7 tonnes of greenlip (*H. laevigata*). Average beach price also increased in 2010, which combined with the higher catch resulted in an increase in gross landed value of more than $11 million to $104 million. Levies paid to the Tasmanian Government increased accordingly, up by $1 million to $7.2 million.

The status of the fishery was assessed using catch and catch rates from divers' catch returns, and samples of catches measured to provide information about the length of abalone. Information on stocks also comes through consultation with the abalone industry to obtain their observations on the state of the stocks and market drivers affecting the fishery.

The major findings of this assessment are summarised for each fishing zone.

Eastern Zone
The Actaeons continued to be the most productive region in the zone, but catch rates here fell substantially. Because the annual catch has been capped at 340 tonnes for several years in most of this region, falling catch rates suggest inadequate recruitment to sustain catch.

The annual catch from the Bruny region has declined over the last 10 years with recent annual catch totals from Blocks 14, 15 and 16 approximately half that from the years prior to zoning (2000), and approximately one quarter of the size that they reached during the years prior to quota management (1985). Catch rates fell sharply from 2009 levels, and have been in a sustained multi-year decline in the southern Bruny sub-blocks. This combination of declining catch and catch rates is a strong indicator that stock levels have fallen. In conjunction with an increase in size of abalone, these trends imply that fishing mortality was high, that recruitment has been reduced in recent years, and that stock levels were low. The prolonged trend in stock data from this area suggests that the region now has reduced productivity.

In Storm Bay, fish stocks have been reduced in all parts of the region, but more so near Nubeena and further north. In conjunction with falling catch rates, the increasing median size suggested that recruitment levels continued to fall in 2010.

In all parts of the East Coast from Tasman Island north to Eddystone Point stock levels were severely reduced, which suggests that the size of the 2010 catch was too large for the region. Abundance was higher north of Eddystone Point (Block 31) but much of the stock in this region was of lower quality and not suited for export as live product. Consequently, processors were reluctant to accept catch from this block.

During 2009 across many parts of the Eastern zone, catch rates had either increased or were stable at moderate to high levels, indicating that stocks were continuing to rebuild. It is therefore of concern that catch rates fell so precipitously in 2010, and that stock levels were evidently much lower than assessed. While local mortality events were

reported in early 2010, apparently associated with warm water temperature stress, they do not sufficiently account for the widespread decline in stock across the east coast because mortality events were confined to shallow water on small sections of coast. These results emphasise the need for caution.

Central Western Zone
The creation of the Central Western Zone in 2009 has led to historically high levels of catch in the region. When the zone was initially established, the TACC was purposefully set high, both to transfer catch away from the South West, and because it was recognised that low levels of effort in Blocks 6, 7 and 8 had enabled stocks to build up, particularly in areas not regularly fished by local divers.

In Block 6 (Couta Rocks region), catch rates were generally stable or if lower, apparently reflected market pressures, not stock declines. In sub-block 6C, catch rates and consequently stock levels appeared to be higher. It is considered likely that stock levels in Block 6 were stable or had even increased slightly in 2010. There appeared to be a rapid increase from north to south in size at maturity, maximum size and growth rates in this block, and the southern sub-blocks (6C, 6D) may have been under-protected by the size limit as applied under the two-year rule of thumb.

Further south in Blocks 7 and 8 (Granville Harbour region), catch rates had fallen for two successive years, from high to moderate levels, and it was clear that fish-down of built-up stocks had occurred. The increase in size of fish was attributed to the abandonment of the practise of selectively avoiding larger fish, and was not seen as an indication of trend in stock. Continuing fishing at the prevailing high levels of catch is likely to further reduce stocks. Stocks do not appear to have become depleted to levels that should concern managers, but any further falls in catch rates warrant scrutiny.

Western Zone
In Block 9 (Strahan) the catch was stable. Catch rates were lower than previous years but remained at moderate to high levels. In summary, stock levels on inshore reefs were stable.

Further south in Blocks 10, 11 and 12A (South West), catch was approximately two thirds of the levels of catch taken between 2000 and 2008 which had caused extensive depletion. This catch reduction appears to have halted the catch-rate decline, and catch rates increased for the second consecutive year. It is therefore likely that stock levels in the region, while remaining low, were stable or had increased slightly in 2010.

On the South Coast (Sub-blocks 12B-13B), the annual catch has been high in recent years, at over 300 tonnes. Since 2002, catch rates have been stable at moderate levels and the median size has fallen, which indicated increased dependence on new recruits. This combination of performance measures suggested that stocks were stable or decreasing slowly. Thus the fishery in this area appears stable although with the increased reliance on recruits implies risk of exposure to low recruitment.

Northern Zone
The King Island catch increased from a low level. This was not due to increased abundance, but was a result of the easing of restrictions which had displaced catch from the island to the Tasmanian mainland following the Victorian AVG outbreak in 2008. Catch rates fell for the second successive year but again, this was not purely a function

of reduced abundance, but due more to a shift in the distribution of effort from deep water stocks where catch rates were high to the shallows where stocks were less abundant but more highly valued. Stock levels were assessed to be in the moderate to high level.

High levels of catch have been taken in the North West for many years. Effort has been concentrated in the established fishing areas, despite an attempt to spread catch more widely with a size-limit reduction. Catch rates in target areas have fallen to moderate levels, most likely as a result of intensive fishing. Since the size-limit reduction, the median size of fish has fallen, although there were no indications that dependency on recruits had increased. While stocks in the North West continued to be fished down in 2010, it is likely that they remained at moderate levels.

The maximum size and growth rates of blacklip abalone populations in the North West (Blocks 5, 47- 49) were spatially variable, with large differences over small spatial scales. This has made choosing appropriate size limits for sustainable fishing difficult. The market clearly favoured the larger faster growing fish, and most processors rejected fish from the smaller growing populations because they were of poor quality. Reducing size limits to an average length across the region that meets the two-year rule will meet management guidelines and increase stock size, but will carry increased risk at places where better quality abalone are fished, such as at Albatross Island and Bluff Hill Point. An average length is likely to be insufficiently small to enable adequate access to stocks in the slow growth areas. In this region, it may be more appropriate to manage size limits to meet market demands and protect the better quality fish, rather than meet the bare minimum under the two-year rule.

At Circular Head (Block 47) it was reported that there were extensive populations of very small blacklip that were clearly much smaller than any other Northern Zone fish, and possibly smaller than similar populations fished at Rocky Cape to the east. The potential yield from this region is unknown. If there were sufficient market demand for fish of this size and quality, it may be appropriate to investigate management changes that enable access to these abalone.

In the North East (Sub-block 31B, Blocks 39, 40) the area of fished reef is small and stock levels are quickly depleted by excessive levels of catch. This part of the fishery appeared to be still recovering following high levels of catch in 2007. The 2010 catch was in the moderate to high range. Catch rates were slightly higher compared with previous years, but in this region changes in catch rate were difficult to interpret because divers frequently fished for both greenlip and blacklip on the same trip. Considering the size of catch and moderate catch rates, stock levels were assessed as moderate in 2010.

Bass Strait Zone

There was a large increase in catch from the east and south east of the Furneaux Group (Blocks 33, 38) as a result of its transfer from the Northern Zone to the Bass Strait Zone in 2010. The concurrent 13-mm reduction in size limit greatly increased the stock size and 48 tonnes was landed, with large catches taken at high catch rates. Because of the management changes, this was effectively a virgin fishery, and comparison with previous annual catches and catch rates was meaningless. As a result, catch and catch-rates were not indicators of trend in stock size, and consequently there was no formal assessment of stocks in Blocks 33 and 38. Divers reported good fishing, but considering

the small area of reef and high levels of catch, expressed doubts that such a high level of catch could be sustained.

Despite lower catches and catch rates, stock levels in the Hogan Group appeared unchanged from previous years, and stock levels there were assessed as moderate and stable.

On the Central North Coast, stocks have been either slow to recover or have not recovered from previous years fishing, and stocks there were assessed as low.

Greenlip

Changes in catch rates and catch are frequently inadequate as indicators of stock levels in the greenlip fishery. This was not always the case, but in recent years there have been changes to both management and markets that have reduced the effectiveness of fishery-based performance measures. Because of this, stock assessment of most parts of the greenlip fishery was more uncertain, and only in the Perkins Bay (Black Reef) region were the conditions met under which catch and catch rates could be assumed to reliably correlate with abundance. In the other regions, greater reliance was placed on the divers' perception of stock levels.

Divers on both King and Flinders Islands fishing reefs that produced larger fish reported that growth rates and fish quality were often reduced in areas of high recruitment whereas on reefs producing high grade fish, recruitment was frequently inadequate. Several divers have expressed strong opinions that production could be increased by translocating juveniles from the high-density slow-growing areas to areas where they regularly caught high grade fast-growing fish.

In the North East, divers believed that the smaller legal-sized fish appeared to be at a fast-growing stage and that if the size limit was increased, the fish would rapidly reach the larger size, quality would be improved, and the population size would be increased.

At Perkins Bay, divers said that intensive fishing following the large size-limit reduction in November 2007 had improved fish quality. Reducing fish density had enabled the remaining fish to grow faster and larger with better meat yield. Because of their small size, fish from Black Reef were more suited to the less lucrative processed export market. Stock levels remained high, and the only limitation to larger catches was the limited availability of quota for this market. The catch has been stable (capped at 20 tonnes) since 2008, and catch rates had risen slowly to moderately high levels, which indicated stable or increasing abundance.

No divers expressed concerns about greenlip stock levels in any of the five management areas. Most reported average to good fishing, and that catches generally matched their expectations.

Recreational and other fisheries

The most recent survey of recreational divers estimated the recreational catch at 1.5% (39 tonnes) of the total abalone catch in Tasmania, over half which was taken in the east and south east. This figure did not include abalone taken as part of cultural fishing activities by indigenous people, or under permit for special events and research purposes, or through illegal fishing. There was no estimate for either the illegal catch or

the cultural fishing activities; however, the quantity of abalone taken under permits was less than two tonnes.

Recommendations

The assessment indicated the need for management response to changing stock in the Eastern Zone with catch reduction required to target stock rebuilding. The spatial distribution of the large eastern zone TAC was problematic in 2010 because it forced catch into areas where stock was known to be depleted. This process has previously caused sustained loss of value in some locations and the concern is for this problem to be expanded. A lower TAC should enable populations to increase, not just in the high production hotspots (which can give the impression of recovery), but also across the broader fishery which is important for maintenance of the long term yield from the Eastern Zone.

Localised recruitment overfishing remains a concern despite ITQ management and may occur if divers persist in fishing sparsely distributed populations at low catch rates. This practice will stall recovery of the reef for many years and thus reduce long run yield. The risk of local recruitment overfishing is normally reduced by divers moving to areas of higher catch rates, however, requirements to meet processor's orders for product of specific market traits can concentrate effort into local areas. Divers and processors need to be aware of the costs, both to individual fishing operations and to the wider fishery, when remnant stocks are harvested at low catch rates. Under these circumstances, alternative fishing locations with higher stock levels should be considered.

In the South West of the Western Zone, catch rates rising from low levels indicated stock recovery. Fish from this zone were relatively larger and faster growing, and current size limits may offer less than adequate protection from intensive fishing. On the South Coast, annual catches have been at very high levels for several years, and this part of the fishery operates at a high level of risk because the fishery is exposed to inter-annual variation in recruitment. While there are no current signals of concern other than high catch, it is recommended that managers pay particular attention to stock levels in these regions.

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Introduction

This assessment relies on fishery-dependent data. Principally, changes in catch and catch rate have been used to make inferences about changes in abalone abundance. In addition, information is presented on changes in the median length of abalone sampled from the commercial catch across relatively fine spatial scales. Combined with changes in median length, trends in catch rates can be useful indicators of changes in abalone populations in Tasmania.

The use of catch and catch rates to monitor changes in abalone abundance has often been criticised as unreliable and elsewhere is infrequently used. In theory, the fishing of abalone aggregations, serial depletion and changes in fishing efficiency reduce the link between catch rates and abundance. These factors are more problematic in areas where effort and catch data are sparse and compounded by the use of arithmetic means which are sensitive to skewed data.

However, when abalone populations are intensively fished, as occurs throughout much of the Tasmanian fishery, catch and catch rate trends appear to be reliable indicators of changes in abundance. When fishing pressure is sufficient, large aggregations are unable to develop, and high visitation rates prevent stock build up and subsequent serial depletion. The confounding effects of effort creep may be reduced by using short-term (10 years or less) catch and catch-rate trends to assess changes in stock levels. Under these circumstances, catch and catch-rate trends appear to reflect changes in abundance.

This document makes use of fisheries data collated over progressively diminishing spatial scales. The top level scale is the zone. The use of zones was first introduced into the Tasmanian fishery in 2000 to manage the spatial distribution of catch. Since 2003, the Tasmanian blacklip fishery has been divided into four zones: Eastern, Western, Northern and Bass Strait. A fifth zone (Central Wes t) was introduced in 2009. The greenlip abalone fishery is managed separately from the blacklip fishery. The greenlip fishery is restricted to the north of the state, and the spatial distribution of its catch is managed by regions.

Whilst zones are now the established method of managing the fishery, they mask details important for fishery assessment. Zones are too large and include too many physical differences (e.g. water temperature regimes, types of habitat, accessibility for divers), and may include divergent recruitment patterns, and different levels of abundance and fishing methods. There is a risk that recruitment in particular parts of a zone may be very different to that of the wider region. In this assessment, understanding of stock abundance is improved by looking at fishing patterns across smaller regions within each zone which have a greater likelihood of sharing common fishing practises and stock levels.

The regions and region boundaries used in this assessment have been set arbitrarily, but are generally based upon commonly used Tasmanian regions, about which boundaries have been placed aligned with the abalone fishery reporting blocks. Where necessary, reference is made to the component blocks or sub-blocks within a region to help understand the performance of its fishery, with a proviso that the annual catch was 10t or more in any one of the years since 2000.

The zones, regions and statistical blocks from which the 2010 commercial catch was reported or which are referred to in this document are shown below (Figure 1; for sub-blocks see Appendix 11: Maps of catch-reporting blocks and sub-blocks). Note that there were changes to the Northern Zone and Bass Strait Zone boundaries in the Furneaux Group in 2010. For information about charts of catch, catch rates and median length, see Appendix 2: Preliminary assessment of the fishery, Appendix 3: Interpreting graphical information.

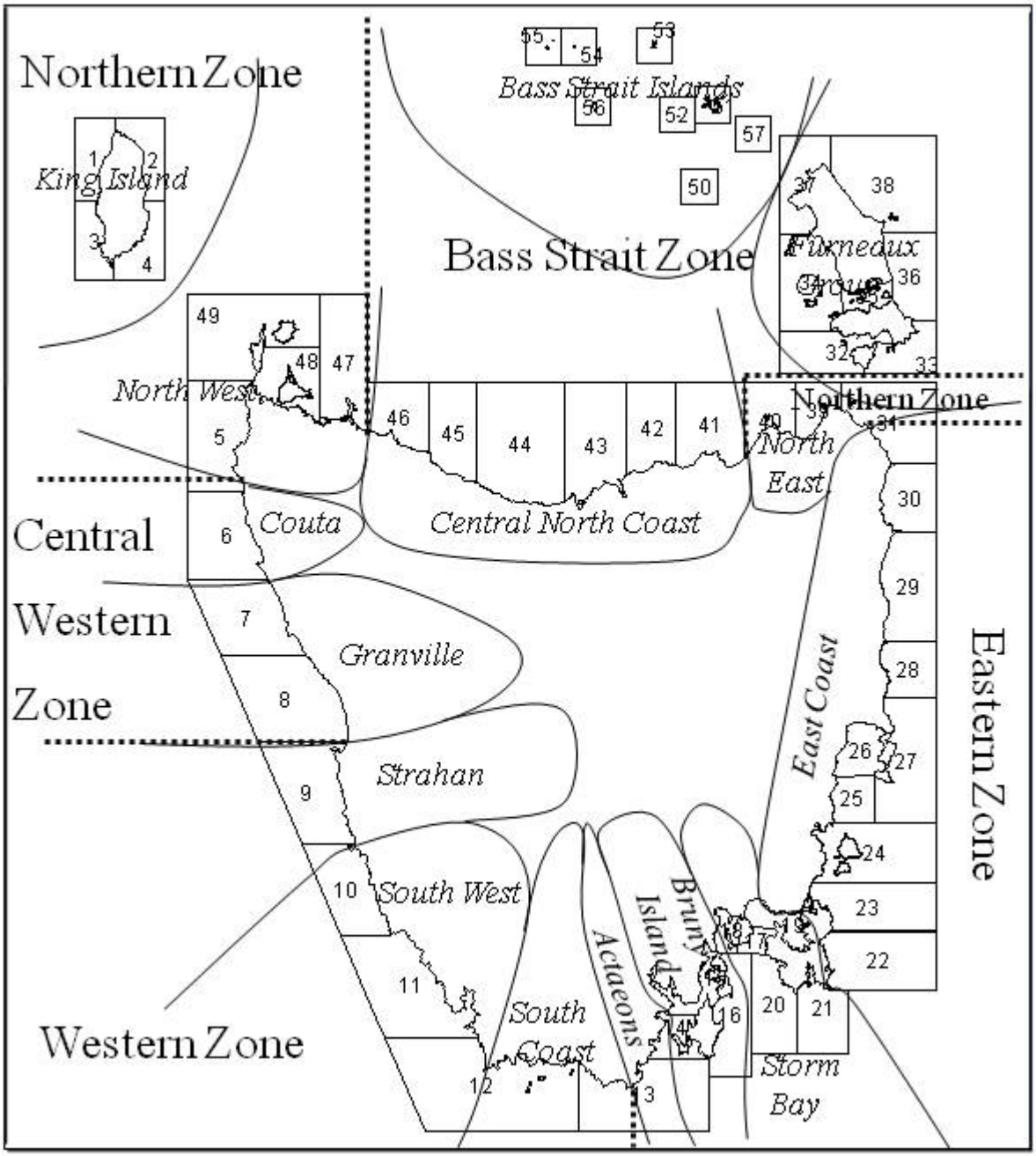


Figure 1. Zones and statistical blocks used in the Tasmanian abalone fishery in 2010. Also shown are the regions used for assessment purposes in this document. Zone boundaries are shown as dotted lines. The greenlip fishery has no geographical boundaries, but mostly takes place on coasts included in the Northern and Bass Strait Zones. The boundaries of the Bass Strait and Northern Zones around the Furneaux Group were changed in 2010. More detailed maps of catch reporting areas are shown in Appendix 11.

The zone boundaries and their reporting blocks for the 2010 fishing year were as follows:

Zones (blacklip fishery)
Eastern Zone:
Whale Head to Great Musselroe River, Sub-blocks 13C, 13E, 13E, Blocks 14 to 30, Sub-block 31A.
Northern Zone:
Great Musselroe River to Anderson Bay, Cowrie Point to Arthur River including King Island, Sub-block 31B, Blocks 39 to 40, Blocks 47 to 49, Sub-blocks 5A, 5B, 5C.
Bass Strait Zone:
Central North Coast: Cowrie Point to Anderson Bay, Blocks 41 to 46, remote Bass Strait Islands: Blocks 50 to 57, Furneaux Group: Blocks 32 to 38.
Central Western Zone:
Arthur River to Ocean Beach, Sub-block 5D, Blocks 6 to 8.
Western Zone:
Ocean Beach to Whale Head, Blocks 9 to 12, Sub-blocks 13A, 13B.

The greenlip fishery has no spatial boundaries but is restricted by the natural distribution of greenlip to waters north of the Great Musselroe River in the east and Cape Grim in the west.

Regions
The regions used for blacklip assessment purposes in this document comprise the following reporting blocks:
Actaeons (and lower Channel): Sub-blocks 13C, 13D, 13E, 14A, 14B
Bruny Island: Sub-blocks 14C, 14D, 14E, Blocks 15 and 16
Storm Bay: Blocks 17 to 21
East Coast: Blocks 22 to 30, Sub-block 31A
North East: Sub-block 31B, Blocks 39 and 40
Furneaux Group: Blocks 32 to 38
Bass Strait Islands: Blocks 50 to 57
Central North Coast: Blocks 41 to 46
King Island: Blocks 1 to 4
North West: Blocks 47 to 49, Sub-blocks 5A, 5B, 5C
Couta: Sub-block 5D, Block 6
Granville: Blocks 7 to 8
Strahan: Block 9
South West: Blocks 10 to 11, Sub-block 12A
South Coast: Sub-blocks 12B, 12C, 12D, 13A, 13B

The greenlip fishery is reported from the *North West* (Blocks 5, 48B, 48C and 49), *King Island* (Blocks 1 to 4), the *Furneaux Group* (Blocks 32 to 38), the *North East* (Blocks 31, 39 and 40) and *Perkins Bay* (Blocks 47, 48A). Small catches are occasionally reported from the *Central North Coast* (Blocks 41 to 46) and the remote *Bass Strait Islands* (Blocks 50 to 57).

This document contains charts of annual total catch and geometric mean catch rates, catch-rate distributions and annual median length. Important details about the use of these charts and the data from which they were produced are summarised here (a more detailed explanation may be found in Appendix 3: Interpreting graphical information):

- The catches from all reported catches between 1975 and 2010 (inclusive) were used to estimate annual total catches i.e. no catches were omitted. The catch and effort database is known to contain duplicate, incorrect and incomplete records. These records are difficult to detect, but are corrected when they are encountered. Consequently, there may be minor variations in annual catch reported in these documents from year to year. (See Appendix 8: Treatment of errors in catch data in 2010 for details of recent corrections.)

- 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, by the diver, per landing. Estimated weights by block are unavailable for this period, which means that catches taken from several blocks in one trip may be reported as caught from one of those blocks. Since 1992, *estimated* weights by block have been used, to enable the best spatial resolution of catch. The sum of estimated weights by zone is usually within 2-3% of the sum of landed weights by zone, but between 1992 and 1995 was up to 10% less.

- Annual catch rates were derived from the geometric mean of individual catch rates, and all mean catch rates referred to in this document are geometric means. Geometric means are more reliable estimators of the mean catch rate across all divers than arithmetic means (averages), because they are less affected by variable skewness of distributions (e.g. where there are small but variable percentages of high catch rates), and the standard error of the geometric mean is smaller than that of the arithmetic mean. Only catch rates from catches of 40kg or more were considered when calculating catch-rate means (to reduce the effects of fishing events that were adversely affected by mechanical breakdown or calculating catch rates on the by-catch of fishing for different species).

- Catch-rate distribution charts show the distribution of catch rates across all divers i.e. the proportion of daily records having catch rates in categories grouped from low to high. By comparing the distribution of catch rates between recent years, it is possible to see where changes in catch rate have occurred, and the effect that they have had on the mean catch rate.

- The annual median length of abalone, when viewed as a time series of data, is used to show changes in the length of abalone which may reflect changes in fishing pressure or levels of recruitment. Between 1998 and 2000, median length was derived from length measurements obtained from photographs of 25 abalone taken from divers' catches, photographed aboard divers' boats. Since 2000, median lengths were derived from samples of 100 measured abalone randomly selected from individual catches, and in most cases, sampling has been undertaken at factories. Since 2008, sampling has been undertaken by the larger processors on behalf of IMAS. As a rule of thumb, median lengths are deemed useful when more than 4% of catches in a reporting area have been sampled, although in the less productive blocks where relatively few catches are landed, a much higher proportion of sampled catches is required to produce reliable information.

- The performance measures (catch, catch rates and median length) for each region of the fishery were assigned a status (stable, rising, falling and erratic or no data), and an initial assessment made (Appendix 2: Preliminary assessment of the fishery). The regional assessments were combined and presented as a draft fishery assessment to panels of divers and other industry participants at meetings in Hobart and other regional centres, where the status of performance measures was reviewed. The initial assessments were subsequently modified where it was apparent that the performance measures reflected changes caused by factors other than changes in stock levels, and a final assessment was developed.

Total landings and gross revenue

At the end of 2010 annual totals of reported landings comprised 2526.8 t of blacklip and 132.7 t of greenlip, a total of 2659.5 t from a TAC of 2660.0 t (Table 1). Total landings increased in 2010, attributable to TAC increases of 46.5 t in the Eastern Zone and 10.5 t of greenlip.

Table 1. 2010 landings by zone, in tonnes

Zone	2010 TAC	2010 Landings (tonnes)
Greenlip	133	132.666
Eastern Blacklip	896	891.156
Northern Blacklip	332.5	330.967
Western Blacklip	924	932.155
Central Western Blacklip	304.5	303.094
Bass Strait Blacklip	70	69.412

Processor returns showed that the 2010 catch had a gross landed value of $104.3 million, up by $11.3 million from the previous year. Blacklip beach prices were stable until the last quarter, when weak demand for live product and large volumes of landed catch caused prices to fall. Canning blacklip (Northern Zone, Bass Strait Zone) prices were less affected (Figure 2).

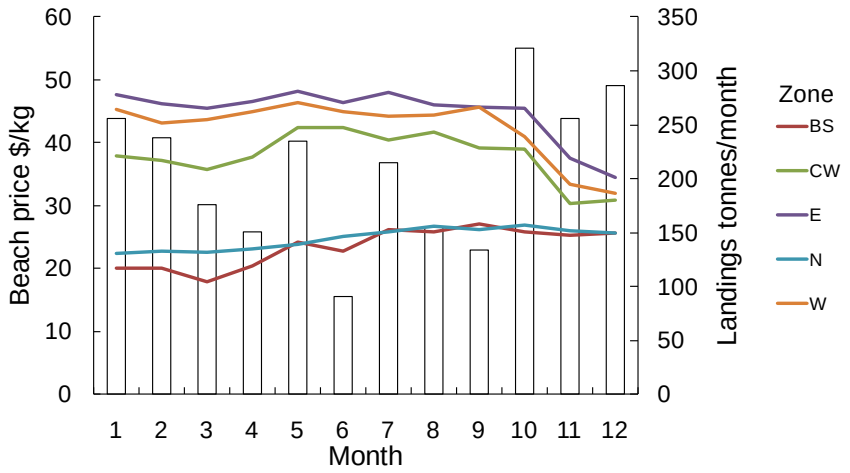


Figure 2. Monthly trends in average beach price for blacklip abalone, by zone. Bass Strait (BS) and Northern Zone (N) abalone were predominantly used for canning; Eastern (E), Western (W) and Central West (CW) Zone abalone were mostly sold to the live market. Greenlip beach prices followed a similar trajectory to Eastern Zone prices.

Royalties collected by the Tasmanian government increased by $1.0 million to $7.2 million in 2010 as a result of higher beach prices and the increased TAC.

Assessment of the Tasmanian abalone fishery

Eastern Zone

Actaeons and Lower Channel (Sub-blocks 13C, 13D, 13E, 14A, 14B):

Fishery-dependent data
There was a minor (5 t) increase in catch in the region, to 365 t. The Actaeons capped area (sub-blocks 13C, 13D and 13E, cap set at 340 t) was closed in mid-September by which time the catch had reached 342 t. Like previous years, most catch was reported from 13E (275 t), with 29 t and 38 t reported from 13D and 13C respectively. Further north the catch from sub-blocks 14A and 14B was also capped to protect stocks should there be a large transfer of effort from the Actaeons following its closure. However the fishing was so poor that most divers avoided 14A and 14B and consequently only 24 t of the 30 t cap was caught (17 t was taken from 14A and 7 t from 14B).

Regional catch rates fell sharply from approximately 85 kg/hr, where they had been since 2007, to 69 kg/hr in 2010. The highest catch rates were reported from 13E (73 kg/hr), and the lowest in the Lower Channel sub-blocks 14A and 14B (46 kg/hr, 35 kg/hr).

In previous years Eastern Zone catch rates were generally at higher levels in the cooler months, falling away in late spring and then recovering later in the following autumn. This pattern is likely to be associated with rapid seasonal growth of recruits during summer and autumn, recovery of fish condition following spawning, and a reduction in kelp coverage over winter which increases catchability. At the Actaeons in 2010 there was a small increase in catch rates in June, but generally catch rates trended downward (Figure 3). Almost one third of the catch was taken in January at high catch rates (81 kg/hr), but they did not recover to this level during the year, and at the time of the closure had fallen to 65 kg/hr. It is likely that January's 102 t catch took much of the stock before it had the chance to gain weight either through recovery from spawning, or through seasonal growth, and that as a consequence, a substantially higher number of fish were removed than if they had been caught later in the year.

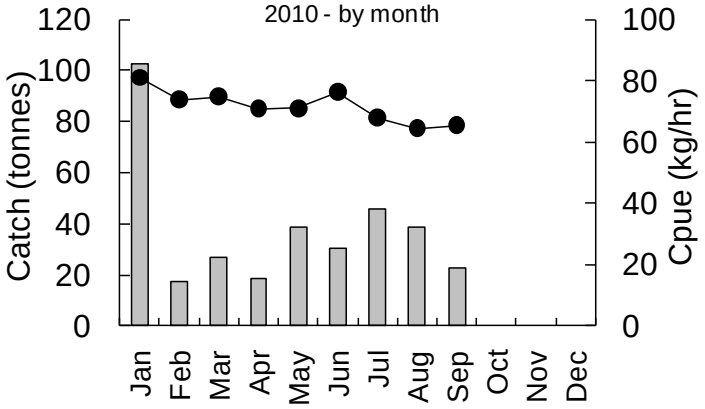


Figure 3. Monthly catch and catch rates, 2010, Actaeons capped area (sub-blocks 13C, 13E, 13D).

The size of fish sampled from 13C and 13E catches has trended downwards during the last three years, with smaller median and 75th percentile sizes. In both sub-blocks, more

than 15% of the catch was measured. In other sub-blocks, there were no clear trends in size.

Diver perceptions
Divers reported that they had noticed smaller fish, and have been forced to measure fish more often than in recent years. In parts of the Actaeons so much measuring was required that their catch rates were reduced and they avoided some areas where small fish were more prevalent. Many believed that the quantity of small fish was indicative of both strong recruitment and high fishing mortality impacting on growth.

To varying degrees, divers attributed the stock decline to a warm water event in late February and early March 2010. During calm sunny weather, they reported that water temperatures in the shallows reached 20°C. At the margins of the shores, many abalone were found only weakly attached to the reef; others were found detached and upside down and either dead or dying. The most common size of dead abalone was said to be within 10mm either side of the size limit, but abalone of all sizes were affected. After the warm water event, empty shells were reported clustered in holes in the reef. Tests were conducted on samples of the dead abalone by DPIPWE. No abnormalities were found, and it was assumed that they had died from heat-related stress. The divers were of course unable to accurately quantify the amount of mortality, but estimates ranged between hundreds of kilograms to many tonnes of abalone.

Divers said that fishing was best at the start of the year when large amounts of abalone were landed. The increased landings were due to high beach prices and strong demand to fill orders for the Chinese New Year. By spring, the fishing had become a lot slower. However, they believed that the region was still fishing better than the East Coast or Bruny Island, and questioned why the Actaeons was closed in October, yet fish stocks were clearly under greater pressure elsewhere.

Qualitative assessment
In recent years, IMAS has monitored coastal water temperatures at a limited number of sites around Tasmania. A temperature logger has been installed at George III Rock (approximately three kilometres north-west of Actaeon Island) at a depth of seven metres, initially on an intermittent basis, since September 1999. A chart of annual temperature cycles is shown below (Figure 4).

In 2010, the logger was set to record temperatures at two-hourly intervals. In mid-February 2010, logger temperatures were above 18°C on three occasions (maximum 18.2°C), and for extended periods of up to eleven days in February and March, temperatures did not fall below 17°C. Whilst approximately one degree warmer than previous years for which data were collected, these temperatures are not outside the range of temperatures known to support blacklip abalone population elsewhere.

A number of abalone growth studies have been conducted by abalone researchers from IMAS, TAFI, and the fisheries research divisions of the state government at the Actaeons, particularly at George III Rock, but also at other sites including Actaeon Island, Sterile Island, Black Reef and at the Breaks. There appears to be a difference in growth rates between studies conducted prior to 2007, and studies conducted thereafter. The growth parameters of abalone from both Black Reef and the Breaks were smaller than expected, particularly as the Breaks had a reputation for producing larger abalone than usual for the region. At Georges III Rock where there is a time series of growth

studies, abalone from the most recent (2007) study grew more slowly, and to a smaller size than in earlier studies. This change in growth parameters implies that there may have been a reduction in net productivity in the region, although there is no understanding of why this should occur.

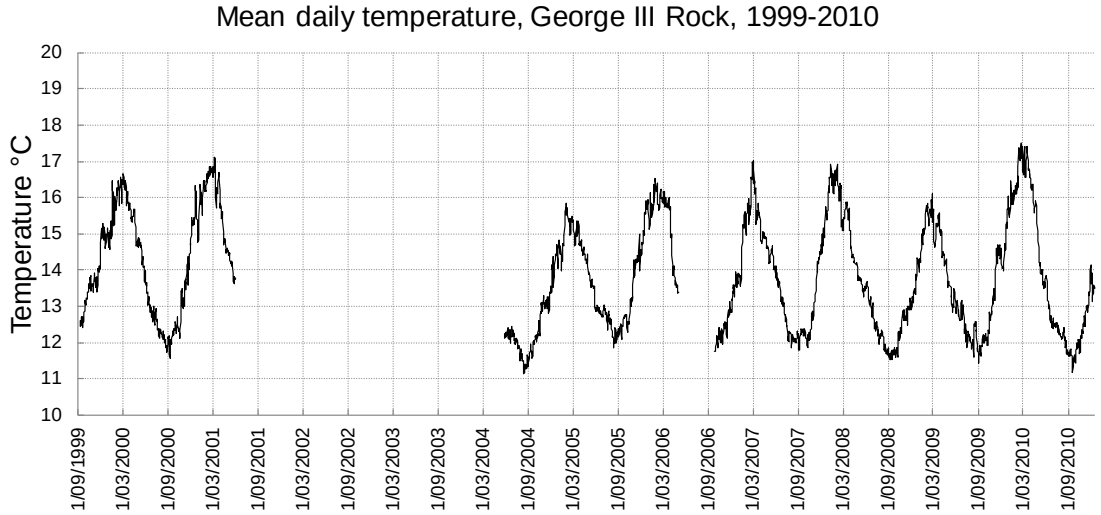


Figure 4. Mean daily water temperature (°C), September 1999-December 2010 at George III Rock, south-east Tasmania. The logger was positioned one metre above the reef at approximately seven metres depth. Gaps in daily temperature are due to lapses in the data collection program. The chart shows that mean daily temperatures typically ranged between 11.5°C and 17°C each year.

The catch and catch-rate performance measures showed that this part of the fishery was fully exploited. Because catch has been capped at 340 t from 2008 in most of this region, falling catch rates almost certainly reflect lower stock levels.

The almost continuous decline of catch rates throughout the year indicates insufficient recruitment to the fishery for the level of catch. In conjunction with the falling catch rates, smaller median sizes were interpreted to mean that fishing mortality has been high, so that fish have less opportunity to grow prior to capture, and are being caught at progressively smaller sizes. It may also indicate that recruitment fell, or that growth rates of fish became slower, both of which mean that productivity of the region was reduced.

Bruny Island (Sub-blocks 14C, 14D, 14E, Blocks 15 and 16):

Fishery-dependent data
The Bruny Island catch has more than halved in the last 10-year period, falling from 221 t in 2001, to 86 t in 2010. A catch cap of 70 t was set in 2010, but not implemented to prevent the transfer of effort onto equally or more vulnerable stocks elsewhere. Catches have fallen in all sub-blocks, although less so closer to Dover (14C, 14D).

Catch rates in the region rose from a low of ~50 kg/hr between 2002-2004 to more moderate levels (~75 kg/hr) between 2006 and 2009. In 2010 they fell sharply, from 77 kg/hr in 2009, to 48 kg/hr in 2010. In the south-eastern part of the island (Boreel Head, the Friars etc.) where concern was raised about falling catch rates in the 2009 assessment, catch rates fell by 25 kg/hr to 42 kg/hr (14E), and by 22 kg/hr to 54 kg/hr (16A). On the eastern side of the island, catch rates fell from 78 kg/hr to 44 kg/hr (16C) and from 73 kg/hr to 51 kg/hr (16B).

While catch rate declines of these proportions indicate large stock declines, they were exacerbated by a shift in effort to the region after the closures of the Actaeons and Block 22 in October. The monthly catch chart shows that effort intensified and almost half the catch was taken after these closures (Figure 5).

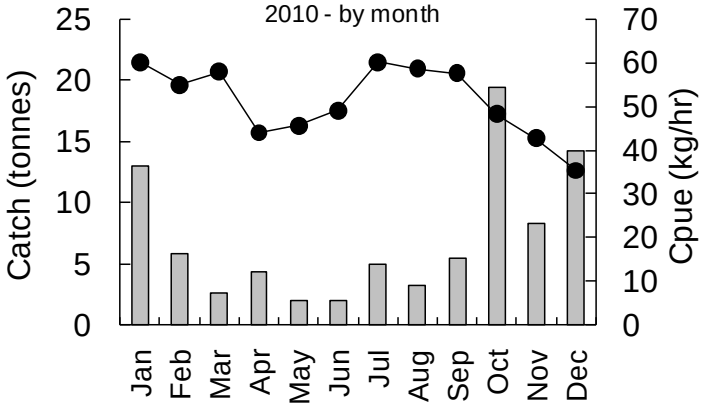


Figure 5. Monthly catch and catch rates, Bruny Island (Blocks 14C, 14D, 14E, 15, 16).

Monthly catch rates show high variability at low levels of catch (i.e. February to September) and should be disregarded, but when catch levels are higher (>10 t), there is less likelihood that catch rates reflect individual divers or weather patterns, and are more likely to indicate changes in abundance.

The size of fish tended to increase in some sub-blocks (16A, 16C and 16D), with no clear trend in 14E and 16B, while the size of fish trended smaller in 14D.

Diver perceptions

There was widespread concern at the low catch rates, particularly at the end of the year. Many expressed disbelief that divers would continue to fish south Bruny when the divers (and processors) knew that they would probably catch 150kg or less per day, and that they did not move elsewhere. They could not understand why managers let the Bruny fishery decline to such a level after the closure of the Actaeons, and said that in future, Actaeons closures should be accompanied by simultaneous Bruny closures.

On the eastern side of Bruny (Block 16), divers with good local knowledge were able to maintain better catch rates by fishing reefs that they knew would consistently produce fish. However, by the end of the year, catch rates had declined on these reefs as well.

There were no reports of natural mortality like those received from the Actaeons.

Qualitative assessment

The annual catch from the Bruny region has undergone a major decline in the last 10 years. Recent annual catch totals from Blocks 14, 15 and 16 are approximately half the size that they were in the years prior to zoning (2000), and approximately one quarter of the size that they reached during the years prior to quota management (1985). This part of the Eastern Zone fishery has lost the capacity to produce the level of catch expected of it, and it appears that the area of economically productive reef has been considerably reduced.

In the east catch rates have fallen sharply from 2009 levels, and in the southern sub-blocks catch rates are in a sustained decline that has continued over several years. The 2009 catch-rate increase in 16B, 16C and 16D appears to have been a response to reduced effort and not improved stock levels. The 2010 decline in catch rates between January and December indicates inadequate recruitment. Most divers considered 50 kg/hr catch rates as a threshold "break even" level in the Eastern Zone, and considering that mean catch rates were at or below that threshold across much of the region, many divers would have suffered a financial loss fishing there in 2010.

The combination of declining catch and catch rates is a strong indicator that stock levels have fallen. In conjunction with an increase in size of fish, these trends are interpreted to mean that fishing mortality was very high, that recruitment has been reduced in recent years, and that stock levels were low.

Storm Bay (Blocks 17-21):

Fishery-dependent data
The Storm Bay catch rose by 18 t, to 142 t in 2010, approximately equal to the recent 10-year average (148 t). Catches were substantially higher in the south; in 20C (26 t), and near Port Arthur in 21A (18 t), and 21C (40 t). Catches were lower at Nubeena and further north; in 17B (Blackjack shore) the catch fell to 8 t, and between there and White Beach (20A), the catch was 9t.

Regional catch rates fell from a steady 4-year range of 80 - 90 kg/hr to 69 kg/hr. Almost all sub blocks had catch rate declines of more than 20 kg/hr, more so in the north, (17B, 20A, 20B, but also 21A), while 20C and 21C were least reduced.

Effort increased sharply in the last quarter of the year, particularly in Block 21 (Port Arthur). Divers worked deeper in this period, and in December, one third of all effort was spent at depths of 10m or more, and of that, one quarter was spent at depths >20m (Figure 6).

