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Spatial and temporal trends in the abundance of long-spined sea urchins (*Centrostephanus rodgersii*) in Eastern Victoria using available fishery and fishery independent information

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1 Executive Summary

The long-spined sea urchin, *Centrostephanus rodgersii*, has the capacity to overgraze temperate reef habitats, creating barrens habitat devoid of macroalgal growth with negative implications for abalone populations and broader ecosystem health.

The Eastern Zone Abalone Industry Association (EZAIA) have been actively attempting to prevent further loss of healthy abalone habitat by culling long-spined sea urchins on important abalone reefs that have been deemed to be under threat from urchins since 2011. Additionally, a licensed commercial fishery has developed (it was formerly under permit) for the species with landings of >50 t in recent years.

The present study uses available information from Fishery Independent Surveys (FIS), the eastern Victorian urchin fishery, and EZAIA culling operations to describe spatial and temporal trends in the abundance of urchins on reefs across the Eastern Zone abalone management region.

The available information indicates a general increase in long-spined sea urchin abundance within the Eastern Zone over the last ~15 years. However, the increase is non-linear, with peaks in 2004 and 2013, followed by declines before reaching a historic maximum in 2019.

Trends in long-spined urchin abundance show high spatial and temporal variability, however, several general trends are apparent. Urchin abundance tends to be higher in the far east of the Zone from Little Rame through to the New South Wales border. Unsurprisingly, the above trend means that the two Spatial Management Units located in the east of the Zone (Mallacoota East and Airport) show the greatest increases in overall abundance through time. There was no detectable increase in most of the other Spatial Management Units, despite some individual sites within each showing some signs of increasing abundance.

Contrary to this overall long-term trend, long-spined sea urchin numbers have declined from historic highs in several instances, which can be attributed to both culling operations and commercial harvesting. This suggests that both activities have the potential to mitigate the destructive effect of the species. Future targeted, practical research and information collection will be important to:

- Improve understanding of urchin spatial dynamics in the eastern zone.
- Inform how future harvesting and culling activities can best be conducted to mitigate against barren formation and potentially recover lost habitat.

The current level of commercial urchin fishing and culling only covers a relatively small proportion of the Eastern Zone and is only likely to be useful as a preventative mechanism for relatively small-scale remediation. Opportunity for targeted restoration of key reefs with important fishery, biodiversity and/or amenity values – in partnership with other stakeholders – should be explored to increase the coverage and impact of remediation or mitigation activities.

2 Introduction

The long-spined sea urchin, *Centrostephanus rodgersii*, has the capacity to overgraze temperate reef habitats, creating barrens habitat devoid of macroalgal growth (Ling, 2008). As a result, these reefs no longer provide suitable habitat for a range of species, especially abalone, resulting in considerable economic loss to commercial fisheries.

Rehabilitation of barrens habitat has been investigated in small-scale manipulative experiments many times in the past (Andrew and Underwood, 1993; Hill et al. 2003; Strain and Johnson, 2009; Wright, 2005). These experiments indicate that it is possible to recover healthy reef ecosystems if urchin densities are reduced to relatively low levels.

The first major attempt to recover a large amount of abalone habitat lost to long-spined sea urchins (hereafter termed urchins) was undertaken at Island Point in 2011 in a collaborative project between the Eastern Zone Abalone Industry Association (EZAIA) and the Victorian Fisheries Authority (Gorfine et al., 2012). This study, and those that followed in Tasmania, showed that it was possible to recover relatively large areas of habitat provided sufficient resources were available to reduce urchin density over large spatial scales. Since then, EZAIA has been actively trying to prevent further loss of healthy abalone habitat by culling urchins on important abalone reefs that are deemed to be under threat by urchins. Additionally, a commercial fishery has developed for the species in eastern Victoria, which for many years operated under developing fisheries permits. The urchin fishery has been subsidised at times by the abalone industry to both maximise urchin catch and also direct urchin fishing to areas important to the abalone fishery. Subsidised fishing of urchins has been necessary in the eastern zone because the species often produces sub-standard roe and the price obtained is generally lower than for other urchin species.

This report, uses available information from Fishery Independent Surveys (FIS), the eastern Victorian urchin fishery, and EZAIA culling operations to describe spatial and temporal trends in the abundance of urchins on reefs across the Eastern Zone abalone management region.

3 Methods

3.1 Fisheries Independent Surveys

Fishery independent surveys in the Victorian Abalone Fishery have been conducted at fixed sites along the Victorian coastline since 1989/90, however the current format has only been consistently used since 2003. Therefore, for the current report, FIS data can only be used reliably from 2003 onwards.

The FIS surveys were designed to monitor temporal trends in the abundance of abalone of various sizes, but a variety of other data are gathered during the surveys, including the abundance of urchins. At each site, all abalone and urchins are counted within six random belt transects, which are strips of bottom 30 m long by one meter wide radiating out from a fixed central point marked by a buoyed shot-line.

Data were available from 2003 up until April 2019. Data from all available sites are presented (n = 77). Because some sites were added and removed during the time period, analyses at Reef Code, Spatial Management Unit (SMU), or Zone-wide scales, were restricted to data from the 58 FIS sites that have been surveyed throughout the entire time-period. This prevents bias from the addition and removal of sites during the time series. Note, however, that the FIS was not conducted at Marlo in 2004 but these sites were left in the analysis as removing them would prevent investigation of their influence on the remainder of the time series. Retaining the Marlo sites in the analysis does have an effect, which is discussed in the results.

Additionally, as urchin abundance is positively correlated with depth, and urchin barrens are more likely to be present in deeper waters, analyses were also undertaken by limiting the sites to those located in water 8m or deeper. This analysis was not limited to sites surveyed throughout the entire time period as filtering by depth removed a large amount of data (40 available sites) and the depth limitation removed much of the bias imposed by the reduction in site numbers in 2016. This analysis did not reveal anything contrary to the full analysis so results are included in Appendices and not described in detail.

The location of the FIS sites in relation to each abalone Reef Code is provided in Appendix 1.

3.2 Commercial urchin fishery

In addition to natural variation in urchin abundance, the commercial urchin fishery can affect spatial and temporal trends in urchin abundance. As such, annual landings of long-spined urchins (reported as black urchins) were presented from 1985 onward (landings prior to this were negligible). Data were available up until the 19/5/2019 meaning the current urchin quota year is incomplete, however these data align well with the timing of the most recent FIS so the most recent incomplete year is included.

Since the implementation of the sea urchin mobile phone application for commercial catch reporting, spatial resolution of the fishing effort is recorded either by the phones’ GPS, or manually entered by each fisher. To allocate this fishing effort to abalone reef codes, a spatial join was undertaken using a GIS shapefile layer of the abalone reef codes and the individual fishing locations. Note, however, that only ~17% of fishing events were able to be allocated to the shapefile polygons. Due to time constraints involved in collating spatial information, the most recent version of commercial urchin data retrieved did not contain spatial data. As such, the spatial effort from previously accessed urchin fishery data (6/8/2014 to 16/8/2018) were assumed to represent the spatial fishing patterns up until the end of the most recently accessed data (12/6/2019).

3.3 Culling Operations

The EZAIA has been undertaking culling of urchins on selected Eastern Zone reefs since January 2011. This has included experimental culling to determine its efficacy, government funded culling designed to recover denuded reefs that are unlikely to recover without dedicated culling regimes, and culling funded by industry to recover and/or maintain reefs of high importance to the abalone industry. For the purposes of the current assessment, the EZAIA provided a database containing information on industry led culling operations undertaken to date. These data include spatial and temporal information on culling effort, including estimates of cull rate (high = 30 urchins/minute; medium = 20 urchins/minute; low = 10 urchins/minute) and time spent culling, enabling the total number of urchins culled to be estimated. These cull rate estimates are relatively well aligned with those measured during a previous study (see Gorfine et al. 2012).

Additionally, EZAIA provided GIS information on culling operations in the form of boundaries of their culling areas. These were relatively large areas and no further information is available regarding the intensity of culling within these areas. As a result, the level of spatial information was varied for FIS (exact site location known), harvesting (a single point for a day’s fishing or unavailable) and culling (boundaries of culling effort known). To best incorporate all three levels of spatial resolution, analyses was undertaken at the reef code, SMU, and Zone wide levels.

4 Results and discussion

4.1 Spatial patterns in urchin abundance

Trends in urchin abundance are highly spatially variable (Figure 1). However, some spatial generalities can be drawn from the individual sites. Firstly, there are generally low urchin abundances in the far western areas of the Zone, particularly Marlo, which is reflected in the Reef Code (Figure 2) and SMU (Figure 3) level analyses. There is also relatively low abundance in the Mallacoota West and Mallacoota Large SMU (Figure 3). However, there are notable exceptions to this general pattern; for example, one of the sites at Petrel Point (Petrel Point 1, Figure 1) has comparatively high urchin abundance compared to other areas in the west.

At the other end of the spectrum, sites in the east of the Zone have notably higher urchin abundances. These include sites at Gabo Island, Gabo Harbour, Tullaberga Island, Bastion Point, Shipwreck Creek, Little Rame Lee, and Little Rame Reef Codes (Figure 1 and Figure 2). Again, this is reflected at larger spatial scales with the Mallacoota East, Airport and Mallacoota Small SMU having notably higher abundances than the other SMU (Figure 3).

The above trend has remained relatively consistent through time as depicted in Figure 4, which shows the density of urchins throughout the Eastern Zone during 2019.

Limiting the analysis to sites >8m depth did little to change the abovementioned trends. As such, these results have been provided in Appendix 2 and will not be discussed in detail herein. The largest notable change was at the Gunshot where the >8 m depth filter resulted in a single site remaining, which had a marked increase in abundance and was at ~3 urchins per square meter when it was removed from the FIS sampling regime.

4.2 Temporal trends in urchin abundance

Many of the sites in the Zone have displayed relatively stable urchin abundance throughout the time period investigated (Figure 1). However, the following sites show an increasing trend in urchin abundance through time:

- Two, or arguably, all three of the three sites at Tullaberga Island,
- Two of the three sites at the Benedore, although this seems to have reversed in recent years,
- Two of the four sites at Little Rame,
- One of the three sites at Shipwreck Creek,
- The Iron Prince site, though this has reversed during the last three years,
- Bastion Point 1.

The above site level trends are consistent with the increasing urchin abundance in the following Reef Codes for the 58 sites surveyed throughout the entire time period: Bastion Point, Little Rame, Little Rame lee, Quarry/Betka Beach (Shipwreck Creek Sites fall within this Reef Code), and Tullaberga Island (Figure 2). Of note, all of these reef codes are in the eastern end of the Zone and there has been a notable increase in urchin abundance at the Airport and Mallacoota Small SMU through time (Figure 3).

Overall, the trends at site and reef code scales mean that there has been a general increase in urchin abundance at the Zonal scale since 2003 (Figure 5). The increasing trend has, however, not been consistent through time, with a peak in 2004 (described below), followed by a decline in 2005 and then a subsequent increase to 2013, followed by a decline over two years, before a sustained increasing trend reaching an historic maximum in 2019 (Figure 5).

The increase in urchin abundance at the Zone scale in 2004 is not a result of increased abundance at any FIS sites in particular, but more so a result of the FIS not being conducted at Marlo in that year, which has the lowest abundance in the Zone. As such, the Zone wide annual mean is atypically high during that year and not necessarily representative.

Limiting the analysis to sites >8m depth did not affect the temporal trends in urchin abundance in most Reef Codes, other than at the Gunshot (as described in the above section) (Appendix 2, Figure A2.1).

The fact that the largest increases in urchin abundance have occurred in the eastern portion of the Eastern Zone supports the notion that the strengthening Eastern Australian Current is playing a role. Potentially coincidental, the increase in urchin abundance in the east is also generally occurring in areas with abalone populations that tend to grow to smaller sizes, which could be a result of these populations being less productive, less resilient, and less able to compete with urchins than in other areas within the Zone. However, the fact that the coastline in the east of the Zone faces eastward and therefore receives less of the prevailing southerly swell than sites further down the coast may result in both a smaller overall size of abalone in these populations and also the ability for urchins to inhabit shallower water. That is, there is potentially a common cause, but not a direct relationship, between the two effects.