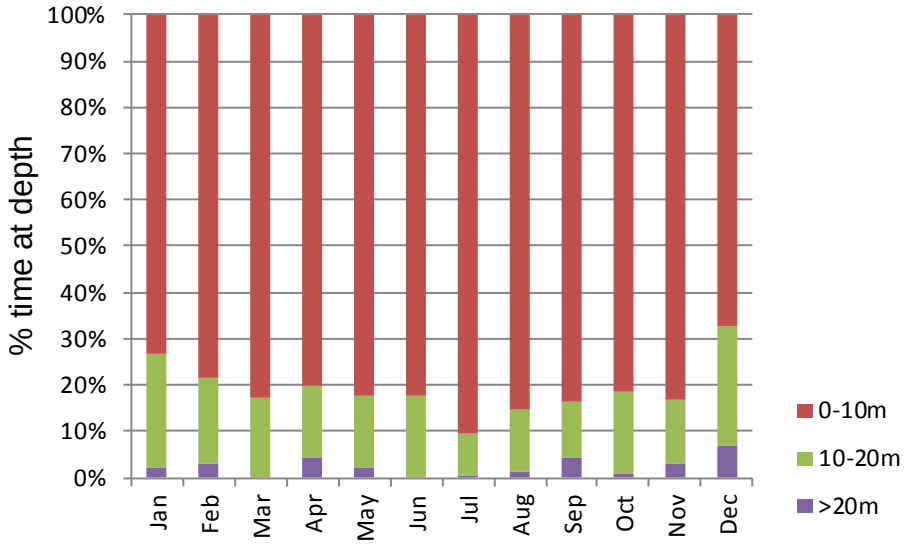


Figure 6. Percentage distribution of effort, by month, by depth stratum, Storm Bay (Blocks 17-21) 2010. In December divers increased effort in deeper water.

The size of fish, particularly the median and 75th percentiles of length continued to increase in most sub-blocks, as it has done in previous years.

Diver perceptions
During the first few months of the year, fishing in this region appeared to be as good as the previous year, with plenty of fish and moderate to high catch rates. Catch rates of over 100 kg/hr were common on both shallow and deeper reefs. However, during the colder months the fishing deteriorated as it became evident that much of the coast was not recovering sufficiently from fishing and high-catch-rate days became less common. Fishing intensified in Storm Bay following the closure of the Actaeons in October. At the end of the year many divers worked deeper water in Block 21 from Port Arthur and were able to get moderate to high catch rates on less frequently fished deep reefs. The size of individual landings was reduced by the limited time available at depth.

There were no reports of natural mortality like those received from the Actaeons.

Qualitative assessment
Fish stocks have been reduced in all parts of the region, but more so near Nubeena and further north. Towards Cape Raoul (20C) and in Maingon Bay (21A, 21C) catch and catch rates indicated that stock levels were higher, but were still substantially lower than previous years. In conjunction with falling catch rates, the increasing size of fish is assumed to mean that recruitment levels continued to fall in 2010.

East Coast (Blocks 22 to 30, Sub-block 31A):

Fishery-dependent data
The East Coast catch continued to increase, reaching 294 t in 2010. In a long-term context, this is not particularly large, but it is 40 t larger than the recent 10-year average. Approximately quarter of the catch came from each of Block 31 (Eddystone Point and northward - 67 t), Block 22 (Tasman Peninsula - 73 t), and Maria Island and the Forestier Peninsula (Blocks 23 and 24 – 87 t). The Freycinet-Bicheno region (Blocks 26-29A) produced an unusually low catch (52 t), and the balance of the catch came from the St Helens region (29B to 30A – 14 t).

Mean annual catch rates fell sharply across the entire region. In Block 31 where fishing pressure has been negligible for many years, the fall was least, and the mean catch rate was 101 kg/hr. Elsewhere catch rates fell by between 30% and 50%. In Block 22 catch rates were 62 kg/hr, in the Maria-Forestier region 57 kg/hr, and at Freycinet-Bicheno, 49 kg/hr.

Monthly catch rates were affected by lack of consistent effort and were consequently highly variable, but showed a persistent downward trend throughout the year ending at or below 50 kg/hr in December.

The size of fish increased in 22B, fell in 31A and exhibited no clear pattern in other areas.

Diver perceptions
By early March 2010 divers were reporting that the East Coast fishery was in trouble, with poor catch rates and consequently reduced daily landings. By winter, when catch

rates should have peaked, many divers had difficulty landing 200 kg per day, and it became evident to all that fishing would only get worse from thereon.

The areas that appeared to cause most concern were Maria Island (Block 24), the eastern side of the Forestier Peninsula south of Dunalley (Block 23), the Freycinet Peninsula (Block 27) and Seymour/Long Point (29A). Many fishermen relied on these areas to supply fish during the cooler months, and were forced elsewhere, which impacted on those stocks. For most of the year, Block 22 (Eaglehawk Neck) fished better than other areas, but in December was particularly poor, and the only reason divers fished there was because processors would collect fish from either Eaglehawk Neck or Port Arthur (Block 22), and fishing from Port Arthur was often not practical because of poor weather conditions.

For the first time in many years substantial quantities of fish were landed from Block 31 (north of Eddystone). This area has not produced significant quantities of fish since 2001, when an earlier downturn in Eastern Zone stocks forced divers there. To make the area more attractive to divers in July 2010 the State government issued divers with permits to take fish in the northern half of Block 31 at a smaller size (132 mm) instead of the normal 138-mm limit. In stark contrast to the rest of the Eastern Zone, divers reported excellent fishing with abundant stocks on most reefs. In places they had to selectively fish to maintain quality, but generally processors accepted the fish without complaint and a high proportion of the fish landed were of quality suitable for live export. A number of divers reported that they were asked to fish at the higher size limit in the north because of buyer resistance to the smaller fish. They said that they were able to maintain high catch rates, despite fishing at the higher limit.

In 2009, catch rates increased in nearly all productive areas of the East Coast region (reporting blocks with >10t catch p.a.) to between 80 and 100 kg/hr, against the prevailing downward trend of the previous few years, and prompted speculation by industry that stock levels had increased. That the reverse should occur has created considerable confusion, and prompted discussion about the cause of the stock decline.

The following points were noted regarding the decline:

- Divers remained concerned about the presence of the long-spined sea urchin *Centrostephanus* and its destructive effect on abalone habitat. *Centrostephanus* was reported widespread between Eddystone Point and Tasman Island, but much less common in Block 31.
- A diver reported seeing dead abalone in shallow water early in the year at Maria Island, at the same time that abalone were reported dying at the Actaeons, and some divers speculated that the warm-water die-off was more widespread in the Eastern Zone than initially thought. Other divers refuted this, and said that the quantity of empty "dead" shells was the same as they had seen in previous years.
- Some divers raised the possibility of a recruitment “hole”, a consequence of low abundance and egg production between 2000 and 2003.
- Many said that the 46.5 t TAC increase coupled with the Actaeons closure in October exacerbated the problems caused by the stock decline, and called for better management of caps to limit fishing in depleted areas.

Qualitative assessment
In all parts of the East Coast except Block 31, it is apparent that stock levels have been severely reduced. It is now evident that the size of the 2010 catch was too large for the region.

Abundance levels were higher in Block 31 than elsewhere, and effort was transferred there. To meet the TAC, it is likely that a similar amount of catch will be required from this block in 2011. Much of Block 31 abalone was of lower quality and not suited for export as live product. Because of quality concerns, and its distance from the south-east, it seems that processors will accept fish from here only as a last resort.

Central West Zone

Couta Rocks Region (Sub-block 5D and Block 6):

Fishery-dependent data
The catch from Block 6 increased to 151 t, up 8 t over the previous year. The 6D catch was capped with the Block 7 and 8 catch, was closed to fishing in November, and was lower than previous years at 23t. Effort intensified in the remaining sub-blocks, particularly 6C and 6B. The 6C catch increased by almost threefold to 55 t, the 6B catch rising from 23 t to 37t.

In 6A, 6B and 6D, catch rates were stable or fell slightly to 123 kg/hr. In contrast, there was a sharp increase in 6C catch rates to 155 kg/hr.

The size of fish was similar to previous years in 6C, but in the other three sub-blocks, fish were smaller.

Diver perceptions
Divers reported good fishing in this region. In particular, the short stretch of coast between the Gannet and the Sandy Cape beach (sub-block 6C) fished unusually well, which divers attributed to higher than normal levels of recruitment. The catch in 6C was high, in part because of the good fishing, but also because the fish were of better quality there, and after the cap closure in the southern half of the zone (including Sandy Cape), processors preferred the 6C fish to those from 6A and 6B. Some divers were asked to fish 6C with a larger (than legal-) size measure because of market preferences, and they said that their catch rates were not greatly affected.

In the northern sub-blocks particularly 6A where fish were generally smaller and of lesser quality, divers found it more difficult to supply high grade fish. This reduced effort in 6A and caused a reduction in catch rates there. In 6B, fishing at Couta Rocks and in its immediate vicinity was as good as ever and many divers would have fished there if processors had not directed otherwise.

Divers considered that stock levels were adequate throughout the region. Most were pleased that Sandy Cape (6D) was receiving some respite after years of hard fishing. As a means to resolve the problems caused by capping the southern part of the Zone, they suggested that the Northern Zone boundary be moved south to the 6B/6C boundary, that all fish in the Central West be fished at 138 mm, and that all fish in 6B and 6A be fished at a smaller size appropriate for canning fish. They thought that because the fish

from 6C south to Granville Harbour were all of similar (live market) quality, this change would remove the need for a cap in the south of the zone.

Qualitative assessment
The small increase in catch in the region was not significant for assessment purposes. Apart from 6C, catch rates were generally stable or if lower, apparently reflected market pressures, not stock declines. In 6C catch rates and consequently stock levels appeared to be higher.

The size of fish in all sub-blocks was reduced (but less so in 6C) compared with 2009. In conjunction with stable or increasing catch rates, this might be attributed to increased recruitment (greater quantities of small fish). In this region however, there has been a change in the proportion of samples obtained from predominately live market versus canning market processors since 2008, and any changes in size were probably influenced by market preferences for different sizes and grades of fish rather than changes in the size of fish amongst the stock. For assessment purposes, this change in size of fish is therefore not significant.

From the evidence above, it is considered likely that stock levels in Block 6 were stable or had increased slightly in 2010.

Granville Harbour Region (Blocks 7 to 8):

Fishery-dependent data
The catch from 6D and Blocks 7 and 8 was capped at 150 t, and the region was closed to fishing in November when that limit was reached. The catch from the Granville region (Blocks 7 and 8) was 147 t, 11 t less than the previous year, but approximately 50% more than the recent 10-year average of 94t. The catch from Conical Rocks (7B) and the coast immediately south of Granville Harbour (8A) increased to 84 t and 26 t respectively, but fell in other sub-blocks.

Regionally, catch rates declined for the second successive year, from 153 kg/hr to 124 kg/hr. Catch rates were lowest north of the Pieman River in 7A (116 kg/hr) and highest closer to Trial Harbour in 8B (128 kg/hr). The CPUE distribution shows a marked reduction in higher catch rate categories (>150 kg/hr) and a corresponding increase in lower catch rate categories.

There was a downward trend in monthly catch rates throughout the year, from a high of over 150 kg/hr in February, to 115 kg/hr in October when 40 t was caught.

Since 2008, the median size of fish has increased, reaching 163 mm in 2010.

Diver perceptions
Divers reported good fishing from Granville Harbour, although most thought that it was not as good as the previous year, and that there were obvious signs of high fishing pressure throughout the region. In particular, they said that Conical Rocks (7B) and Rupert Point (7A) were both heavily fished, and as a consequence, catch rates and stock levels had declined.

They repeated earlier observations that the reef area in this zone was not extensive, and did not extend far from the shore. This meant that (a) catch rates fell sharply during

periods when wave heights exceeded two metres and drove divers offshore, and (b) there was a comparatively limited area from which the catch could be taken.

The fish in this region were considered to be of better quality than fish from Couta Rocks, and most processors tried to obtain their Central Western Zone fish from Granville Harbour. This preference for fish has led to the development of the cap for the region, which after high levels of fishing activity during each suitable weather pattern, has led to the closure of the region relatively early each year. Some divers are concerned that this intensive fish-down of stocks temporarily denudes the reef of abalone, enabling other organisms to fill the void created by their absence and potentially changing it to habitat less supportive of abalone populations. They say that steady fishing of abalone throughout the year (i.e. no cap) would better protect abalone populations.

It was suggested that the zone boundary be moved south to what appears to be a natural live vs canned market boundary at 6C, and the TACs adjusted appropriately. A common size limit could be applied throughout the new Central West Zone, and the need for a cap eliminated. The fish in 6A and 6B could be fished at the Northern Zone size limit.

Divers said that previously they would avoid taking larger fish, particularly from places where they grew particularly large such as Rupert Point or the cliffs north of Trial Harbour. In 2010 the competition for fish from the region was strong, and there was no size-selective fishing.

Qualitative assessment
Since the development of the Central Western Zone, the catch has been at very high levels. When the zone was initially established, it was purposefully set high, both to transfer effort away from the South West, and because it was recognised that low levels of effort had enabled stocks to build up, particularly in areas not regularly fished by local divers.

In Block 6 (Couta Rocks region), apart from 6C, catch rates were generally stable or if lower, apparently reflected market pressures, not stock declines. In 6C catch rates and consequently stock levels appeared to be higher. From the evidence above, it is considered likely that stock levels in Block 6 were stable or had even increased slightly in 2010. There appears to be a rapid increase from north to south in size at maturity, maximum size and growth rates in this block, and the southern sub-blocks (6C, 6D) may be under-protected by the size limit as applied under the two-year rule of thumb.

Further south in Blocks 7 and 8 (Granville Harbour region) catch rates have fallen for two successive years, from high to moderate levels, and it is clear that the built-up stocks have become depleted. The increase in size of fish is attributed to the abandonment of the practise of selectively avoiding larger fish, and is not seen as an indication of low recruitment or low fishing pressure. Stock levels in the region have fallen, and fishing at the current rate is likely to further reduce stocks. There is no information that stocks have become depleted to levels that should concern managers, but any further falls in catch rates would indicate that too much catch was being taken from the area.

Western Zone

Strahan Region (Block 9):

Fishery-dependent data
Total catch was estimated at 159 t, slightly less than the 166 t cap. The catch was evenly divided between 9B and 9C (less than 1 t of catch was taken from 9A).

Regional catch rates were 154 kg/hr, reverting to the 10-year average (151 kg/hr) after reaching 170 kg/hr in 2009. Catch rates were slightly higher in 9C (160 kg/hr) than in 9B (152 kg/hr).

The percentage of size-sampled catches was very low in 2010, barely reaching the 4% threshold. The size of fish was relatively small in both sub-blocks (median length 151 mm in 9B, 153 mm in 9C).

Diver perceptions
Divers thought that catches and catch rates were at acceptable levels. They said that they usually experienced good fishing in Block 9 in 2010, and that while catch rates were better in 2009, this was due to unusually long periods of flat sea conditions. In addition, in 2010 there were large amounts of uncaught quota towards the end of the fishing year which required divers to work in less than optimum conditions, thus reducing catch rates.

At times, the size of daily landings was constrained by the capacity of the market to take fish, and in the cooler months, processors wanted fish landed by early afternoon (so that their truck drivers could avoid frost and ice on the Lyell Highway), thereby limiting the hours that they could work.

Divers said that fishing was much better on the recovery bottom (i.e. reef which supported high numbers of recruits) than in places which formerly supplied larger fish. Many of the “large fish” places and offshore reefs that could be worked in moderate sea conditions had become depleted to the extent that they were no longer worth fishing.

They thought that the 166 t catch cap was the correct amount of catch for this block.

Qualitative assessment
The catch was stable. While there was a reduction in catch rates, they remained at moderate to high levels, and in consideration of the conditions reported by divers under which much of the catch was taken, indicated that stock levels on inshore reefs were stable.

South West (Blocks 10, 11, Sub-block 12A):

Fishery-dependent data
The total catch was historically moderate (434 t), similar to the previous year (437 t), and substantially lower than the recent 10-year average (584 t). More catch was taken further north in Block 10 (158 t) and less than from 12A (31 t) than in 2009. Block 11 catch was unchanged at 245t.

Catch rates continued to rise from the 2008 low (114 kg/hr), reaching 128 kg/hr. Catch rates were highest in Block 10 (148 kg/hr), and lowest in the south in 12A (107 kg/hr). The catch-rate distribution shows a small shift towards higher catch rates.

South West catches are generally landed from a mixture of sub-blocks due to fishing multiple days and reducing the percentage of catches from which size-sampling can be collected to less than useful levels. Where the number of sampled catches was greater than threshold levels (10D, 11A), the size of fish varied erratically, and there were no clear trends.

Diver perceptions
Divers were confident that fishing in 2010 was better than the previous year, and that stock levels in the South West were increasing. They said that fishing had improved in the north of the region (Block 10), and that stocks there were at reasonable levels. Closer to Port Davey in Block 11, fishing was more difficult, and most divers thought that fishing was poor between Port Davey and South West Cape (12A).

Qualitative assessment
Catch levels have been reduced to approximately two thirds of the levels of catch taken between 2000 and 2008 which apparently caused extensive depletion. This catch reduction appears to have halted the catch rate decline, and catch rates increased for the second consecutive year. It is therefore likely that stock levels in the region, while remaining low, were stable or increased slightly in 2010.

South Coast (Sub-blocks 12B, 12C, 12D, 13A, 13B):

Fishery-dependent data
Once again, the South Coast catch was at historically high levels, with 314 t caught. The region was closed to fishing after the 300 t cap had been reached in early December.

In 2010, regional catch rates were 95 kg/hr. Catch rates have fluctuated in a tight range between 93 kg/hr and 104 kg/hr since 2002, but before then were substantially higher. The highest catch rates occurred in 12C (Maatsuyker Group) at 116 kg/hr and were 82-100 kg/hr in the other sub-blocks.

By month, catch rates fell in response to high levels of catch. Over the cooler months when successive monthly catch totals were below 30 t, catch rates recovered but quickly fell again after heavy fishing later in the year.

While the inter-annual median size of fish has been variable, it has generally trended smaller during the past 10 years. This variability continued in 2010, with larger fish in four out of the five sub-blocks, the exception being 13A.

Diver perceptions
Large catches have been taken from the South Coast since the development of zoning, because the South Coast fish are a high grade live market product, a large number of divers operate from Southport and Dover, and the region is close to Hobart and the south-east where most processors are based. For these reasons, divers said that they would continue to fish the South Coast at lower catch rates than they would tolerate elsewhere in the Western Zone.

There were mixed opinions about fishing on the South Coast. While all divers said that fishing pressure was high there, and that the small size of the fish was symptomatic of high fishing pressure, they were divided about the effect of high catch levels on stocks. There was a strong body of opinion that the South Coast could be fished hard compared with the South West because it recovered faster, due to the greater amount of cryptic habitat and fast growth rates. High catch levels and the presence of large numbers of small fish in catches in recent years appear to confirm this. However, there is an equally strong body of opinion that the high catch levels were relentlessly lowering stock levels, and that the small fish catches were indications that fish have an increasingly shorter amount of time to grow between recruitment and capture.

Fishing was become increasingly patchy. Generally fishing improved with distance from the boat ramps at Southport, and was best in the offshore islands near Maatsuyker (12C). Paradoxically there was sometimes surprisingly good fishing in South Cape Bay and other heavily fished places close to Southport, while often fishing to the west of Cox's Bight was more difficult.

Qualitative assessment
The annual catch has been high in recent years, at over 300 t. Since 2002 catch rates have been stable at moderate levels. The median size of fish has fallen during this period and indicates increased dependence on recruits, which means that stock levels would decline quickly should recruitment fall. This combination of performance measures suggests that stocks were stable or decreasing slowly. There is no evidence that these high catch levels are unsustainable, and while affecting catch rates and the size of fish, the fishery appears able to continue in perpetuity at the current level of catch albeit at a high level of risk.

Northern Zone

Most of the Northern Zone catch is taken from the North West, particularly from Block 5, which in recent years has been capped at 152.5 t. The remainder of the zone was by default capped at 180t.

King Island (Blocks 1 to 4):

Fishery-dependent data
The King Island blacklip catch rose to 72 t in 2010, approximately equal to its recent 10-year average. More than half of the catch (40 t) came from the west coast between Whistler Point and Ettrick River (1C, 3A), and 24 t was taken from Block 4 in the south east.

There have been recent changes to the distribution of effort at the standard reported depth ranges, particularly from the west-coast Blocks 1 and 3. Starting in 2003, divers reported increasingly greater amounts of time spent at depth > 10m and in 2007 > 65% of effort was spent in the deeper water (i.e.>10m). In 2009 and 2010 there was a shift in effort back to shallower water (Figure 7).

Catch rates have fallen from high levels since 2008, and in 2010 were 99 kg/hr. Catches are not reported by depth, but anecdotally, catch rates were higher in deeper water than in depths <10m.

Diver perceptions

Divers reported good fishing at King Island. The AVG quarantine issues were resolved so that a workable method of transferring live fish to mainland Tasmanian processors has been developed. In addition, limited sales were possible to a fish handling facility on the island. These factors have encouraged mothership operators back to the island.

Generally, divers found good fishing in shallow water. Divers believed that stock levels had mostly recovered from depletion following the large catches of 2004-2005. Shallow water fish were usually of better quality than those from the offshore reefs in deeper water, and were preferred by both live and canning markets. However fishing shallow water required settled weather patterns because sea conditions had a greater impact on fishing in shallow water than in the deep.

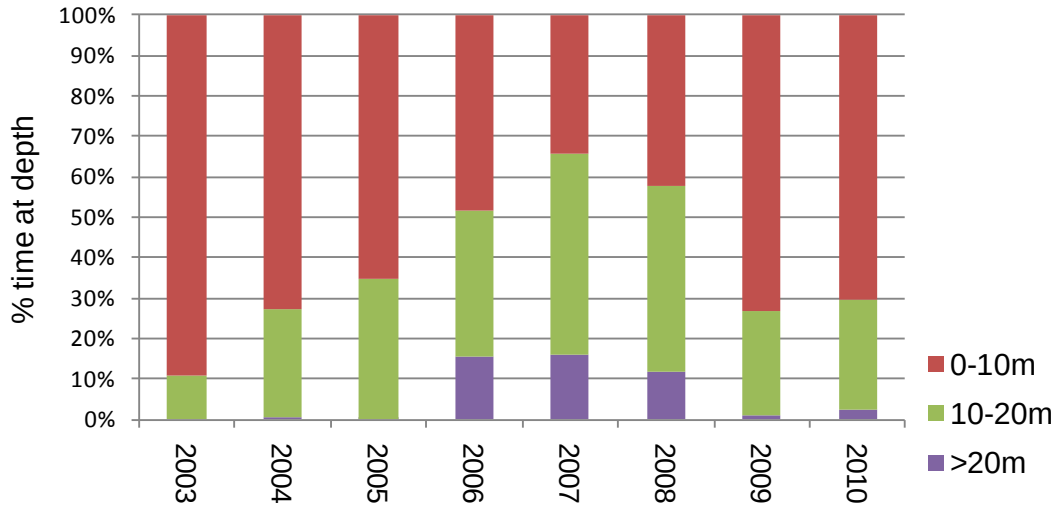


Figure 7. Percentage distribution of effort by depth category by year, King Island ‘s west coast blacklip fishery.

In deeper water, recovery from recent fishing has been slow, and it is apparent that the abalone from deep water populations are smaller sized and slower growing than in the shallows. There are also large quantities of small abalone between the Ettrick River and Cataraqui Point in shallower water which are too small for viable fishing under the current 127-mm size limit.

Qualitative assessment

The annual catch increased from a low level. This was not due to increased abundance, but was a result of the easing of restrictions on moving catch from the island to the Tasmanian mainland following the Victorian AVG outbreak in 2008, and an improvement in market demand. Catch rates fell for the second successive year but again, this was not purely a function of reduced abundance, but due more to a shift in the distribution of effort from deep water stocks where catch rates were high to the shallows where stocks were less abundant but more highly valued. Stock levels are assessed to be in the moderate to high level.

North West (Blocks 47 to 49, Sub-blocks 5A, 5B, 5C):

Fishery-dependent data
Since its inception most of the Northern Zone catch has been taken from the North West, although in 2010, its share had dropped from three quarters to two thirds of the zone TAC, at 212t. This was due mostly to a reduced annual catch from Block 5, which although capped at 152.5 t, only reached 132t. In particular, the 5C (Bluff) catch fell by 50% to 44t. In Block 49, the catch from Albatross Island (49B) also fell by 50%, to 21t. There were small increases in catch in 5A and 49C (Woolnorth/Trefoil/Hunter Island area) to 60 t and 36 t respectively.

Across the region catch rates fell from 100 kg/hr to 89 kg/hr. Catch rates fell in all sub-blocks producing 10 t or more, but remained in the moderate to high range, between 80 kg/hr (49C) and 111 kg/hr (5B). The distribution of catch rates features a complete shift in catch rates to the next lowest category.

Throughout the year, catch rates tended to fall for all months where 10 t or more was caught. At the end of the year after heavy fishing pressure during the last quarter, regional catch rates had fallen to 84 kg/hr.

Mapping of GPS logger data showed that effort was concentrated in three main regions: Trefoil (5A), West Point-Nettley Bay and Bluff Hill Point (5C), and that the coast between Trefoil and Nettley Bay was sparsely fished. Within the heavily fished areas logger data showed patterns of fishing consistent with spatial depletion of reefs. There was no evidence that divers were moving into inshore bays to fish smaller fish as a consequence of the size limit reduction from 132 to 127 mm.

In Block 5 the median length of fish sampled from divers' catches remained small. The length distributions of the sub-blocks were slightly smaller than in 2009, which in turn were larger than in 2008 when the reduced size limit under permit was first introduced. Since the size-limit reduction, the median size of fish has fallen by approximately 5 mm in all three sub-blocks. Over 20% of catches from all sub-blocks were sampled in 2010.

Sampling of smaller sized blacklip populations near Circular Head was undertaken by two divers operating under permit in 2010. They found extensive populations of very small abalone with median sizes between 88 and 96 mm at four sites, and slightly larger abalone (median size 111 mm) at a fifth site.

Diver perceptions
Total annual landings have been high in the North West in recent years. This has been driven by a number of factors: built-up stock levels since the large TAC reductions of the late 1980's, a desire to make use of the stocks in the fishery (size limit reduction and the development of the Northern Zone), improved access at Bluff Hill Point and Woolnorth and attempts to improve fish quality by thinning stocks.

In Block 5 particularly near Trefoil Island (5A) and near Bluff Hill Point (5C), fishing has been intensive, and catch rates have fallen. Local divers said that they regularly watched visitors from other parts of Tasmania fish areas only recently vacated by the previous week's visitors, which they say causes low catch rates. The visiting divers say they have a limited window of opportunity to catch fish and little time to find better fishing outside their known fishing grounds. They said that the quality of fishing away

from the Woolnorth, Bluff or West Point areas was variable. When they arrived in the North West with orders to fill, time was better spent in the water at the places they knew were productive, even at low catch rates, rather than driving up and down the coast looking for places with no certainty that they would do better.

Divers believed that the lower catch rates were also the consequence of a big decline in stock levels. They said that this was hardly surprising, because there had been a substantial reduction in the built-up stocks over the last ten years. While they felt that fish stocks were in no immediate danger, the high fishing pressure reduced the size of their daily catches and increased fishing costs. They did not want increased levels of catch directed to Block 5.

Divers saw no evidence of improvement in fish quality in areas where substantial thinning had occurred. They said that the recruits were as poor quality as the older fish that were removed. One diver reported that quality had deteriorated in the areas where he formerly caught good quality fish, despite high and ongoing levels of effort.

The size limit in Block 5 was reduced (under permit) to 127 mm in 2008. This was expected to make smaller inshore fish available to divers, and give respite to the heavily fished reefs yielding larger fish. Instead divers mostly stayed out of the small fish reefs. They said that the fish quality was too poor, and that the fish were unacceptable to processors. The area covered by the small-fish reefs was small, and limited to a few bays and inshore areas. Much of the coast between the Doughboys (5A) and Mt Cameron (5B) held no fish, no matter what size limit was used. In their opinion, the reduction of the size limit had not opened up new areas to fishing, and they remained fishing in the established areas.

At Albatross Island in Block 49 stock levels, particularly in shallow and mid-depth water, have fallen. Divers said that excessive amounts of catch have been taken here in recent years, that catch rates had fallen too low and that fishing was usually better elsewhere.

Elsewhere in Block 49, fishing was reported worse in 49C (south west side of Hunter Island and offshore islands and reefs) and at Three Hummock Island (49A). In 49C, divers said that offshore reefs which formerly supported good fishing years ago now no longer held fish. At Three Hummock Island good catches were possible, but the reef on shoreline that had acceptable quality fish was very narrow, and if fishing following recent harvesting, then catch rates were usually poor.

Qualitative assessment

The maximum size and growth rates of blacklip abalone in this region are extremely variable, with large differences over small spatial scales. This makes choosing appropriate size limits for sustainable fishing difficult. The market clearly favours the larger faster growing fish, and most processors reject fish from the smaller growing populations because they are of poor quality. Reducing size limits to an average length across the region that meets the two-year rule will meet management guidelines and increase stock size, but will carry increased risk at places where better quality abalone are fished, such as Albatross Island and Bluff Hill Point. An average length is likely to be insufficiently small to enable adequate access to stocks in the small fish areas. In this region, it may be more appropriate to manage size limits to meet market demands and

protect the better quality fish, rather than meet the bare minimum under the two-year rule.

At Circular Head (Block 47) there are extensive populations of very small blacklip that are clearly much smaller than any other Northern Zone fish, and possibly smaller than similar populations fished at Rocky Cape to the east. If there is sufficient market demand for fish of this size and quality, it may be appropriate to investigate management changes that enable access to these fish.

Catch levels have been high for many years. Effort has been concentrated in the established fishing areas, despite the size-limit reduction. Catch rates have fallen to more moderate levels, most likely as a result of such intensive fishing. Since the size-limit reduction, the median size of fish has fallen, although there are no indications that dependency on recruits has increased. While stocks in the North West continued to be reduced in 2010, it is likely that they remained at moderate levels.

North East (Sub-block 31B, Blocks 39 and 40)

Fishery-dependent data
The North East catch increased to 41 t in 2010, 36 t of which came from 31B (Swan Island), the balance reported from 39A (Cape Portland).

Catch rates were higher than the previous year, and reached moderate levels (71 kg/hr).

Diver perceptions
This region supplies good quality Northern Zone blacklip, as well as high grade greenlip, and although they occupy different fishing areas, many divers will fish for both species on a single trip. The area is remote, and many hours travel for divers and processors alike, so that when the area cap for greenlip brings greenlip fishing to a halt, most divers lose interest in the area and move to the North West for blacklip. This affects the amount of blacklip catch taken from the North East.

Divers found that fishing was quite variable. The main fishing area around Swan Island is relatively small, and unsurprisingly catches were affected if following other divers without sufficient time for recovery.

Qualitative assessment
Stock levels in this region appear to be quite sensitive to excessive levels of catch, and the fishing has been adversely affected since 2007, when catches totalled 66t. At 41 t, the 2010 catch was in the moderate to high range.

Catch rates were slightly higher compared with previous years, but in this region changes in catch rate are difficult to interpret because divers frequently fish for both greenlip and blacklip on the same trip. Under these circumstances, it is difficult to accurately apportion effort to each catch appropriately.

Considering the size of catch and moderate catch rates, it is likely that stock levels were at moderate levels in 2010.

Bass Strait Zone

There are three main regions in the Bass Strait zone: the Central North Coast of the Tasmanian mainland (Blocks 41-46), the Furneaux Group (Blocks 32-38) and the remote Bass Strait islands, including the Hogan, Kent and Curtis Groups (Blocks 50-57). In 2010 all Furneaux Group blocks were incorporated into the Bass Strait Zone (formerly all but Block 37 were in the Northern Zone), and the size limit there was reduced from 127 mm to 114 mm.

Fishery-dependent data
Most of the Bass Strait catch was reported from the Furneaux Group, where 47 t was taken. Of this, 26 t was taken in Block 38 (Babel Island), and 20 t in Block 33 (south-east Cape Barren Island). Almost no catch was taken from Block 37 which between 2008 and 2009 produced over 30t. Elsewhere, the Central North coast (Blocks 42-46) catch dropped to 6 t (from 24 t in 2009) and the remote Bass Strait Island catch, mostly from the Hogan Group (Block 53), was 15t.

Catch rates in the Furneaux Group Blocks 33 and 38 were mostly moderate to high (95 kg/hr). This represents a large increase, attributable to the size limit reduction. In the Bass Strait Islands catch rates were lower than in previous years at 62 kg/hr, and also fell on the Central North Coast to 42 kg/hr.

Diver perceptions
Divers reported good fishing at both Babel Island (Block 38) and Cape Barren Island (Block 33). They said that they were fishing a built-up stock, and that they did not expect catches and catch rates to remain at such high levels for much longer. They did not see any point shifting operations elsewhere in the Furneaux Group while fishing in at Babel and Cape Barren Island was so productive.

Comparatively little fishing was done at the Hogan Group (Block 53), and most of the 2010 catch was taken over a four-day period in November by eight divers. This intensive fishing activity may have reduced catch rates there. Divers reported evidence of fishing by divers operating from Victoria.

On the Central North coast, most divers found that fishing was slow, and that areas that were fished in previous years yielded poorer results.

Qualitative assessment
There was a large increase in catch from the east and south east of the Furneaux Group (Blocks 33, 38) as a result of its transfer from the Northern Zone to the Bass Strait Zone in 2010. The concurrent 13-mm reduction in size limit greatly increased the stock size and 48 t was landed, with large catches taken at high catch rates. Because of the management changes, this was effectively a virgin fishery, and comparison with previous annual catches and catch rates is meaningless. As a result catch and catch-rates are not indicators of stock size, and consequently there is no formal assessment of stocks in Blocks 33 and 38. Divers reported good fishing, but considering the small area of reef and high levels of catch, expressed doubts that such a high level of catch could be sustained.

Despite lower catches and catch rates, stock levels in the Hogan Group appeared unchanged from previous years, and stock levels there are assessed as moderate and stable.

On the Central North Coast, stocks have been either slow to recover of have not recovered from previous years' fishing, and stocks there are assessed as low.

Greenlip fishery

The greenlip fishery is different in many ways to the much larger blacklip fishery. The greenlip fishery takes place in the more remote northern parts of the state. The catch is comparatively small, contributing approximately 5% to Tasmania's total abalone catch. Typically, half the greenlip TAC is caught by six or seven divers, and one third by three divers. These divers mostly operate exclusively in specific regions of the fishery (North West, King Island, North East, Furneaux Group, Perkins Bay).

Greenlip are usually more highly valued than blacklip, and large high quality greenlip command a premium price. High grade greenlip are usually sold on the domestic live market, while smaller greenlip are usually processed locally and exported, typically as frozen meats.

Fishery derived performance measures such as changes in catch rates and catch are frequently inadequate as indicators of stock levels in the greenlip fishery. This was not always the case, but in recent years there have been changes to both management and markets that reduced the effectiveness of fishery-based performance measures:

- The greenlip TAC is relatively small, and each region's catch is capped, effectively masking changes in distribution of catch that might indicate changed stock levels in one or more regions

- Current knowledge of a region's stocks can greatly increase an individual's catch rates. Increases in catch rate can occur when individual divers fish exclusively in a region gaining local knowledge and expertise, and then catch increasingly larger proportions of the available regional cap. Conversely catch rate declines may be caused regardless of changes in stock size by increased numbers of visitors to a region.

- Where divers catch both greenlip and blacklip in a single fishing trip, effort may be reported in two ways. Some divers estimate the proportion of time taken to catch each species, while others report the total amount of fishing time twice, once for each species. Reliability of the first method depends upon the divers' ability to accurately gauge how much time was devoted to catching each species. The second method is likely to be more accurate, but catch rates will be lower (for both species). The effect of the second method is noticeable in CPUE distributions from these regions where up to 20% of catches were reported with catch rates of less than 25 kg/hr. It is also noticeable in a CPUE time series, where varying proportions of the usage of both methods masks the abundance signal. In 2009, DPIPWE wrote to all divers requesting that they report effort for each species as a proportion of the trip's total effort.

- The differences in price between high and lesser grades of greenlip are often sufficient for some divers to selectively fish for large greenlip (e.g. > 160 mm), which means that they catch less fish per day than if they were fishing the stock from its 145-mm legal minimum size. The size of the stock for such large fish is much smaller compared with the stock at the legal size limit, and divers' catch rates are reduced accordingly.

Fishery-dependent data
The annual catch was distributed as per caps, slightly overrun on King Island (33 t), the North West (23 t) and North East (25 t), and under caught in the Furneaux Group (34 t). The Perkins Bay catch was 20 t, all of which was taken from Black Reef.

Interpretation of catch-rate trends is subject to the above limitations. On King Island, catch rates have been ranging between 51 and 62 kg/hr since 2001 and in 2010 were slightly below peak levels at 59 kg/hr. In the North West and North East, catch rates have fluctuated over much greater ranges (53-79 kg/hr and 41-72 kg/hr respectively). In 2010, catch rates were 79 kg/hr in the North West, and 63 kg/hr in the North East. At the Furneaux Group catch rates broke out of their narrow (53-60 kg/hr) 10-year range and reached 68 kg/hr. In Perkins Bay, where a recent 13-mm size-limit reduction greatly increased stock size, catch rates have been steadily increasing, reaching 117 kg/hr in 2010.

Diver perceptions
No divers expressed concerns about stock levels when fishing at the legal minimum size limit in any of the five management areas. Most reported average to good fishing, and that catches generally matched their expectations.

Divers on both King and Flinders Islands fishing reefs that produced larger fish reported that there was a disconnect between high growth rates and recruitment i.e. growth rates and fish quality were often reduced in areas of high abundance whereas on reefs producing high grade fish, recruitment was frequently inadequate. Several divers have expressed strong opinions that production could be increased by moving juveniles from the high-density slow-growing areas to areas where they regularly caught high grade fast-growing fish.

In the North East, divers said that the smaller legal-sized fish appeared to be at a fast-growing stage and that if the size limit was increased, the fish would rapidly reach the larger size, quality would be improved, market demand for larger fish would be met and the population size would be increased.

At Perkins Bay, divers said that intensive fishing following the large size-limit reduction had improved fish quality. Reducing fish density had enabled the remaining fish to grow faster and larger with better meat yield. Because of their small size, fish from Black Reef were more suited to the less lucrative processed export market. Stock levels remained high, and the only limitation to larger catches was the limited availability of quota for this market.

Qualitative assessment
Because of the inadequacy of the existing fishery-derived performance measures, stock assessment of the greenlip fishery remains uncertain. At best it can be said that there

were no indications of stock declines. The most reliable indicator of changes in stock levels appears to be diver perception.

Recreational fishery

Recreational fishing licenses are issued annually, expiring on 31st October each year. New licenses are available from 1st November. Most licenses are issued prior to Christmas, coinciding either with the opening of the rock lobster season in November or with the holiday period over Christmas.

The number of recreational abalone dive licenses trended strongly upwards between 1996 and 2007, but since then has slowly declined. By 7 June 2011, 11914 abalone licenses had been issued for the fishing season 2010/2011 (Figure 8). The downward trend was similar to that for recreational rock lobster fishing and it's likely that the reduced recreational participation in abalone fishing is linked to decline in the rock lobster stock.

The most recent catch survey of recreational abalone fishing was undertaken for the 2008/2009 season (Lyle and Tracey, 2010). This survey resulted in an estimate of 81,500 abalone (approximately 39 t) taken by the recreational fishery, i.e. about 1.5% of the total Tasmanian abalone catch. Almost 60% of the recreational catch was taken in the east and south-east between Southport and Eddystone Point, i.e. the area covered by Blocks 14 to 30. Another 20% was taken on the coast north of latitude 41° (which passes near Eddystone Point in the east, and Bluff Hill Point in the west, and includes the Bass Strait islands), and the remainder was caught on the west and south coasts, east to longitude 147° (near Southport).

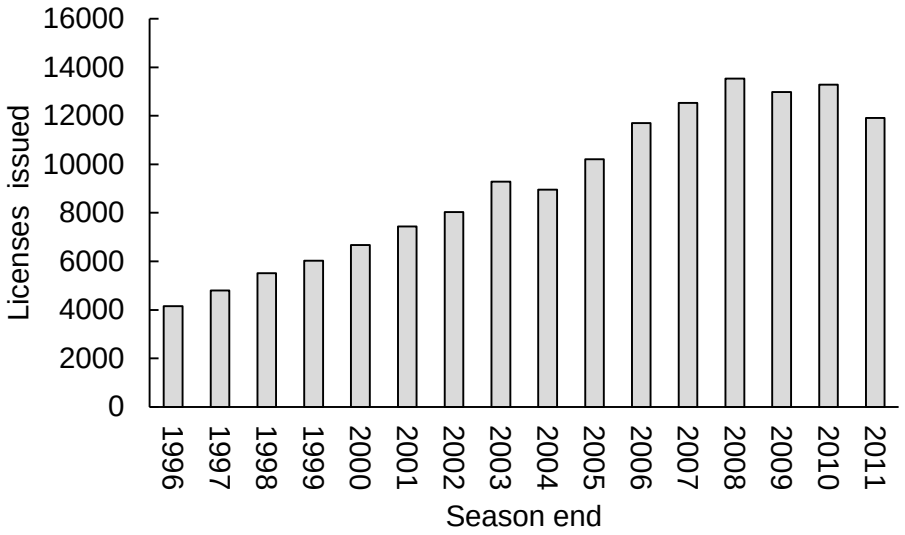


Figure 8. The number of recreational abalone diving licenses issued for the fishing seasons 1996-2011.

Indigenous, illegal and permit fisheries

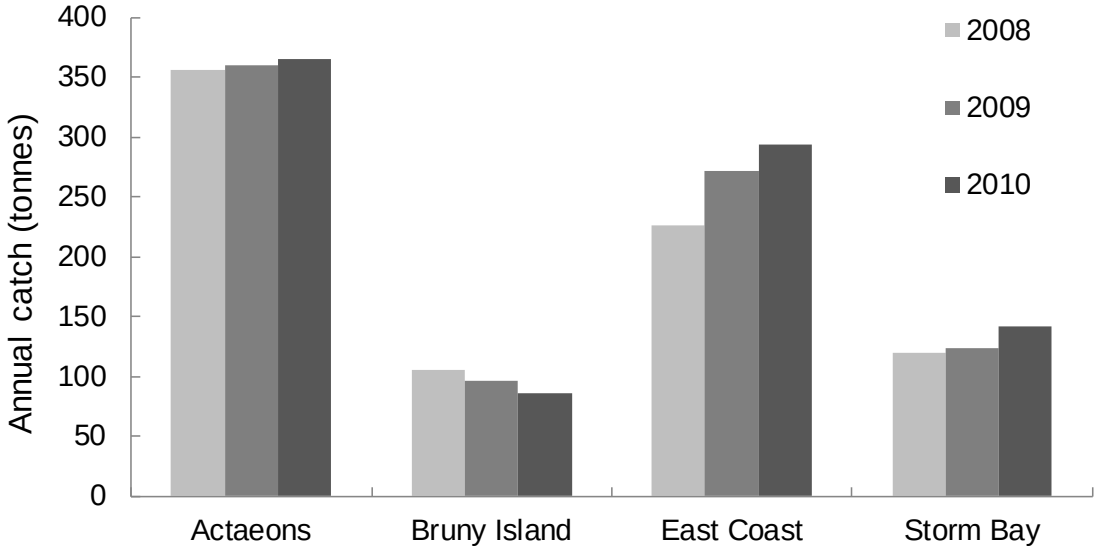
Abalone were caught in Tasmanian waters as part of cultural fishing activities by indigenous people, under permits for special events and research purposes, and as part of illegal fishing operations. There were no estimates available for either the illegal

catch or for the total catch from cultural fishing activities. The quantity of abalone taken under permits for special events and research purposes was less than two tonnes.

Appendix 1: Catch, catch-rates and size-composition

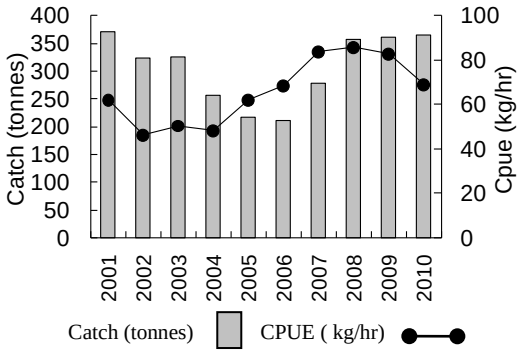
Eastern Zone blacklip fishery

Distribution of catch between the four main regions of the fishery:

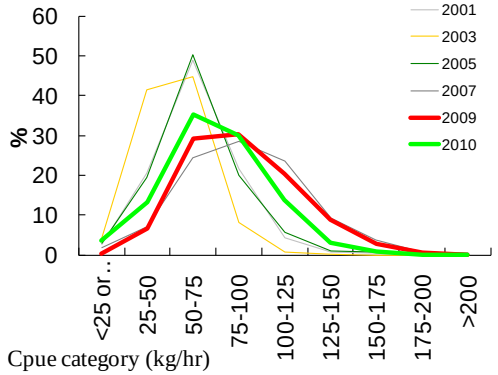


Eastern Zone - Actaeons, Lower Channel (Sub-blocks 13C, 13D, 13E, 14A, 14B)

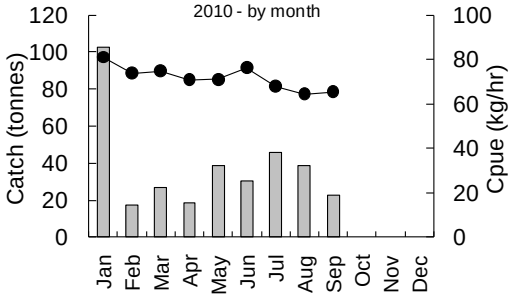
Regional view:



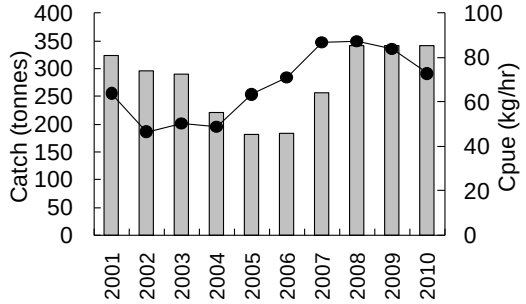
CPUE distribution:



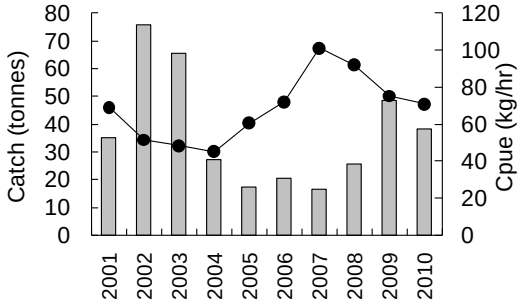
Actaeons regional catch and catch rates by month



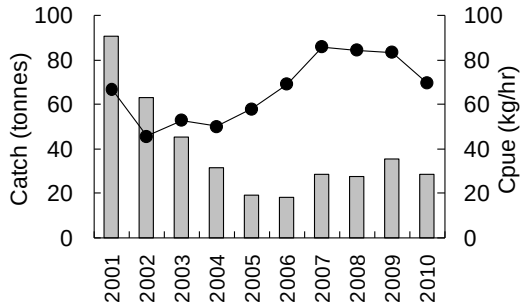
13C, 13D, 13E area cap 340t in 2010, 342t caught:



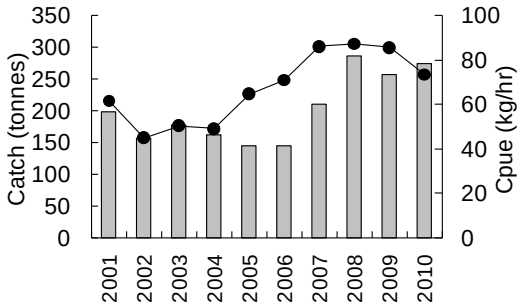
Sub-block 13C
Fishers Point to Whale Head



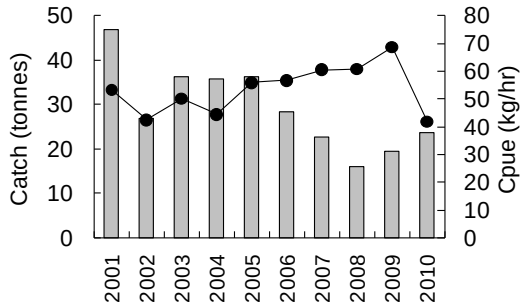
Sub-block 13D
Fishers Point to Southport Lagoon Beach, including Recherche Bay



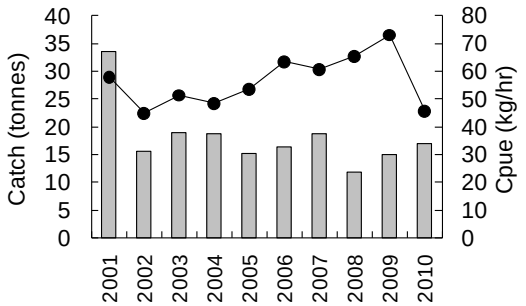
Sub-block 13E
Actaeon and Sterile Islands, and reefs to the south (the Breaks)



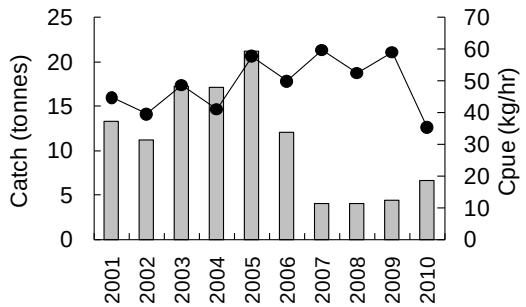
14A, 14B, area cap 30t in 2010, 24t caught.



Sub-block 14A
Southport Lagoon Beach to Burnett Point

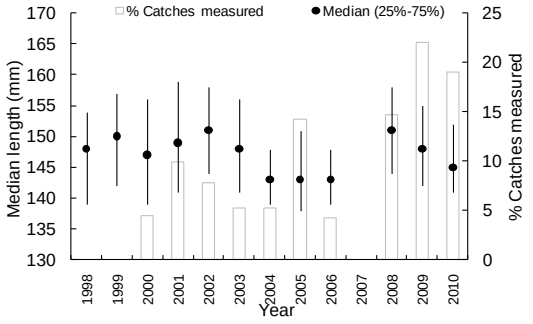


Sub-block 14B
Burnett Point to Blubber Head

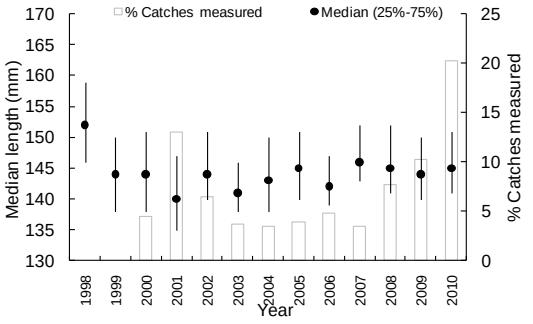


Actaeons, Lower Channel (Sub-blocks 13C, 13D, 13E, 14A, 14B)
Median length of catch

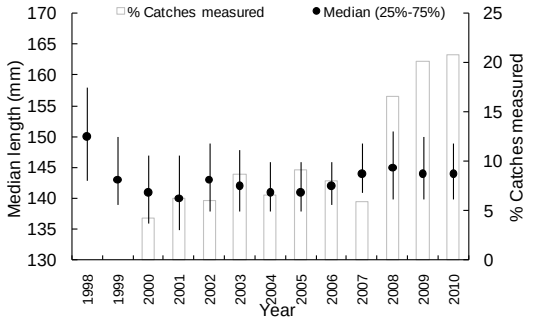
Sub-block 13C
Whale Head to Fishers Point



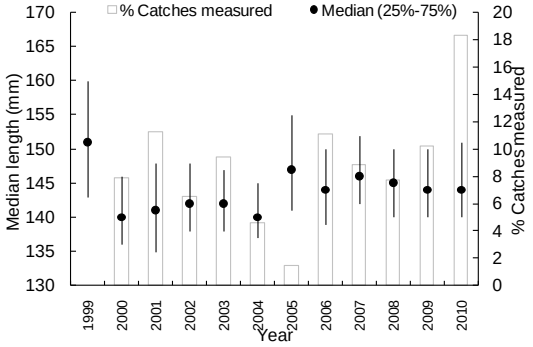
Sub-block 13D
Fishers Point to Southport Lagoon Beach, including Recherche Bay



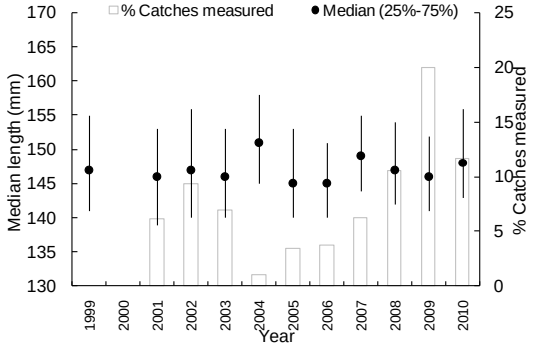
Sub-block 13E
Actaeon and Sterile Islands, and reefs to the south (the Breaks)



Sub-block 14A
Southport Lagoon Beach to Burnett Point

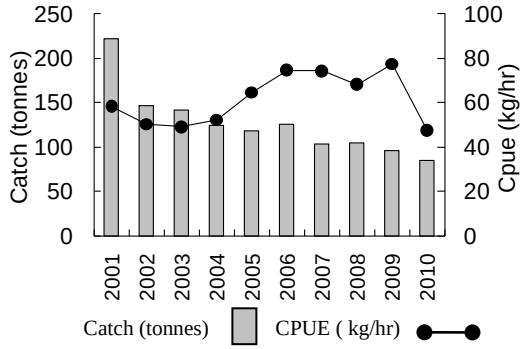


Sub-block 14B
Burnett Point to Blubber Head

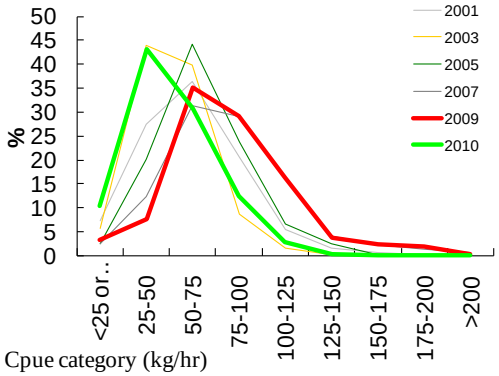


Eastern Zone – Bruny Island (Blocks 14C, 14D, 14E, 15, 16).

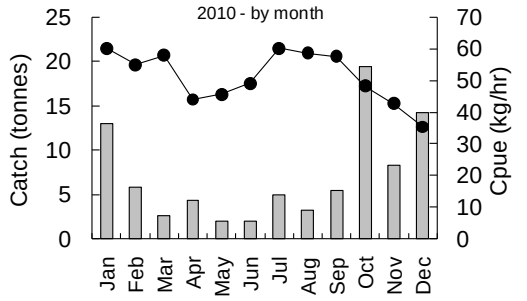
Regional view, area cap 70t in 2010, 86t caught.



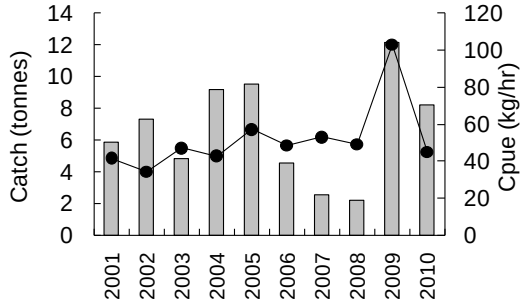
CPUE distribution:



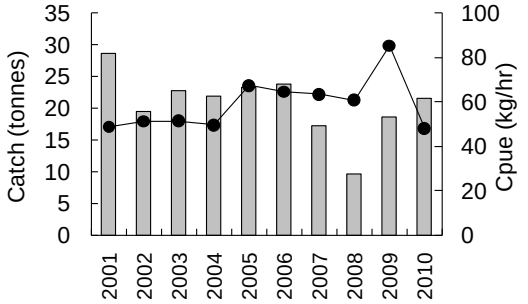
Bruny regional catch and catch rates by month.



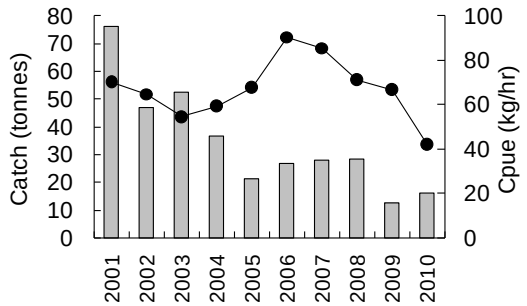
Sub-block 14C Mays Creek to Hopwood Light (Lower Channel) – significant catch reporting errors in 2009.



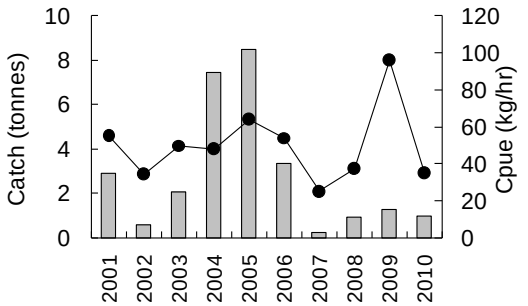
Sub-block 14D Hopwood Point to West Cloudy Head - significant catch reporting errors in 2009.



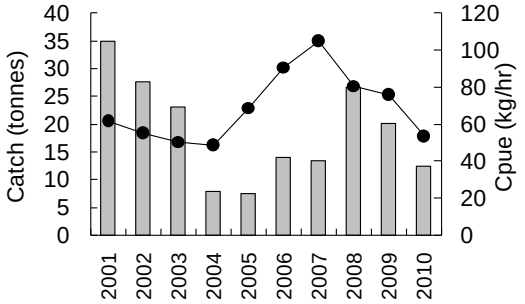
Sub-block 14E
West Cloudy Head to Boreel Head, including the Friars



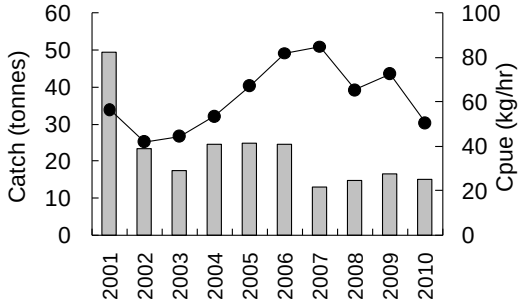
Block 15 D'Entrecasteaux Channel, Huon Estuary- significant catch reporting errors in 2009.



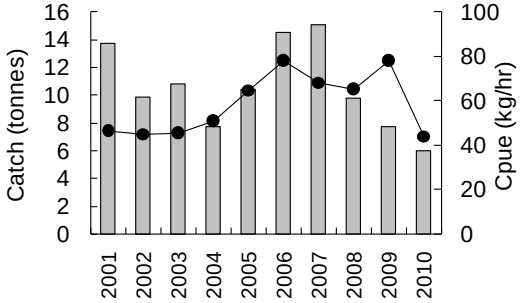
Sub-block 16A
Boreel Head to North Mangana Bluff



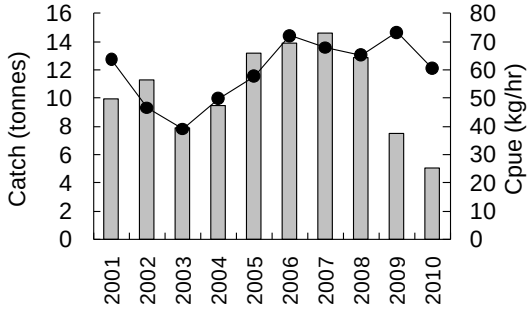
Sub-block 16B
North Mangana Bluff to Neck Beach



Sub-block 16C
Neck Beach to Trumpeter Bay

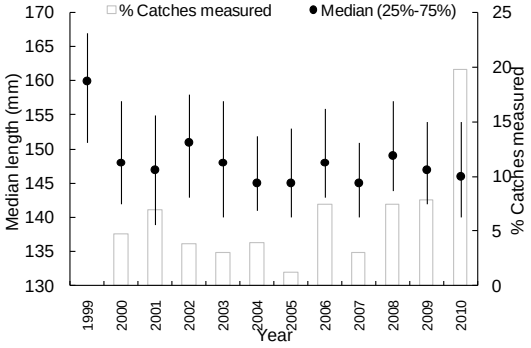


Sub-block 16D
Trumpeter Bay to Dennes Point

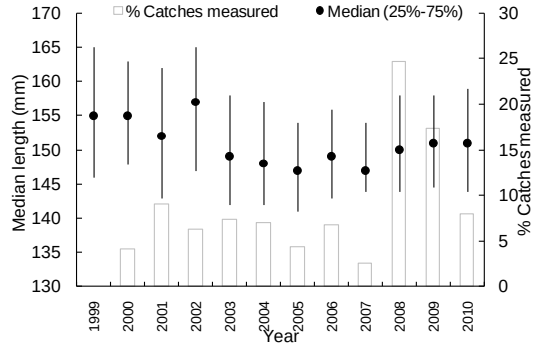


Eastern Zone – Bruny Island (Blocks 14C, 14D, 14E, 15, 16).
Median length of catch

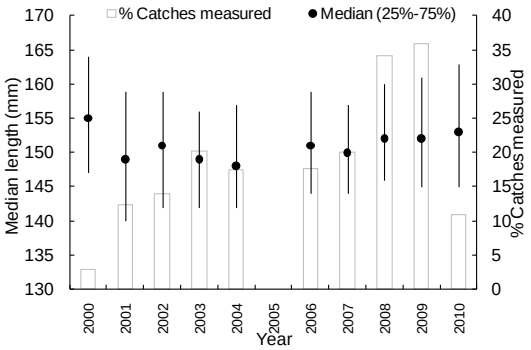
Sub-block 14D
Hopwood Point to West Cloudy Head



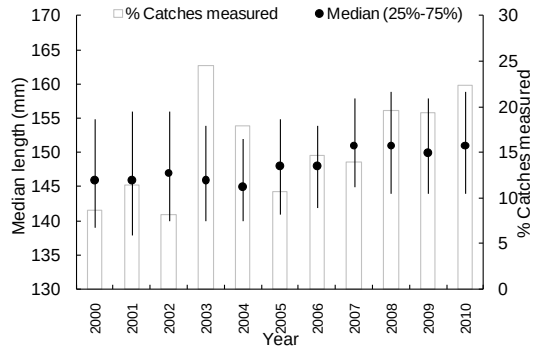
Sub-block 14E
West Cloudy Head to Boreel Head, including the Friars



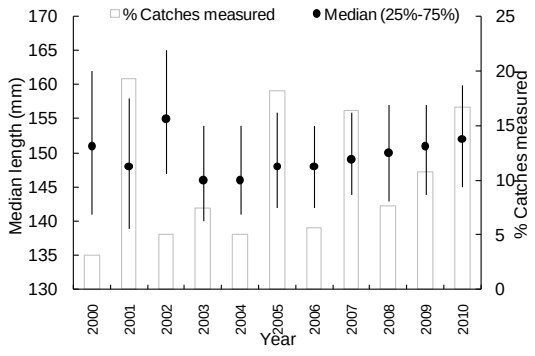
Sub-block 16A
Boreel Head to North Mangana Bluff



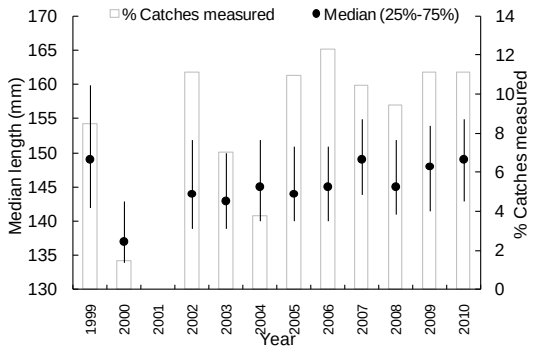
Sub-block 16B
North Mangana Bluff to Neck Beach



Sub-block 16C
Neck Beach to Trumpeter Bay

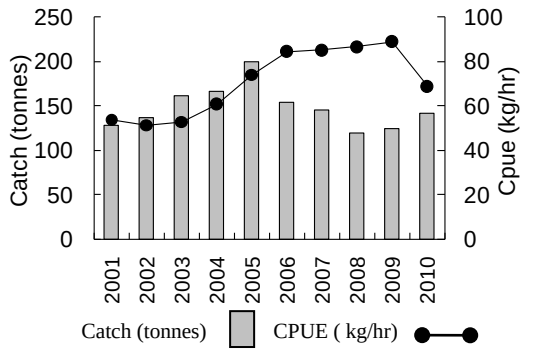


Sub-block 16D
Trumpeter Bay to Dennes Point

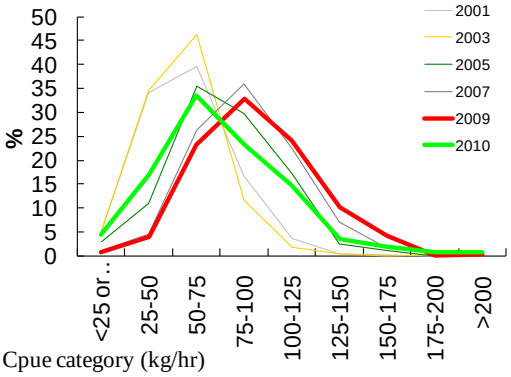


Eastern Zone - Storm Bay (Blocks 17-21)

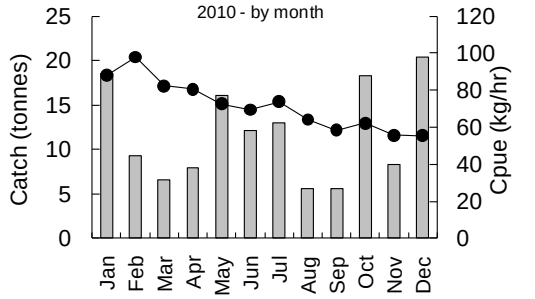
Regional view, area cap 174t in 2010, 142t caught



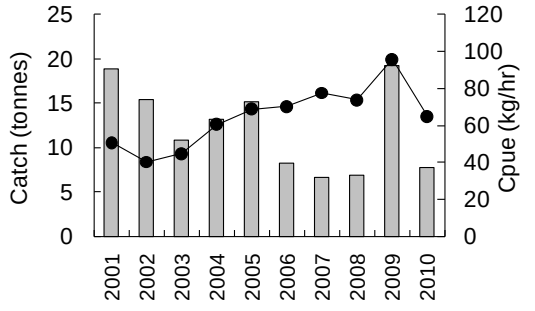
CPUE distribution:



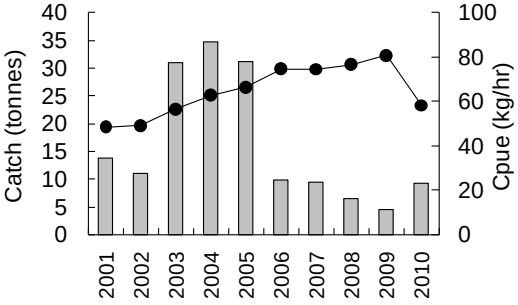
Storm Bay regional catch and catch rates by month.



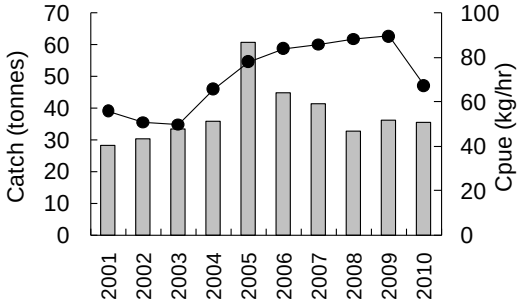
Sub-block 17B
Blackjack shoreline from Lobster Point to Outer North Head



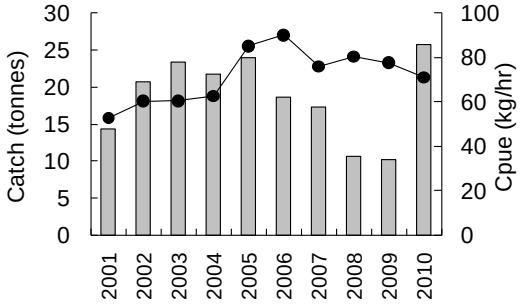
Sub-block 20A
Outer North Head to White Beach



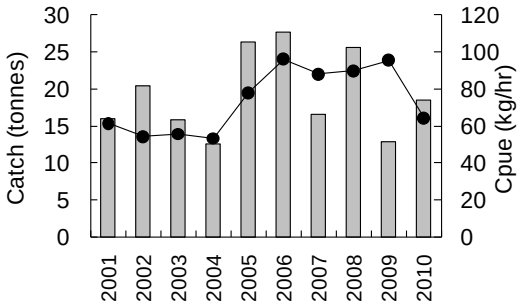
Sub-block 20B
White Beach to Salters Point



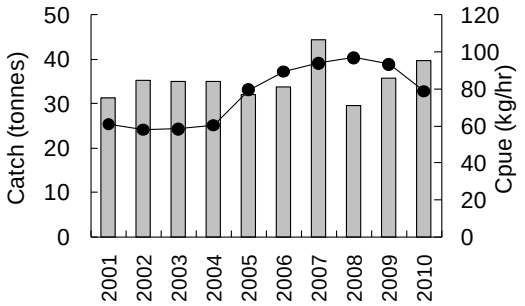
Sub-block 20C
Salters Point to Cape Raoul



Sub-block 21A
Cape Raoul to Port Arthur

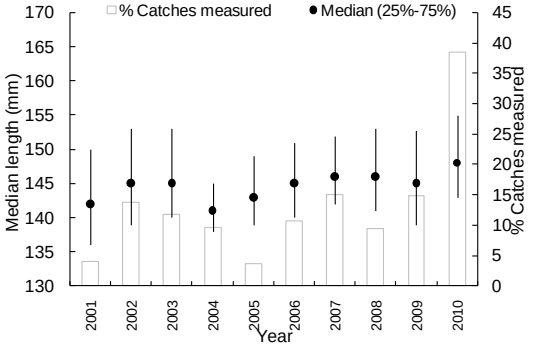


Sub-block 21C
Port Arthur to Cape Pillar

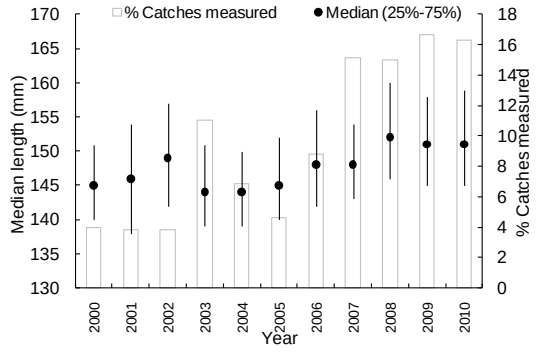


Eastern Zone - Storm Bay (Blocks 17-21)
Median length of catch

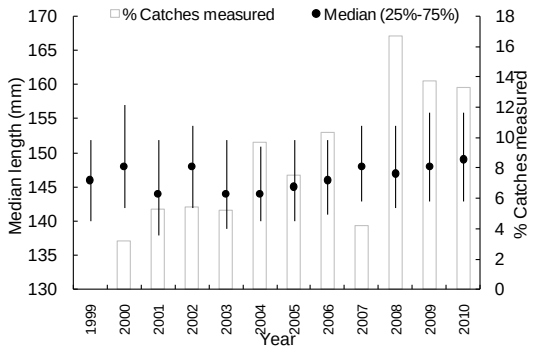
Sub-block 17B
Blackjack shoreline from Lobster Point to Outer North Head



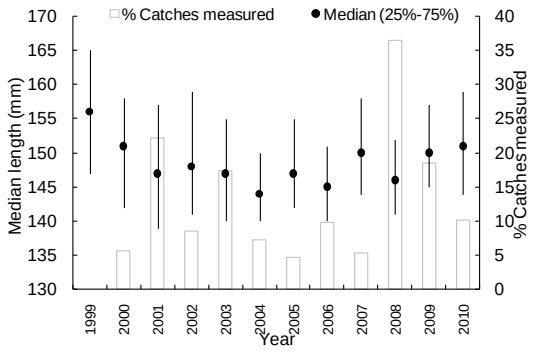
Sub-block 20A
Outer North Head to White Beach



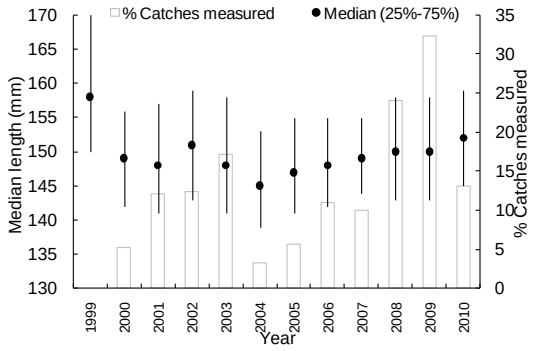
Sub-block 20B
White Beach to Salters Point



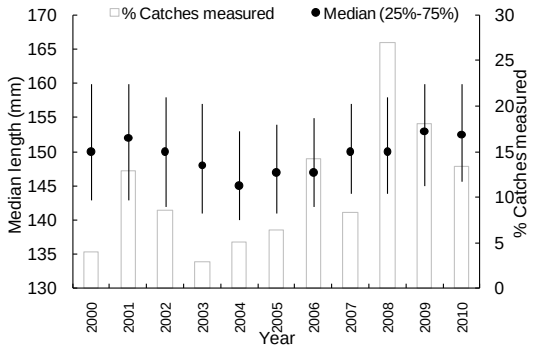
Sub-block 20C
Salters Point to Cape Raoul



Sub-block 21A
Cape Raoul to Port Arthur

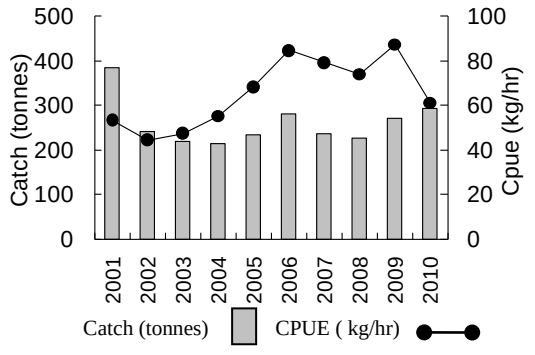


Sub-block 21C
Port Arthur to Cape Pillar

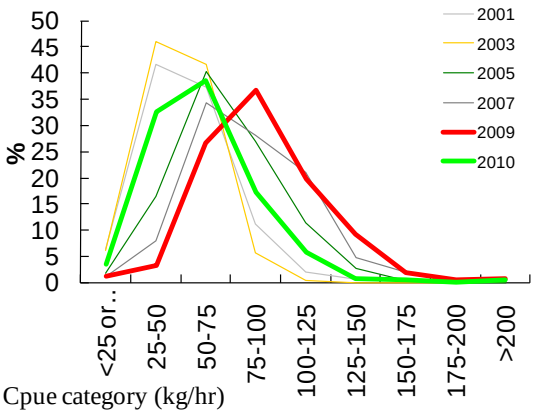


Eastern Zone – East Coast (Blocks 22-31)

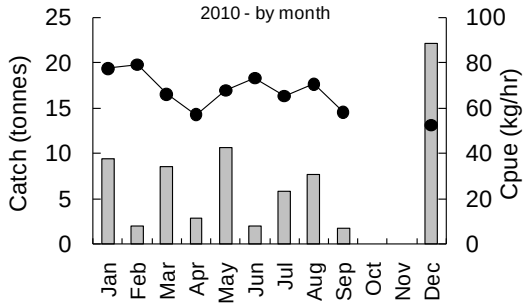
Regional view:



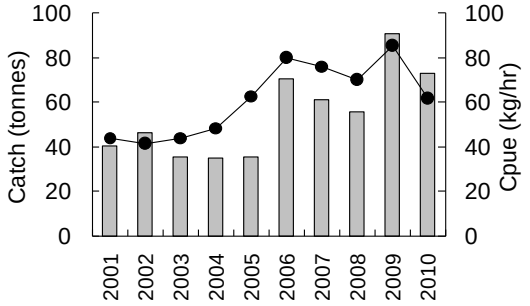
CPUE distribution (does not include Block 31-has not been fished like remainder of region)



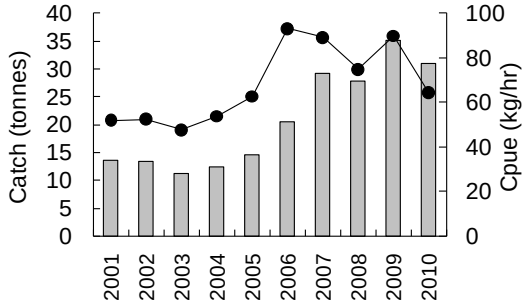
Block 22 catch and catch rates by month.



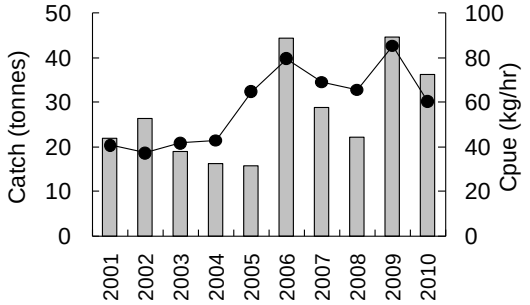
Block 22, area capped at 60t in 2010, 73t caught



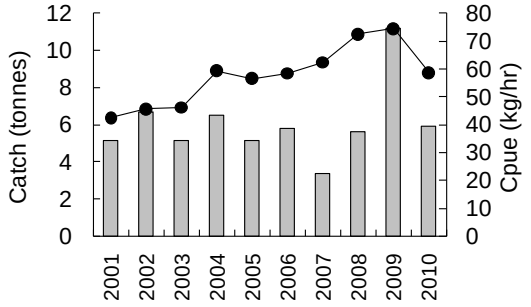
Sub-block 22A
Cape Pillar to the Lanterns



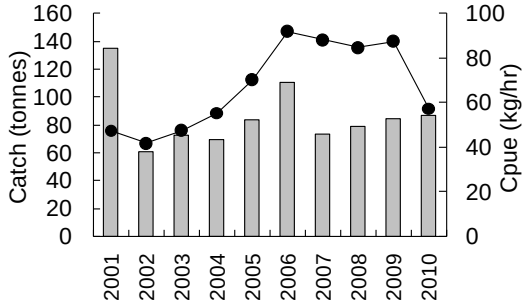
Sub-block 22B
The Lanterns to Eaglehawk Neck



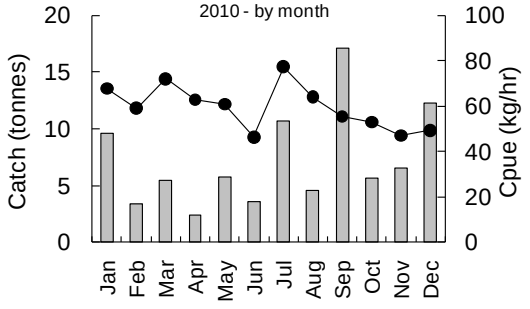
Sub-block 22C
Eaglehawk Neck to Deep Glen Bay



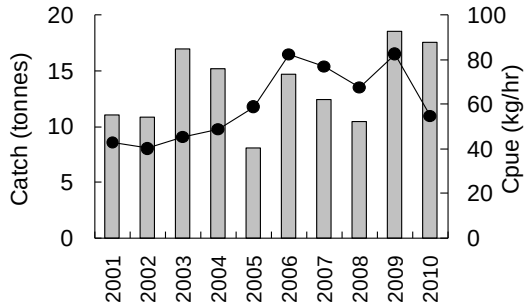
Forestier Peninsula, Maria Island (Blocks 23, 24), area cap 86t, 87t caught



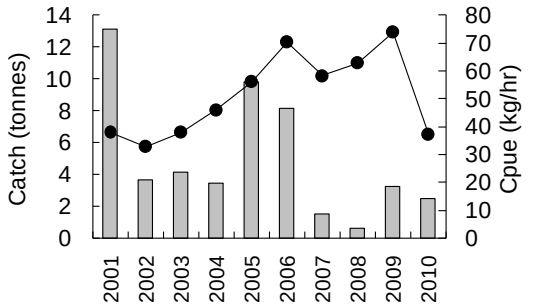
Forestier, Maria regional catch and catch rates by month.