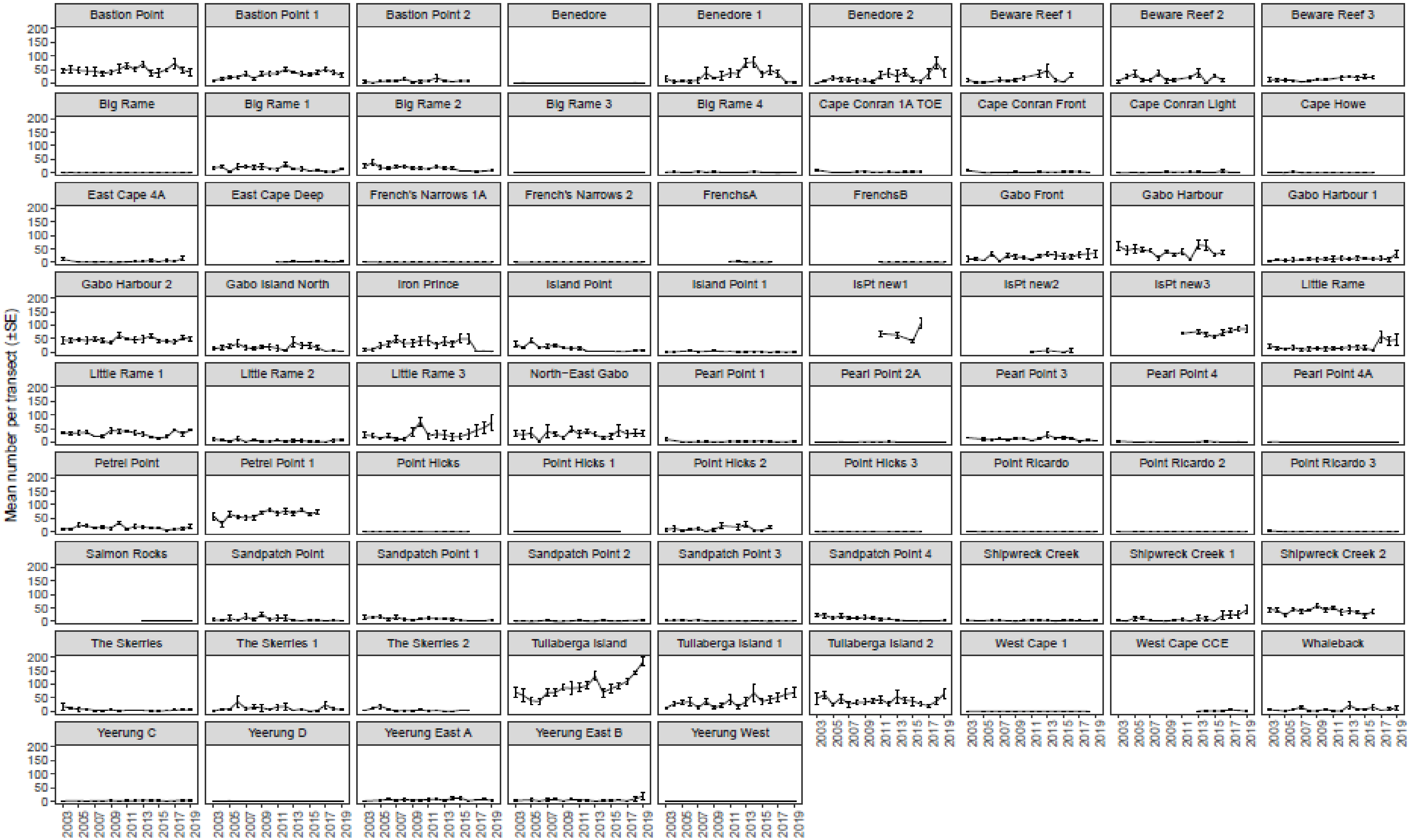

Figure 1: Temporal trends in the abundance (±SE) of black urchins at all Eastern Zone FIS sites. A transect is 30 m^2. Sites are ordered alphabetically.

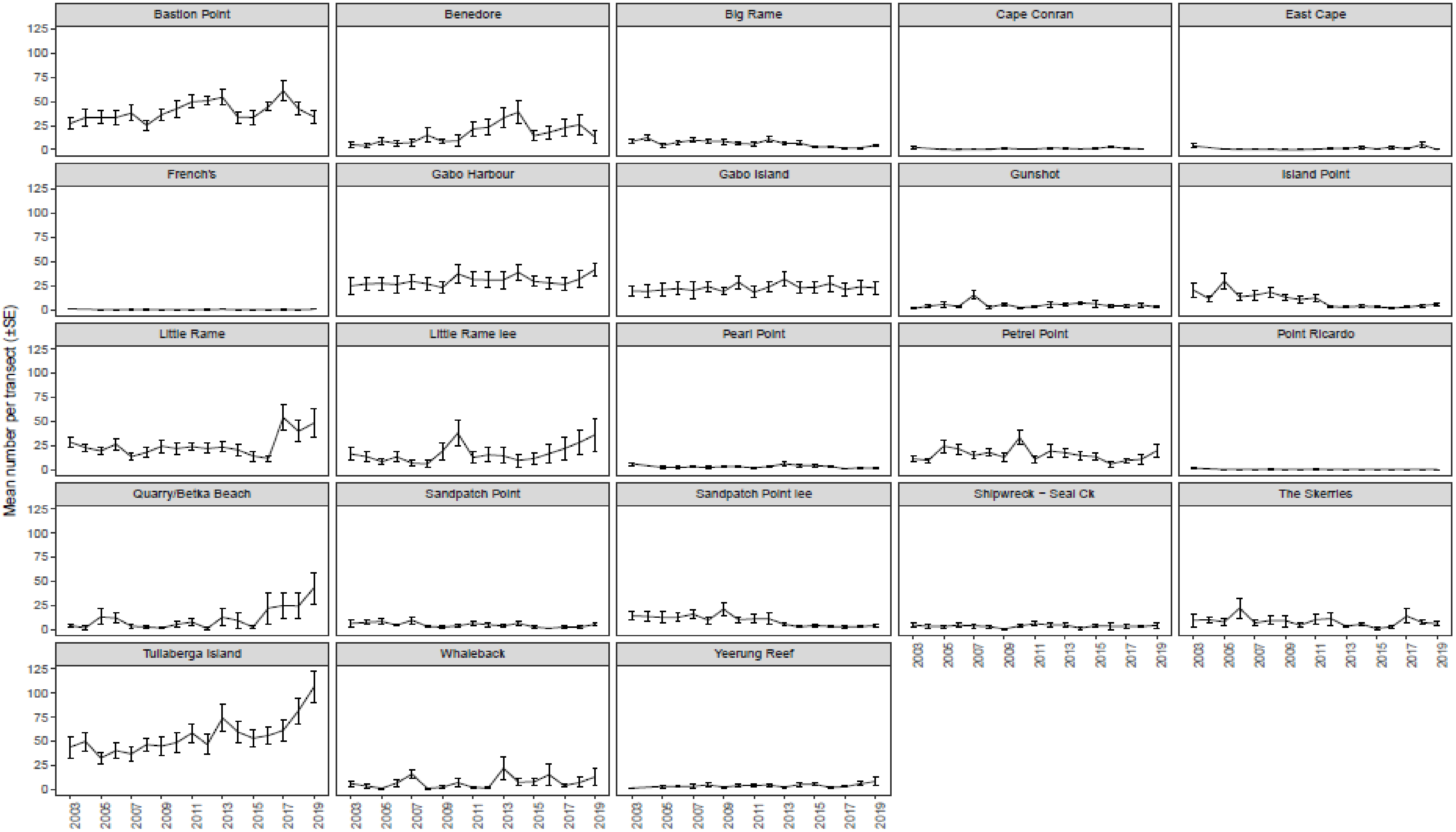

Figure 2: Temporal trend in the abundance of black urchins (±SE) within each Eastern Zone Reef Code. A transect is 30 m^2. Note: analyses were limited to sites surveyed throughout the entire time period. Sites are ordered alphabetically.

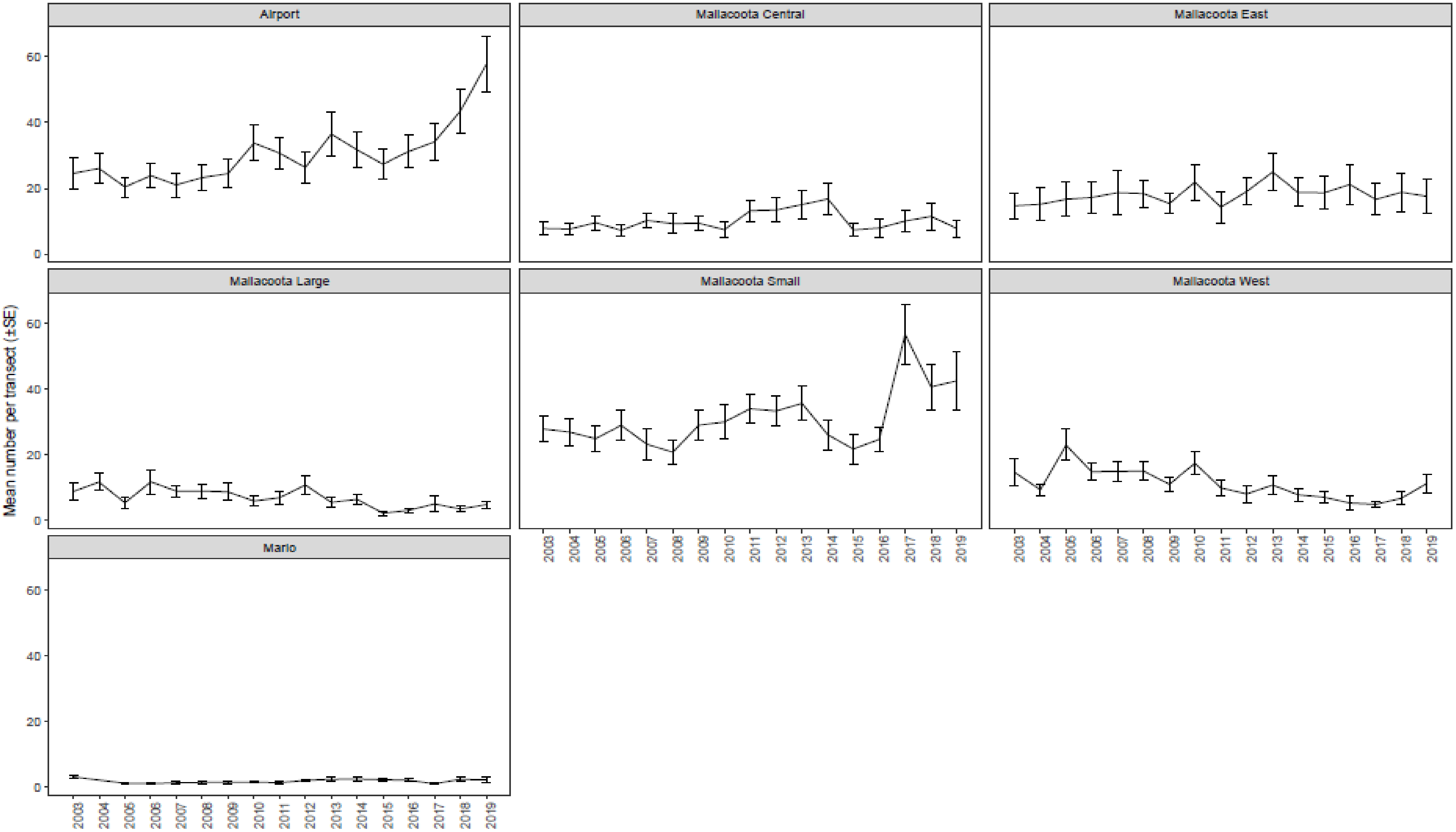

Figure 3: Temporal trend in the abundance of black urchins (±SE) within each Eastern Zone SMU. A transect is 30 m^2. Note: analyses were limited to sites surveyed throughout the entire time period.