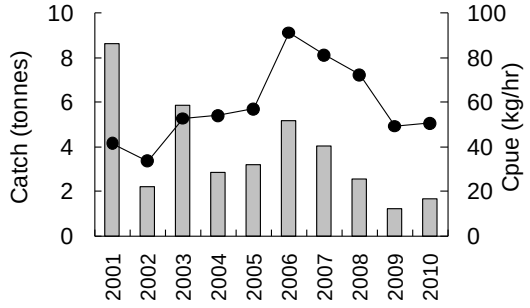
Sub-block 23A
Deep Glen Bay to Lagoon Bay



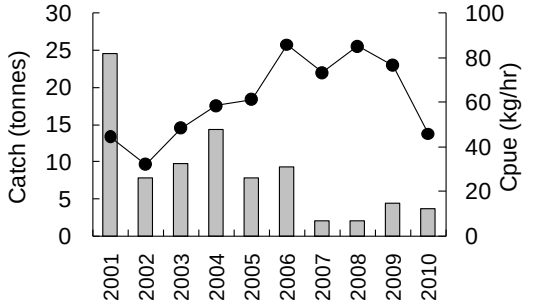
Sub-block 23B
Lagoon Bay to Marion Bay



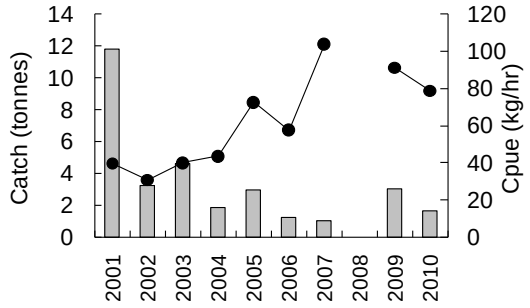
Sub-block 24A
Marion Bay to Rheban



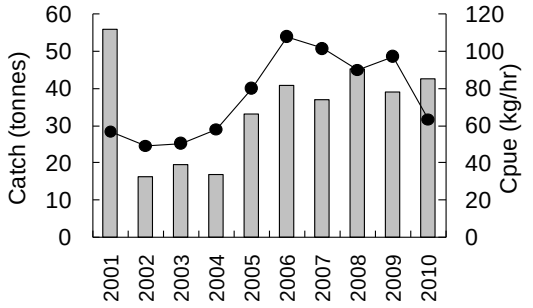
Sub-block 24B
Eastern shore of Mercury Passage



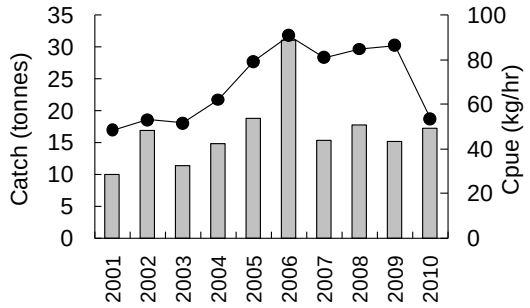
Sub-block 24C
Rheban to Cape Bougainville



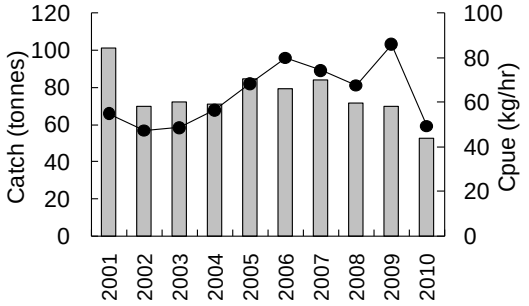
Sub-block 24D
north-east side of Maria Island



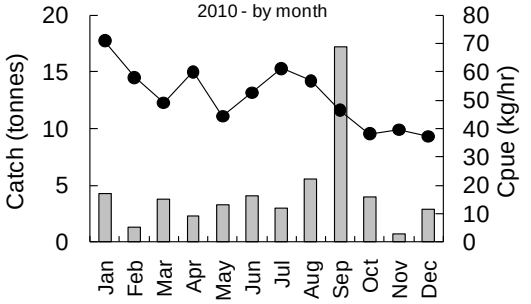
Sub-block 24E
south-east side of Maria Island



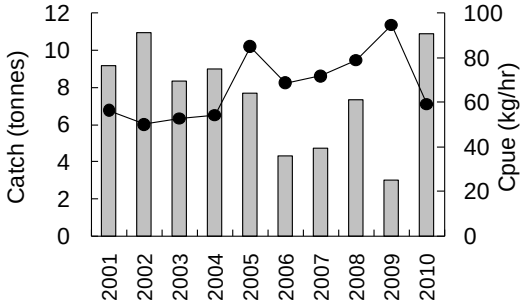
Freycinet-Bicheno (Blocks 25, 26, 27, 28, 29A), area cap 62t in2010, 52t caught



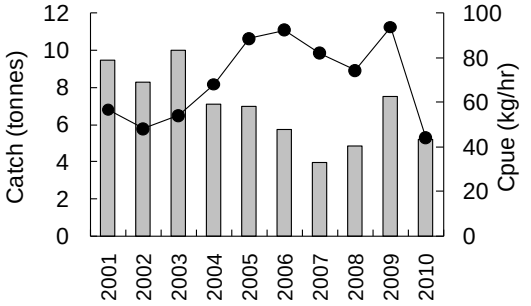
Freycinet-Bicheno regional catch and catch rates by month.



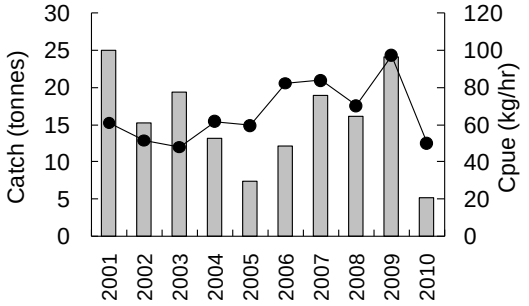
Sub-block 27A
south side of Schouten Island



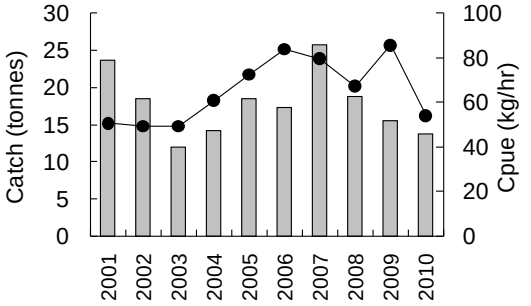
Sub-block 27B
east side of Schouten Island



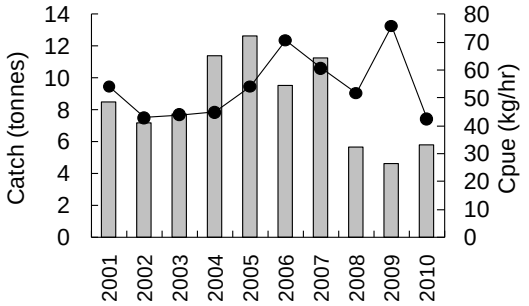
Sub-block 27C
Schouten Passage to Wineglass Bay



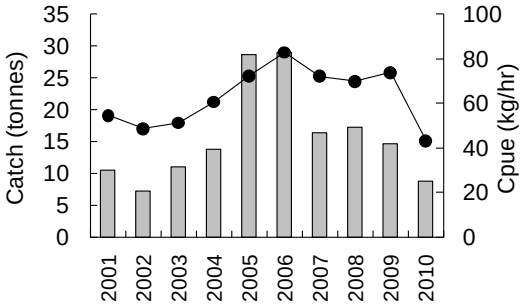
Sub-block 27D
Wineglass Bay to the Friendly Beaches



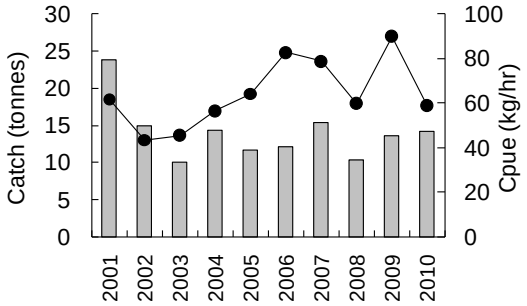
Block 28
Friendly Beaches to Long Point



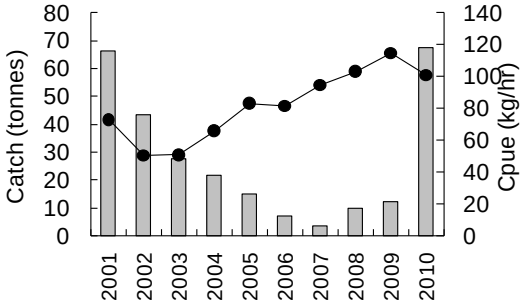
Sub-block 29A
Long Point to Templestowe Beach



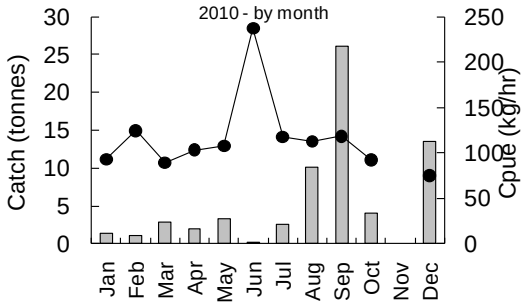
Sub-block 29B, 29C, 29D, 30A, Templestowe Beach to Taylors Beach, uncapped in 2010, 14t caught



Sub-block 31A (also includes old E zone part of 31B), Eddystone Point to Musselroe, area cap 100t in 2010, 67t caught

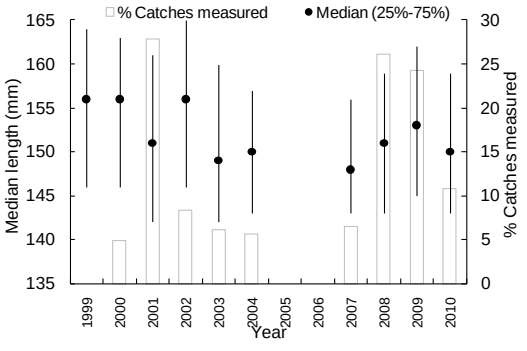


Sub-block 31A catch and catch rates by month

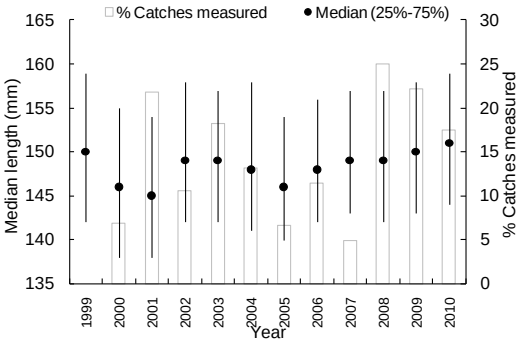


Eastern Zone – East Coast (Blocks 22-31)
Median length of catch

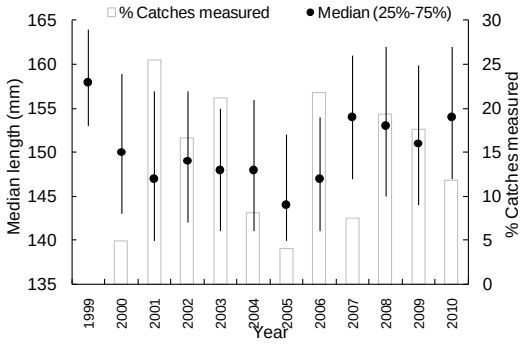
Sub-block 22A
Cape Pillar to the Lanterns



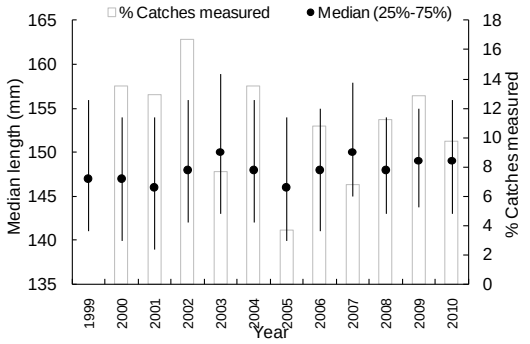
Sub-block 22B
The Lanterns to Eaglehawk Neck



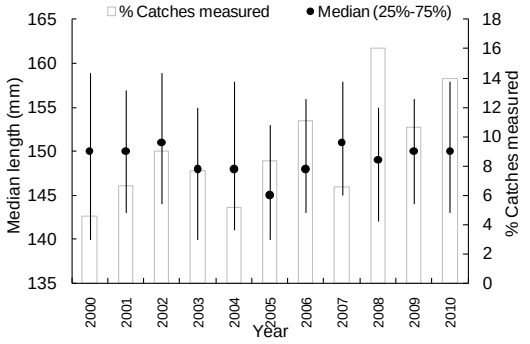
Sub-block 23A
Deep Glen Bay to Lagoon Bay



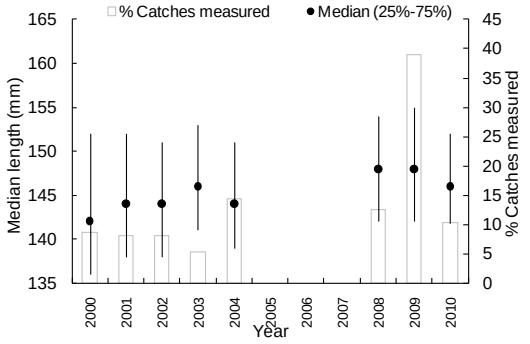
Sub-block 24D
north-east side of Maria Island



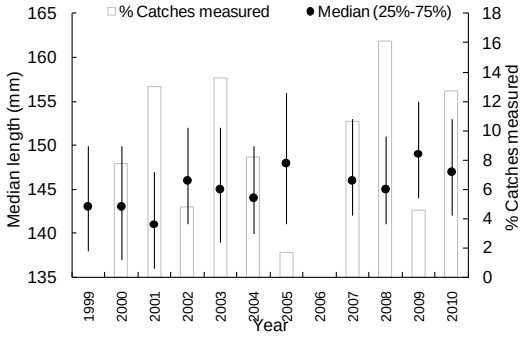
Sub-block 24E
south-east side of Maria Island



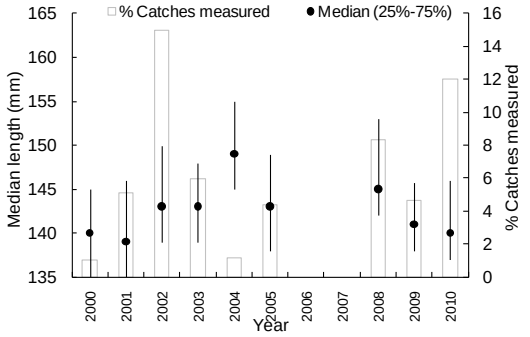
Sub-block 27B
east side of Schouten Island



Sub-block 27D
Wineglass Bay to Friendly Beaches

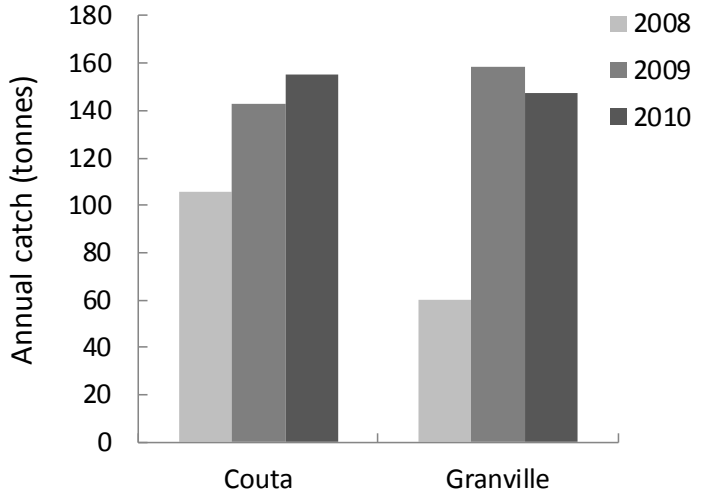


Sub-block 31A
Eddystone Point to Musselroe



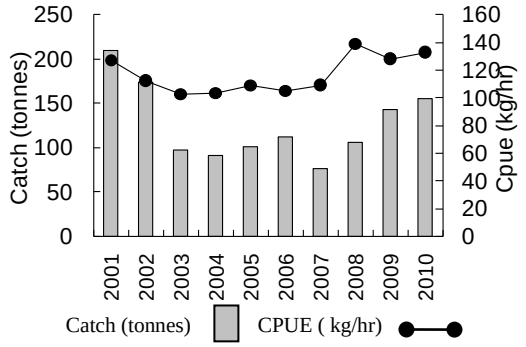
Central Western Zone blacklip fishery

Distribution of catch between the Couta Rocks region (Block 6) and the Granville Harbour region (Blocks 7 and 8):

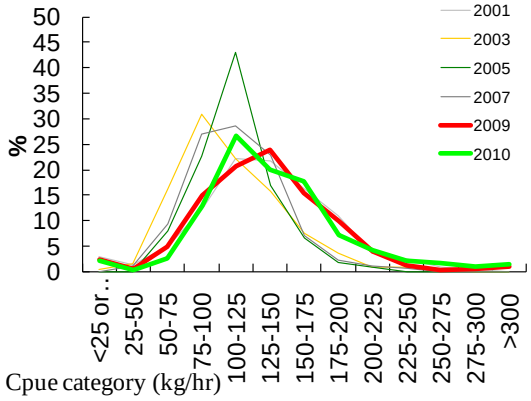


Central Western Zone – Couta Rocks (Block 6)

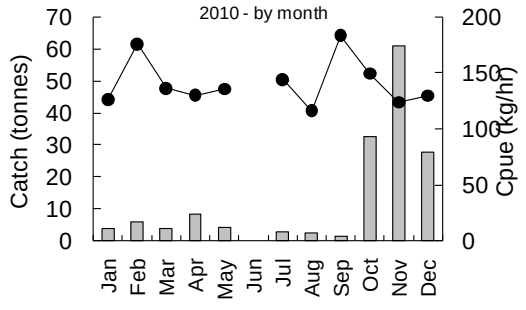
Regional view:



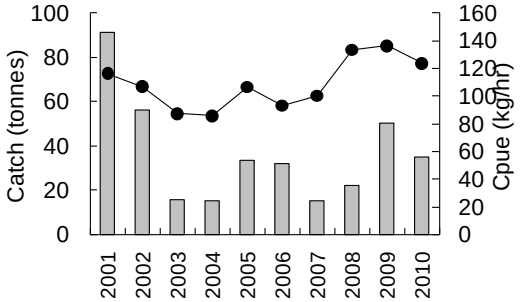
CPUE distribution:



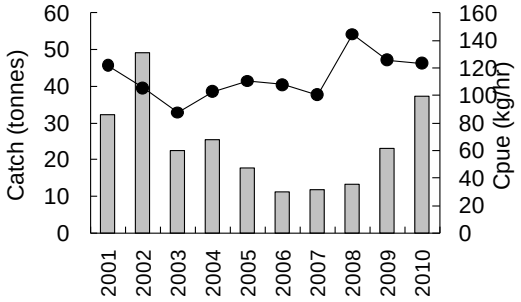
Block 6 catch and catch rates by month



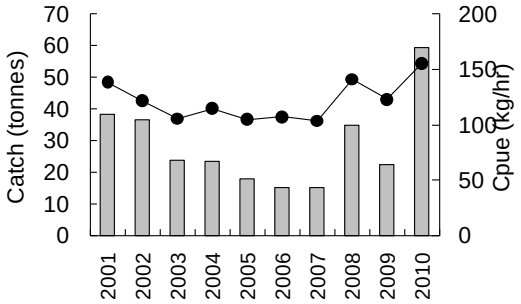
Sub-block 6A
Sundown to Temma



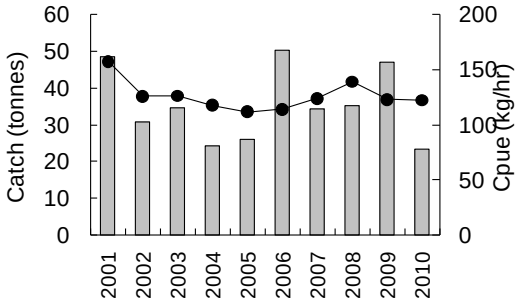
Sub-block 6B
Temma to north of Dawson River



Sub-block 6C
Dawson River to Wild Wave River

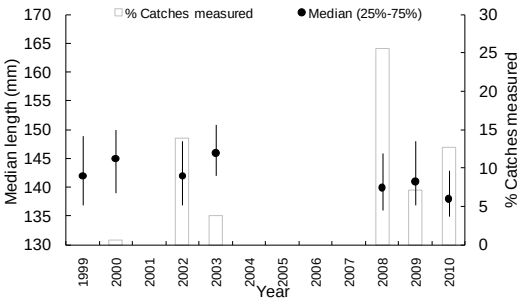


Sub-block 6D - capped area see below
Wild Wave River to Italian River, including Sandy Cape

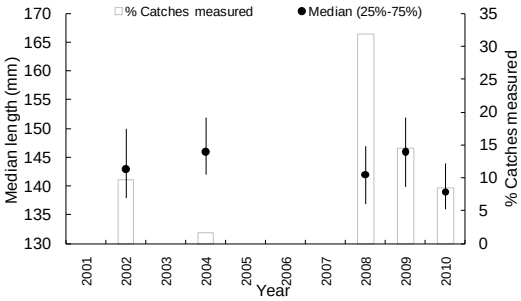


Central Western Zone – Couta Rocks (Block 6)
Median length of catch

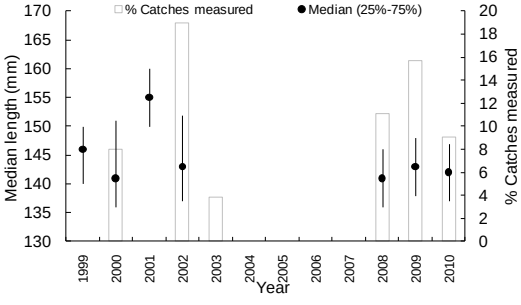
Sub-block 6A
Sundown to Temma



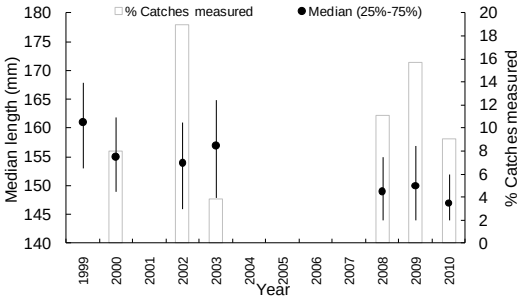
Sub-block 6B
Temma Harbour to north of Dawson River



Sub-block 6C
Dawson River to Wild Wave River

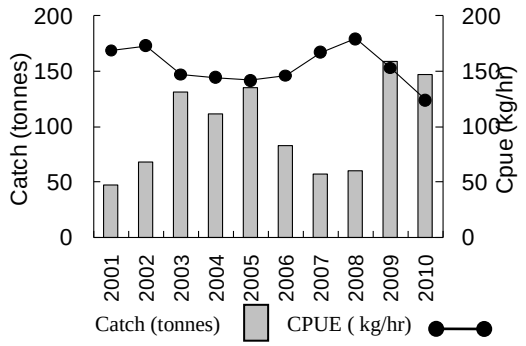


Sub-block 6D
Wild Wave River to Italian River, including Sandy Cape

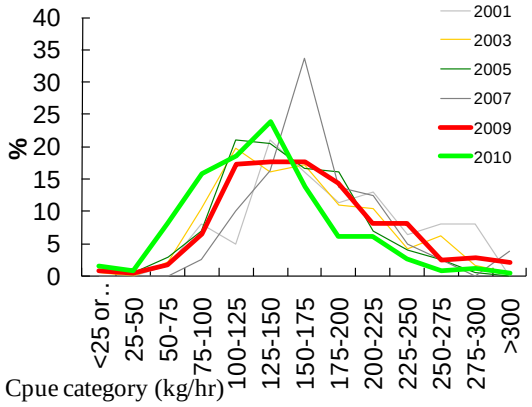


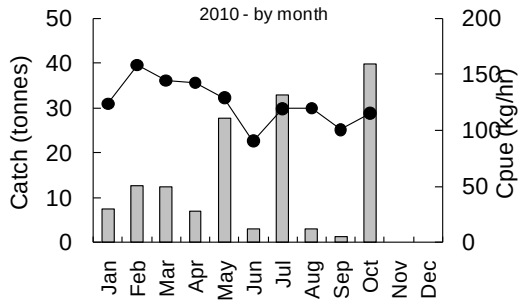
Central Western Zone – Granville Harbour (Blocks 7 and 8)

Blocks 7 and 8

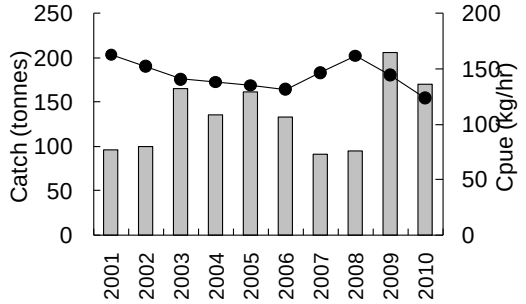


CPUE distribution:

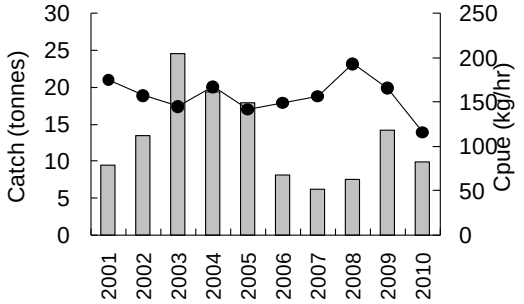




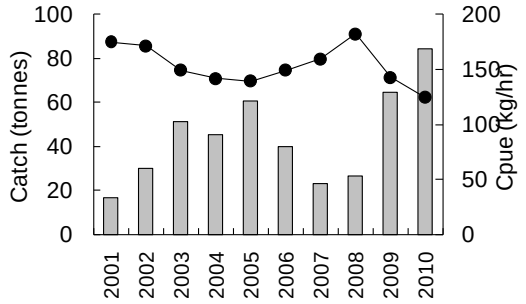
Sub-block 6D, Blocks 7 and 8, cap set at 150t in 2010, 171t caught



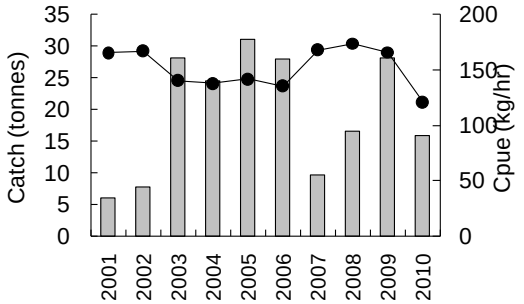
Sub-block 7A
Italian River to Pieman River



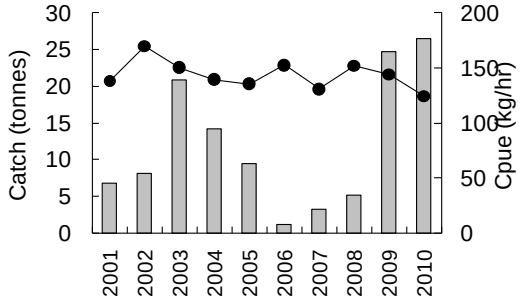
Sub-block 7B
Pieman to Ahrberg Bay



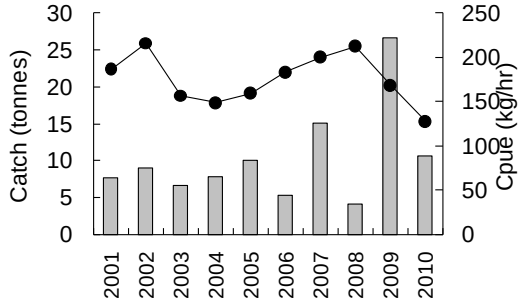
Sub-block 7C
Ahrberg Bay to Granville Harbour



Sub-block 8A
Granville Harbour to Tasman Bay

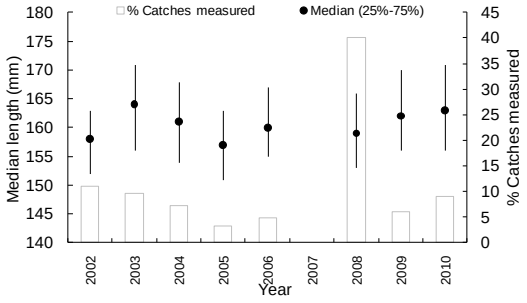


Sub-block 8B
Tasman Bay to Henty River



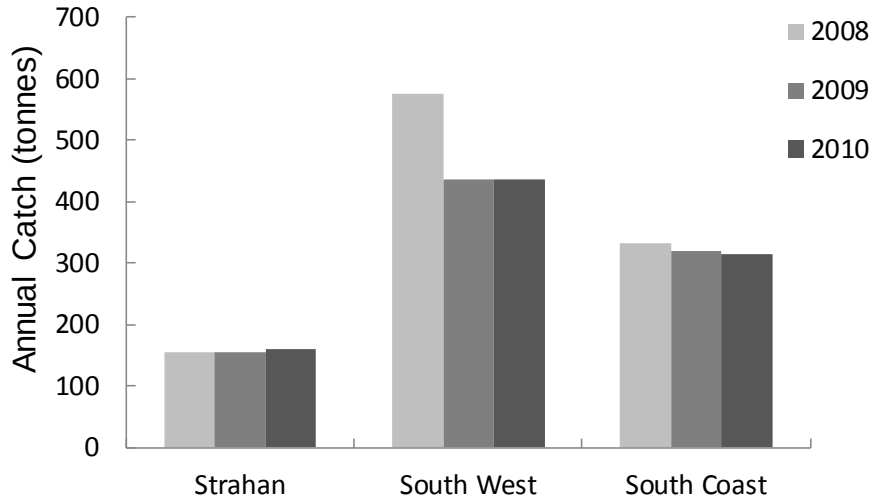
Central Western Zone – Granville Harbour (Blocks 7 and 8)
Median length of catch

Sub-block 7B
Pieman to Ahrberg Bay



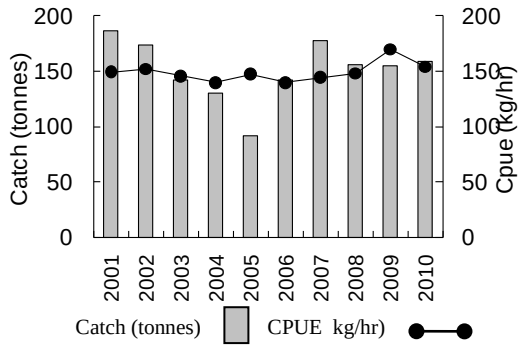
Western Zone blacklip fishery

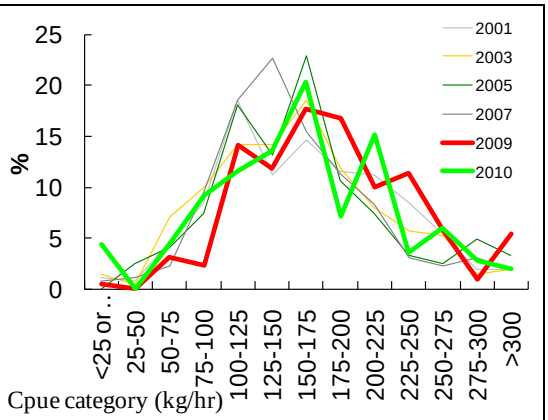
Distribution of catch in the Western Zone:

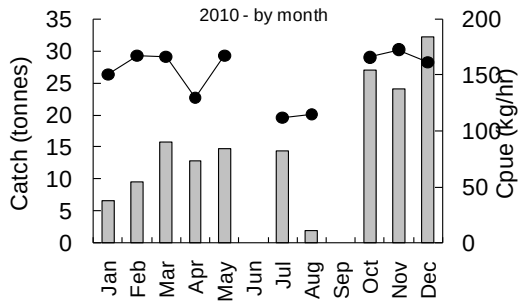


Western Zone – Strahan (Block 9)

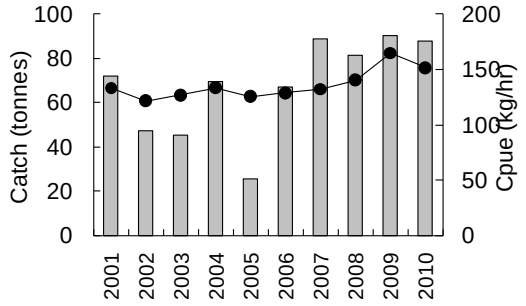
Regional view, cap set at 166t in 2010, 159t caught



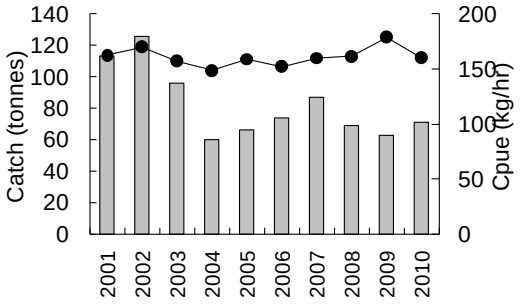




Sub-block 9B
Cape Sorell to Gorge Point

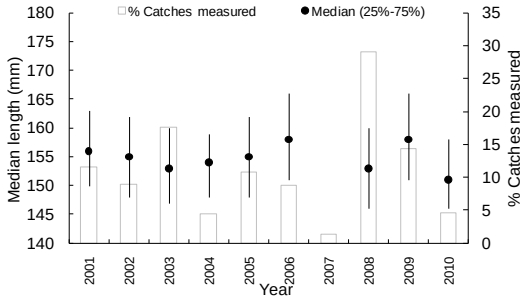


Sub-block 9C
Gorge Point to Point Hibbs

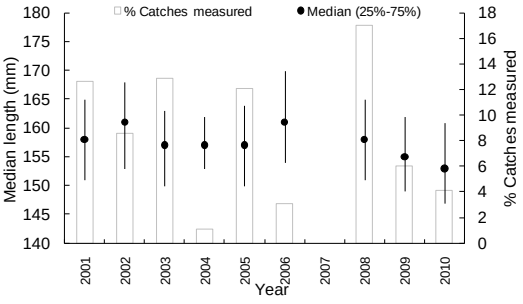


Western Zone – Strahan (Block 9)
Median length of catch

Sub-block 9B
Cape Sorell to Gorge Point

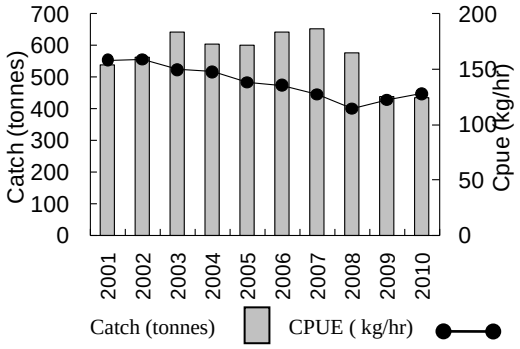


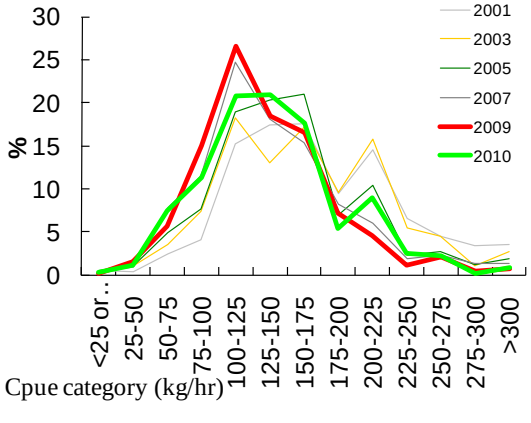
Sub-block 9C
Gorge Point to Point Hibbs



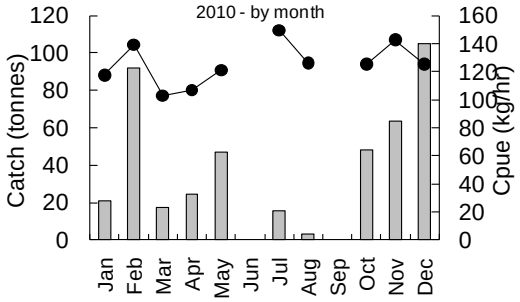
Western Zone - South West (Blocks 10-11, Sub-block 12A)

Regional view, no cap set, balance of WZ TAC=458t, 434t caught in 2010.