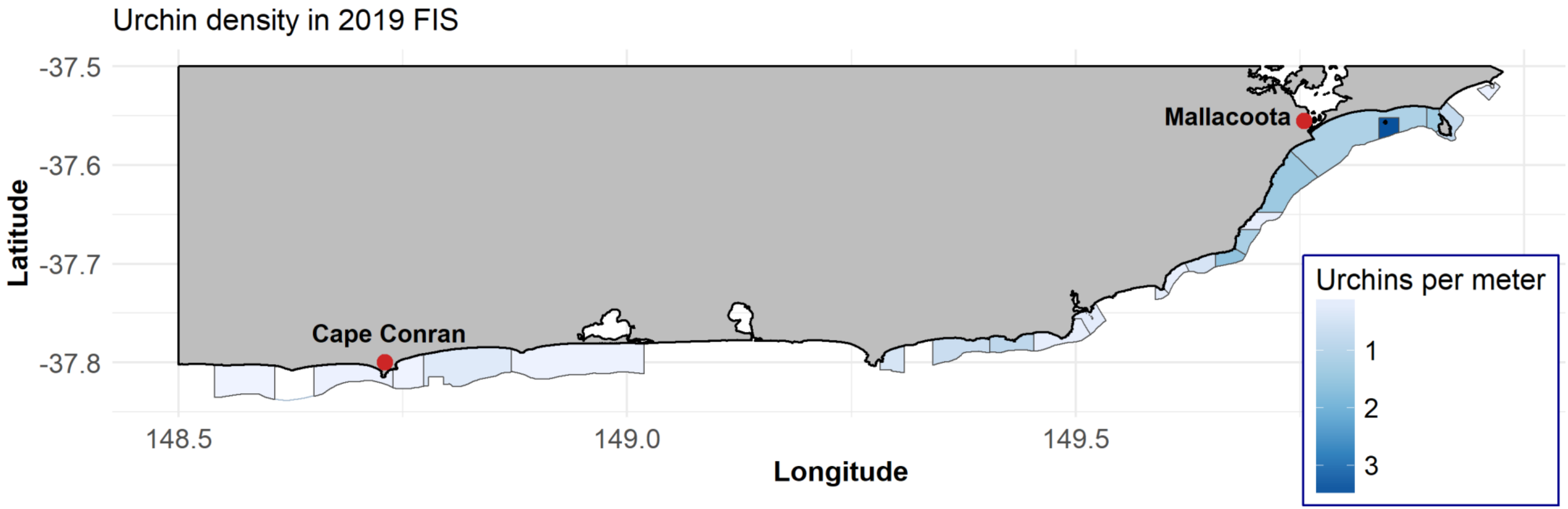

Figure 4: Black urchin density in each Eastern Zone Reef Code during the 2019 Fishery Independent Surveys.

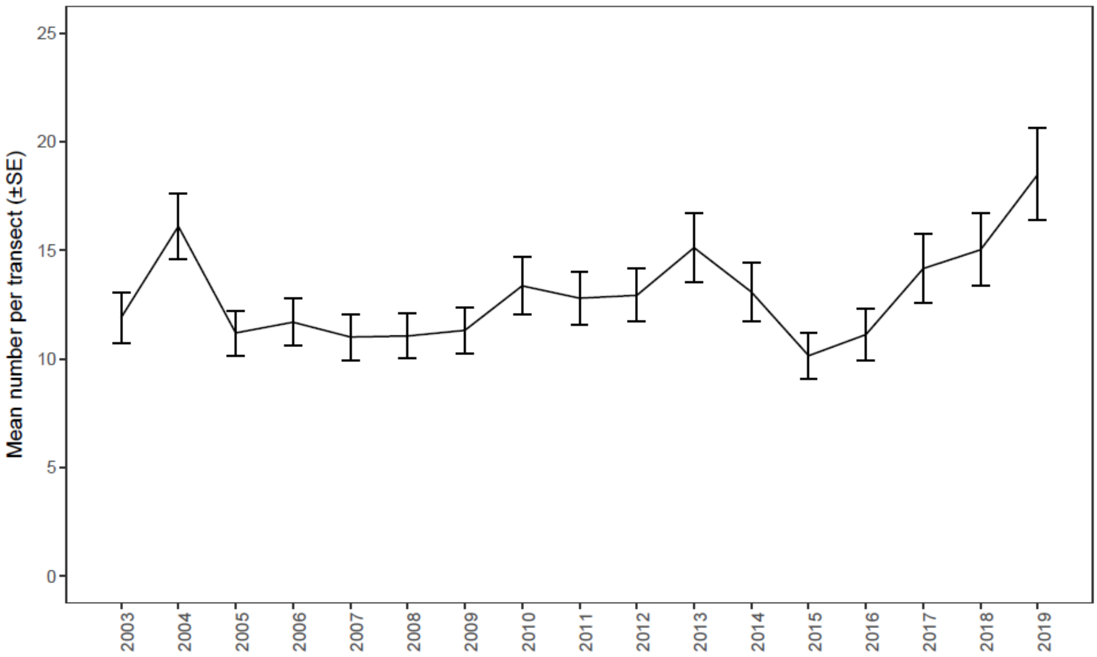

Figure 5: Temporal trend in the abundance of black urchins (±SE) within the Eastern Zone. Note: analyses were limited to sites surveyed throughout entire time period, other than 2004 when Marlo was not surveyed (see results for explanation). A transect is 30 m^2.

4.3 Spatial and temporal trends in commercial urchin harvesting

Urchin landings (long-spined urchins only) have cycled through time as the fishery has developed and subsequently wound down (Figure 6). Peaks have occurred in the late 1980’s, mid to late 2000’s and again in the last few years.

As urchin roe quality varies spatially, and quality is the primary driver in urchin fishing operations, it is unsurprising that urchin fishing is not evenly distributed along the coast. Nor is it surprising that the majority of the catch is landed relatively close to Mallacoota (Figure 7) as *C. rodgersii* achieves relatively modest returns meaning it is not economically viable to travel long distances to harvest them, particularly if sufficient high-quality urchins can be found close to port.

Of the urchin landings data that were able to be attributed to Reef Codes, the largest quantities (>30%) were landed from the Quarry/Betka Beach Reef Code (Figure 8). Similar quantities (5–15%) were landed from most other reef codes near to Mallacoota, whereas only very small quantities were landed from the Yeerung Reef Code at Marlo.

Discussions with abalone and urchin industry members suggest that the urchin fishery has been subsidised when fishing along the Airport reef codes to minimise the need for culling, resulting in proportionally higher landings from this area. However, this is one of the few sections of coast where GSM coverage enables fishing location to be accurately recorded by the smart phone application meaning that fishing effort in this area is more likely to be allocated to the correct abalone Reef Codes and may therefore be overrepresented. This bias also potentially affects the proportion of the catch allocated to Reef Codes further away from Mallacoota where there is no GSM reception (i.e. reduces their proportional contribution). Additionally, these landings are also potentially biased towards fishers who manually enter their fishing locations accurately.

The declines in urchin abundance at the Iron Prince and Big Rame 2 FIS sites cannot be attributed to urchin culling and may therefore represent harvesting from within the vicinity of the FIS sites. There is also a small decline at the Shipwreck Creek 2 FIS site, which may be due to the considerable harvesting which occurs along the Airport area (Figure 2).

The above suggests that the harvest of urchins is capable of aiding in the control of urchins in its own right, although there are insufficient data available to quantify its benefit at present. FRDC projects are currently underway in Tasmania that aim to measure the effectiveness of urchin harvesting on preventing further expansion of urchin barrens. Additionally, EZAIA has been in discussion with VFA about ways that this could be measured in the Eastern Zone.

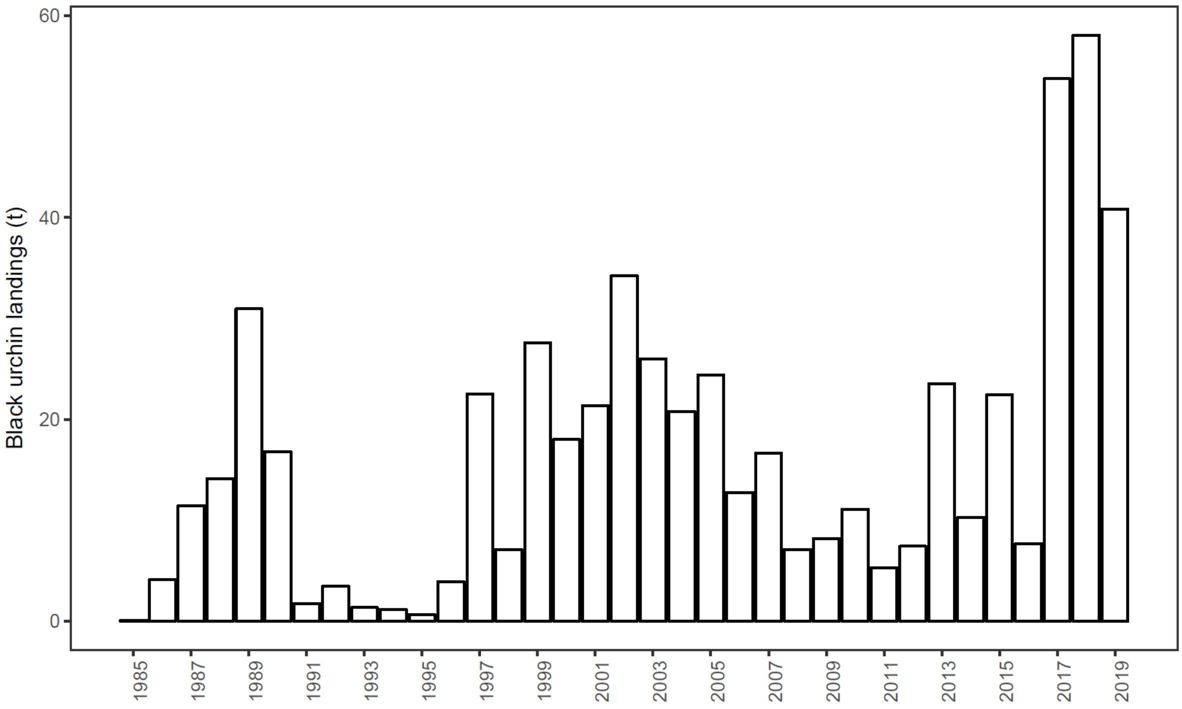

Figure 6: Landings of black urchins from the Eastern Zone. Note: landings for 2019 are up until the 19th May 2019.

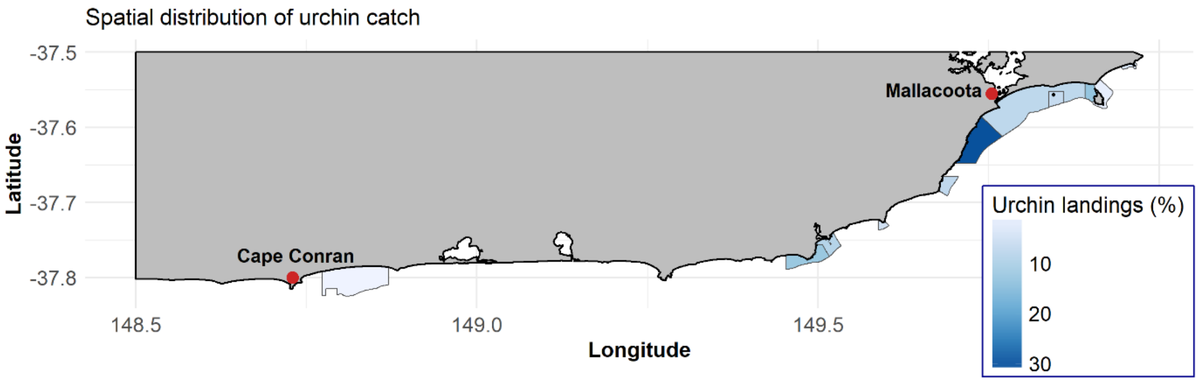

Figure 7: Spatial distribution of black urchin catch. Note: landings are presented as a percentage because this analysis represents only the proportion of landings for which spatial information could be attributed to catch from the urchin fishing application.