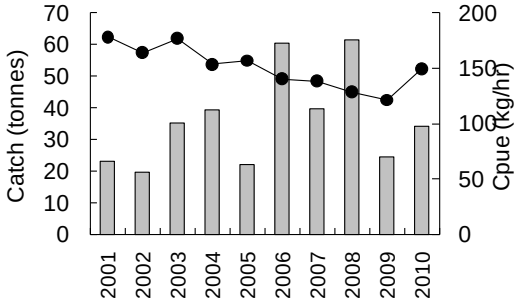




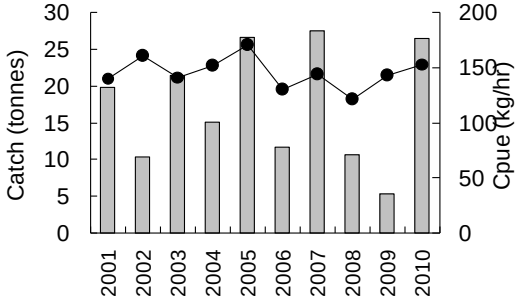
CPUE distribution:



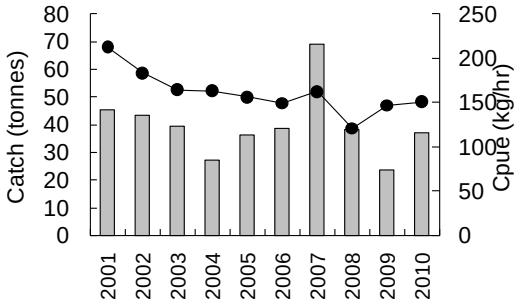
Sub-block 10A
Point Hibbs to Endeavour Bay



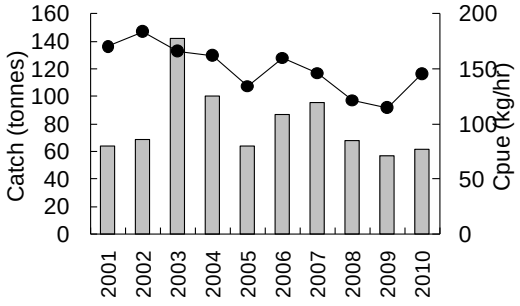
Sub-block 10B
Endeavour Bay to High Rocky Point



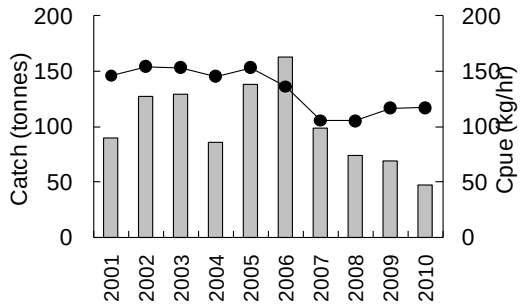
Sub-block 10C
High Rocky Point to Mainwaring River



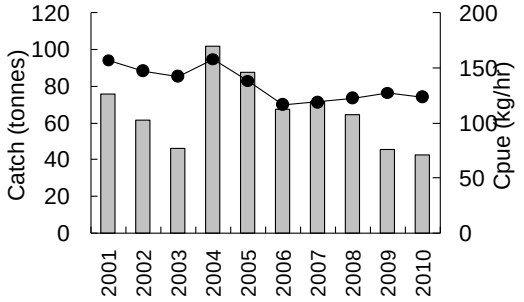
Sub-block 10D
Mainwaring River to Low Rocky Point



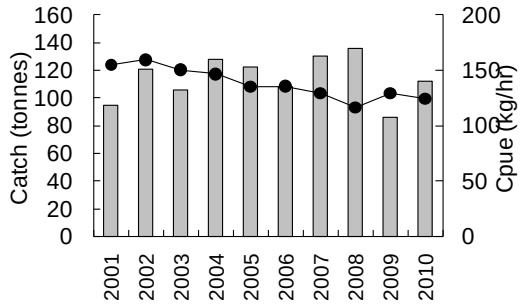
Sub-block 11A
Low Rocky Point to Elliott Point



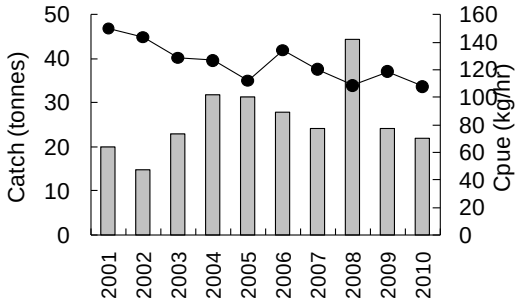
Sub-block 11B
Elliott Point to Svenor Gulches



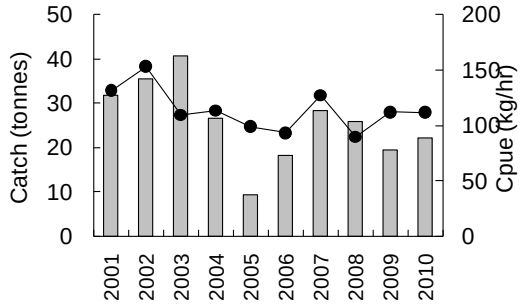
Sub-block 11C
Svenor Gulches to Point St Vincent



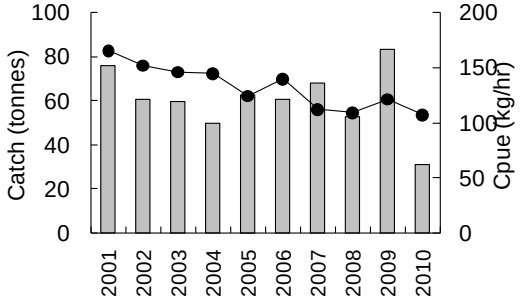
Sub-block 11D
Hilliard Head to Faults Bay



Sub-block 11E
Point St Vincent to Hilliard Head, including Port Davey

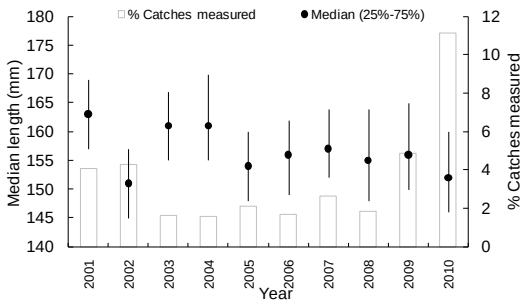


Sub-block 12A
Faults Bay to South West Cape

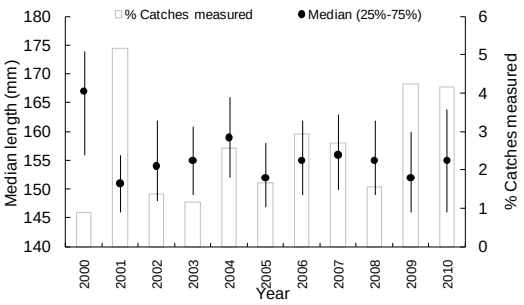


Western Zone - South West (Blocks 10-11, Sub-block 12A)
Median length of catch

Sub-block 10D
Mainwaring River to Low Rocky Point

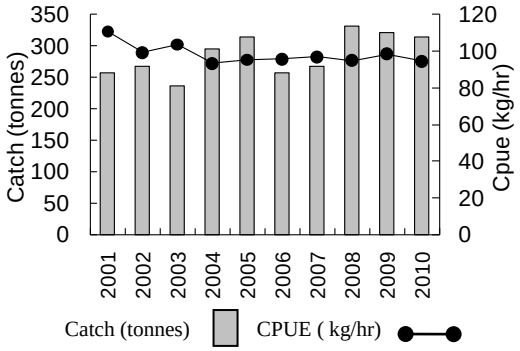


Sub-block 11A
Low Rocky Point to Elliott Point

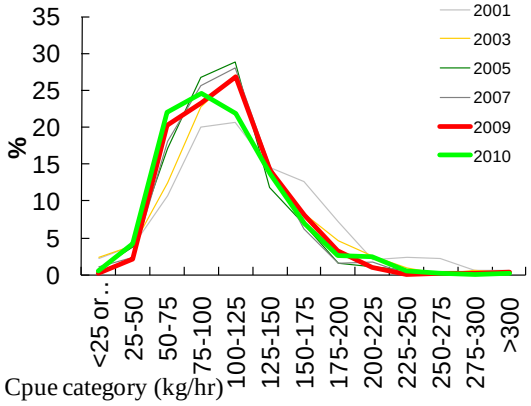


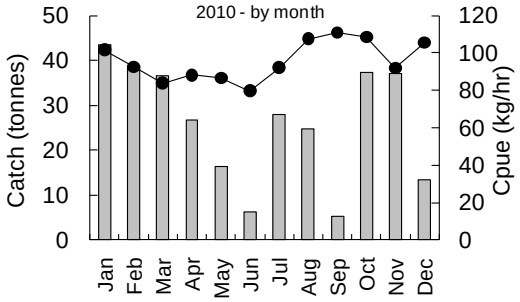
Western Zone - South Coast (Sub-blocks 12B, 12C, 12D, 13A, 13B)

Region view, cap set at 300t in 2010, 314t caught

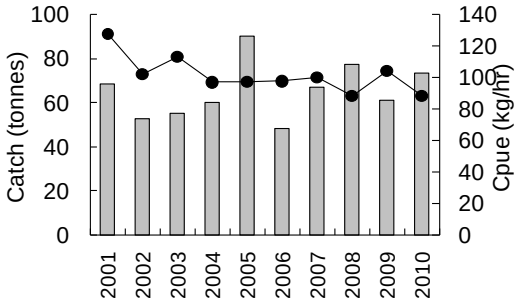


CPUE distribution:

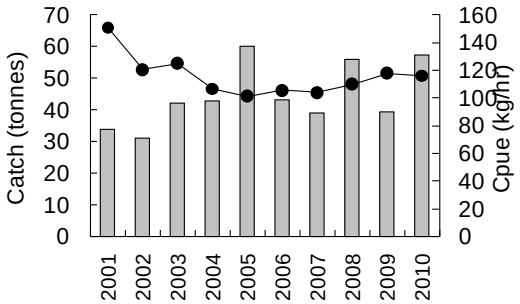




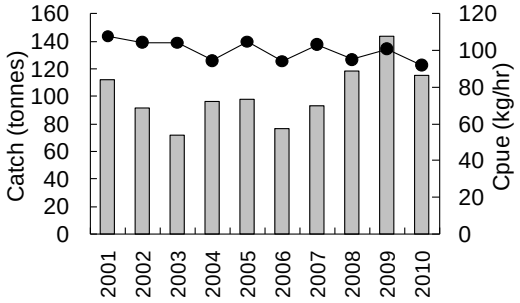
Sub-block 12B
South West Cape to Cox ‘s Bluff



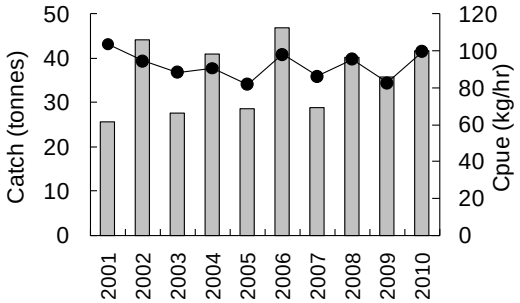
Sub-block 12C
Maatsuyker Group



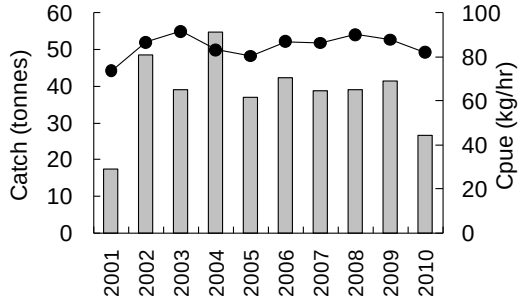
Sub-block 12D
Cox’s Bluff to Prion Beach



Sub-block 13A
Prion Beach to South Cape

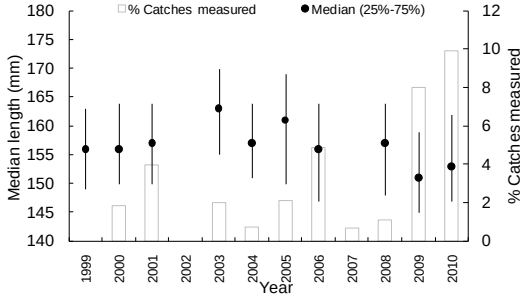


Sub-block 13B
South Cape to Whale Head

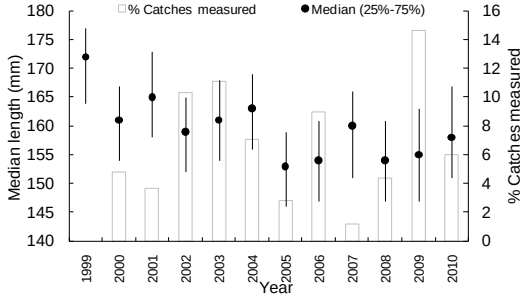


Western Zone - South Coast (Block 12, Sub-blocks 13A, 13B)
Median length of catch

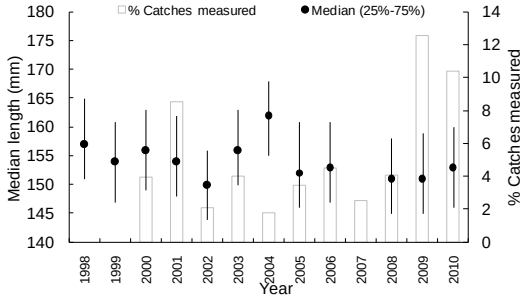
Sub-block 12B
South West Cape to Cox ‘s Bluff



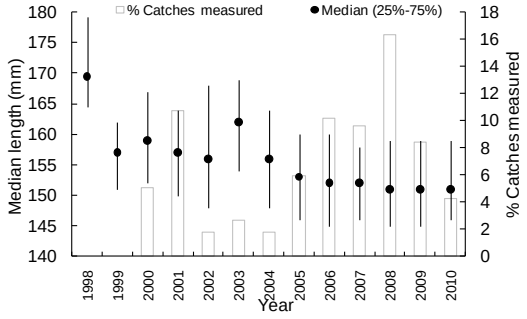
Sub-block 12C
Maatsuyker Group



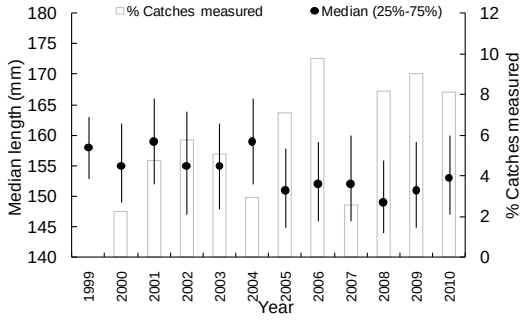
Sub-block 12D
Cox’s Bluff to Prion Beach



Sub-block 13A
Prion Beach to South Cape



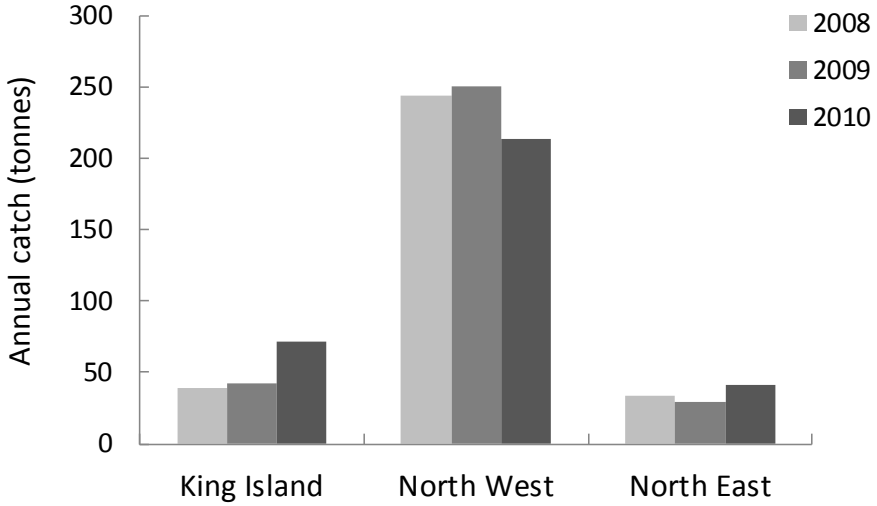
Sub-block 13B
South Cape to Whale Head



Northern Zone blacklip fishery

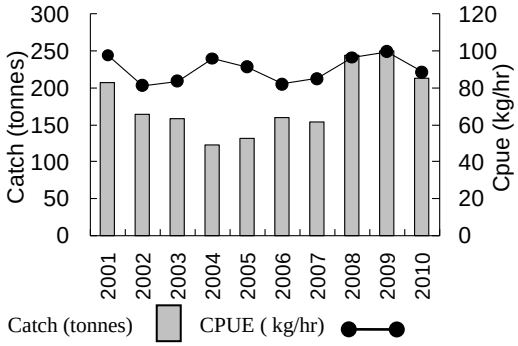
In 2010, the size limit operating in the Furneaux Group was reduced from 127 mm to 114 mm, and this part of the fishery was moved from the Northern Zone to the Bass Strait Zone. Most of the Northern Zone catch is taken from the North West, particularly from Block 5, which in recent years has been capped at 152.5 tonnes. The remainder of the zone was by default, capped at 180 t.

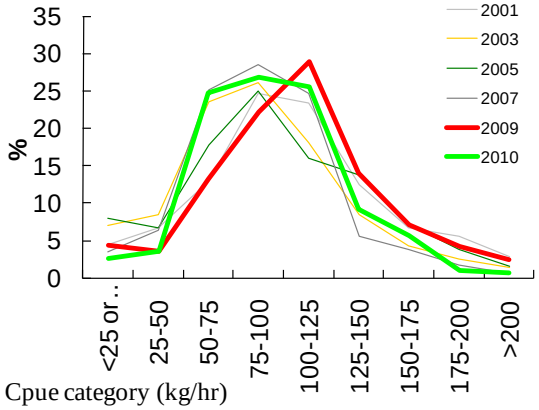
Distribution of catch between Northern Zone regions:

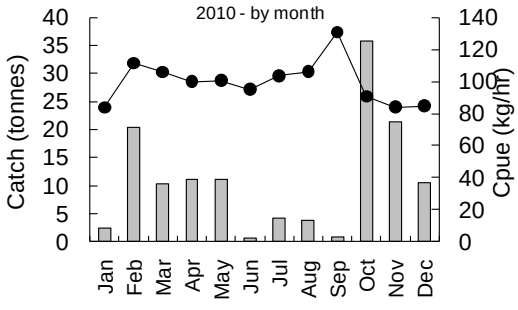


Northern Zone - North West (Blocks 5, 47- 49)

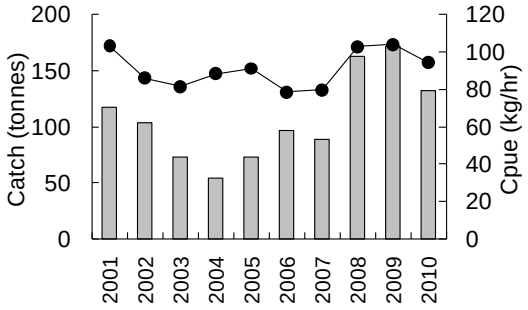
Regional view:



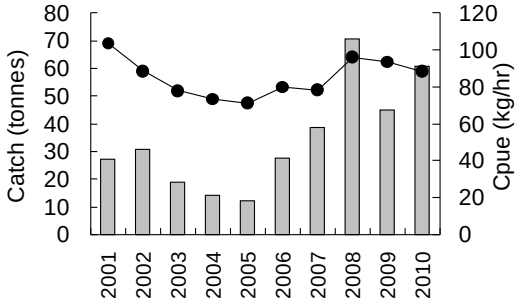




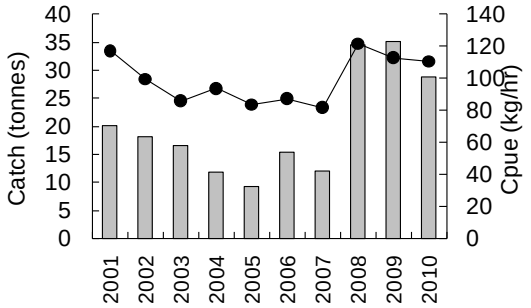
Block 5, area capped 152.5t in 2010, 132t caught.



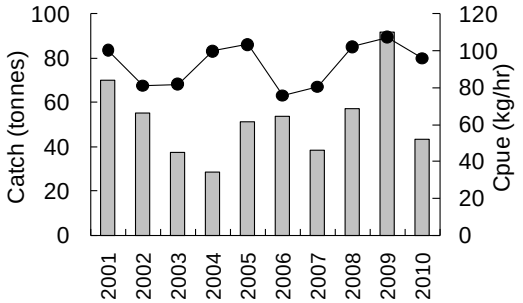
Sub-block 5A
Woolnorth Point to Studland Bay



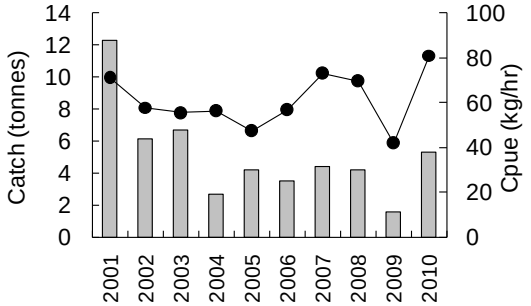
Sub-block 5B
Studland Bay to Greens Beach, including Mt Cameron West



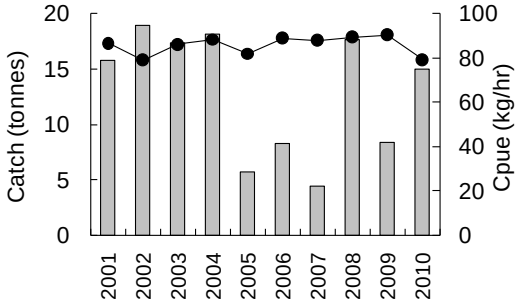
Sub-block 5C
Greens Beach to Arthur River



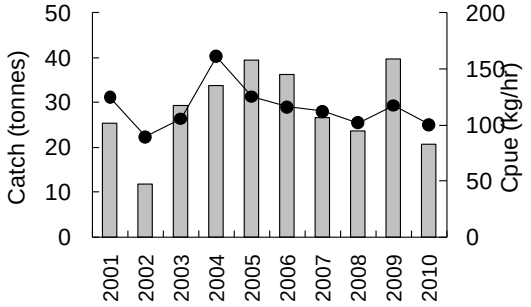
Sub-block 48C
Hunter Island to Robbins Island. 2009 CPUE affected by multi-species fishing.



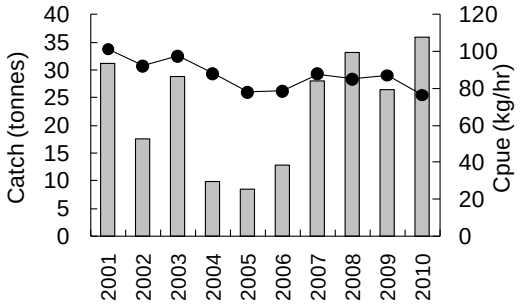
Sub-block 49A
Three Hummock Island



Sub-block 49B
Northern part of Hunter Island and Albatross Island

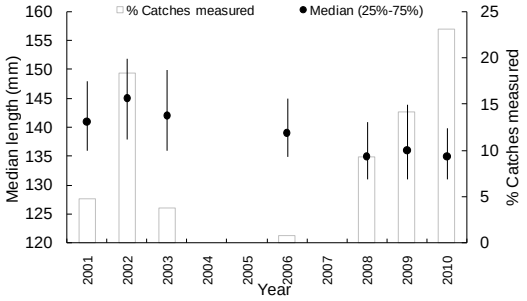


Sub-block 49C
South-western Hunter Island

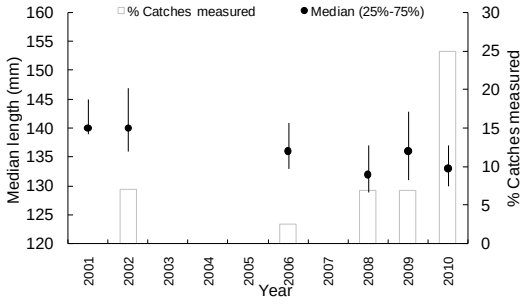


Northern Zone – North West (Blocks 5, 47- 49)
Median length of catch

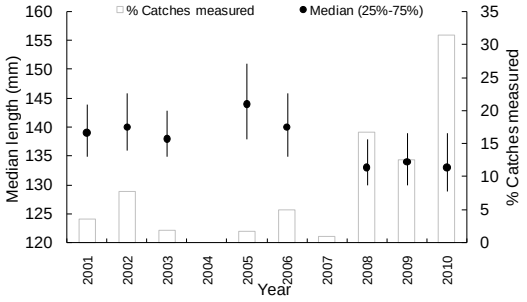
Sub-block 5A
Woolnorth Point to Studland Bay



Sub-block 5B
Studland Bay to Greens Beach, including Mt Cameron West

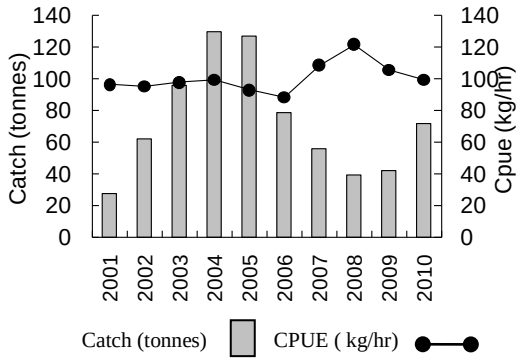


Sub-block 5C
Greens Beach to Arthur River

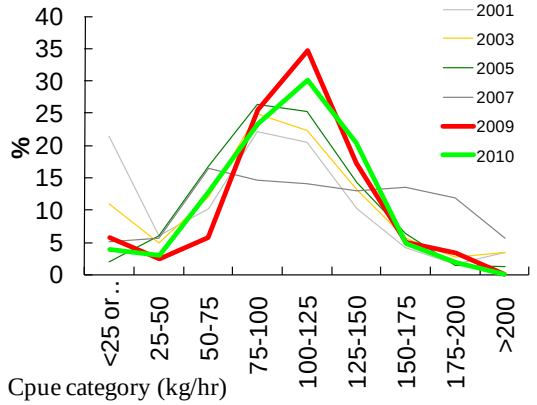


Northern Zone - King Island (Blocks 1-4)

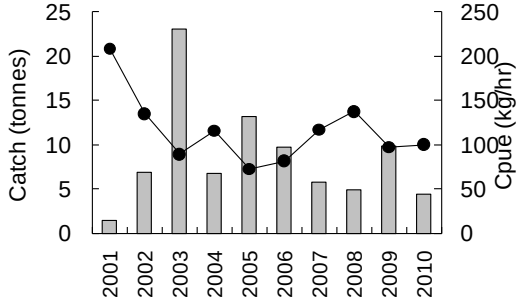
Regional view:



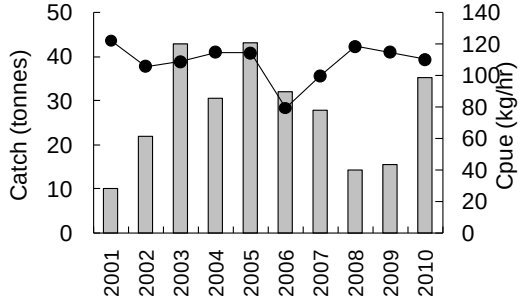
CPUE distribution:



Sub-block 1C
North-west King Island

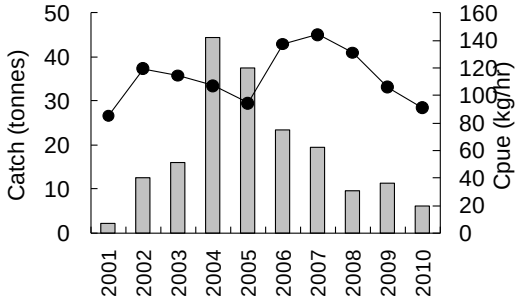


Sub-block 3A
west King Island

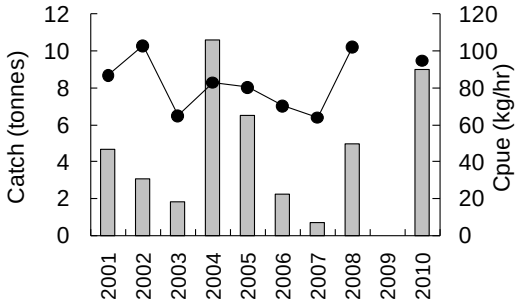


Sub-block 3B
South-west King Island
No catch reported 2010

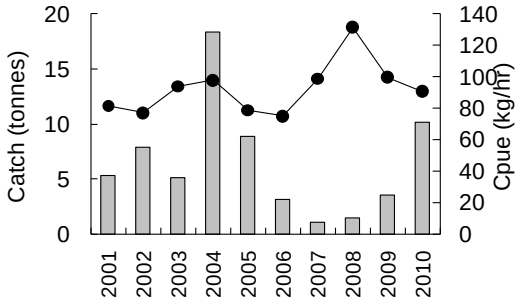
Sub-block 3C
South-west King Island



Sub-block 4B
South-east King Island

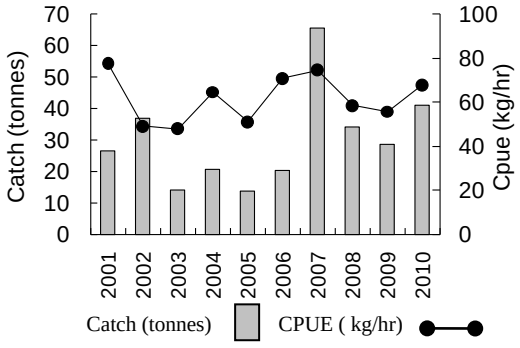


Sub-block 4C
South-east King Island

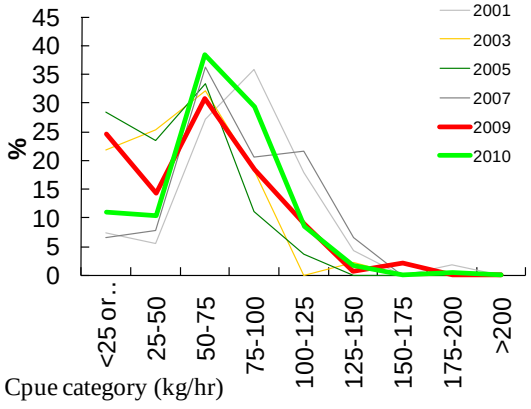


Northern Zone - North East (Sub-block 31B, Blocks 39, 40)

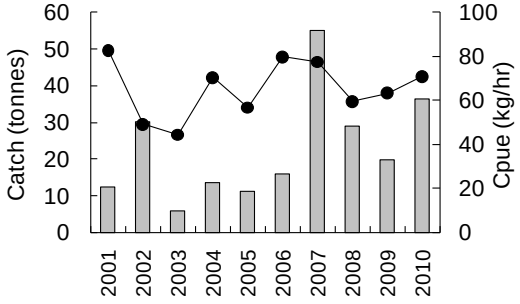
Regional view:



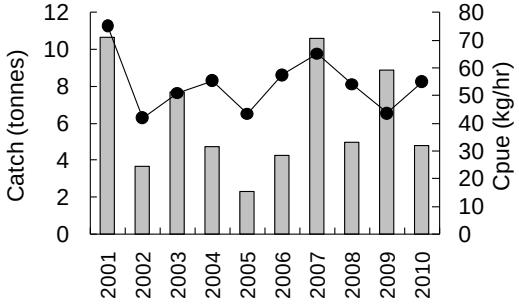
CPUE distribution:



Sub-block 31B
Cape Naturaliste to Little Musselroe Bay



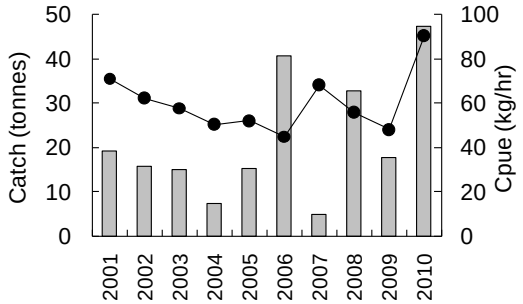
Sub-block 39A
Little Musselroe Bay to Petal Point



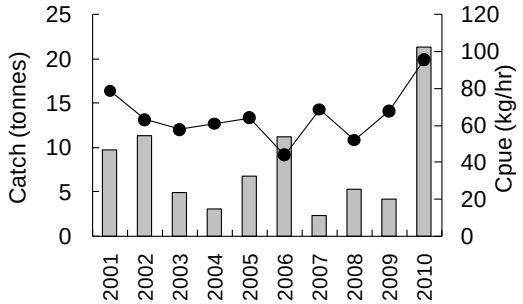
Bass Strait Zone blacklip fishery

Bass Strait Zone - Furneaux Group (Blocks 32-38)

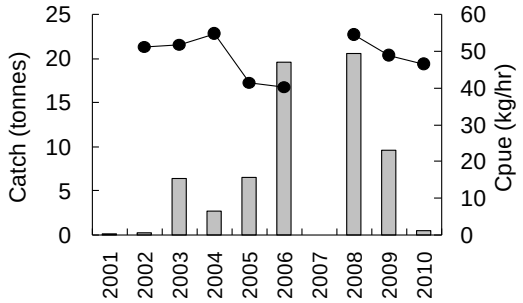
Furneaux Group: (Blocks 32-38)
Region cap set at 35t in 2010, 48t caught.



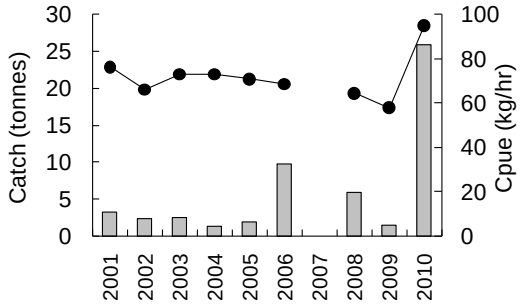
Block 33
South-east Furneaux Group



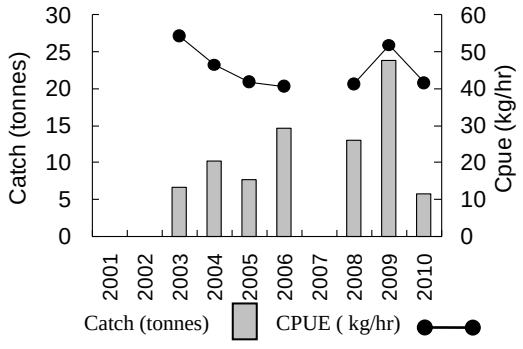
Block 37



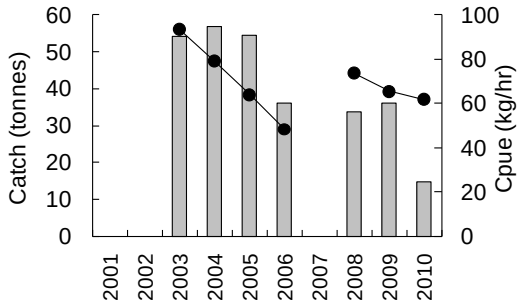
Block 38
East side of Flinders Island, inc Babel Island



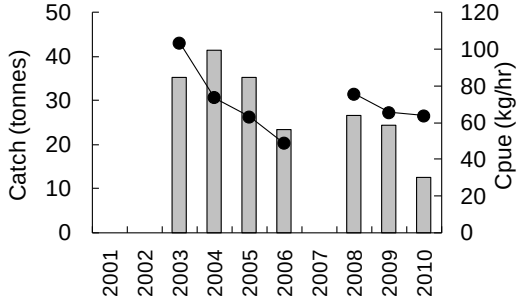
Central North (Blocks 40-46)



Bass Strait Islands (Blocks 50-56)



Block 53
Hogan Group



Greenlip fishery

The 2010 greenlip TAC of 133t was distributed between five regions:

King Island – 30t
North West – 18t
Perkins Bay- 20t
North East – 23t
Furneaux Group – 42t

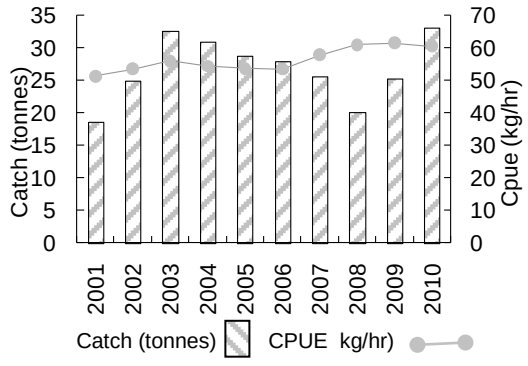
Annual catches:

Year	King Island	North West	North East	Furneaux Group	Perkins Bay	Total
2000	9.6	41.0	38.9	42.5	8.1	140.1
2001	18.6	28.9	30.4	44.2	17.8	139.9
2002	25.0	29.9	31.3	43.3	10.0	139.5
2003	32.6	30.3	35.3	37.6	4.0	139.8
2004	31.0	25.3	31.4	36.8	4.0	128.5
2005	28.8	25.2	19.4	42.4	7.2	123.0
2006	27.9	22.9	16.2	39.6	16.1	122.7
2007	25.6	22.8	33.5	31.1	10.5	123.5
2008	20.0	19.1	24.4	34.9	22.1	120.5
2009	25.3	13.7	35.0	27.3	20.1	121.4
2010	33.1	22.8	24.6	33.6	19.7	133.7

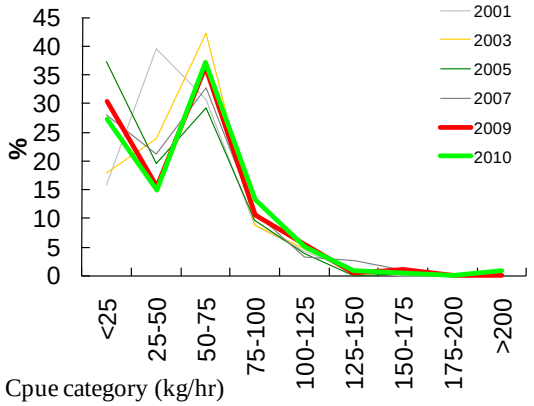
Small quantities (<1.0t pa) have also been taken in recent years from Blocks 41 to 46.

Greenlip - King Island (Blocks 1-4)

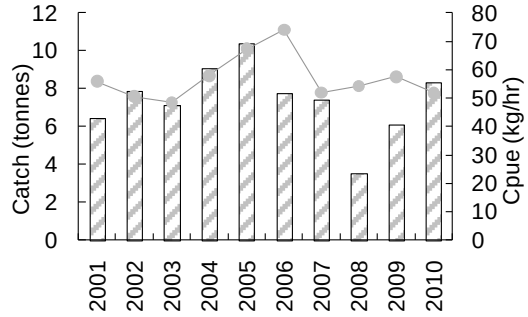
Blocks 1-4, region cap 30t in 2010, 33t caught.



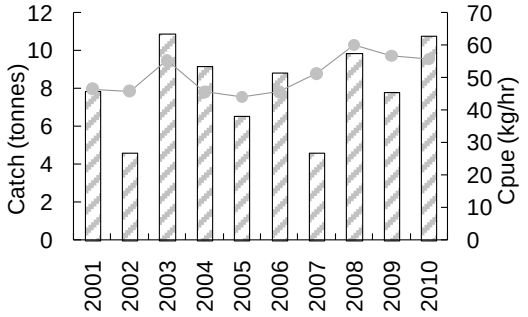
CPUE distribution:



Sub-block 1B
north-west King Island

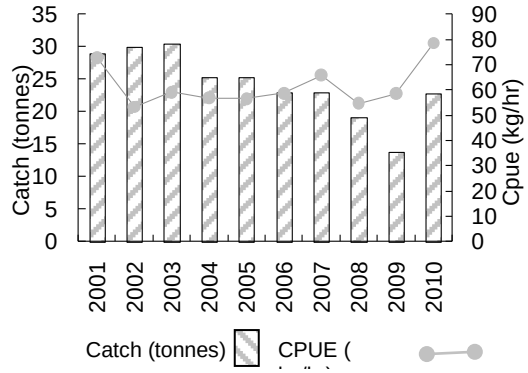


Sub-block 2C
east King Island

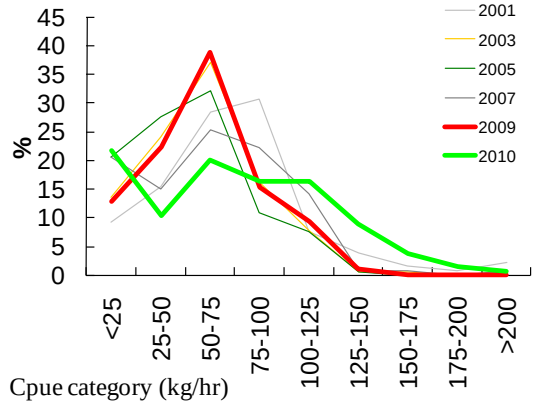


Greenlip - North West (Blocks 5, 48B, 48C, 49))

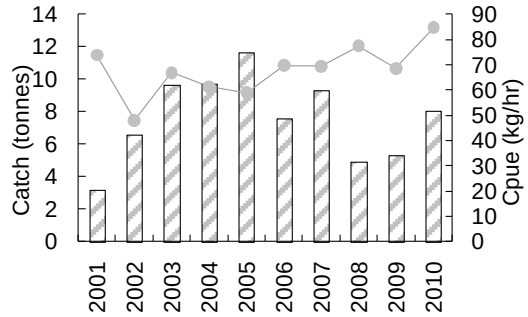
Regional view:



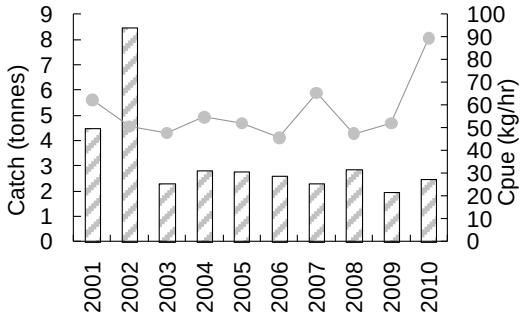
CPUE distribution:



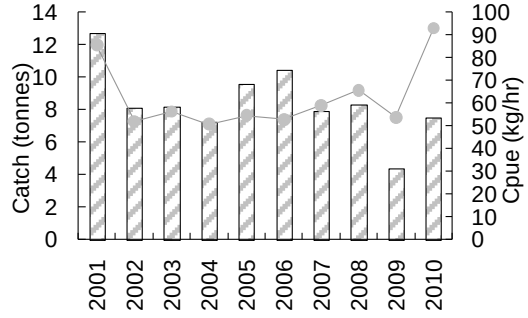
Sub-block 5A
west of Woolnorth Point



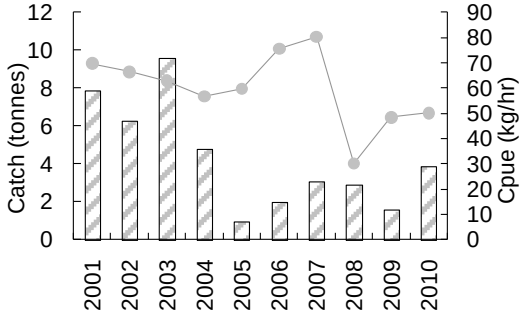
Sub-block 48B
Petrels



Sub-block 48C
Woolnorth to Robbins Island

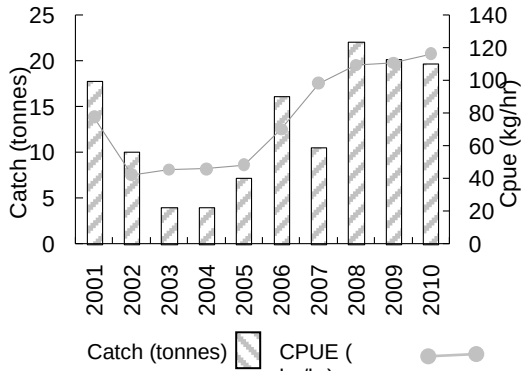


Sub-block 49C
west of Hunter island

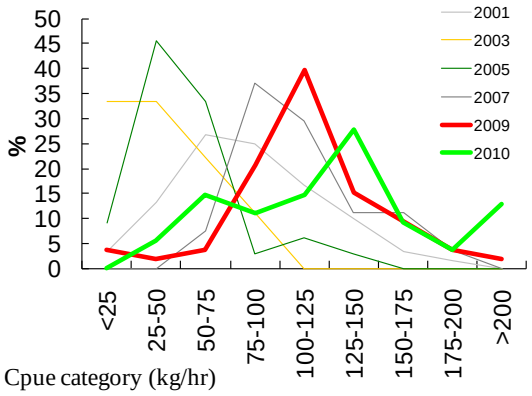


Greenlip – Perkins Bay (Blocks 47, 48A)

Sub-block 48A, Black Reef. Only small (<100kg pa) amounts of catch have been reported from Block 47. Region cap was 20t in 2010, 20t caught.

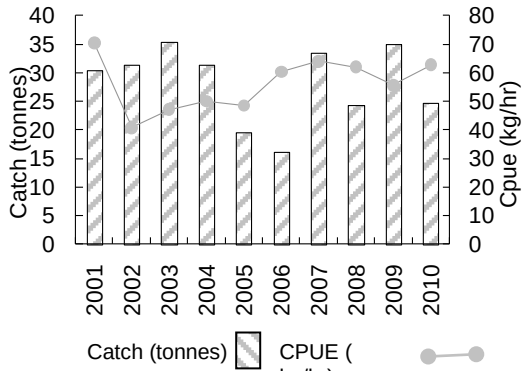


CPUE distribution:

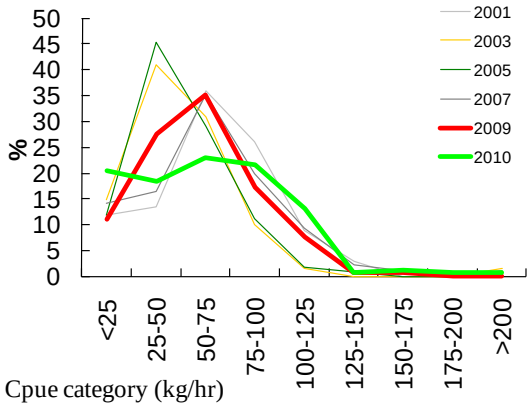


Greenlip - North East (Blocks 31, 39, 40)

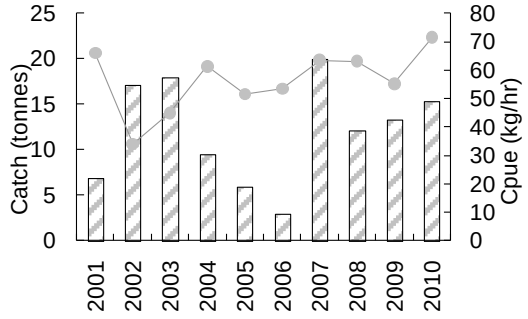
Regional view:



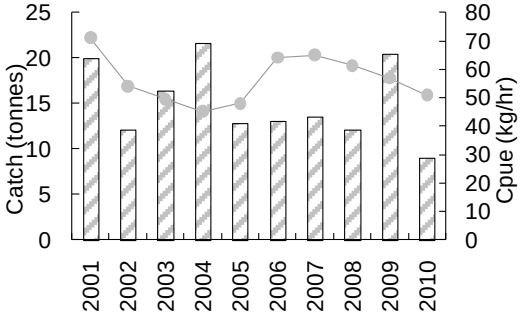
CPUE distribution:



Block 31
Eddystone Point to Little Musselroe, Swan Is.

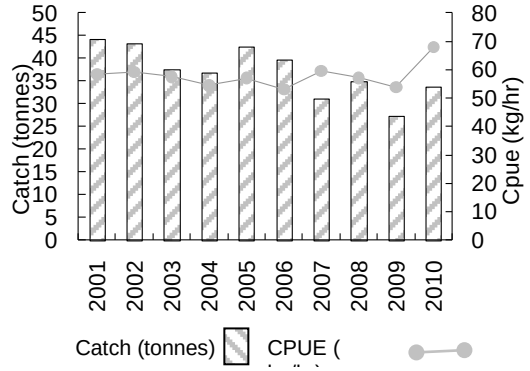


Block 39
Tomahawk to Little Musselroe

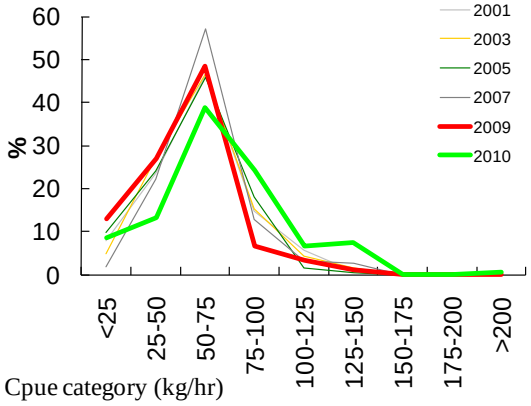


Greenlip – Furneaux Group (Blocks 32-38)

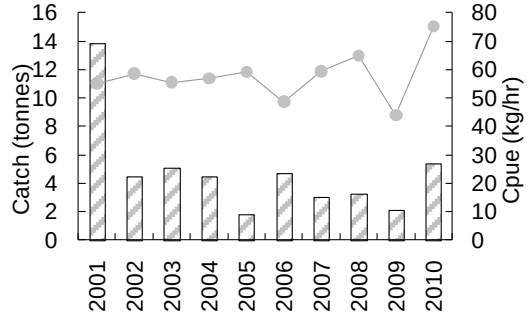
Regional view:



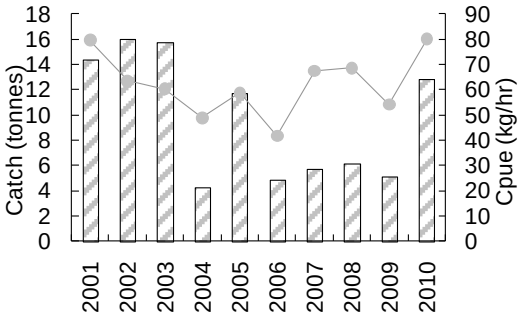
CPUE distribution:



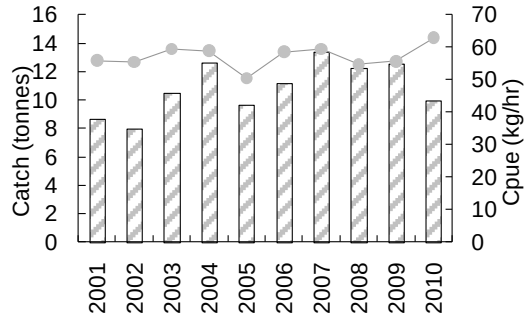
Block 32
western side of Clarke Is, Armstrong Passage



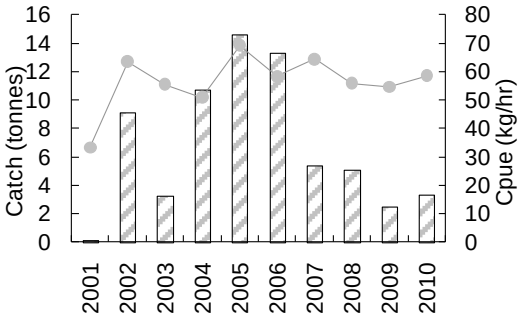
Block 33
south east Clarke, Cape Barren Islands



Block 35
Franklin Sound



Block 38
north-east Flinders Island



Appendix 2: Preliminary assessment of the fishery

Table 2. Summary of changes in catch, catch rate (CPUE) and median length, by region, and preliminary assigned fishery status prior to review by divers.

Region	Catch	CPUE	Length	Probable change in abundance
South West (WZ), Perkins Bay (G)	stable	rising	rising	Stable or increasing abundance, low levels of fishing mortality enable growth of fish
	stable	rising	falling	Stable or increasing abundance, falling median length indicates substantial increase in recruits
	stable	rising	stable	Stable or increasing abundance, no effect on length of fish detected
	stable	rising	no data or erratic	Stable or increasing abundance
Actaeons and Lwr Channel (EZ)	stable	falling	rising	Falling abundance, falling recruitment
	stable	falling	falling	Falling abundance, high fishing mortality reduces fish length, serial depletion possible
	stable	falling	stable	Falling abundance
	stable	falling	no data or erratic	Falling abundance
Block 9 (WZ)	stable	stable	rising	Increasing abundance, survival rates > fish mortality, sufficient to enable growth of median length
	stable	stable	falling	If catch and CPUE low, implies falling abundance through serial depletion, which maintains CPUE and catch, but fishing pressure reduces size. If catch and CPUE moderate to high, implies stable stock levels, increasing recruitment
	stable	stable	stable	Abundance stable or falling
South Coast (WZ)	stable	stable	no data or erratic	Abundance stable or falling
	stable	erratic	rising	Depends on relative strength of cpue, but in absence of rising cpue, abundance probably falling
	stable	erratic	falling	
	stable	erratic	stable	
	stable	erratic	no data or erratic	

Region	Catch	CPUE	Length	Probable change in abundance
	falling	rising	rising	Insufficient exploitation for clear signal, indicates current levels of exploitation insufficient to impact on stocks, which could be at low or high levels
	falling	rising	falling	
	falling	rising	stable	
	falling	rising	no data or erratic	
Bruny Island (EZ)	falling	falling	rising	Stock levels almost certainly falling, absence of recruits causes median length to rise, indicates weak recruitment
	falling	falling	falling	Stock levels almost certainly falling, high fishing mortality reduces median size
	falling	falling	stable	Stock levels almost certainly falling
Bass Strait Islands (BSZ)	falling	falling	no data or erratic	Stock levels almost certainly falling
	falling	stable	rising	Stock levels almost certainly falling, absence of recruits causes median length to rise, indicates weak recruitment
	falling	stable	falling	Stock levels almost certainly falling, high fishing mortality reduces median size
	falling	stable	stable	Stock levels almost certainly falling
	falling	stable	no data or erratic	Stock levels almost certainly falling
	falling	erratic	rising	Stock levels stable or decreasing, less likely to be increasing.
	falling	erratic	falling	Stock levels stable or decreasing, less likely to be increasing.
	falling	erratic	stable	Stock levels stable or decreasing, less likely to be increasing.
Furneaux Group (G)	falling	erratic	no data or erratic	Stock levels stable or decreasing, less likely to be increasing.
	rising	rising	rising	Increasing abundance, low levels of fishing mortality enable growth of fish
Block 6 (CWZ)	rising	rising	falling	Increasing abundance, falling median length indicates substantial increase in recruits or size limit decrease
	rising	rising	stable	Increasing abundance
	rising	rising	no data or erratic	Increasing abundance

Region	Catch	CPUE	Length	Probable change in abundance
East Coast (EZ), Storm Bay (EZ), North West (NZ), Blocks 7 & 8 (CW)	rising	falling	rising	Stock levels falling, reduced recruit levels
	rising	falling	falling	Stock levels falling, increasing fishing mortality
	rising	falling	stable	Stock levels falling
	rising	falling	no data or erratic	Stock levels falling
King Island (G)	rising	stable	rising	Stock levels stable or increasing, less likely to be decreasing
	rising	stable	falling	Stock levels stable or increasing, less likely to be decreasing
	rising	stable	stable	Stock levels stable or increasing, less likely to be decreasing
	rising	stable	no data or erratic	Stock levels stable or increasing, less likely to be decreasing
	rising	erratic	rising	No clear signal
	rising	erratic	falling	No clear signal
	rising	erratic	stable	No clear signal
	rising	erratic	no data or erratic	No clear signal
	erratic	rising	rising	No clear signal
	erratic	rising	falling	No clear signal
	erratic	rising	stable	No clear signal
	erratic	rising	no data or erratic	No clear signal
King Island (NZ)	erratic	falling	rising	No clear signal
	erratic	falling	falling	No clear signal
	erratic	falling	stable	No clear signal
	erratic	falling	no data or erratic	No clear signal

Region	Catch	CPUE	Length	Probable change in abundance
	erratic	stable	rising	No clear signal
	erratic	stable	falling	No clear signal
	erratic	stable	stable	No clear signal
	erratic	stable	no data or erratic	No clear signal
North East (NZ), North East (G), Central North (BSZ), Furneaux Group (BSZ), North West (G)	erratic	erratic	rising	No clear signal
	erratic	erratic	falling	No clear signal
	erratic	erratic	stable	No clear signal
	erratic	erratic	no data or erratic	No clear signal

Appendix 3: Interpreting graphical information

Catch and catch rate by region, block and sub-block.
Catch and catch rate information is shown across a range of geographical scales ranging from large (regional) to small (sub-block) where relevant (i.e. catches consistently larger than 10 t pa, or six or more divers contributed to the catch). Figure 9 shows catch and catch rates for the last eight years for sub-blocks. The vertical columns show catch in tonnes, for the period 2000-2007. The black line with balls shows catch rates (CPUE) over the same period. Greenlip charts show catch as hatched columns, and catch rates as grey balls joined with a grey line.

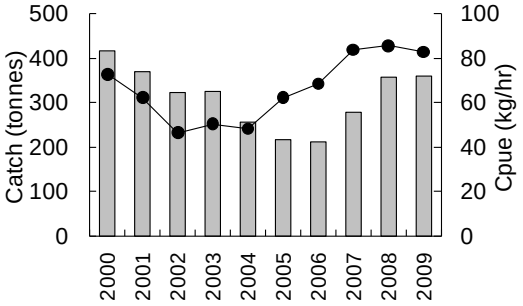


Figure 9. Annual catch (tonnes) and geometric mean catch rates (kg/hour), 2000 - 2009.

Catch and effort were not reported by sub-block and zone prior to 2000, and consequently are shown only from that year onwards. Additionally, catch rates trends over short periods (compared with longer periods) are more likely to reflect changes in abundance of abalone and not changes in fishing methods, and catch rates earlier than 2000 are not used in this assessment.

Regional catch-rate distribution:
The distribution of catch rates provides information about how divers are catching abalone that is not explained by the mean (Figure 10). That the distributions are skewed (not evenly distributed about the category with the highest percentage) implies that fewer divers are achieving high catch rates. Skewness tends to be greatest when abalone abundance is low or has been recently reduced, making high catch rates less common.

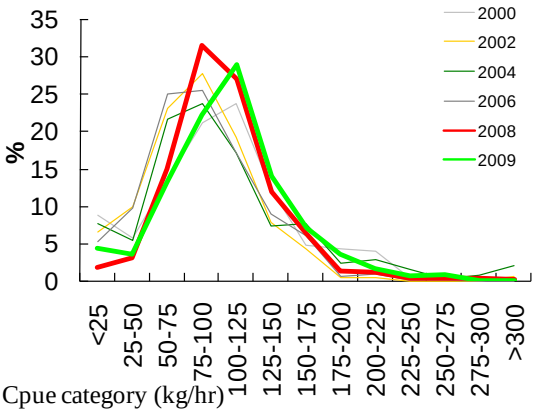


Figure 10. The percentage distribution of catch-rates, 2000 - 2009.

Size-composition charts.

The size-composition of divers' catches is reviewed at sub-block level (Figure 11). At this spatial scale, there is a greater likelihood that the catches come from populations with similar growth characteristics than at larger scales. We are unable to estimate the percentage of catches sampled prior to 2000 because sub-block reporting was not introduced until then. We are able to attribute some sampled catches to sub-blocks in earlier years, because we know the location from where the catches were taken.

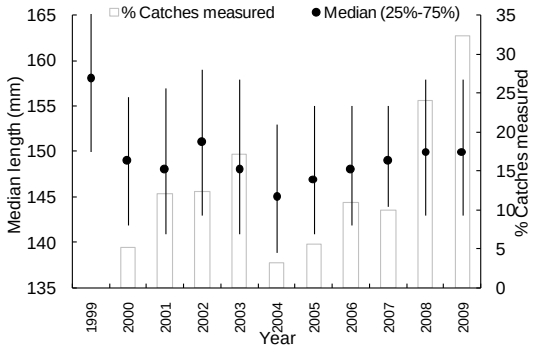


Figure 11. Median length with 25%-75% inter-quartile size range of abalone from commercial catch samples. The vertical columns represent the percentage of catches sampled.

Size-composition charts plot median length (the middle or 50th percentile length if all abalone were sorted from smallest to larges t) for the period 1998-2008 (or the period since catches can be attributed to sub-blocks). They also show the size of abalone at the 25th and 75th percentiles i.e. the size range of the middle 50% of abalone from the sampled catches.

Appendix 4: Interpreting trends in catch and catch rate, and the size composition of the commercial catch

a) 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. Despite CPUE being much discredited as an index of abalone abundance (e.g. Breen (1992), Prince (1992), Shepherd *et al.* (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: gregarious behaviour of abalone, serial depletion of local populations constituting the stock, and changes in fishing efficiency. 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.

Gregarious behaviour

Abalone tend to aggregate in favourable habitat (e.g. gutters, sand-edges, shallow margins), and a large proportion of abalone may be found in only a small area of each reef (Prince, 1992). When these aggregations are fished, the remaining abalone tend to form new aggregations (Officer et al., 2000), and thus reefs may become depleted while catch rates are maintained (McShane, 1995; Officer et al., 2000). Similar problems among other commercially fished marine species are well documented (e.g. Hilborn and Walters (1992), Rose and Kulka (1999)).

Where abalone abundance is high and abalone are aggregated, catch rates are primarily a function of handling time (the time taken to detach abalone from the reef and transfer them to the boa t). As abalone abundance decreases, and aggregations become smaller and further apart, search time increases, and adds significantly to the overall effort required. This makes the relationship between abalone abundance and CPUE non-linear (hyperstable – CPUE remains high even when stock size reduces), and by the time catch rates start to decline rapidly, abalone abundance will already have been greatly reduced (Prince, 1992).

A related problem occurs when divers search for favourable habitats, and the aggregations within them. Time spent searching for aggregations is only weakly related to the number of individuals landed, and catch rates do not necessarily decline at the same rate as the abundance of aggregations (Breen, 1992). Under these circumstances, catch rates are again unreliable, and extra care is needed when attempting to interpret such information. This problem would also occur if divers were searching for areas containing abalone within a specified size range, or where divers were swimming over larger abalone within an area if selecting a particular size range of abalone.

Where abalone abundance is low, a consequence of aggregating behaviour is that the most favourable habitats can accommodate most of the population and the surrounding areas may be relatively sparsely populated. Provided effort is also low (i.e. diver visitation rates are low), legal-sized abalone move to the favourable habitat (Officer et al., 2000; Shepherd and Partington, 1995) between fishing events. Experienced divers can maintain catch rates by fishing the most favourable areas (Shepherd and Partington, 1995), and the CPUE/abundance relationship is again non-linear and hyperstable.

Serial depletion

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). Reefs are abandoned when divers find it harder to maintain levels of daily catch, and effort is focused on reefs with higher stock levels. When there are many reefs with low levels of abundance in a reporting block, divers can move between reefs, depleting stock levels in each, while producing stable but relatively low levels of annual catch at acceptable catch rates.

If management units are large and catch reporting occurs over large spatial scales, falling catch rates caused by depletion of individual reefs are masked when divers transfer effort to reefs with higher levels of abundance. If catch reporting occurred at the scale of individual reefs, the fall in CPUE that precipitated the divers' movements and the fall in catch indicative of depletion would be detected. In Tasmania, the recently introduced sub-block scale of reporting (Appendix 11) is an improvement, but is still too large to detect such fine scale declines in CPUE.

Regular patterns observed in the spatial distribution of catch from Tasmania's East Coast appear to indicate that provided effort is low enough, stock levels on the reefs first depleted may recover sufficiently to support further fishing, thus developing a cycle of depletion and recovery. Analysis of catch data from a range of reporting blocks has revealed historically low levels of annual catch. Such low catch levels may appear stable in the short term, but have been seen to fall slowly over a period of years, presumably as reefs become less productive (i.e. the period between fishing and recovery is greater than the period between fishing events). Examples include Blocks 25, 26, 28, 29 and 30. Catch rates under this scenario typically appear stable, or with improvements in diver efficiency, may even rise slowly.

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 = qB, 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, because of improved efficiency, if stock levels are unchanged, more abalone can 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, in fact, 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 to the boat every time they filled their nets. This increased efficiency because:
(a) time spent ascending to the boat, unloading the catch and descending back to the reef was eliminated,
(b) the diver maintained his position on the productive part of the reef,
(c) catch bags could be reduced in size, which meant that divers could swim more easily and with less effort.

However, the increase in efficiency caused by droplines is not constant across all abalone densities. At low levels of abundance, divers may finish swimming over a reef before their net is full, so the method offers little improvement. At the other extreme, when nets are being filled every few minutes because abalone are particularly abundant, the method offers great savings in time i.e. the method causes catch rates to change non-linearly with abundance.

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 help divers move more quickly between concentrations of abalone, particularly in deeper water.

Changes in fishing efficiency due to behavioural causes, while not as obvious as technological causes, may have a profound effect upon catch rates. Competition between divers for fish or quota, or inducements offered by processors, or management changes, may all improve, or at least alter, the way divers work (Gorfine, 2001). Divers, either individually or as a group may learn to fish an area more effectively (Breen, 1992). Daily catches may increase when divers realise they are catching at a high rate, leading to a correlation between high catch rates and larger catches (Worthington et al., 1998). These types of changes are more difficult to detect and account for than changes in fishing methods.

In Tasmania, the practise of team diving (where two divers share a boat and catch fish on the same quota unit) was legitimised in 2005. Team diving potentially has the effect of reducing diver efficiency, but increasing profitability because of cost-sharing between the divers. Prior to 2005 team diving was illegal and unreported but allegedly quite common. There is no information to show that the incidence of team diving post-legalisation is different to the former level, but it is potentially a cause of changes to diver efficiency.

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 (Figure 12).

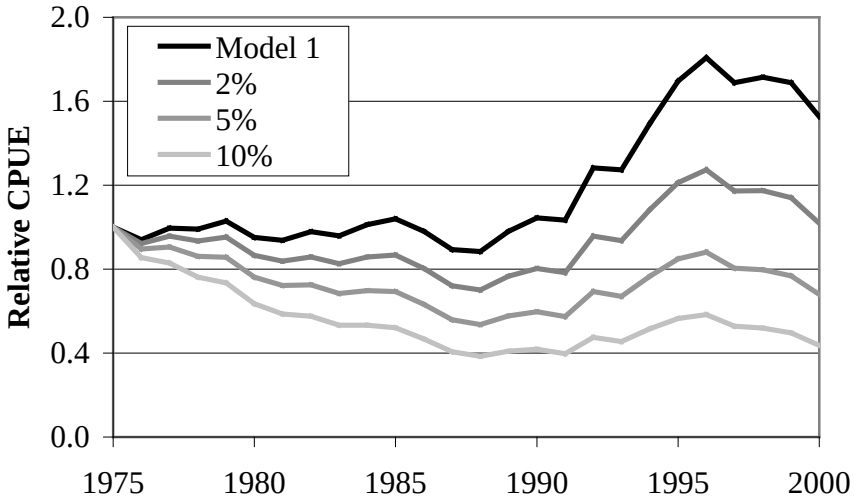


Figure 12. Relative CPUE indices for Block 13, 1975-2000. Model 1 is the raw geometric mean of CPUE. The three effort creep scenarios considered are: (i) 2% per annum; (ii) 5% per annum; and (iii) 10% per annum. All values of CPUE are relative to 1975 (Tarbath et al., 2001).

Improvements in efficiency are extremely difficult to quantify accurately. Without the resources to make an intensive study into historical diving techniques and behaviour (which anyway would have to rely on divers' memories) or alternatively make guesses about how much more efficient current divers have become, we have chosen to limit the comparison of catch rates over a short period during which we assume that divers operated with equal efficiency. This assessment reviews catch-rate trends over the last seven years. (The introduction of sub-blocks and consequent finer scale reporting in 2000 means that most comparisons at a finer geographical scale are currently limited to a seven-year period.) By reducing the period over which comparisons are made, it is assumed to be more likely that changes due to improved fishing methods or diver behaviour are avoided, and there is more confidence that catch-rate trends represent changes in abundance, not changes in fishing power.

Circumstances when catch rates are reliable indices of abalone abundance

When problems caused by abalone aggregations, serial depletion and improved efficiency are understood and measures are taken to counter their effects, catch rates can reliably reflect abundance. For example, in the NSW blacklip fishery, high visitation and exploitation rates preclude the formation of aggregations of legal-sized abalone, and stocks are uniformly maintained at a low level. A consequence of this is that the recovery-depletion cycle evident in other fisheries is removed. Researchers in NSW have concluded that with the lowered stock abundance catch rates had become a reliable index of abundance (Andrew et al., 1997; Worthington et al., 1998). Similarly, in the more heavily fished parts of Tasmania (e.g. the Actaeons) where it is known that diver visitation rates to reefs are high (i.e. restrict the formation of aggregations), divers are unable to successively deplete reefs (because all reefs support continuous levels of effor t). Provided the effects of effort creep are reduced by limiting the review period to years when diving methodology is unchanged, we can assume that catch-rate trends are indicative of changes in abundance.

These conditions of intense fishing pressure are probably common in parts of the Eastern Zone fishery from where most of the catch is taken, particularly the Actaeons and Storm Bay regions, and the more heavily fished parts of the Northern and Western Zone fisheries in North West Tasmania and the South Coast. However, there are many parts of the Tasmanian fishery where these conditions cannot be met, and assessment of these areas based on catch rates must be viewed with caution. The following cases are discussed:

Earlier assessments assumed that abalone abundance was high on Tasmania's west coast because catch rates were relatively high compared with the east coast. It now appears that along much of the coast line, the population remnants contracted to either deep water or the wash zone, where they could still be caught at high catch rates. Earlier assessments also failed to account for the larger size of west coast fish, which accounted for much of the difference in catch rates. The reported decline of stocks and widespread concern among divers who fish in the South West highlights the dangers of relying upon absolute values of catch rates to gauge abundance levels.

Because of past quota reductions, much of the Eastern Zone, particularly the northern part of the East Coast, has been fished at low levels of effort. This means that effort has been not been consistently applied to populations, allowing the formation of aggregations between fishing events, which may span fishing years. In addition, in recent years, catch levels have been dependent upon divers rotating effort and successively depleting reefs on much of the East Coast between Triabunna and Eddystone Point (Blocks 25 – 30). Under these circumstances, the relationship between abalone abundance and catch rates is almost certainly different than under conditions of constant levels of effort, and catch rate trends should be used with caution.

Much of Tasmania's greenlip fishery is fished under similar circumstances to the East Coast blacklip, reducing the value of catch rates for assessment purposes. However, there are two further problems to consider with the greenlip fishery. Firstly, it is evident that many divers are learning to fish greenlip abalone more efficiently, compounding the difficulty faced in interpreting the abundance/catch-rate relationship. Secondly, each region's greenlip catch is relatively small, with few participating divers. The entry or exit of a diver who catches at different rates from the others can change the region's

catch rates (attempts at standardising effort by diver have proved unsuccessful). Throughout southern Australia, fishery managers have a long history of monitoring greenlip fisheries using fishery catch and effort data with a notable lack of success. The Victorian fishery collapsed, and fisheries in South Australia (Shepherd et al., 2001), Western Australia (Hart et al., 1999), and Tasmania (Officer, 1999) have all wiped out greenlip populations because CPUE trends provided inadequate warning of stock depletion. Consequently we have placed less reliance on a CPUE/catch-based assessment in these areas.

Despite the difficulties with interpreting catch-rate information, it is proposed that, when catch rates are examined in combination with trends in the catch itself, along with the median size of captured abalone, some interpretations are more likely than others. The strongest indications of abundance change occur in two situations: (i) when catch rates continue to decline despite a decline in the catch; and (ii) when catch rates increase when catches increase.

Declining catches combined with continuing declines in catch rates could indicate a recruitment decline: despite a reduction in fishing pressure, catch rates continue to decline because there are increasingly fewer recruits each year to the fishery. This is expected to be associated with a decline in the median size of abalone because fishing mortality increases and fewer animals are left to grow to larger sizes.

Catch rates increasing with increasing catches are likely to indicate an increase in fishable biomass. Examples include most of the east, south east and west coast blocks in the early and mid-1990's, and more recently, the Actaeons. It is expected that the median size will eventually increase, though a decrease is possible if the increased catch is due to large numbers of new recruits entering the fishery.

b) Size composition of the commercial catch

Almost since the inception of the fishery, abalone from divers' catches have been sampled for length measurements to provide information about the condition of stocks. However, because the reporting of catches was at the gross spatial scale of blocks, the samples were of limited value in assessing the impact of fishing on populations. While changes in size structure could be seen, it was never certain whether the changes were due to fishing mortality or because divers re-directed effort between populations with vastly different growth characteristics. In 1998, divers started submitting photographic samples of their catches with details of the location from where the catch was taken, which, given adequate levels of sampling, meant that individual populations could be monitored. Although the photographic program stopped in 2000, in that year the start of catch reporting by sub-blocks increased the value of length-based monitoring for the stock assessment.

Between 2000 and 2008, diver's catches from around the State were routinely sampled by TAFI research staff at fish processing factories. Most of the sampling has been from catches taken in the south east and east coasts, but catches from the north and west coasts have also been measured. The fish processing factories have included both canners and live-market traders.

Since 2008, market measuring has been undertaken by four abalone processors (Ralphs Tasmanian Seafoods Pty Ltd, Tasmanian Seafoods (Margate) Pty Ltd, Tasmanian

Seafoods (Smithton) Pty Ltd and Abalone Tasmania Pty Ltd) who together process over 40% of the catch. Processor staff measure samples of 100 abalone from catches using electronic measuring boards.

The aim of catch sampling is to provide information about the size-structure of the catch from fished abalone populations, independent of variation caused by a range of confounding effects. For example, divers' catches from the same sub-block on the same day may comprise abalone of widely varying lengths, caused by fishing populations with different growth characteristics. In the south east, the size-structure of catch samples may be influenced by seasonal growth rates, particularly when exploitation rates are low, and consequently samples collected during autumn and winter contain larger abalone than in spring and summer. Market preferences for abalone within a specific size-range will also be reflected in catch samples. There are also other more minor sources of bias relating to measuring errors, stemming from both the diver and the catch sampler.

Sampling involves measuring 100 abalone randomly selected from a diver's catch. Sample design was loosely based upon work done by Andrew and Chen (1997) in the New South Wales abalone fishery. Their strategy was to collect small samples from many catches, rather than large samples from a few catches, increasing the likelihood that the samples better represented the whole commercial catch and hence the populations from which they were taken.

For the purpose of this assessment, samples have been grouped by year and sub-block. Sub-blocks where less than 4% of catches have been sampled during more than two years have usually not been reviewed, because the level of sampling is probably inadequate to reflect size-structure of fished populations. Across much of the fishery, the level of sampling has been inadequate. Landings from motherships usually comprise catches from more than one sub-block and more than one day, and because it is not possible to identify the sub-block from where the catch came, size-compositions from areas fished predominately by motherships are not available.

The 4% level was chosen arbitrarily, with consideration given to the methods of Andrew and Chen (1997). However, where the number of annual landings is low, much higher percentages of sampling may still be inadequate. For example, during 2003 in the Western Zone sub-block 8A, there were 41 landings. Of these, four were sampled (~10%). The median and inter-quartile length estimates from the samples were larger than both those from earlier years and 2004. One of the four samples was taken from an unusually large catch caught at high catch rates, and it is surmised that, as occasionally happens on the west coast, unusually calm conditions enabled the diver to fish part of a hitherto unexploited population which contained older and larger abalone than normally encountered.

In the Eastern Zone, particularly the south east, the number of landings is much higher and effort is more evenly distributed across populations, thus reducing the effect of unusual catches. The size-composition charts of the south east blocks consistently show similar trends, even those sampled at less than the 4% level. In particular, the median length of 2002 samples in almost all sub-blocks increased, in conjunction with the 4-mm size-limit increase that was applied in that year, regardless of the level of sampling. The relatively high median size of 1998 and 1999 samples and the fall in length since then is also common across sub-blocks where those years were sampled. This trend is

consistent with known decreases in the available stock and confirms that the level of sampling is adequate to detect trends. The level of sampling in 1998-1999 can only be guessed at by applying catch numbers from later years, which suggests sampling was below 4% in many sub-blocks. (The level of sampling of pre-2000 catches could not be determined because although the sampled catch locations were known, all other catches were not reported by sub-block.) We conclude that the 4% level of sampling in the Eastern Zone is adequate, and that trends in median and inter-quartile lengths can reflect changes in the fished population size-structure.

Interpreting annual changes in median and inter-quartile lengths

Catch samples show that since 1998, throughout much of the south east there has been a trend of decreasing median size of abalone in commercial catches. Two opposing scenarios are proposed that might explain falling median length in the south east.

If abundance levels fall yet catch levels remain constant (i.e. exploitation rates rise), the average period of time between attaining legal size (recruiting) and being caught becomes shorter. Because abalone length is a function of time and growth rate, this means that overall growth is reduced, and the median length of the catch will fall. Under these circumstances, the 75th percentile length (the length which, down to the legal limit, includes 75% of the available legal stock) could also be expected to fall with the median. As long as recruitment levels are unaffected, the 25th percentile length would be expected to remain at similar levels to those seen in previous years. If exploitation rates further increase, then the 25th percentile length would eventually fall. As a further indication of falling abundance a corresponding reduction in catch and catch rate trends would be expected.

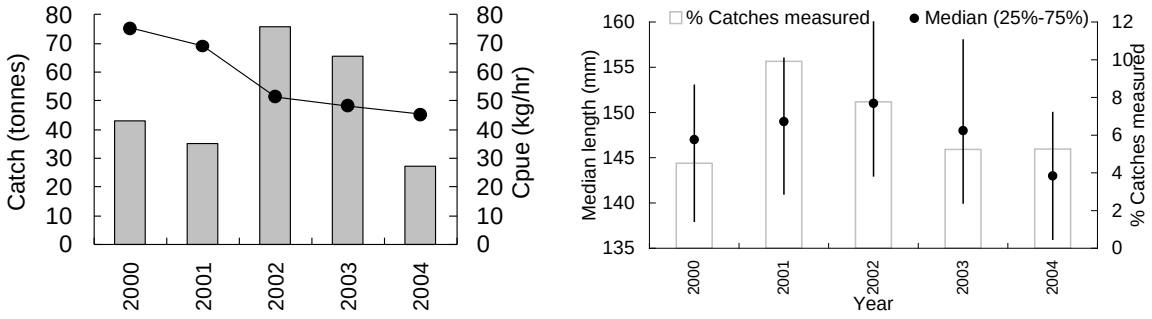


Figure 13. Trends in catch, catch rate and median length (flanked by the 25th and 75th percentile bounds), sub-block 13C, 2000-2004.

For example, in sub-block 13C (Whale Head to Fishers Point, Actaeons region) between 2002 and 2004, firstly catch rates and then catches fell, suggesting high exploitation rates (Figure 13). The median length of landed abalone increased in 2002, when the size limit was raised 4 mm, but has since fallen, again suggesting high exploitation rates. In 2004, the 75th percentile fell sharply, consistent with a fall in the numbers of large abalone landed. In addition, in 2004, the 25th percentile declined suggesting a decline in recruitment. The catch and catch rate trends indicate that abundance here is low. All three indicators suggested unsustainable levels of fishing in 2004 (Figure 13).

The second alternative interpretation of the reduced median length is that abundance of small abalone has increased due to an extraordinarily large influx of recruits. The

median and 25th percentile length could be expected to fall, but, unless the fishery was dominated by recruits, the 75th percentile length would be stable or possible increase as exploitation rates fell. Increased levels of catch and catch rate would confirm that abundance had increased. An example of this has occurred in sub-block 20B (Figure 14).

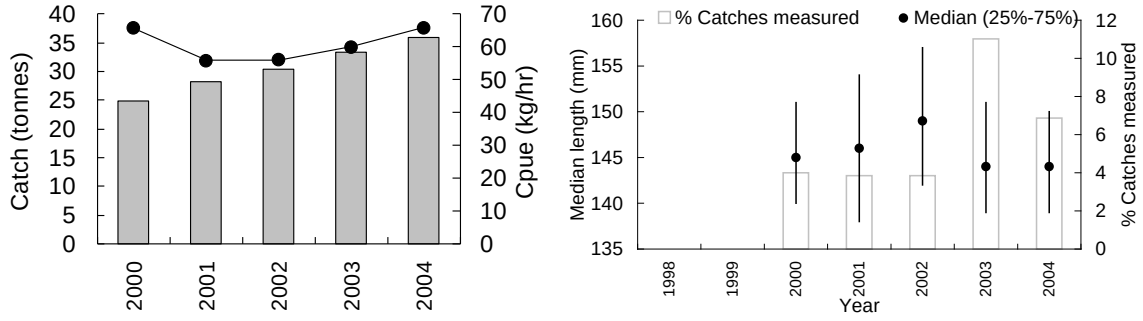


Figure 14. Trends in catch, catch rate and median length (flanked by the 25th and 75th percentile bounds), sub-block 20B, 2000-2004.

Increasing or stable median length, in conjunction with increasing catch and catch rates are strong indicators of rising stock levels. Catch rates and levels of catch in sub-block 24B (Maria Island) have started to recover since 2002 (Figure 15). The median length from catches sampled since then is also consistent with stock recovery. The increase in median length associated with the 4-mm increase in size limit in 2002 is again apparent; however, in contrast to sub-block 13C (Figure 13), the size-structure has been maintained, indicating that the levels of fishing pressure currently appear to be sustainable.

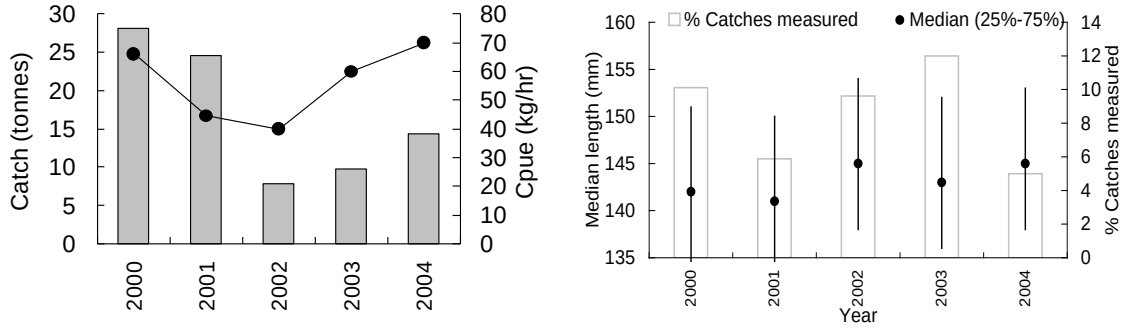


Figure 15. Trends in catch, catch rate and median length (flanked by the 25th and 75th percentile bounds), sub-block 24B, 2000-2004.

Appendix 5: Early abalone production 1960-1981

Annual totals (tonnes) of abalone production from Tasmania. Totals have been derived from three sources: the first two - divers' catches[a] and Tasmanian processors' receipts[b] have been reproduced from "Summary of Statistics – Tasmania", Abalone Situation Report 10, Demersal Mollusc Research Group, published by CSIRO, 1982. Tasmanian Year Book[c] 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).

All three totals 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. 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 is unknown.

Year	Diver [a] returns	Processor [b] returns	Tasmanian Year Book [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 6: Annual Catches by Zone – 1975-2010

Eastern Zone

The Eastern Zone comprises Sub-blocks 13C, 13D, 13E, Blocks 14 to 30 and Sub-block 31A). The Western and Eastern Zones were not established until 2000, and the Northern Zone until 2001; prior to those years catches cannot be accurately assigned to zones in blocks where zone boundaries occur (Blocks 13 and 31). Catches in these blocks are reported as Eastern Zone because the majority of later catches occurred there, and consequently the average catch for these two blocks may be overestimated.