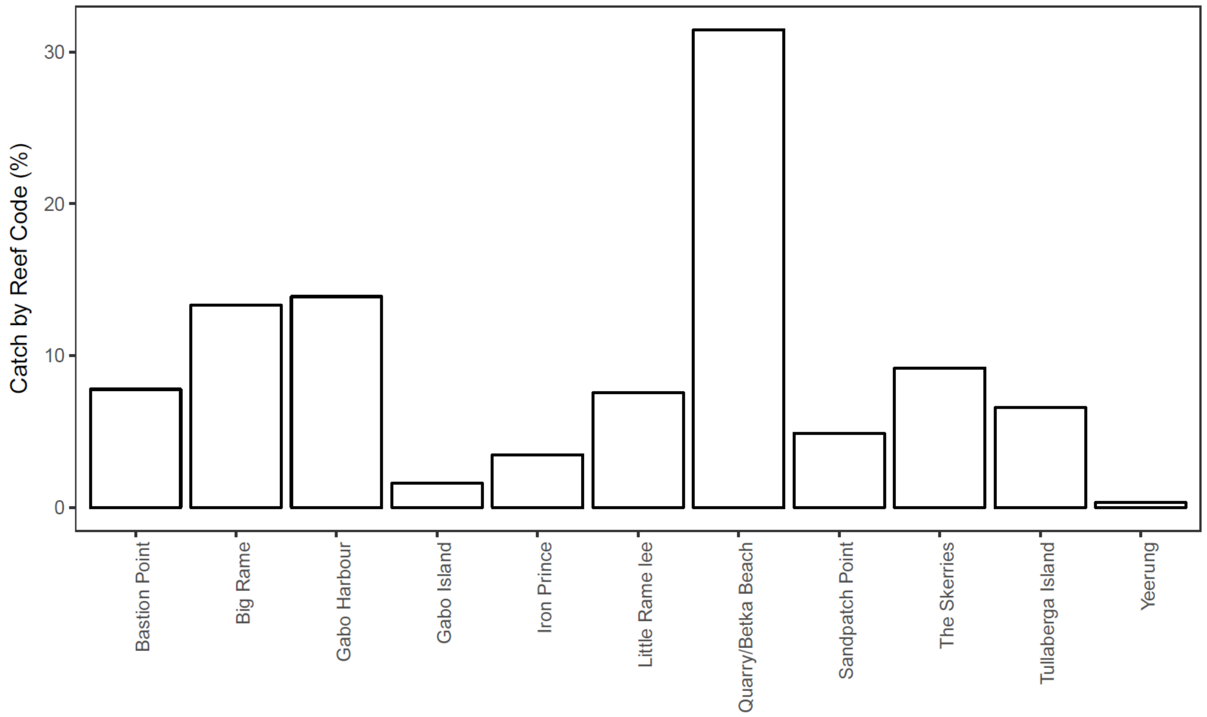

Figure 8: Landings of long-spined sea urchins by abalone Reef Code. Note: landings are presented as a percentage because this analysis represents only the proportion of landings for which spatial information could be attributed to catch from the urchin fishing application.

4.4 Spatial and temporal trends in urchin culling

Consistent with an objective of improving the prospects of an abalone fishery that has been impacted by urchin proliferation, a large proportion of culling has taken place at Reef Codes that are historically important for the abalone fishery. This includes, in descending order of the 2019/20 abalone catch targets, Sandpatch Point lee (30 t), Gabo Island (22 t), Island Point (18 t), Petrel Point (15 t) and the Benedore (7 t) (Figure 9). There has also been a lesser amount of culling undertaken around Marlo, however, the FIS suggest that urchin abundance is typically lower in this SMU implying that urchins in high densities are likely to be quite patchily distributed compared with the other SMU and there is therefore less need for remediation (Figure 3).

Urchin culling began in earnest in 2011 as part of the joint EZAIA and VFA project at Island Point (Figure 10). The following year, EZAIA began their own culling regime and the number of urchin culled during this year remains the highest to date. The number of urchins culled has remained quite consistent during most years with 2016 being the only obvious outlier with the very high number being culled as a result of an FRDC Project (FRDC 2014/224) and the ongoing EZAIA culling regime.

The culling efforts by industry have corresponded with decreasing urchin abundance at several of the FIS sites: Benedore 1, Benedore 2, Sandpatch Point, Sandpatch Point 1, Sandpatch Point 4, Island Point, Gabo Island North, and arguably others to a lesser degree (Figure 1).

The decrease in urchin abundance observed at Sandpatch Lee and the Benedore Reef Codes appears be related to culling alone. Although a large proportion of the urchin harvest cannot be spatially allocated, Industry members have indicated that very little urchin harvesting has occurred at both of these reef codes so it appears likely that culling alone has been responsible for decreasing urchin abundance on these reefs.

Overall, urchin culling appears to have had a measurable influence on urchin abundance. For example, at Reef Codes where culling has occurred urchin abundance declined markedly between 2013 and 2015 (Figure 11), corresponding with the onset of culling operations (Figure 10). A lesser decline in urchin abundance occurred between 2015 and 2017 on these same reefs that could be attributed to both culling and a very large increase in urchin harvesting in 2017. This resulted in a historic low in urchin abundance in 2017 on these reefs with slight increases from then until 2019.

On reefs where no culling has occurred, there was also a decline in urchin abundance between 2013 and 2015, but since that time there has been a sustained increase, reaching historic highs in 2019 at almost one urchin per square meter (Figure 11). This further supports the notion that urchin culling has been successful in preventing further incursion and has likely prevented reefs of importance to the abalone industry, where culling has been focussed, from experiencing similar increases in urchin abundance. It must be noted, however, that some lines of thought believe that high abalone density helps to reduce the incursion of urchins and therefore reefs that are important to the abalone industry, where the majority of urchin culling has occurred, are more resilient. This notion is being tested within an FRDC project currently underway in Tasmania.

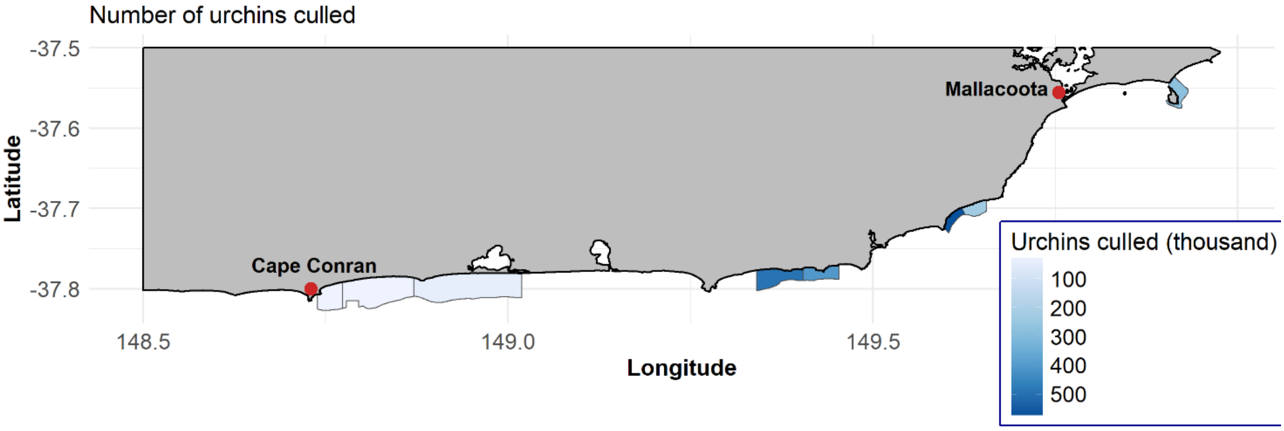

Figure 9: Spatial distribution of urchin culling depicting the estimated numbers of urchins culled from 2011 – 2019. Note: These analyses were undertaken using the high, medium and low cull rate categories reported by divers and the associated cull rate per minute.

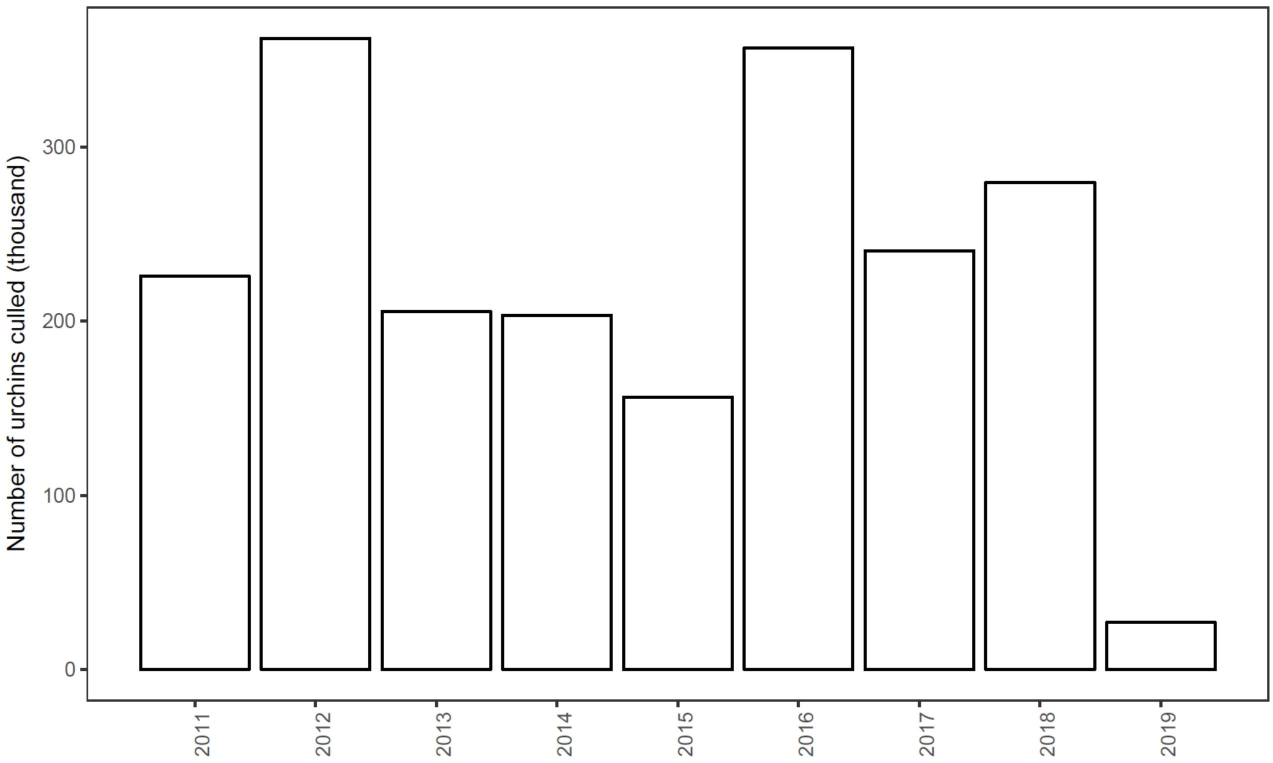

Figure 10: The annual number of urchins culled in the Eastern Zone. Note: 2019 is incomplete with data only up until 21/04/2019.