	Year	13	14	15	16	17	19	20	21	22
Estimated weights	1975	247	111	10	47	11	0	16	27	49
	1976	208	156	0	64	36	1	18	25	45
	1977	245	232	2	190	11	1	23	35	37
	1978	322	218	6	119	24	1	32	65	60
	1979	374	251	8	148	25	2	51	52	43
	1980	272	255	7	145	30	1	33	30	42
	1981	254	299	18	127	48	4	45	69	35
	1982	337	218	15	147	24	3	36	62	63
	1983	250	300	10	189	28	3	43	63	54
	1984	318	297	18	166	35	5	47	70	73
Landed weights	1985	256	262	4	89	83	11	68	80	43
	1986	220	262	22	82	93	4	65	66	70
	1987	224	229	7	47	80	1	43	44	32
	1988	219	258	6	76	57	4	62	44	43
	1989	156	172	2	56	43	2	61	42	22
	1990	132	193	4	76	29	3	33	51	40
	1991	127	207	2	60	37	3	53	50	47
Estimated weights	1992	140	106	3	28	20	2	51	43	49
	1993	257	116	4	100	40	1	59	78	48
	1994	295	139	10	114	46	1	109	80	55
	1995	310	247	1	100	35	1	95	74	34
	1996	391	195	0	78	18	3	71	55	44
	1997	471	137	0	64	25	2	79	49	47
	1998	470	108	1	116	23	2	85	64	63
	1999	491	66	2	113	35	6	102	72	50
	2000	381	98	2	71	29	4	62	60	69
	2001	324	157	3	108	20	2	56	50	40
	2002	296	101	1	72	16	1	62	58	46
	2003	291	116	2	60	17	1	88	54	35
	2004	221	104	7	50	20	2	92	52	35
	2005	181	90	8	56	20	3	116	62	36
	2006	184	84	3	67	13	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	341	63	1	52	20	1	51	52	91
	2010	342	70	1	39	10	2	71	59	73
Average 75-10		282	168	5	90	31	3	60	56	50
Average 85-10		281	143	4	73	32	3	70	59	50
Average 00-10		287	92	3	63	16	2	72	58	56

continued next page

Eastern Zone (continued).

	Year	23	24	25	26	27	28	29	30	31	Total
Estimated weights	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	1196
	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	1519
	1983	92	99	31	14	99	103	65	296	90	1828
	1984	61	109	10	11	106	112	52	148	76	1714
Landed weights	1985	44	120	20	17	86	71	5	84	171	1515
	1986	56	88	12	20	50	58	14	124	164	1472
	1987	34	66	12	8	76	45	11	67	54	1082
	1988	34	79	10	6	65	52	16	93	90	1214
	1989	16	34	7	8	41	31	11	39	27	770
	1990	36	61	1	2	61	77	21	54	22	897
	1991	31	67	2	9	64	66	12	30	21	890
Estimated weights	1992	23	67	1	1	67	45	7	10	13	676
	1993	24	73	1	1	86	39	8	15	15	964
	1994	16	53	0	3	103	24	8	11	21	1088
	1995	19	38	0	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	160	2	25	180	77	31	10	15	1476
	1999	53	143	0	9	95	60	26	11	39	1374
	2000	44	104	1	8	101	16	21	10	90	1171
	2001	24	111	1	14	68	9	27	13	78	1104
	2002	15	46	0	2	53	7	15	12	44	847
	2003	21	51	0	3	50	8	19	3	27	848
	2004	19	51	1	1	44	11	24	6	22	761
	2005	18	66	0	0	43	13	36	7	15	770
	2006	23	88	1	1	40	10	41	0	7	773
	2007	14	59	0	1	55	11	32	0	4	766
	2008	11	68	0	1	48	6	28	0	10	807
	2009	22	63	0	0	50	5	26	2	12	852
	2010	20	67	0	0	38	6	20	3	67	888
Average 75-10		37	74	7	7	75	49	22	56	49	1123
Average 85-10		28	77	3	6	74	32	20	26	43	1022
Average 00-10		21	70	0	3	54	9	26	5	34	871

Central Western Zone

Annual tonnages of blacklip abalone caught within the statistical blocks and sub-blocks comprising the Central Western Zone (Sub-block 5D, Blocks 6, 7 and 8). Catches from Block 5 prior to 2001 are reported in the Northern Zone.

	Year	5	6	7	8	Total
Estimated weights	1975		110	36	42	188
	1976		63	56	77	196
	1977		50	24	22	96
	1978		79	13	27	118
	1979		112	19	23	154
	1980		196	81	63	340
	1981		257	88	87	432
	1982		147	34	34	215
	1983		231	102	58	390
	1984		298	78	38	413
Landed weights	1985		322	99	23	444
	1986		213	97	11	321
	1987		185	84	44	313
	1988		241	53	27	320
	1989		192	49	46	287
	1990		197	56	21	275
	1991		169	54	30	253
Estimated weights	1992		235	70	36	341
	1993		154	64	38	256
	1994		79	33	38	150
	1995		112	30	17	159
	1996		103	67	13	183
	1997		98	75	28	201
	1998		126	51	27	204
	1999		149	60	24	233
	2000		183	61	23	266
	2001	0	210	32	15	257
	2002	2	173	51	17	243
	2003	0	97	104	27	229
	2004	3	88	89	22	203
	2005	6	95	110	26	236
	2006	4	109	76	6	196
	2007	0	76	39	18	133
	2008	0	105	51	9	166
	2009	0	143	107	51	301
	2010	0	150	110	37	297
Average 75-10		2	154	64	32	250
Average 85-10		2	154	68	26	249
Average 00-10		2	130	75	23	230

Western Zone

Annual tonnages of blacklip abalone caught within the statistical blocks and sub-blocks comprising the Western Zone in 2009 (Blocks 9 to 12, Sub-blocks 13A, 13B). Pre-zoning (1975-1999) catches from Block 13 are reported in the Eastern Zone.

	Year	9	10	11	12	13	Total
Estimated weights	1975	126	130	191	143		590
	1976	252	179	240	153		824
	1977	123	98	153	189		562
	1978	115	258	275	208		855
	1979	172	166	269	325		933
	1980	316	195	338	351		1200
	1981	444	260	417	246		1366
	1982	249	100	303	235		887
	1983	199	174	430	242		1045
	1984	248	284	681	258		1471
Landed weights	1985	246	140	478	155		1019
	1986	133	127	289	193		742
	1987	252	82	339	195		868
	1988	159	124	270	162		715
	1989	120	109	212	144		586
	1990	95	80	232	125		532
	1991	102	106	219	140		567
Estimated weights	1992	91	95	266	159		611
	1993	110	65	197	177		548
	1994	77	60	202	160		499
	1995	44	68	186	182		479
	1996	59	75	145	148		428
	1997	140	66	224	227		657
	1998	78	47	163	192		480
	1999	115	58	220	251		645
	2000	205	148	326	282	54	1015
	2001	186	152	312	290	43	983
	2002	174	143	360	236	93	1005
	2003	142	239	345	229	67	1023
	2004	130	181	374	250	96	1031
	2005	92	149	389	311	65	1006
	2006	142	198	384	228	89	1041
	2007	178	231	354	267	68	1097
	2008	156	178	345	305	79	1064
	2009	155	110	244	327	77	913
	2010	159	158	245	277	68	907
Average 75-10		161	140	295	221	73	839
Average 85-10		136	123	282	216	73	787
Average 00-10		156	172	334	273	73	1008

Northern Zone

The Northern Zone comprises 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.

	Year	31	39	40	47	48	49	5	1	2	3	4	Total
Estimated weights	1975		2	1	1	12	9	38	32	1	27	15	139
	1976		5	0	1	12	33	46	39	0	51	8	195
	1977		6	2	0	8	17	51	17	1	87	8	196
	1978		8	2	3	10	11	65	21	3	55	25	204
	1979		6	1	0	27	7	85	24	2	10	9	172
	1980		3	1	0	10	1	92	51	3	33	3	197
	1981		6	2	3	33	10	120	19	8	32	9	242
	1982		5	2	1	45	7	121	22	9	27	13	253
	1983		7	4	9	45	19	228	22	2	31	52	418
	1984		6	3	4	80	44	312	10	1	33	55	548
Landed weights	1985		5	1	4	48	50	319	43	0	26	11	508
	1986		10	5	15	85	97	267	35	4	24	13	556
	1987		6	1	18	58	67	198	44	62	24	54	531
	1988		3	1	18	30	38	165	29	16	21	60	380
	1989		1	28	14	15	24	88	14	7	10	5	206
	1990		0	0	6	14	20	82	11	10	9	11	164
	1991		1	0	8	12	10	97	6	7	14	26	182
Estimated weights	1992		4	0	3	10	11	76	2	3	9	8	126
	1993		0	0	1	7	7	65	8	3	8	9	107
	1994		0	0	0	7	12	49	15	2	4	1	90
	1995		0	0	0	6	2	62	11	3	1	8	94
	1996		0	0	0	4	0	63	7	2	1	2	80
	1997		1	0	0	6	2	56	10	1	10	6	91
	1998		0	1	0	7	3	61	3	1	0	2	78
	1999		5	0	0	14	4	57	5	1	6	6	97
	2000		5	2	0	12	25	45	0	0	9	10	108
	2001	12	11	3	0	17	72	117	2	1	12	12	260
	2002	30	4	3	0	12	48	103	10	2	35	16	262
	2003	7	8	1	0	10	76	73	25	1	61	10	270
	2004	14	6	1	0	6	62	55	10	0	85	34	273
	2005	11	2	0	0	6	54	73	15	2	92	18	273
	2006	16	4	0	0	5	57	96	11	3	57	8	258
	2007	55	11	0	0	6	59	89	6	0	47	3	276
	2008	29	5	0	0	7	74	163	5	0	24	10	317
	2009	20	9	0	0	4	75	172	10	0	27	5	322
	2010	36	5	0	0	8	72	132	5	1	41	24	324
Average 75-10		23	4	2	3	19	33	111	17	5	29	16	244
Average 85-10		23	4	2	3	16	39	109	13	5	25	14	240
Average 00-10		23	6	1	0	8	61	102	9	1	45	14	267

Bass Strait Zone

Annual tonnages of blacklip abalone caught within statistical blocks comprising the Bass Strait Zone. The fishery was temporarily closed in 2007.

	Year	32	33	34	35	36	37	38	41	42	43	44
Estimated weights	1975	1	10	1	7	7	0	2	0	0	0	0
	1976	0	5	0	1	1	0	0	0	0	1	0
	1977	6	11	0	0	3	1	2	0	0	0	0
	1978	1	5	2	6	5	0	4	0	0	1	0
	1979	2	9	0	0	2	1	2	0	0	0	0
	1980	2	6	1	1	2	1	0	1	0	0	0
	1981	1	6	1	1	0	2	0	0	0	1	0
	1982	0	6	1	0	2	1	4	0	0	0	0
	1983	0	3	0	1	5	1	3	0	0	0	0
	1984	0	7	0	1	2	0	1	0	0	1	0
Landed weights	1985	3	6	1	2	1	0	0	2	0	2	0
	1986	0	9	2	3	2	1	1	1	0	4	0
	1987	0	7	0	2	1	2	1	2	0	8	1
	1988	0	11	1	1	0	0	0	0	0	1	1
	1989	0	3	0	0	0	8	0	19	11	34	1
	1990	0	1	0	0	1	0	0	0	0	0	0
	1991	0	2	0	0	0	17	0	0	0	0	0
Estimated weights	1992	0	2	0	0	0	0	0	0	0	0	0
	1993	0	3	0	0	0	19	0	0	0	0	0
	1994	0	3	0	0	0	0	0	0	0	0	0
	1995	0	0	0	0	0	52	0	0	0	0	0
	1996	0	0	0	0	0	0	0	0	0	0	0
	1997	0	0	0	0	0	0	0	0	0	0	0
	1998	0	2	0	0	0	0	0	0	0	0	0
	1999	0	4	0	0	0	0	1	0	0	0	0
	2000	1	5	0	0	0	0	0	0	0	0	0
	2001	5	10	1	0	0	0	3	0	0	0	0
	2002	1	11	1	0	0	0	2	0	0	0	0
	2003	0	5	0	0	0	6	2	1	2	2	0
	2004	0	3	0	0	0	3	1	4	4	1	0
	2005	0	7	0	0	0	6	2	4	1	2	0
	2006	0	11	0	0	0	20	10	1	4	5	0
	2007	0	2	0	3	0	0	0	0	0	0	0
	2008	1	5	0	0	0	21	6	1	2	5	1
	2009	2	4	0	1	0	10	1	5	2	8	6
	2010	0	20	0	0	0	1	26	1	0	3	0
Average 75-10		1	6	0	1	1	5	2	1	1	2	0
Average 85-10		1	5	0	1	0	6	2	2	1	3	0
Average 00-10		1	8	0	0	0	6	5	2	1	2	1

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Bass Strait Zone (continued).

	Year	45	46	50	51	52	53	54	55	56	57	Total
Estimated weights	1975	0	0	0	0	0	0	0	0	0	0	2
	1976	0	0	0	0	0	0	0	0	0	0	2
	1977	0	0	0	0	0	0	0	0	0	0	3
	1978	0	0	0	0	0	0	0	0	0	0	4
	1979	0	3	0	0	0	0	0	0	0	0	7
	1980	0	0	0	0	0	0	0	0	0	0	2
	1981	0	0	0	0	0	0	0	0	0	0	3
	1982	0	0	0	0	0	0	0	0	0	0	5
	1983	0	0	0	0	0	0	0	0	0	0	4
	1984	0	3	0	0	0	0	0	0	0	0	6
Landed weights	1985	0	0	0	0	0	0	0	0	0	0	4
	1986	0	1	0	0	0	0	0	0	0	0	8
	1987	0	0	0	0	0	0	0	0	0	0	15
	1988	0	1	0	0	0	0	0	0	0	0	4
	1989	5	14	1	24	0	41	4	0	6	0	168
	1990	0	0	0	0	0	0	0	0	0	0	1
	1991	0	0	0	14	5	28	1	0	17	15	96
Estimated weights	1992	0	0	0	0	0	0	0	0	0	0	0
	1993	0	0	0	21	4	37	1	0	6	8	96
	1994	0	0	0	0	0	0	0	0	0	0	0
	1995	0	0	1	46	2	44	0	0	0	5	149
	1996	0	0	0	0	0	0	0	0	0	0	0
	1997	0	0	0	0	0	0	0	0	0	0	0
	1998	0	0	0	0	0	0	0	0	0	0	0
	1999	0	0	0	0	0	0	0	0	0	0	1
	2000	0	0	0	0	0	0	0	0	0	0	1
	2001	0	0	0	0	0	0	0	0	0	2	5
	2002	0	0	0	0	0	0	0	0	0	0	4
	2003	0	2	0	7	2	36	2	0	7	2	72
	2004	0	1	0	1	0	42	5	2	7	0	71
	2005	0	0	0	8	0	35	5	3	3	0	70
	2006	0	5	0	3	0	24	5	2	1	1	80
	2007	0	0	0	0	0	0	0	0	0	0	0
	2008	1	3	0	1	0	27	0	0	6	0	73
	2009	1	1	0	5	0	24	1	0	4	2	71
	2010	1	1	0	2	0	13	0	0	0	0	68
Average 75-10		0	1	0	4	0	10	1	0	2	1	30
Average 85-10		0	1	0	5	0	13	1	0	2	1	41
Average 00-10		0	1	0	2	0	18	2	1	3	1	47

Greenlip Fishery

Annual tonnages of greenlip abalone caught from the Greenlip fishery. Greenlip are taken from northern Tasmanian waters, and the fishery is managed by species. Occasionally, small amounts of catch (< 1 t) are taken from northern blocks not listed here. In 2009, 1.1 t was taken from 4 blocks across the central north coast.

	Year	31	39	40	32	33	34	35	36	37	38
Estimated weights	1975	7	3	4	3	17	14	49	69	14	11
	1976	14	2	9	1	26	11	55	49	2	10
	1977	6	8	4	6	23	21	50	24	1	22
	1978	8	1	2	4	12	17	51	38	7	17
	1979	11	6	2	10	21	8	46	15	4	4
	1980	4	3	5	7	15	3	29	13	4	4
	1981	6	4	2	12	17	17	34	10	9	0
	1982	27	1	3	4	13	14	29	7	9	9
	1983	23	2	0	4	21	8	34	9	4	8
	1984	50	8	4	9	27	15	56	7	6	0
Landed weights	1985	53	5	4	9	20	15	42	4	7	7
	1986	39	8	7	4	14	7	36	2	10	0
	1987	32	12	1	8	20	10	30	8	10	7
	1988	35	2	1	8	19	5	28	13	6	0
	1989	22	5	2	4	16	2	22	10	3	0
	1990	23	7	0	4	9	3	25	6	1	3
	1991	20	6	0	4	7	2	31	6	3	0
Estimated weights	1992	15	9	0	3	4	1	18	6	2	0
	1993	9	2	0	1	4	2	16	8	3	0
	1994	12	1	0	3	8	1	17	5	3	0
	1995	24	6	2	2	7	3	15	3	3	9
	1996	11	13	2	3	13	4	17	2	8	12
	1997	17	22	1	8	13	1	12	4	11	15
	1998	4	17	24	5	5	1	23	1	2	2
	1999	6	2	4	2	17	1	15	1	2	4
	2000	12	15	12	8	11	2	14	3	2	2
	2001	7	20	4	14	14	2	9	3	1	0
	2002	17	12	2	4	16	2	8	2	2	9
	2003	18	16	1	5	16	1	10	2	1	3
	2004	9	22	0	4	4	1	13	3	1	11
	2005	6	13	1	2	12	1	10	3	1	15
	2006	3	13	0	5	5	1	11	1	4	13
	2007	20	14	0	3	6	1	13	2	0	5
	2008	13	12	0	3	6	1	12	4	3	5
	2009	13	20	1	2	5	1	13	2	2	2
	2010	16	9	0	5	13	2	10	0	0	3
Average 75-10		17	9	3	5	13	6	25	10	4	6
Average 85-10		18	11	3	5	11	3	18	4	3	5
Average 00-10		12	15	2	5	10	1	11	2	2	6

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Greenlip Fishery(continued)

	Year	38	47	48	49	5	1	2	3	4	Total
Estimated weights	1975	11	0	7	2	8	0	3	0	1	213
	1976	10	0	8	6	14	0	0	0	0	210
	1977	22	0	40	2	17	0	0	0	0	223
	1978	17	1	13	3	12	1	3	0	2	191
	1979	4	0	11	0	8	0	0	0	0	146
	1980	4	0	6	0	5	0	3	0	0	100
	1981	0	3	12	1	9	0	12	0	4	153
	1982	9	2	7	0	2	0	14	0	2	141
	1983	8	14	40	11	9	0	9	0	5	201
	1984	0	52	60	2	11	0	7	1	5	320
Landed weights	1985	7	12	36	3	3	0	1	0	1	222
	1986	0	57	35	14	5	1	8	0	3	251
	1987	7	37	33	3	8	13	125	5	69	431
	1988	0	35	21	4	10	3	33	2	12	240
	1989	0	20	27	4	6	1	70	3	10	227
	1990	3	21	27	11	11	2	49	3	13	218
	1991	0	13	32	6	12	2	29	3	16	191
Estimated weights	1992	0	4	14	2	4	3	21	0	8	115
	1993	0	2	26	4	2	2	18	0	9	110
	1994	0	3	48	3	10	4	25	0	7	149
	1995	9	5	23	5	8	14	9	0	12	149
	1996	12	1	15	0	3	37	33	1	13	190
	1997	15	1	28	3	6	35	33	0	6	215
	1998	2	2	43	8	14	31	34	0	5	222
	1999	4	0	20	1	10	21	25	1	10	142
	2000	2	0	24	12	13	2	4	1	3	140
	2001	0	0	35	9	3	8	8	1	2	140
	2002	9	0	27	7	7	11	6	1	7	140
	2003	3	0	14	10	10	14	11	3	4	140
	2004	11	0	14	6	10	14	10	4	3	128
	2005	15	0	19	1	12	16	7	4	3	123
	2006	13	0	29	2	8	11	10	2	5	123
	2007	5	0	21	3	9	10	7	3	6	124
	2008	5	0	33	3	5	4	10	1	5	121
	2009	2	0	26	2	5	8	8	3	6	121
	2010	3	0	30	5	8	11	13	4	5	134
Average 75-10		6	8	25	4	8	8	18	1	7	178
Average 85-10		5	8	27	5	8	11	23	2	9	173
Average 00-10		6	0	25	5	8	10	8	3	4	130

Appendix 7: Catch/effort data extract query

Catch/effort data from divers' catch dockets were provided by DPIPWE, with tables updated weekly and stored in an Oracle database at the University of Tasmania. The following SQL query was used to extract catch records from the Oracle database:

```
SELECT DISTINCT
     d.docket_number docket
,    f.fishing_date day
,    EXTRACT(month FROM f.fishing_date) month
,    EXTRACT(year FROM f.fishing_date) year
,    UPPER(n3.last_name)||','||REPLACE(TRANSLATE(INITCAP(n3.first_names),
'abcdefghijklmnopqrstuvwxyz','##########################'),'#','') diver_name
,    SUBSTR(d.zone_fishery_code, 3, 2) zone
,    CASE
          WHEN f.block_code BETWEEN 'AB13C' AND 'AB14B' THEN 'ACT'
          WHEN f.block_code BETWEEN 'AB14C' AND 'AB16D' THEN 'BRUNY'
          WHEN f.block_code BETWEEN 'AB17A' AND 'AB21C' THEN 'STMBY'
          WHEN f.block_code BETWEEN 'AB22A' AND 'AB31A' THEN 'EC'
          WHEN f.block_code BETWEEN 'AB32A' AND 'AB38C' THEN 'FG'
          WHEN f.block_code BETWEEN 'AB39A' AND 'AB40C' THEN 'NE'
          WHEN f.block_code BETWEEN 'AB41' AND 'AB46' THEN 'CN'
          WHEN f.block_code BETWEEN 'AB47A' AND 'AB49C' THEN 'NW'
          WHEN f.block_code BETWEEN 'AB01A' AND 'AB04C' THEN 'KI'
          WHEN f.block_code BETWEEN 'AB05A' AND 'AB05C' THEN 'NW'
          WHEN f.block_code BETWEEN 'AB05D' AND 'AB06D' THEN 'COUTA'
          WHEN f.block_code BETWEEN 'AB07A' AND 'AB08C' THEN 'GRANVILLE'
          WHEN f.block_code BETWEEN 'AB09A' AND 'AB09C' THEN 'STRAHAN'
          WHEN f.block_code BETWEEN 'AB10A' AND 'AB12A' THEN 'SW'
          WHEN f.block_code BETWEEN 'AB12B' AND 'AB13B' THEN 'SC'
          WHEN f.block_code BETWEEN 'AB50' AND 'AB57' THEN 'ISLAND'
          WHEN f.block_code = 'AB31B' THEN 'NE'
     END region
,    SUBSTR(f.block_code,1,4) blok
,    f.block_code sub_block
,         ROUND(f.blacklip_estimated_weight,0) blips,
ROUND(f.greenlip_estimated_weight,0) glips,    NVL(dive_time_1,0) + NVL(dive_time_2,0) +
NVL(dive_time_3,0) total_time
FROM qms.abalone_fishing_details f
   , qms.quota_dockets d
   , lmm.clients n3
WHERE EXTRACT(year FROM f.fishing_date)= 2010
   AND d.qudo_id = f.qudo_id
   AND n3.client_id = d.docket_signatory_id
ORDER BY
f.fishing_date  asc
```

Appendix 8: Treatment of errors in catch data in 2010

No amendments were made to catch totals from earlier years presented in this report. Where errors are identified they will be corrected, and any corrections will be reported in subsequent assessment reports. Several errors have been found and corrected in previous years. Although this process is important for rigor of the assessment, the magnitude of any errors identified to date has been small and had no effect on interpretation of stock trends and thus management decisions. This is because errors identified to date typically involve key stroke errors on individual catch records rather than systematic errors affecting a large portion of the catch.

Appendix 9: Ecological effects of abalone fishing.

Abalone fishing is typically regarded as having low ecological impact because there is no bycatch (other than sessile organisms on the shells), the conservation status of the target species is secure, and the high energy coastal environments where the fishery operates are typically subject to large environmental variation which creates resilience. For this reason there is little concern regarding the ecological effects of abalone fishing and thus there has been little research initiated on the issue. Nonetheless, consideration of the issue is important for EBFM. Information from recent research at IMAS is presented here.

This summary is an extract from Chapter 2, *Towards integrated multi-species management of Australia's SE reef fisheries: A Tasmanian example.* Report to Fisheries Research and Development Corporation. No. 2004/013. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania. Frusher S, Buxton C, Barrett N, Tarbath D, Redd K, Semmens J, Pederson H, Valentine J & Guest M (2009).

Summary:

At a global level, overfishing and subsequent depletion leading to the collapse of abalone populations on individual reefs and parts of the coast are common problems (Dugan and Davis, 1993; Karpov et al., 2000; Shepherd and Baker, 1998). While overall the Tasmanian blacklip abalone fishery has been relatively robust, depletion and consequent loss of production are evident in parts of the fishery. For example, following years of fishing at apparently sustainable levels, some reporting areas (‘blocks’) of the abalone fishery in east and north-east Tasmania experienced rapid declines in annual catch to less than 10% of their former levels (Tarbath et al., 2007).

These reporting blocks are large (tens of kilometres), and consequently the history of abalone production at the scale of individual reefs within them is unknown. Divers who once worked extensively along the coastline have reported that many of the reefs had become too depleted to warrant fishing at economic levels, and fishing activity was concentrated on the remaining productive reefs. Similar patterns had also been reported by divers in other previously productive parts of the Tasmanian fishery.

Information was sought about the history of productive abalone reefs from commercial abalone divers. Thirty three divers were interviewed: 16 early divers from pre-1972, 7 mid-era divers from between 1972 and 1992 and 10 current divers. By using a combination of maps, logbooks and diaries, reefs and coastline in use by the fishery were identified in five key areas (Blocks 13, 14, 23, 28, and 30) in the east and south-east, throughout the course of its history.

Perceptions of productivity varied greatly and were affected by economic factors (beach price, costs) as well as abundance. However, by comparing usage of reefs over time, it was possible to identify continuously productive reefs and reefs where production had fallen, and subsequently produce approximate estimates of the extent of reef decline in each of the five key areas. Fished areas were relatively unchanged in Block 13 (10% decline – mostly Recherche Bay), while areas lost to fishing in the east and north-east (Block 28, Block 30) were as high as 90%. Reefs in the northern part of Block 23 were no longer productive, but the remaining 90% of reefs elsewhere in the

block were still fished, while in Block 14, mostly in the vicinity of the southern D'Entrecasteaux Channel, productive reef area had declined by 50%.

To assuage doubts about the validity of these estimates, we compared levels of fishing effort through time in each block (current compared with peak years). We found comparable declines in effort in Blocks 13, 28 and 30, but greater declines in Block 14, and Block 23. It was considered likely that losses of productive reef in the last two blocks were underestimated because current divers could fish these areas at low cost and had heightened perceptions of recent productivity.

Associated with depletion, there have been persistent reports from divers concerning 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. They included the reduction in coverage of crustose coralline algae and its subsequent replacement by sediment, other encrusting organisms and algae. Globally, over-harvesting of herbivores is recognised as one of the main factors contributing to changes in marine systems (Burkepile and Hay, 2006). In abalone fisheries, these changes implied a reduction of habitat type associated with juvenile abalone recruitment (McShane and Smith, 1988; Shepherd and Turner, 1985).

Field surveys were conducted at reefs with a history of abalone production in each region. A quantitative survey of benthic organisms on reefs with contrasting levels of abalone abundance was conducted, and a correlative approach was used to investigate interactions between benthic organisms and abalone to detect effects of fishing on reef communities.

In all regions there were positive correlations between abalone abundance and crustose coralline algae, while understory algae and abundance were negatively correlated. However, these associations were only weakly significant (α=0.05, r^2= 0.02-0.30), implying that abalone abundance explained only a small proportion of the variability in their distribution and abundance. In addition, there were isolated and inconsistent associations between abalone abundance and other understorey groups (sessile invertebrates, canopy-forming algae recruits). Typically, regional differences in community structure were more strongly correlated than abalone density. While not experimentally tested it was apparent that physical characteristics (exposure, reef structure, orientation) played a much greater role in determining community structure than the activities of abalone.

In summary, abalone played a relatively minor role in structuring habitat on reefs fished by abalone divers. As a consequence, it is unlikely that the observed reef-scale changes to habitat on reefs have occurred as a consequence of depletion of abalone stocks. It also means that loss of juvenile abalone habitat (crustose coralline algae habitat) does not necessarily occur following over-fishing.

Appendix 10: History of Management Changes

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

1962	Minimum size limit (MSL) of 5 inches (127 mm) minimum shell diameter introduced.
1964	MSL increased to 6 inches (152 mm).
1965	MSL 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.
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 (TAC) 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 TAC 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. TAC was 3460 tonnes.
1987	MSL increased to 132 mm from 127 mm. The catch per ITQ was reduced to 950 kg (5% reduction) i.e. TAC was 3287 tonnes.
1988	The catch per ITQ was reduced to 855 kg (5% reduction) i.e. TAC 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. TAC was 2076 tonnes. A fishery for abalone in Bass Strait was held in April, with a MSL 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	MSL for blacklip abalone on south and west coasts between the Wild Wave River (north of Sandy Cape) and Whale Head increased to 140 mm. MSL 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 TAC to 2100 tonnes.
1991	A fishery for abalone in Bass Strait was held in May, with a MSL of 118 mm. The TAC 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 MSL of 110 mm. The TAC 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 MSL of 110 mm. Only 12 commercial divers (i.e. non-abalone) participated. While the TAC 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 MSL was 100 mm, and the TAC 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 TAC 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) • MSL 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	MSL for greenlip raised to 140 mm in North West, and 150 mm for the remainder. This applied to the commercial fishery only, the MSL 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 (TAC 1190 t), Western units at 400 kg (1400 t) and greenlip units at 40 kg (140 t), with a TAC 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, MSL 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 MSL of 127 mm except between Woolnorth Point and the Arthur River, where 132 mm prevailed. Catch per unit was 80 kg, with a TAC 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 TAC for the West was set at 1260 t (360kg/unit), and the East at 1120 t (320 kg/unit). The greenlip TAC 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. MSL'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	MSL for Eastern Zone was increased to 136 mm. MSL for greenlip on King Island was reduced to 150 mm. MSL for greenlip in the North West was increased to 145 mm. Eastern Zone TAC reduced to 857.5 t (245 kg/unit). Western Zone TAC remained 1260 t (360 kg/unit) Northern Zone TAC remained 280 t (80 kg/unit) Greenlip TAC remained 140 t (40 kg/unit) Production for the whole fishery was set at 2537.5 t (725 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	A Bass Strait blacklip zone (TAC 70 tonnes (20kg/unit), MSL 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. Eastern Zone TAC remained 857.5 t (245 kg/unit). Western Zone TAC remained 1260 t (360 kg/unit) Northern Zone TAC remained 280 t (80 kg/unit) Greenlip TAC remained 140 t (40 kg/unit) Bass Strait Zone TAC set at 70 t (20 kg/unit) Fishery production was set at 2607.5 t (745 kg/unit) state-wide. Blacklip catch from Block 5 (Northern Zone) was capped at 100 t. MSL 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	Eastern Zone TAC reduced to 770 t (220 kg/unit) Western Zone TAC remained 1260 t (360 kg/unit) Northern Zone TAC remained 280 t (80 kg/unit) Greenlip TAC reduced to 129.5 t (37 kg/unit) Bass Strait Zone TAC remained 70 t (20 kg/unit) Fishery production was set at 2509.5 t (717 kg/unit) state-wide. The greenlip TAC 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	Eastern Zone TAC remained 770 t (220 kg/unit) Western Zone TAC remained 1260 t (360 kg/unit) Northern Zone TAC remained 280 t (80 kg/unit) Greenlip TAC reduced to 122.5 t (35 kg/unit) Bass Strait Zone TAC remained 70 t (20 kg/unit) Fishery production was set at 2502.5 t (715 kg/unit) state-wide. The greenlip TAC 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 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	Eastern Zone TAC remained 770 t (220 kg/unit) Western Zone TAC remained 1260 t (360 kg/unit) Northern Zone TAC remained 280 t (80 kg/unit) Greenlip TAC remained 122.5 t (35 kg/unit) Bass Strait Zone TAC remained 70 t (20 kg/unit)

	Fishery production was set at 2502.5 t (715 kg/unit) state-wide. On 1 January 2006, interim reduction in MSL for Perkins Bay greenlip area (Blocks 47, 48A), from 145 mm to 140 mm. On 20 September 2006, MSL for Bass Strait Zone in Blocks 41-46 (North Coast) reduced from 114 mm to 110 mm. On 1 November 2006, MSL for Eastern Zone was increased to 138 mm from 136 mm. MSL 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 39º 12' S and 39 º 33' S, and longitudes 146 º to 147 º 35' (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	Eastern Zone TAC remained 770 t (220 kg/unit) Western Zone TAC remained 1260 t (360 kg/unit) Northern Zone TAC remained 280 t (80 kg/unit) Greenlip TAC remained 122.5 t (35 kg/unit) Bass Strait Zone TAC remained 70 t (20 kg/unit) Fishery production was set at 2502.5 t (715 kg/unit) state-wide. However, 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	Eastern Zone TAC increased to 808.5 t (231 kg/unit) Western Zone TAC remained 1260 t (360 kg/unit) Northern Zone TAC increased to 332.5 t (95 kg/unit) Greenlip TAC remained 122.5 t (35 kg/unit) Bass Strait Zone TAC remained 70 t (20 kg/unit)

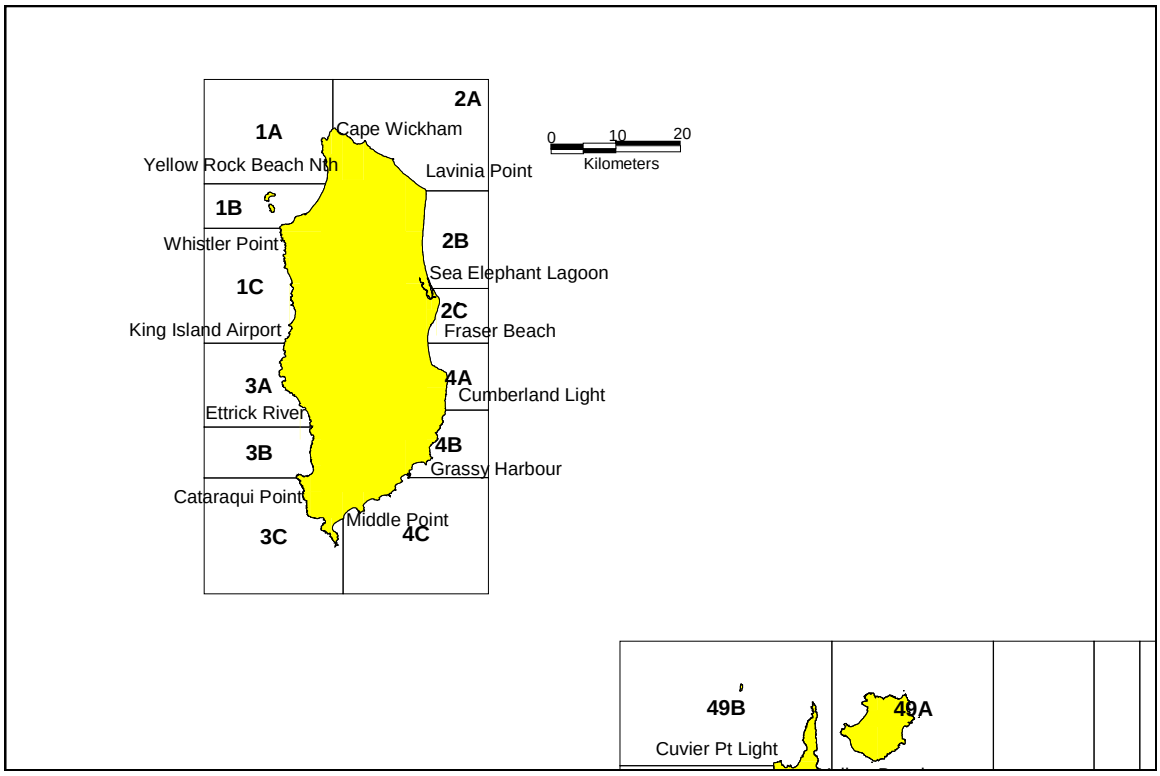
	The total catch state-wide was set at 2,593.5 t, or 741 kg/unit. As part of a controlled trial in the North West, size limits in Block 5 and part of Block 6 were reduced for divers meeting defined operating requirements on the basis that there were large stocks of fish too small to catch at the larger size limit, and that removing these smaller fish would promote growth among the remaining fish. The MSL 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 TAC 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	Eastern Zone TAC increased to 850.5 t (243 kg/unit) Western Zone TAC reduced to 924 t (264 kg/unit) Central Western Zone established at 304.5 t (87 kg/unit) Northern Zone TAC remained 332.5 t (95 kg/unit) Greenlip TAC remained 122.5 t (35 kg/unit) Bass Strait Zone TAC remained 70 t (20 kg/unit) The total catch state-wide was set at 2,604 t, or 744 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.
2010	Eastern Zone TAC increased to 896 t (256 kg/unit) Western Zone TAC remained 924 t (264 kg/unit) Central Western Zone remained 304.5 t (87 kg/unit) Northern Zone TAC remained 332.5 t (95 kg/unit) Greenlip TAC increased to 133 t (38 kg/unit) Bass Strait Zone TAC remained 70 t (20 kg/unit) The total catch state-wide was set at 2,660 t, or 760 kg/unit. In September 2010, the size limit for greenlip caught between Andersons Bay (Block 41) and Cowrie Point (Block 46) was reduced from 145mm to 132mm, in line with Blocks 47 and 48A (Perkins Bay/Black Reef) . 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 October 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).