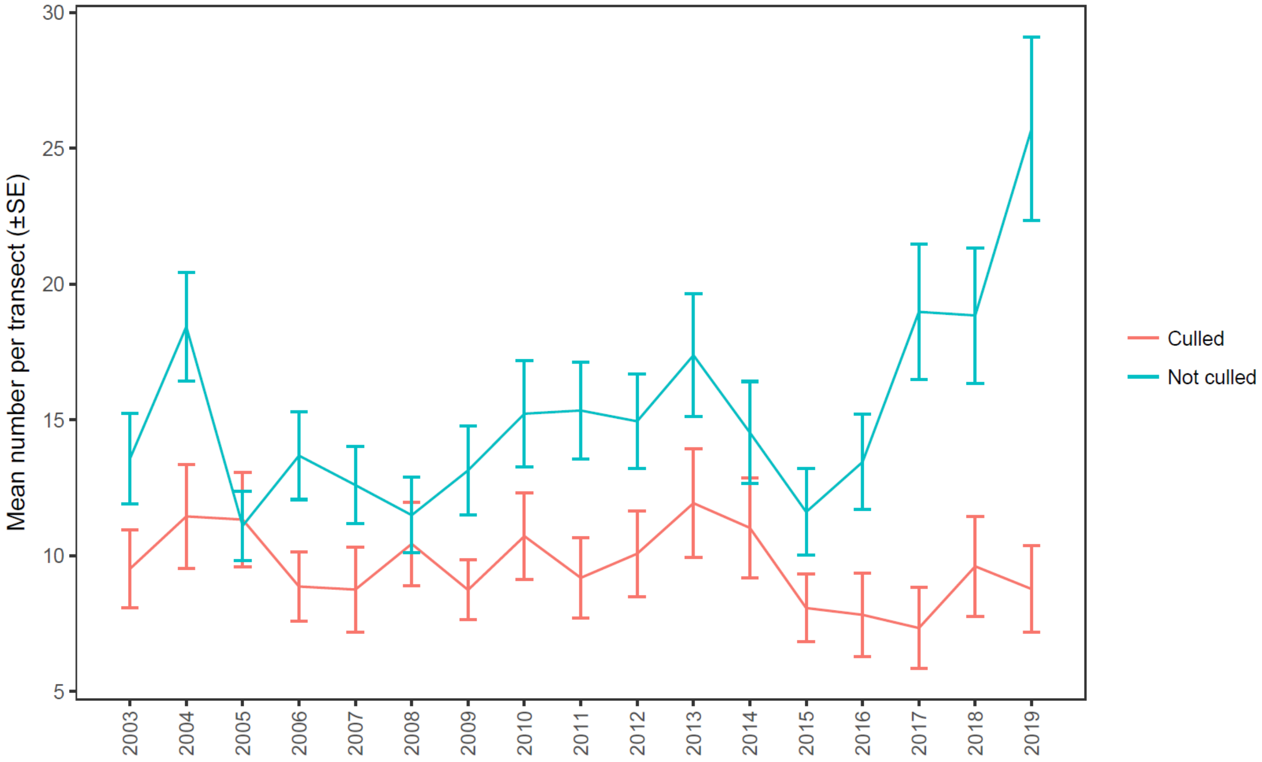

Figure 11: Zone wide temporal tends in urchin abundance on culled (black) and unculled (magenta) reefs. A transect is 30 m^2.

5 Limitations of the current assessment and future research

5.1 Location and suitability of the FIS for determining urchin abundance

The key assumption of the current study is that FIS sites reflect spatial and temporal trends in urchin abundance. The FIS was designed to determine spatial and temporal trends in abalone abundance and are largely located in waters from 5 – 10 m depth over healthy habitat where blacklip abalone are abundant and about 80% of fishing would be expected to occur (Gorfine and Dixon 2001). As a result, there can be relative confidence that the current study is reflective of urchin abundances on healthy abalone habitat and in most instances can show when urchins have encroached on what was once healthy habitat. However, during a reduction in the number of FIS sites, most sites where there has been obvious urchin encroachment were removed as a decline in healthy habitat due to urchin grazing and the resultant reduction in abalone abundance (e.g. Ling, 2008) meant these sites met one or more of the criteria for exclusion determined by the Abalone Working Group (i.e. within site transect count coefficient of variation of >0.5; long term low abalone abundance). This included sites along the Airport and Petrel Point where there had been long term incursion of urchin barrens and two sites at Island Point that were created to monitor the long-term effects of culling at this location. Unfortunately, the removal of these sites has limited the ability of the current study to determine whether there has been further incursion of urchins or to measure reductions in urchin abundance that may relate to culling activities or harvesting. In particular, the removal of the sites at Island Point has meant a lost opportunity for determining long-term trends in the recovery of abalone and the reef community.

In addition to the above, algal cover and habitat composition data are no longer recorded during FIS as they were not deemed to be of importance. These data would have enabled the negative ecological impacts of increasing urchin abundance to be quantified and would also enable any recovery in macro-algal communities due to culling or harvesting to be described, along with any subsequent recovery in abalone abundance.

5.2 Spatial resolution of the available data

One of the major obstacles faced during the present study was the varying amount of spatial information available. For example, the exact location of FIS sites is known, whereas the location of urchin harvesting is unavailable in the majority of cases. Further, industry urchin culling has taken place in a relatively hap-hazard fashion within designated boundaries, so it is not possible to know exactly where it took place, or at a spatially resolved intensity. As a result, it is only possible to investigate these data at relatively gross scales (i.e. Reef Code) when urchin abundance, and barren formation, can occur at very localised scales. A variety of modelling techniques were attempted to statistically measure the influence of culling and harvesting on urchin abundance but these fit the data relatively poorly, presumably because culling and harvesting take place on some FIS sites, but not others and it is not possible to determine which.

At the very least, it should be mandatory for people being employed to undertake culling to record the start and end location of each dive. This takes a matter of seconds but greatly improves the quality of data available for studies such as this and would allow the use of modelling techniques (e.g. Brownian Bridge movement models) utilised that can estimate where divers are when underwater, and therefore the area covered by culling activities. It is also important that accurate spatial information is provided when urchin harvesting.

Currently the data derived from the urchin application is only providing this information accurately for a fraction of the fishing events.

It is important to note that through new collaborative work being undertaken by EZAIA and VFA (“Restoring marine habitat biodiversity in eastern Victoria” funded by DELWP), EZAIA has developed the skills required to collect information that will enable quantitative measures of the effectiveness of urchin culling in rehabilitating reef habitats. This, along with improved spatial resolution using Vessel Monitoring Systems, will enable improved management and maximise the ability for EZAIA to showcase the work they are undertaking. It will hopefully also enable improved efficiency in future industry led culling operations.

5.3 Scaling of FIS to estimate biomass

Initially, EZAIA proposed that the present study attempt to replicate the approach of Worthington and Blount (2003) using the FIS. These authors estimated urchin biomass for a large stretch of the Mallacoota coastline from the New South Wales border to Sandpatch Point as part of an FRDC project (FRDC 1999/128).

The sampling regime undertaken by Worthington and Blount (2003) involved counting urchins along transects from the shore out to the reef edge or barrens, whichever occurred first. This technique is appropriate for sampling over a range of strata/depths and because the density estimates can be expanded up according to the estimated reef area for each strata it is a more suitable method for estimating biomass than the FIS. The FIS program is specifically designed to detect relative temporal changes in abundance.

If the FIS was undertaken in its current form during 2000 when Worthington and Blount (2003) undertook their detailed survey of urchin abundance, it would have been possible to scale/calibrate the two and hence estimate how urchin biomass has trended through time by assuming that changes in abundance at the FIS sites are reflective of changes over the broader area. Unfortunately, this was not the case, and it would be a mistake to simply extrapolate the FIS urchin densities to the areas used by Worthington and Blount as the FIS sites are only reflective of urchin abundance within those sites/depths/strata and not necessarily the abundance of the entire area. In any case, simply multiplying the abundance of urchins observed in the FIS by area does not change the trends in the analyses so there is no real value in doing so given any biomass estimates could be inaccurate and therefore misleading.

5.4 Future priorities

EZAIA has been highly proactive in their efforts to prevent further incursion of urchins onto healthy reef, and in some areas attempting to recover lost habitat. To maximise the benefits of these efforts for the abalone industry in the future it is important to provide support and scientific advice to industry to help develop a feasible structured approach to culling activities with appropriate data collection and reporting. ‘Learning by doing’ in a structured way with appropriate data collection can inform the development of an adaptive approach to culling activities that can result in significant gains in effectiveness, efficiencies and cost savings. Ultimately this would increase the scope for industry led culling to cover greater areas and maximise benefits for abalone and the broader environment. Furthermore, the analysis of information from industry culling activities can be integrated into more targeted research activities (e.g. Island Point and Gunshot projects) and provide leveraging opportunities to attract external funding support and collaboration with other stakeholder groups (discussed further below). This has already occurred with EZAIA currently involved in two FRDC projects and one DELWP project:

- Rebuilding abalone populations to limit impacts of the spread of urchins, abalone viral ganglioneuritis and other external impacts (FRDC 2014/224)
- Monitoring abalone juvenile abundance following removal of *Centrostephanus* and translocation (FRDC 2017/049)
- Restoring marine habitat biodiversity in eastern Victoria (DELWP; BRPM002)

As the above projects are incomplete the results were unable to be incorporated herein, or able to be discussed. As a result, at the time of undertaking this report, a number of questions still remain around urchin culling These include:

- What is the spatial extent of the problem in the Eastern Zone?
- Determining minimum densities that urchins need to be reduced to for promoting recovery across affected areas and different contexts (i.e. reef topography/depth/abalone abundance etc.).
- What are the minimum requirements for ongoing culling to maintain healthy habitat?
- How long does it take for abalone densities to recover to commercially viable levels following culling?
- Are there ways in which abalone fishing behaviour can be modified to help mitigate against urchin barrens expanding or becoming established?
- Economic viability/returns to the abalone industry from ongoing active management of urchins?

EZAIA has certainly gathered anecdotal information on many of the above uncertainties, however, robust quantitative information would make it easier to develop the approaches to apply in future. In Tasmania, the Institute for Marine and Antarctic Studies (IMAS) has received substantial Government funding for structured research projects to answer many of these questions within the context of the Tasmanian environment. However, it is important to note that the studies in Tasmania have had a broader ecological/biodiversity focus on the urchin problem and approaches to mitigate the growth of urchin populations.

Like Tasmania, it is clearly recognised that the expansion of urchins in eastern Victoria has broader ecological implications. Therefore, there are opportunities for development of collaborative research between the abalone industry and other stakeholder groups with interests in the impact of urchins on reef ecosystems and biodiversity. This opportunity has recently been recognised by the implementation of the project “Restoring marine habitat biodiversity in eastern Victoria” funded by DELWP. This project is a collaboration between the EZAIA, DELWP and the VFA, and involves a scientifically designed and monitored urchin culling program at the Gunshot reef. Industry divers will be the primary agents for culling and monitoring under guidance from VFA scientists. The project provides the opportunity for industry to develop the skills necessary to improve industry-based culling and monitoring and evaluation approaches.

While the abovementioned project will equip industry with an expanded capacity to monitor outcomes from urchin culling at individual reefs, there are other monitoring approaches required to understand impacts and changes on broader spatial scales. Mapping of the extent of the urchin barrens is the only reliable way to quantify the spatial resolution and scale of the urchin problem in eastern Victoria. Doing so at repeated time intervals would identify whether the impacted areas are expanding or contracting in response to various environmental conditions, urchin harvesting, urchin control treatments and potentially abalone fishing. A variety of approaches are available that range from highly detailed, expensive options (e.g. multibeam echo sounders) to simpler techniques using towed/drop cameras or potentially even using existing information such as LIDAR. Given the availability of industry vessels in this instance, which is the major cost involved in this exercise, it would be possible to undertake this task relatively cost effectively. If none of these options are available, an alternative could be to build a repository of diver observations through time. Simple information such as urchin abundance, depth and location could build a useful picture if participation is high.

Finally, urchin culling is expensive, and wasteful of a potentially valuable seafood product. The most cost effective, long-term remedy for this problem is to develop markets, alternative products/uses that cover the cost of removing urchins, or even better to turn the harvesting of this species into a profitable exercise, without the need for subsidies. Value-adding, e.g. on-growing cultivation to produce better roe and other endeavours, have been attempted in the past but success remains elusive, primarily because long-spined urchin roe is considered inherently substandard. There may be other options for turning sub-standard urchins into at least a cost neutral product and this should be explored further. This is likely the best way that the problem of urchins in eastern Victoria can be actively managed in an economically viable/sustainable way.

6 Acknowledgements

The authors would like to thank EZAIA for provision of data relating to urchin culling. In particular, we would like to thank John Minehan for providing valuable insight into the Eastern Zone urchin fishery, urchin culling operations and for providing useful comments during drafting of this report.

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8 Appendix 1 - Locations of FIS sites

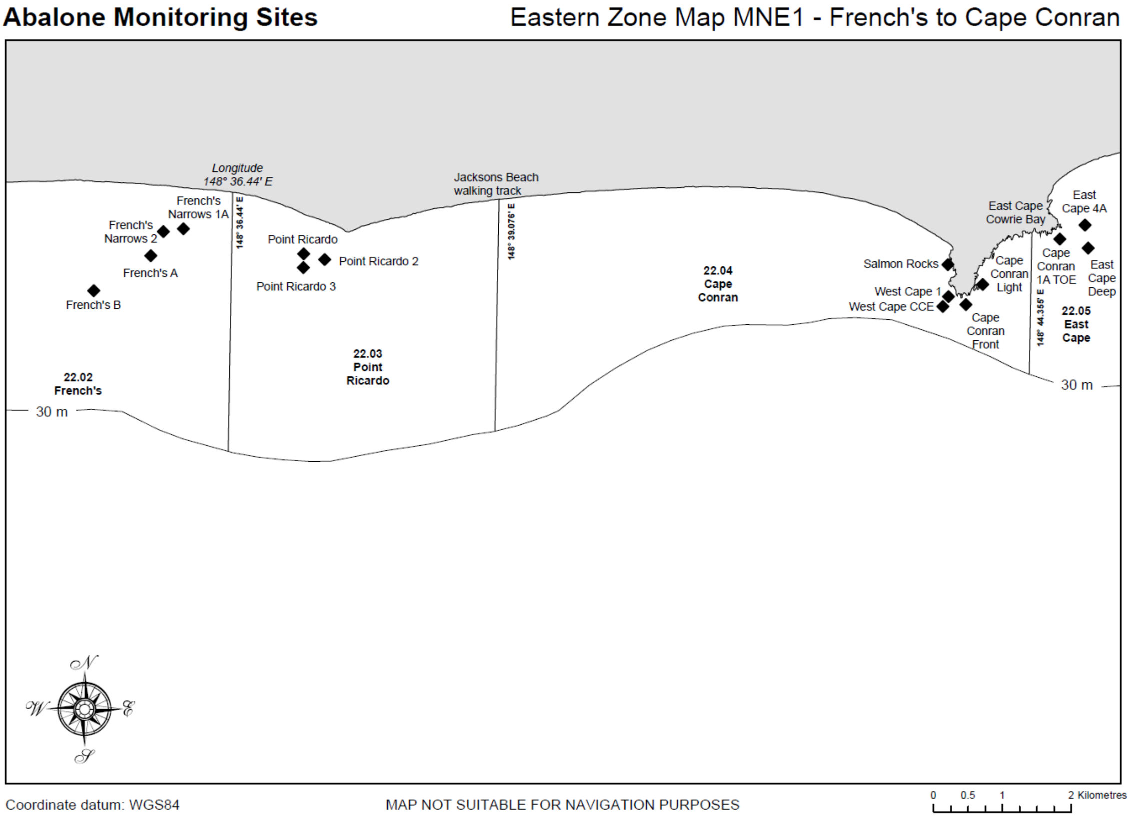
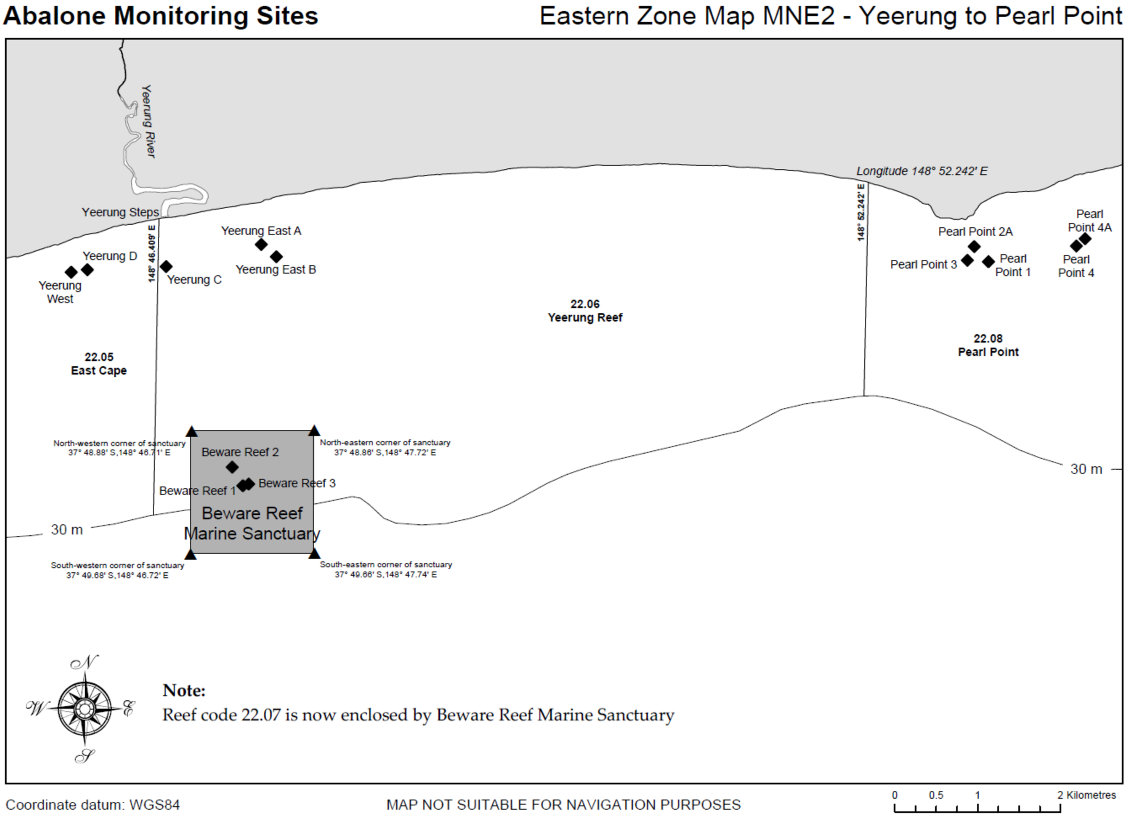


Figure A1.1: Location of FIS sites from French's Narrows to East Cape Conran.



Note:
Reef code 22.07 is now enclosed by Beware Reef Marine Sanctuary

Figure A1.2: Location of FIS sites from Yeerung to Pearl Point.

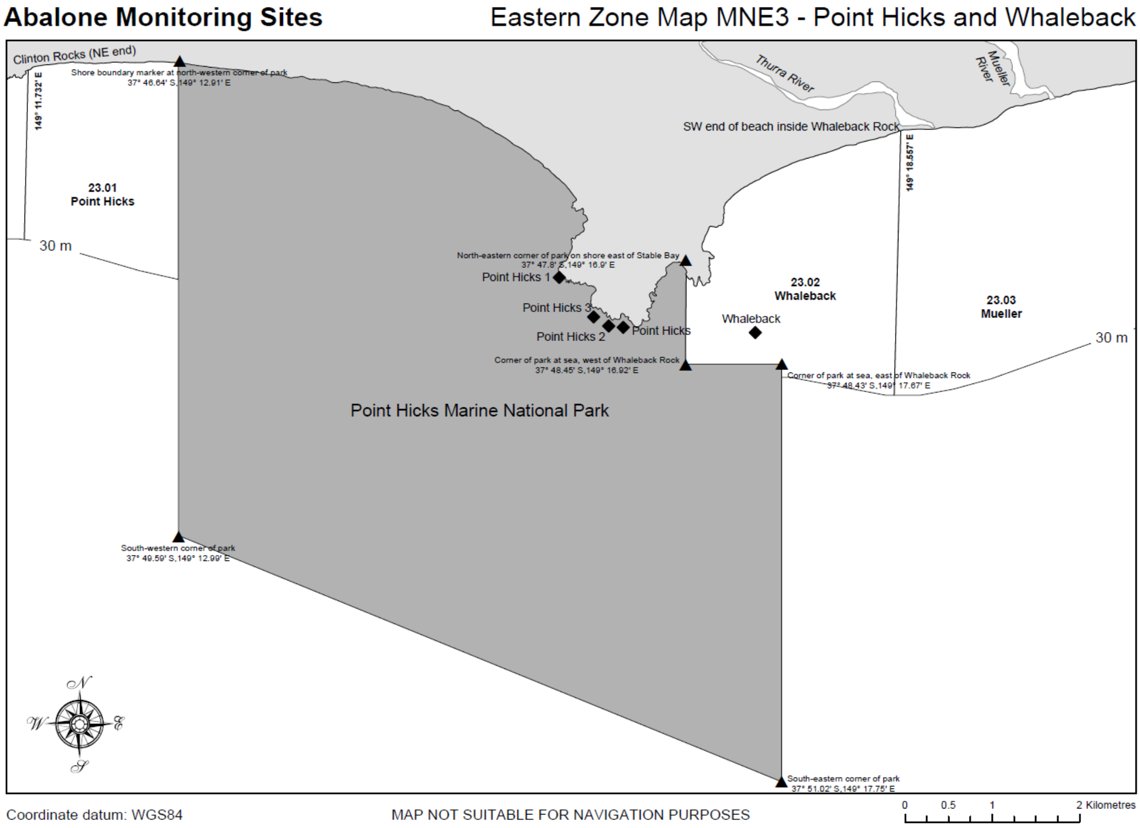


Figure A1.3: Location of FIS sites from Point Hicks to Whaleback.

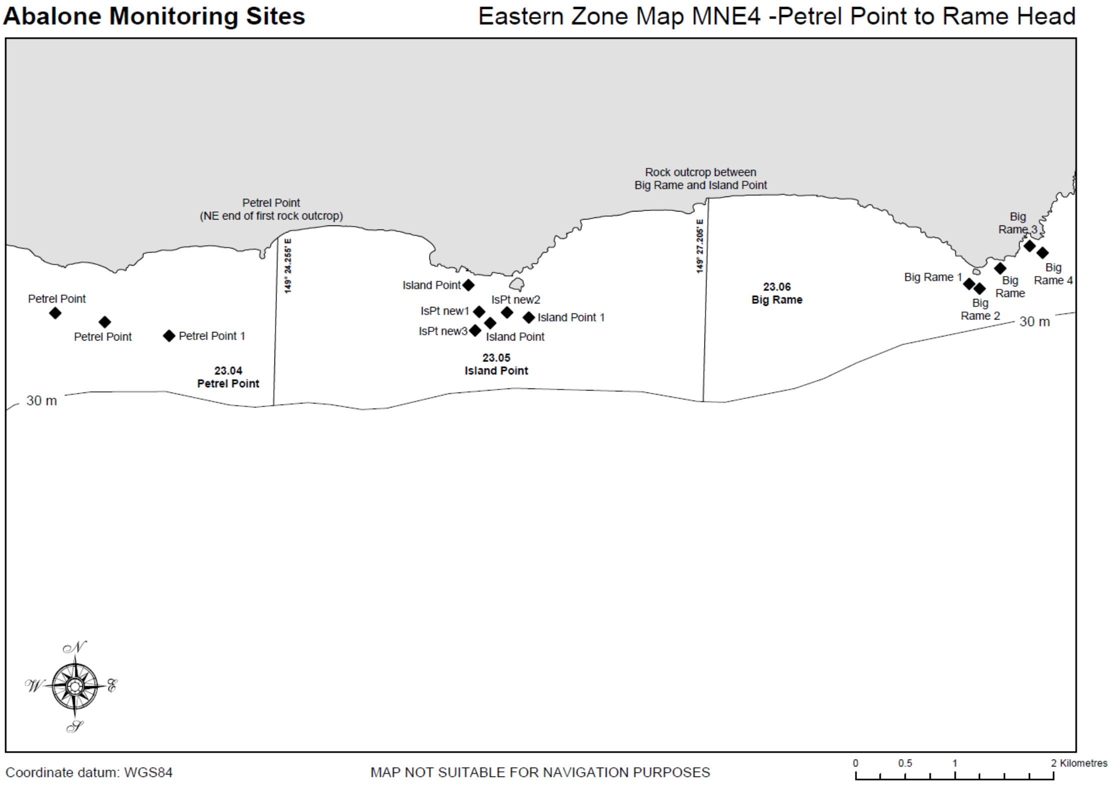


Figure A1.4: Location of FIS sites from Petrel Point to Big Rame.