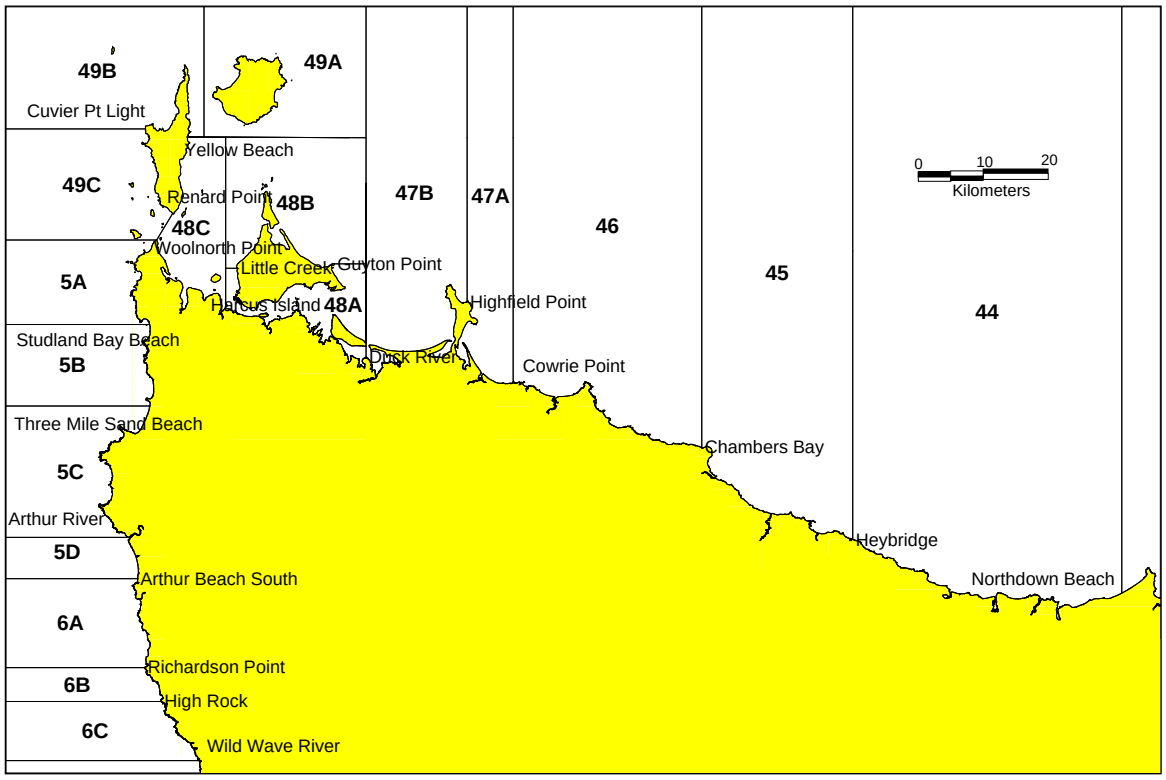
Appendix 11: Maps of catch-reporting blocks and sub-blocks

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

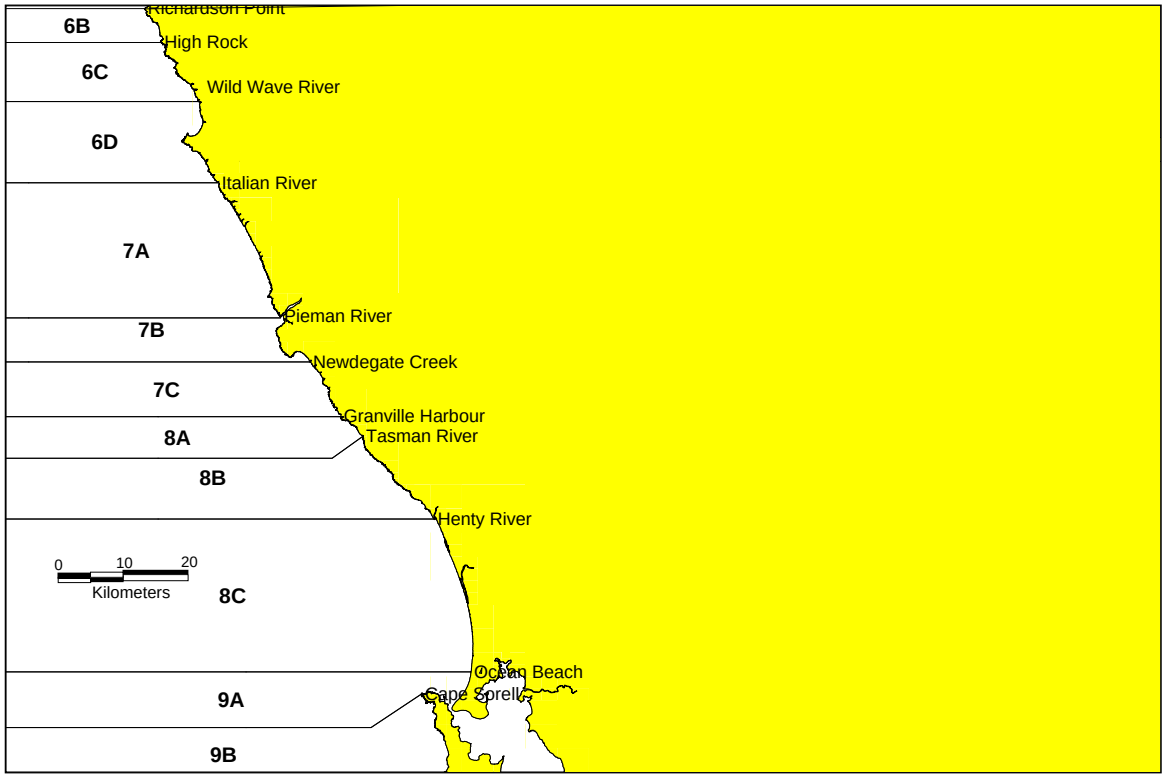
Map1: King Island



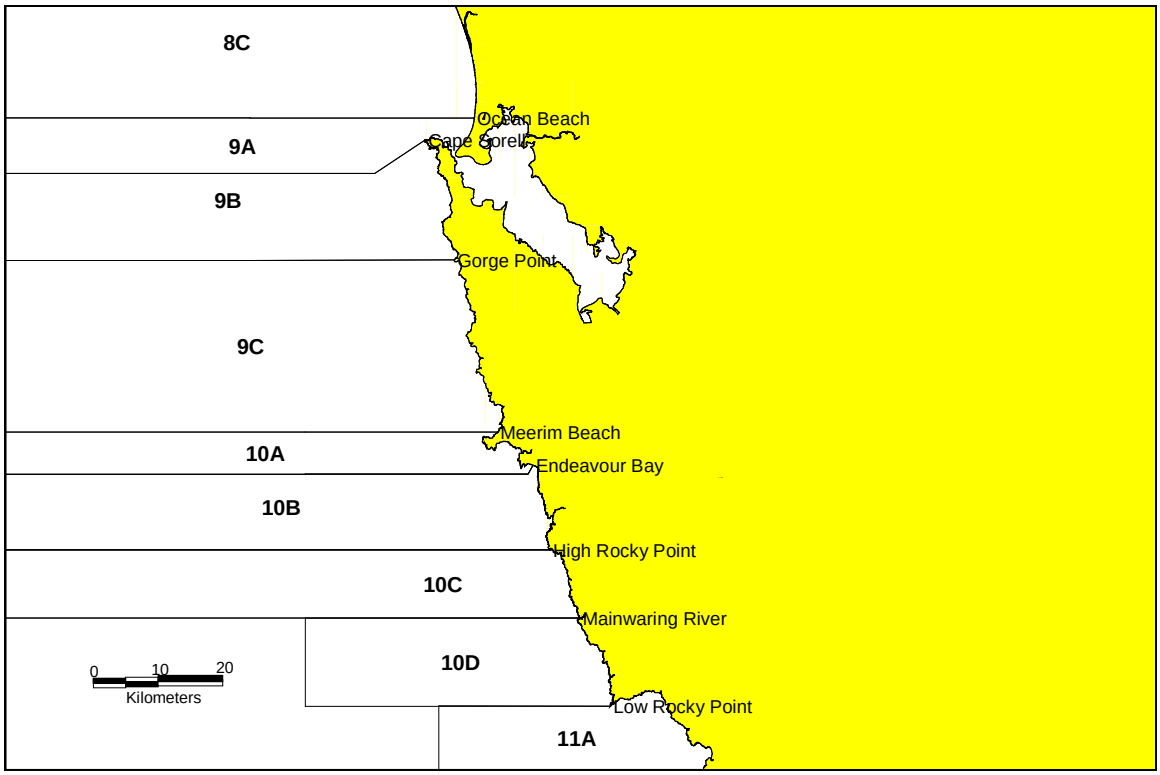
Map 2: North West Tasmania



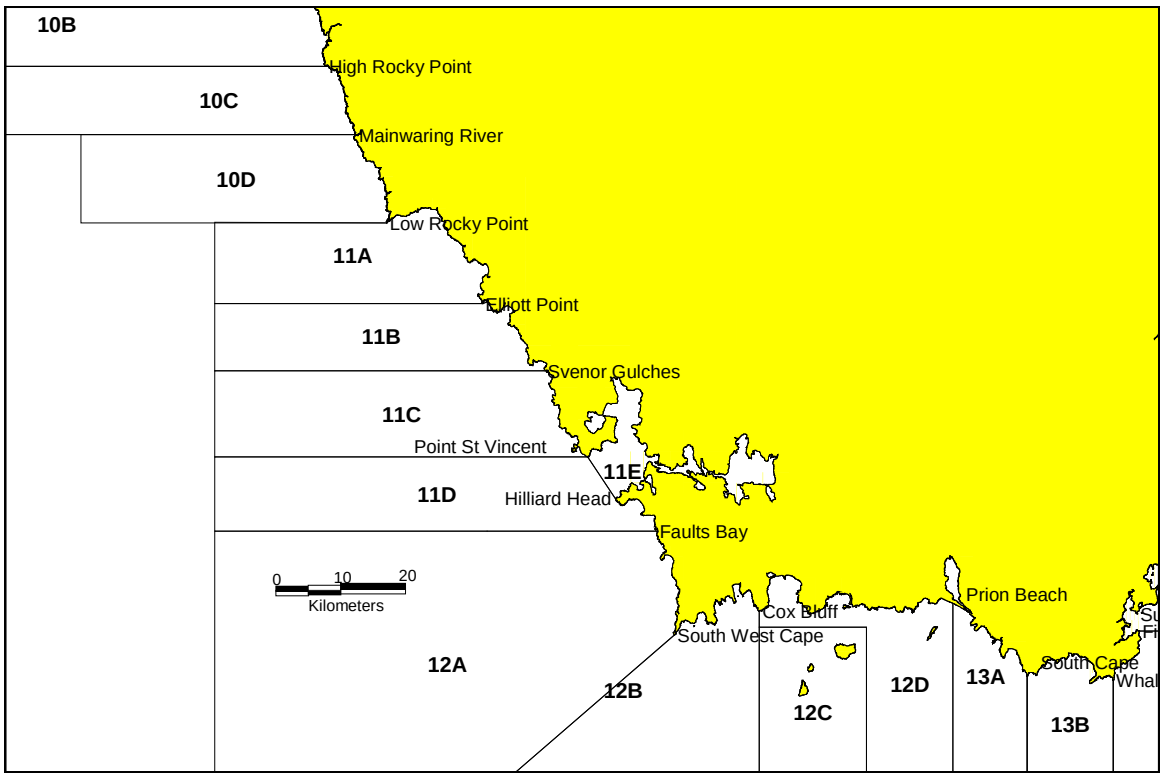
Map 3: Central West Coast (north)



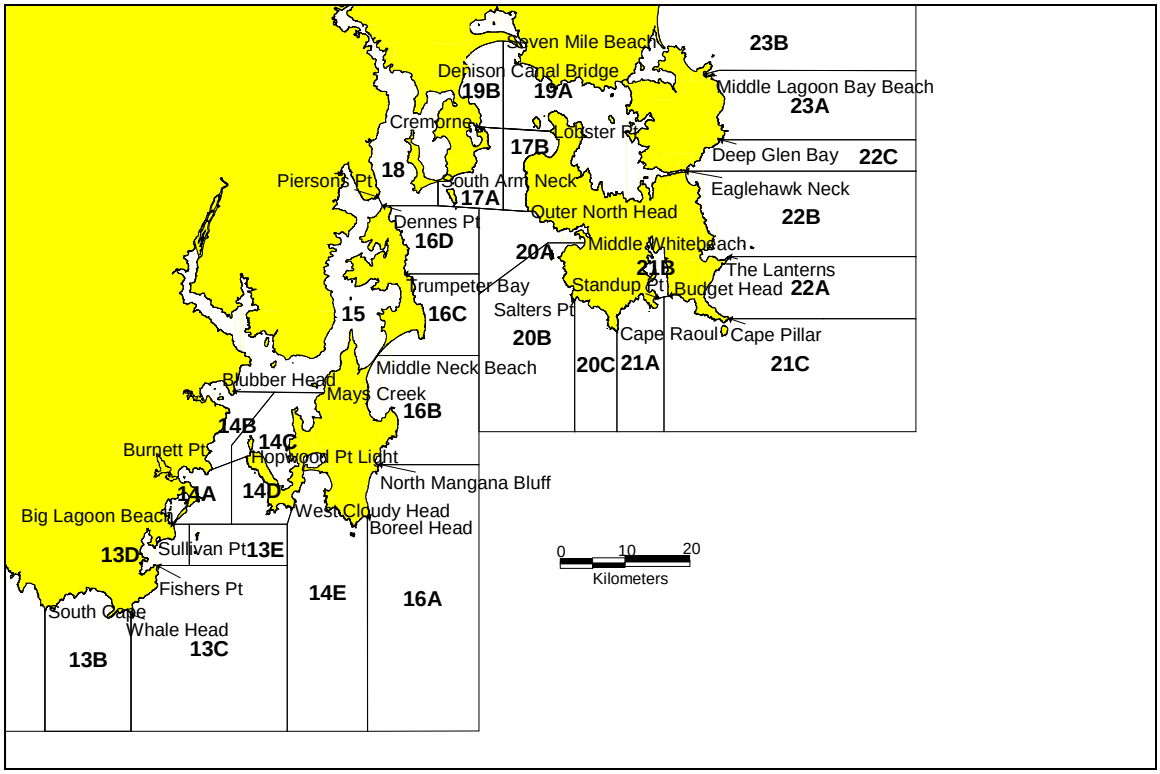
Map 4: Central West Coast (south)



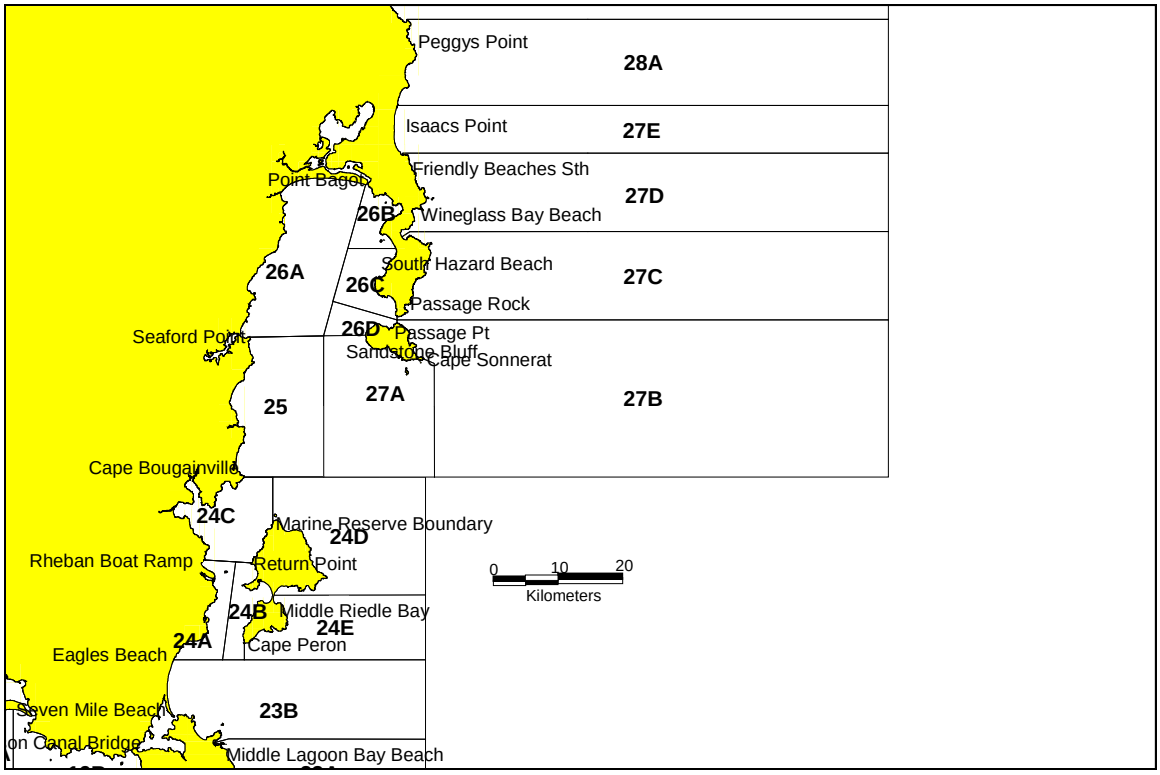
Map 5: South West Tasmania



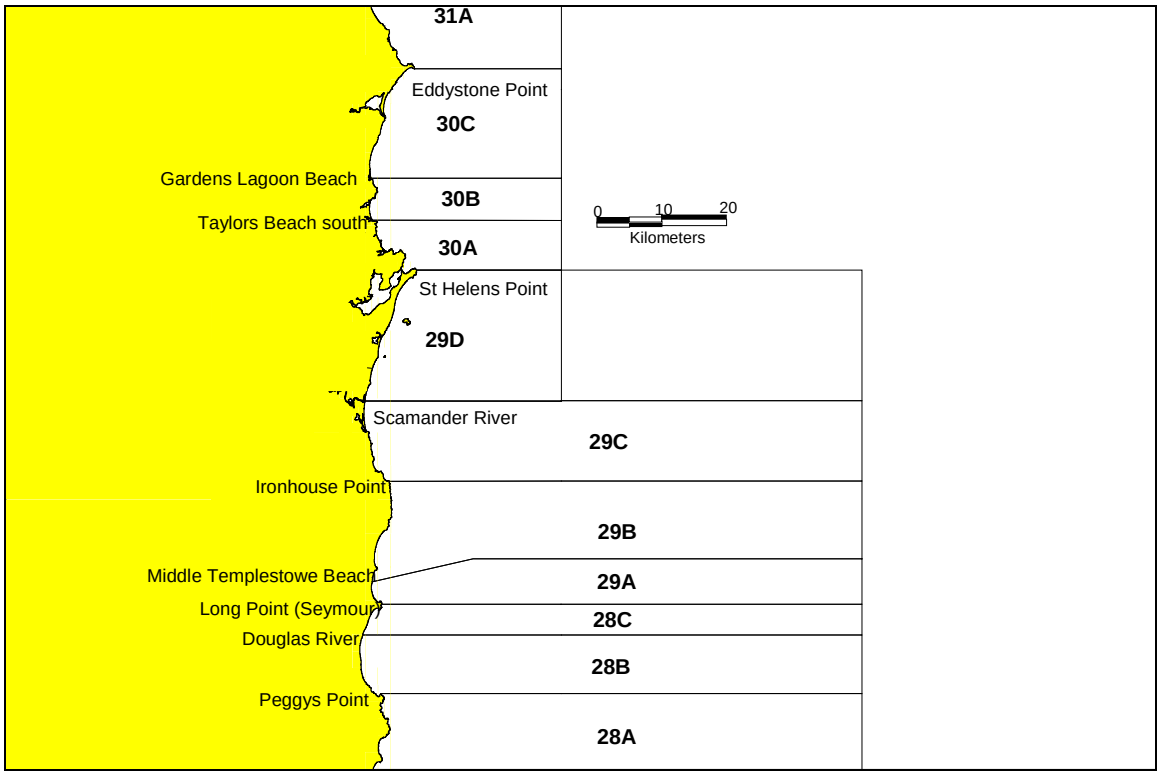
Map 6: South East Tasmania



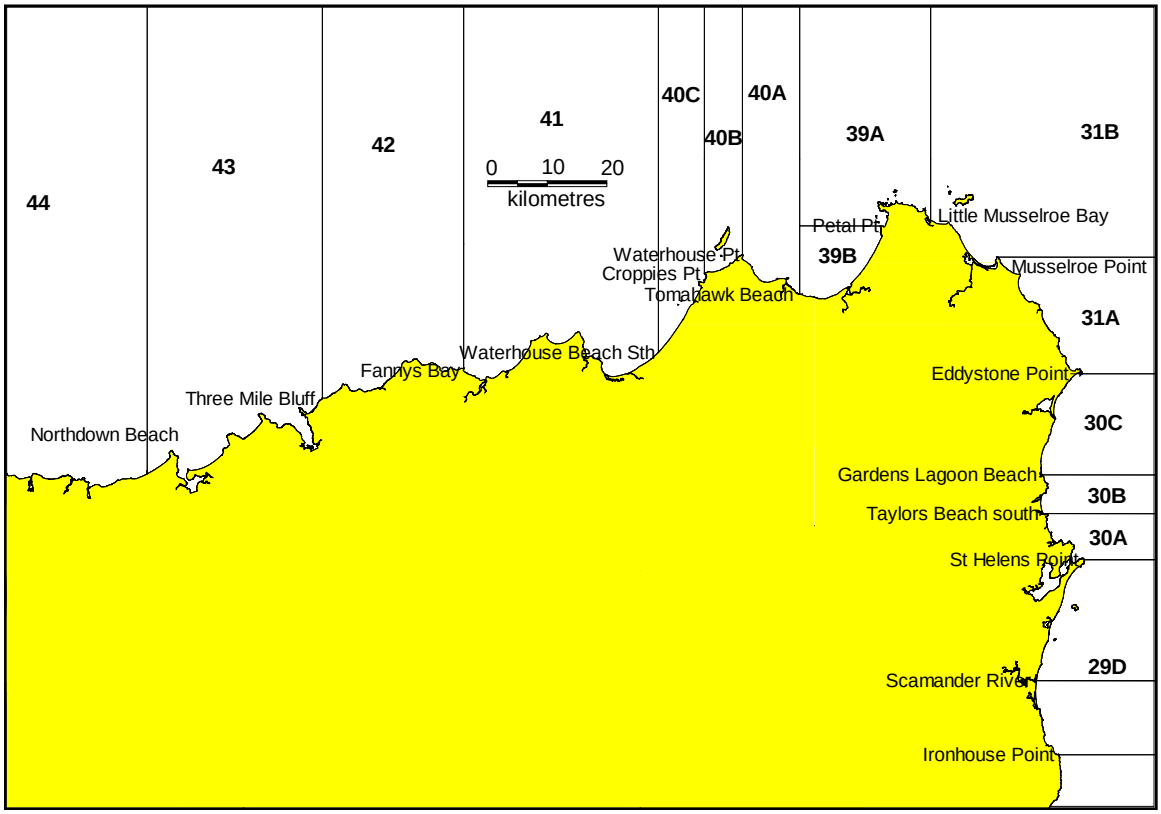
Map 7: Lower East Coast



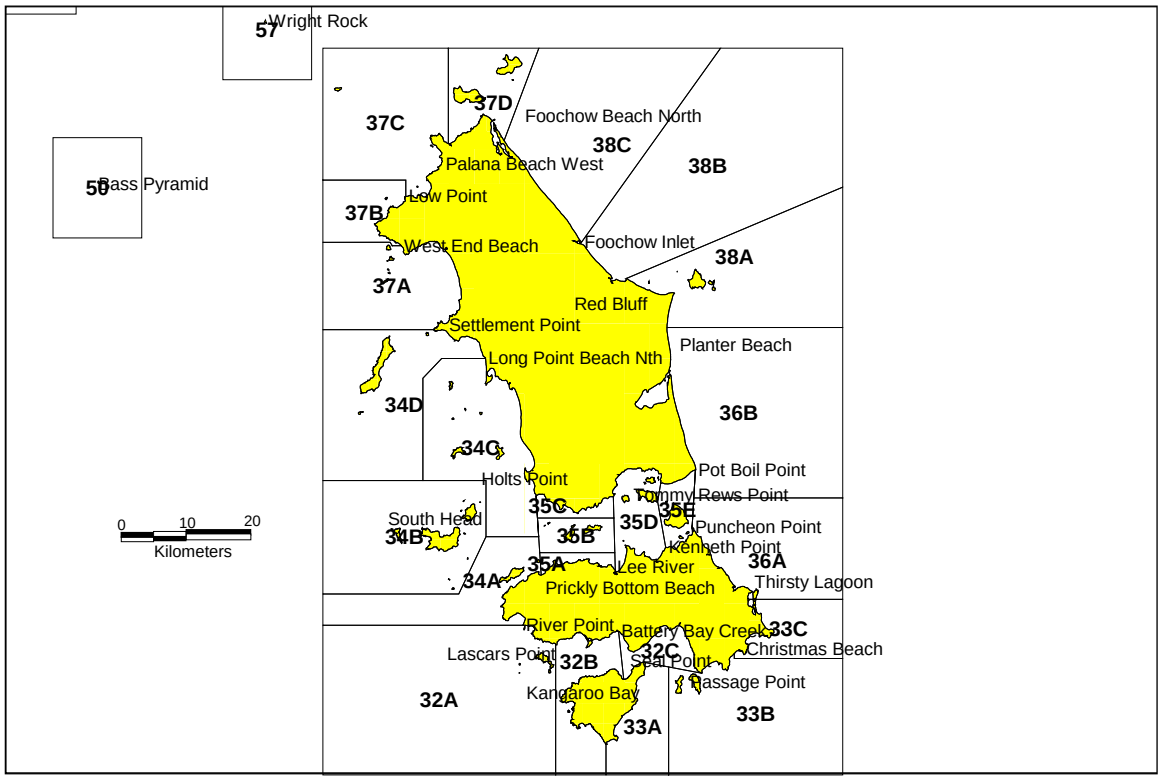
Map 8: Upper East Coast



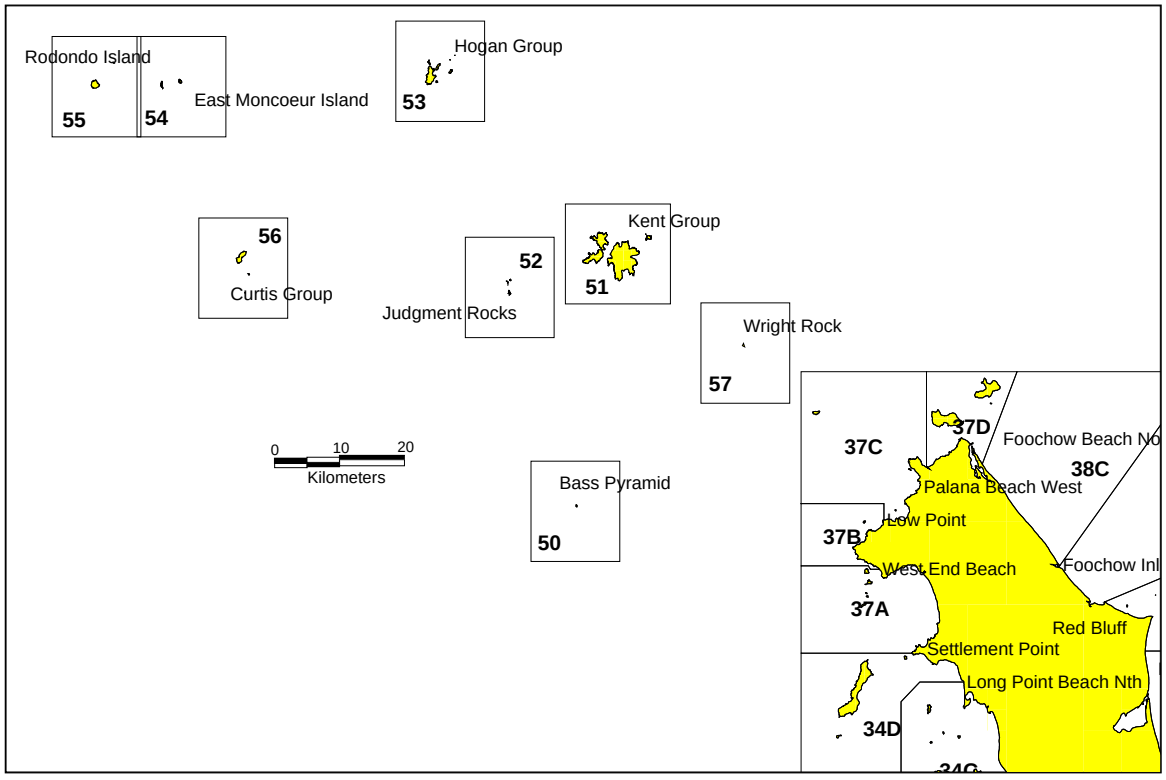
Map 9: North East Tasmania



Map 10: Furneaux Group

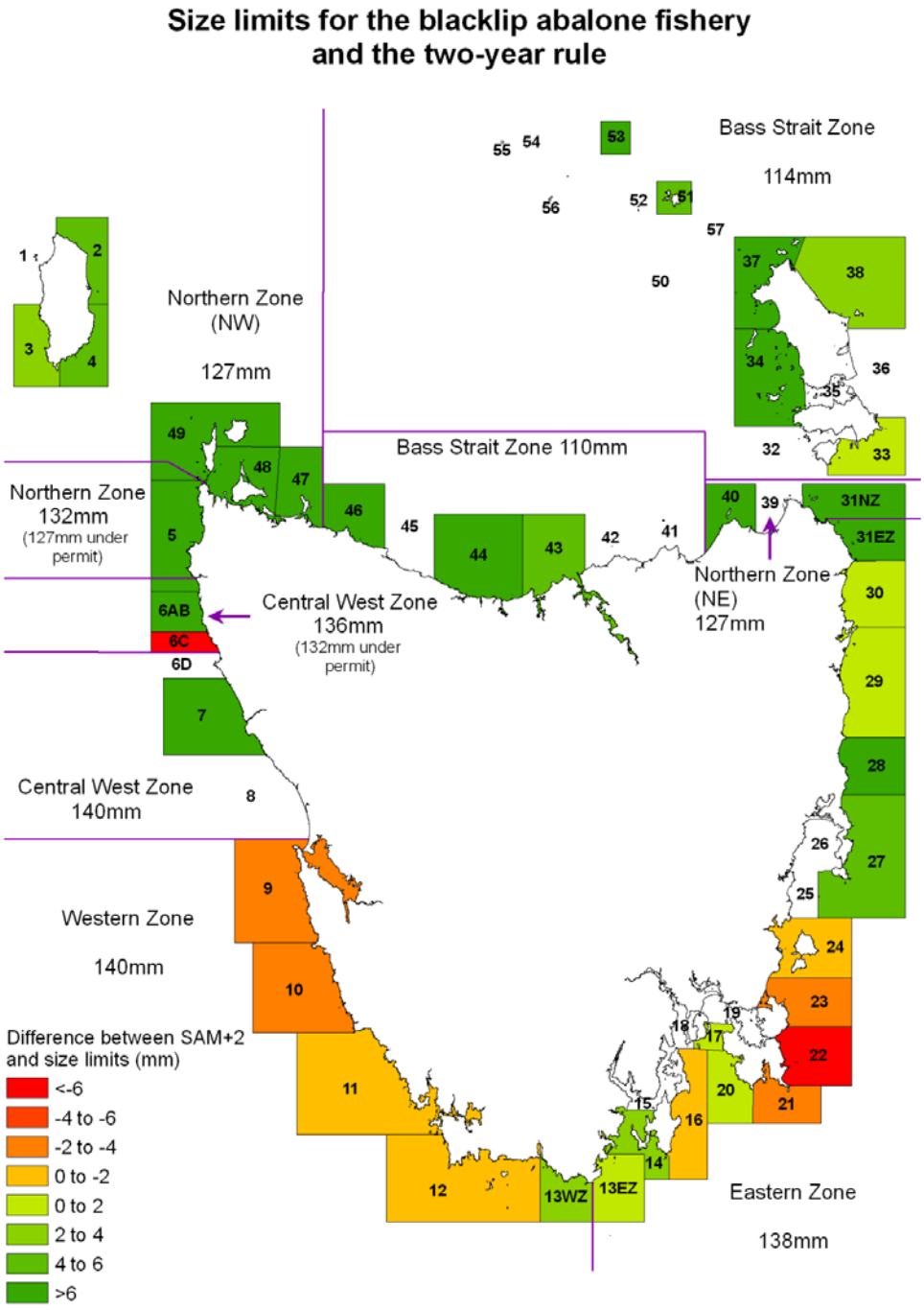


Map 11: Bass Strait Islands



Appendix 12: Application of the "two-year rule" to the blacklip abalone fishery

In the blacklip fishery, management policy specifies that size-limits allow abalone to have had at least two breeding seasons before they reach legal size. This policy is known as the "two-year rule". Biological information from field studies is used to determine the average size to which abalone grow in the two years following maturation. The map below shows how well size limits match the application of the policy to blacklip populations, grouped by reporting block. The map may change from year to year as new biological information becomes available, or size limits change.



Colours between orange and red show that the estimated size at maturity plus two years growth (SAM+2) is greater than the 2010 size limit operating in a particular block, and

by how much (in millimetres). Blocks shaded orange to red means that the size limit is too low to meet the policy. Blocks shaded green show where SAM+2 is less than the size limit, and where the size-limit policy is met. Blocks with no colour indicate no information is available.

The map shows several features of interest:

- The size limit in the Western Zone (Blocks 9 to 12) and the lower part of the East Coast (Blocks 21 to 24) is generally too small to meet management policy.
- In other key parts of the fishery, such as the Actaeons (Block 13), the North West (Block 5, 49), and the Northern part of the East Coast (Blocks 27 to 31), current size limits are adequate.
- There is a high degree of variability in SAM+2 in south-east Tasmania.

Growth rates, maximum size and median size at maturity are highly variable among abalone populations around Tasmania's coast. Generally, abalone in the north grow slower and to a smaller maximum size, and become sexually mature at a smaller size than abalone in the south. There are exceptions, and in the south there are places with significant populations of smaller abalone, while in the north there are places where abalone grow larger and faster than those around them.

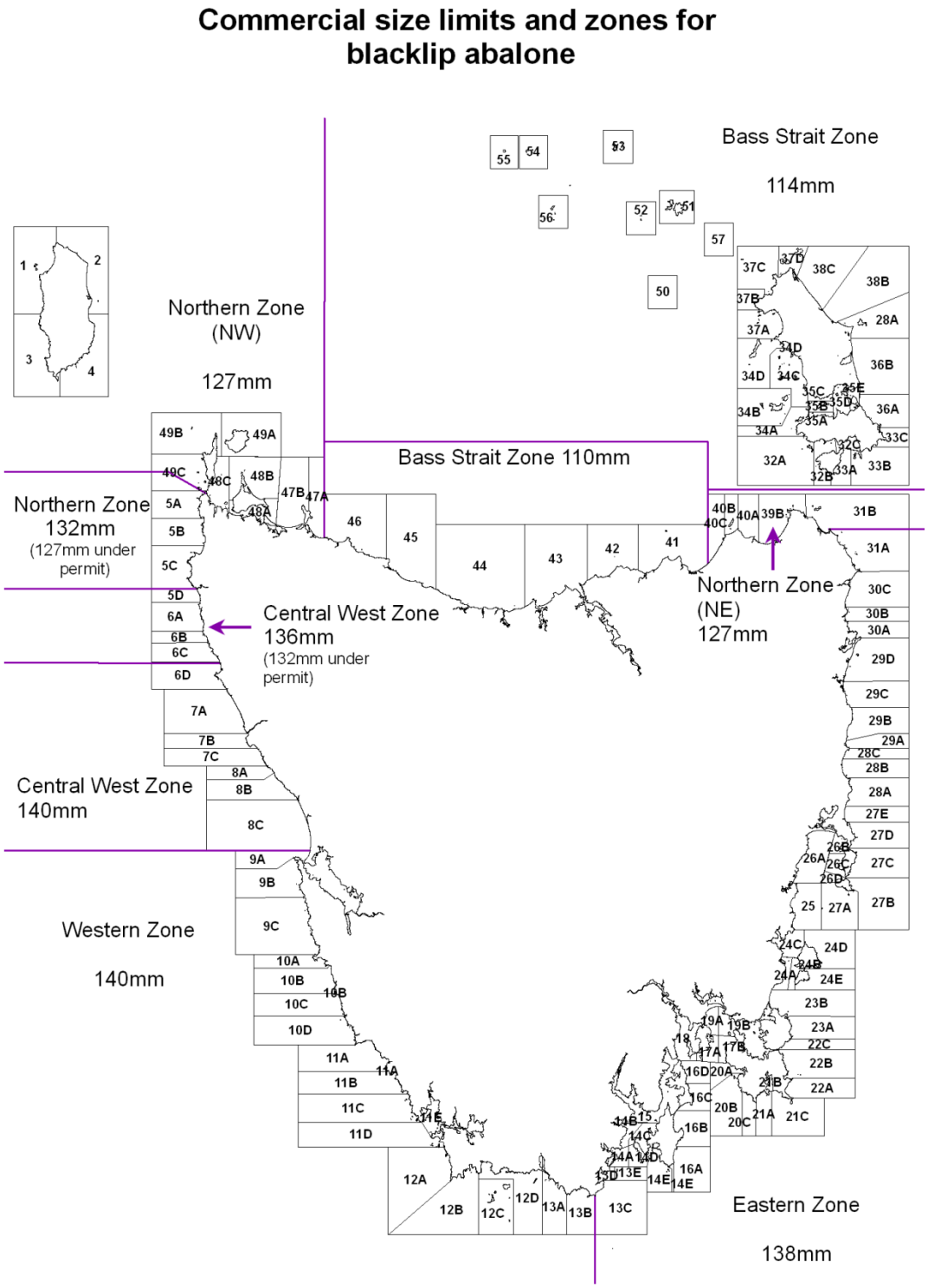
On a smaller scale, within each region, there is also variation in growth and maturity between populations. This occurs particularly in the North East in Block 31 and in the North West, in Block 6, where there are large differences in growth over small distances. In other areas, Block 22 (Tasman Peninsula) and the Western Zone part of Block 13 exhibit greater variation than surrounding blocks. It is impractical to develop size limits that accommodate all the combinations of growth and size at maturity exhibited by populations within a region, so managers aim to achieve the best fit, where the average of SAM+2 meets the management policy.

Abalone populations around the coast are regularly sampled by TAFI for the purpose of estimating their median size at maturity. In addition, abalone growth is measured through tagging programs at key parts of the fishery. These maturity and growth studies are ongoing, have been in place since the late 1980's, and useful information from approximately 500 maturity samples and over 40 growth studies is available.

Acquiring biological information is difficult and costly, and while there is substantial knowledge of abalone populations in some regions, others have less than adequate or no information. Where biological information is sparse, there are limitations with the application of SAM+2 across populations within an area, and the map needs to be viewed accordingly. Many of the SAM+2 estimates for the North West, North Coast and Central West blocks were derived from just a few samples, or the samples were collected many years ago, and consequently there is less confidence about these estimates.

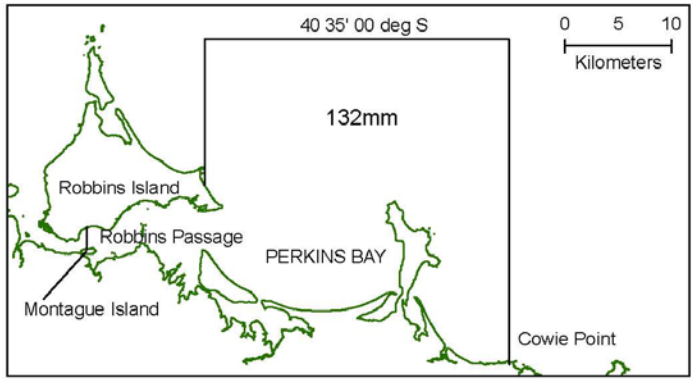
Most sites where maturity sampling has occurred lack population-specific growth information, so assumptions about population growth characteristics are made, and growth parameters from regionally similar populations are applied. This means that SAM+2 estimates are only as valid as the assumptions made about regional population growth, and while the best available knowledge is used when developing these assumptions, it is possible that there are some regions where these assumptions are not met.

Appendix 13: Commercial Size Limits for blacklip and greenlip abalone, 2010



In 2010, the size limit for blacklip in the Furneaux Group was reduced to 114mm as a result of the transfer of this part of the fishery from the Northern Zone to the Bass Strait Zone. In sub-block 31A, the size limit in the Eastern Zone fishery north of latitude 40°54’53” (Cod Bay) was reduced under permit to 132mm in August 2010 as a temporary measure to increase the catch in the area.

Commerical size limits for greenlip abalone (*Haliotis laevigata*)



King Island

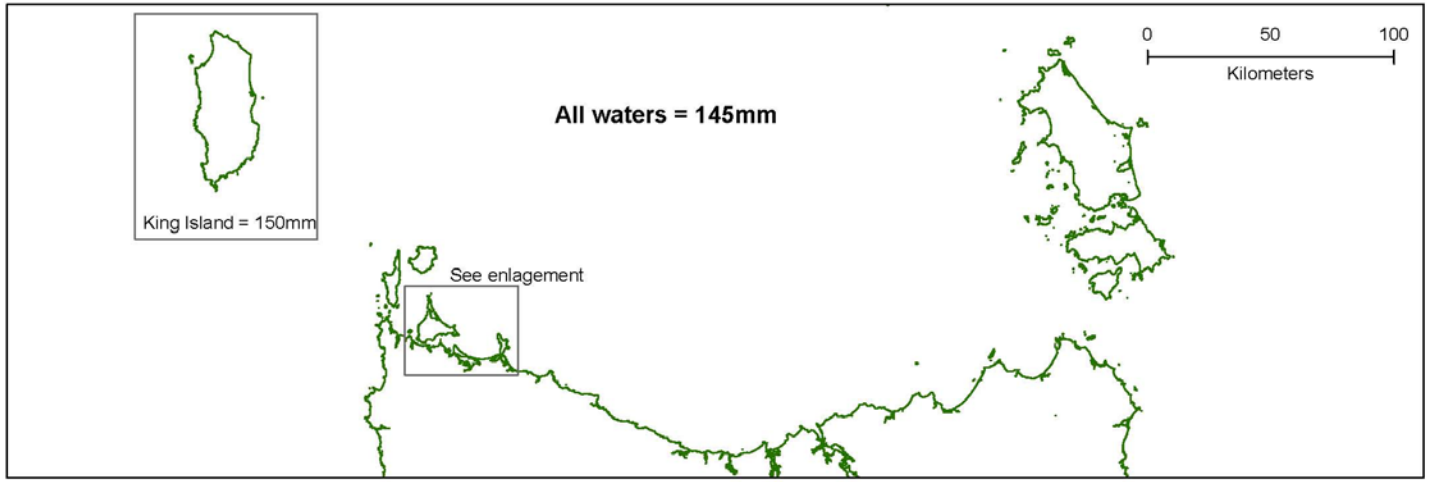
- All fish taken from King Island waters 150mm or greater.

Perkins Bay

- A 132mm size limit applies in Perkins Bay which is defined by waters which are enclosed with the following boundaries:
  - N/S of Montagu Island in Robbins passage to Cowrie Pt. and to a northward extent of 40 35' 00 deg S. to a western extent of 145 02' 52 E.

All other waters

- A 145 mm size limit exists for all other state waters for the take of greenlip abalone.



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