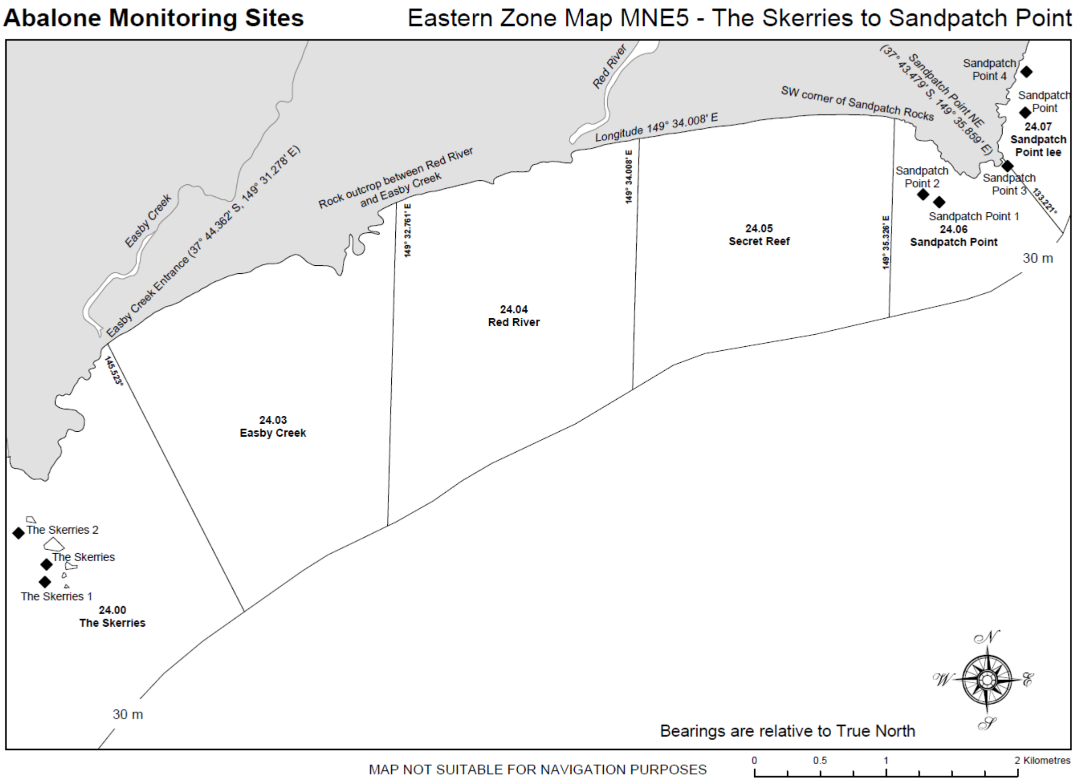


Figure A1.5: Location of FIS sites from Sandpatch to the Skerries.

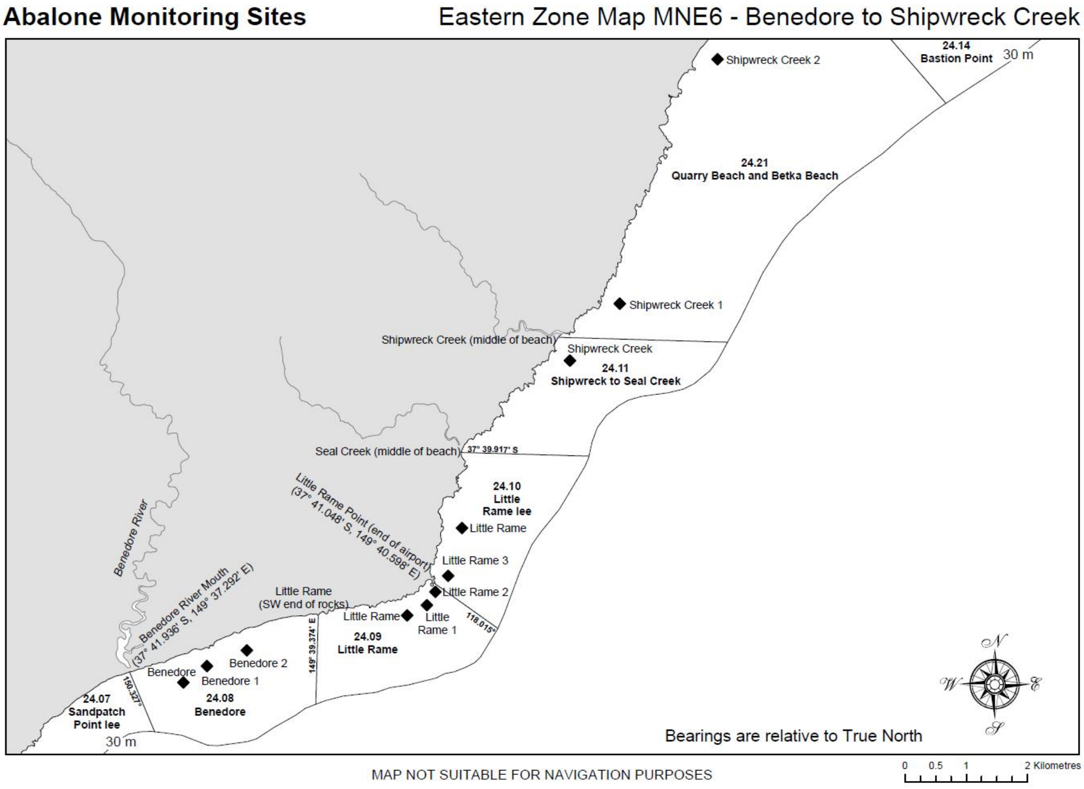


Figure A1.6: Location of FIS sites from Sandpatch Lee to Betka Beech.

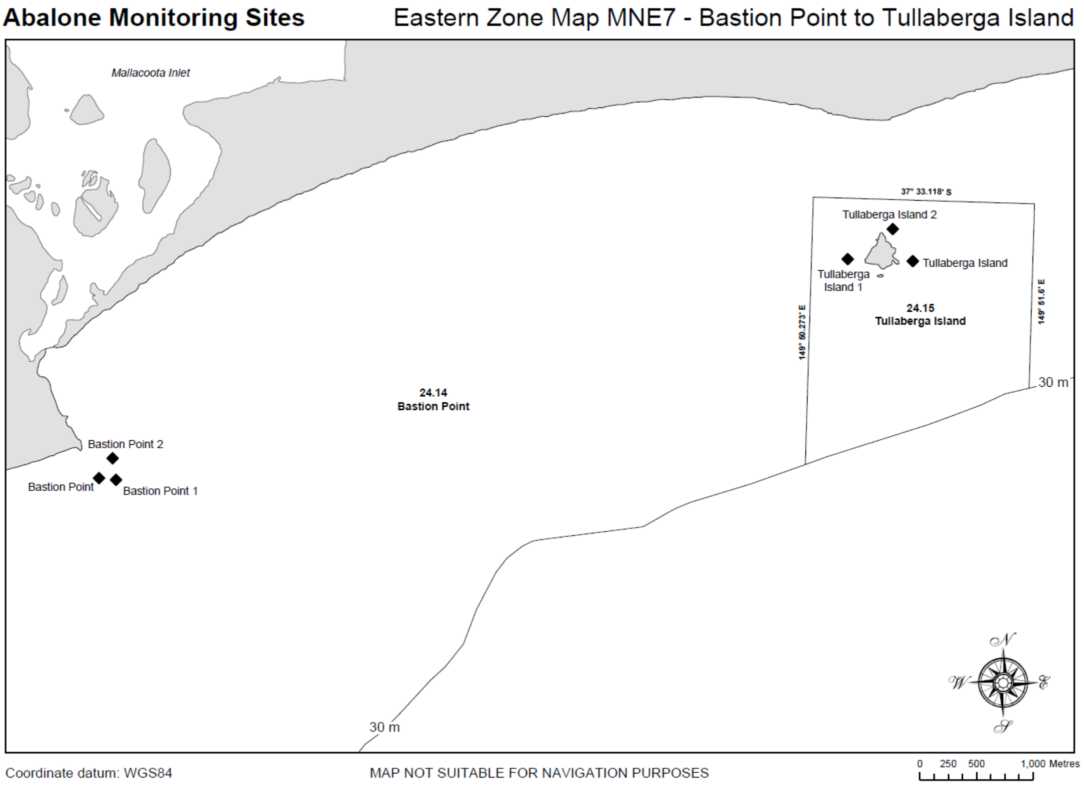


Figure A1.7: Location of FIS sites from Bastion Point to Tullaberga Island

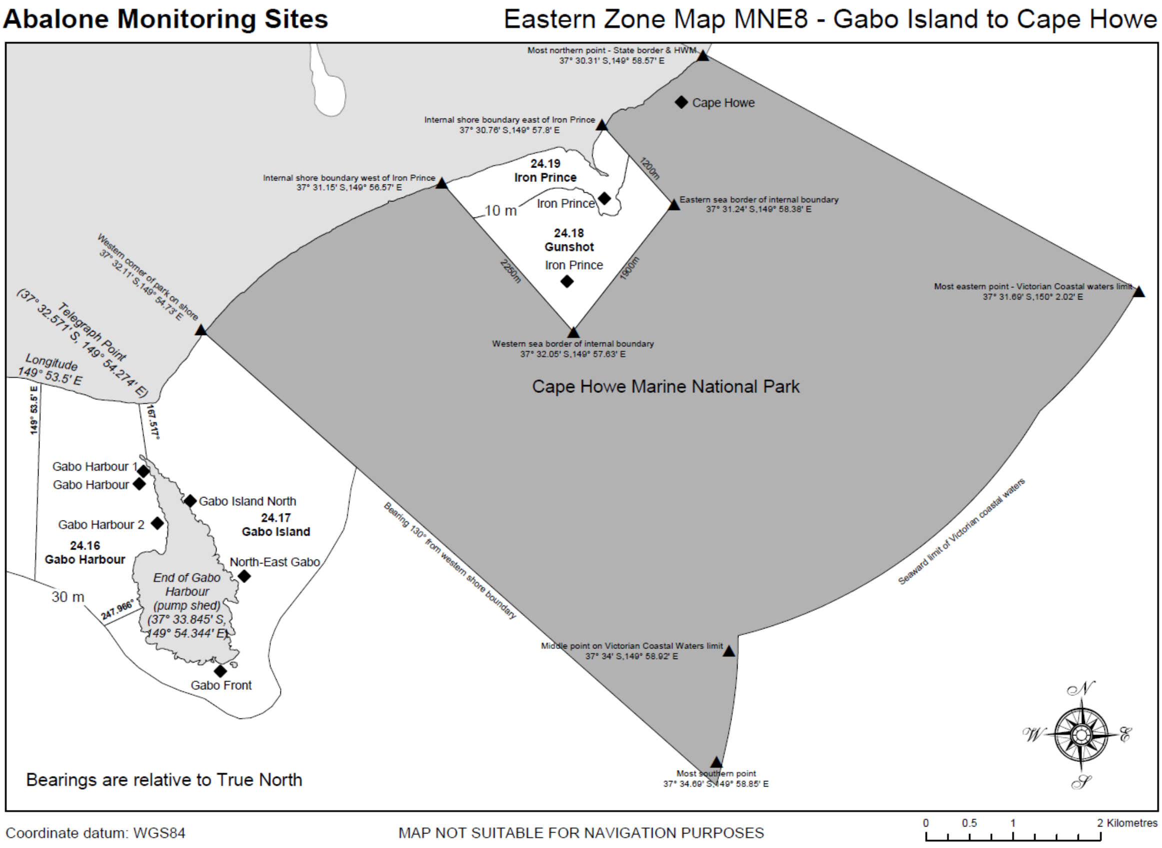


Figure A1.8: FIS sites in the from Gabo Island to the New South Wales border.

9 Appendix 2 – Urchin abundance at FIS sites in >8 m depth

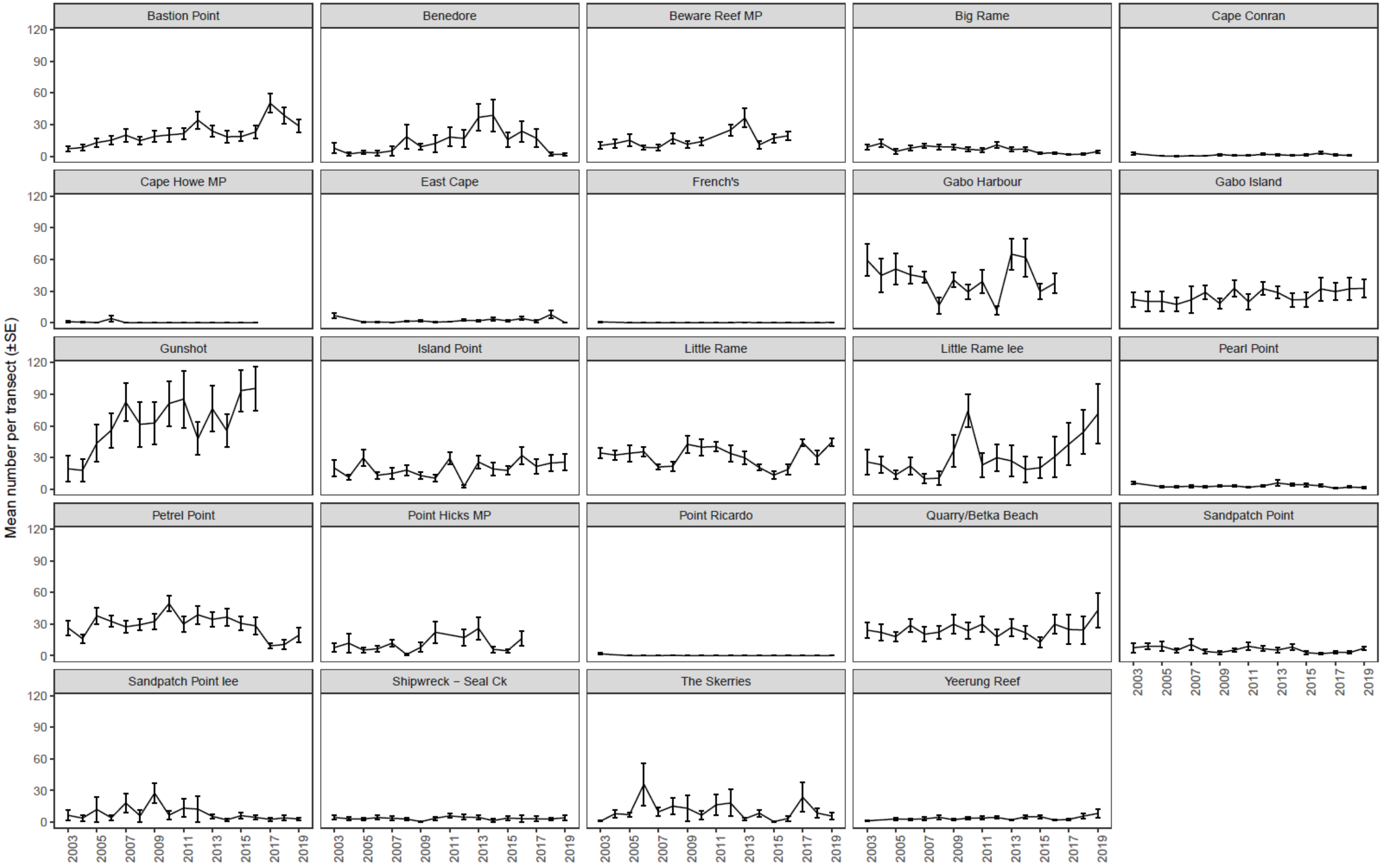


Figure A2.1: Spatial and temporal trends in urchin abundance within each abalone Reef Code limited to sites that are in >8m depth.

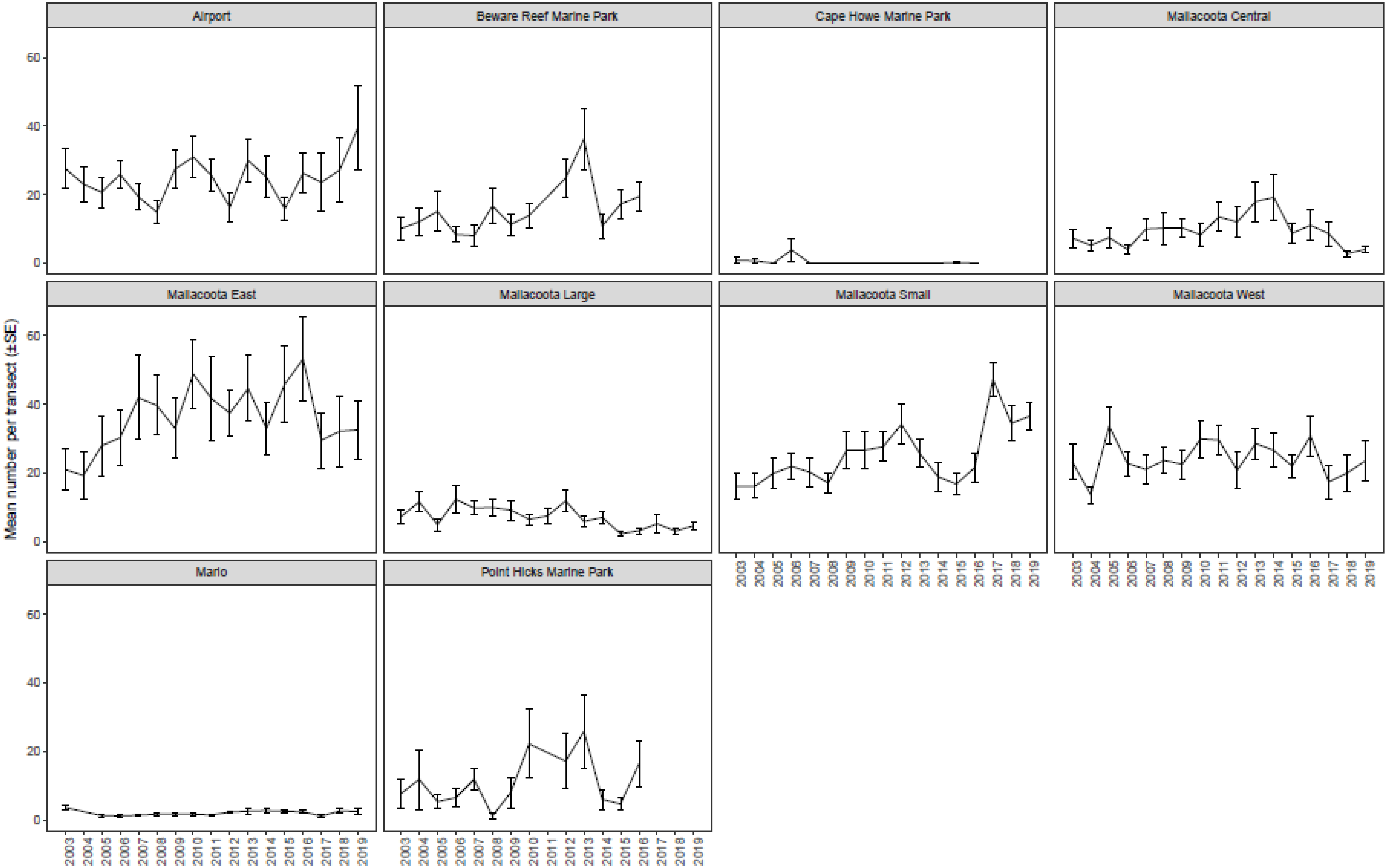


Figure A2.2: Spatial and temporal trends in urchin abundance within each abalone SMU limited to sites that are in >8m depth.

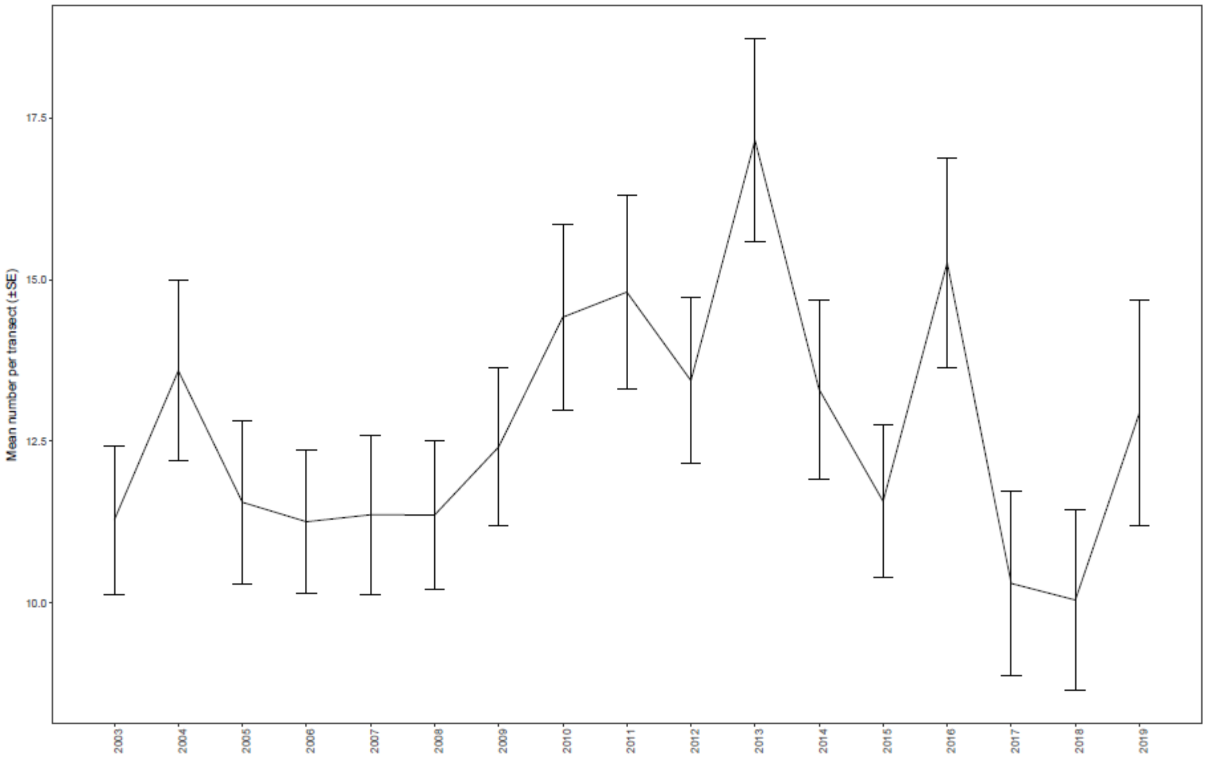


Figure A2.3: Spatial and temporal trends in urchin abundance within the eastern zone limited to sites that are in >8m depth.