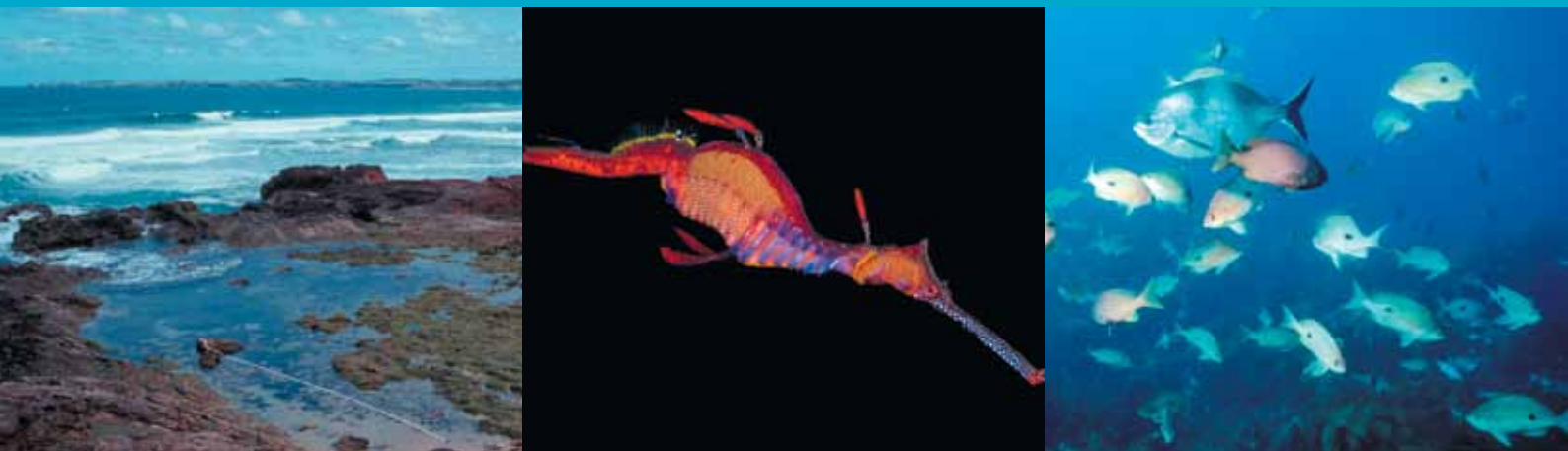




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# Intertidal Reef Monitoring Program: Central Victoria Marine Protected Areas June 2013

*H. Brown, D. Donnelly, B. Woods and M. Edmunds*  
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### **Authors:**

Hugh Brown – Marine Ecologist, Australian Marine Ecology Pty. Ltd.

David Donnelly – Marine Ecologist, Australian Marine Ecology Pty. Ltd.

Bryan Woods – Marine Ecologist, Australian Marine Ecology Pty. Ltd.

Matt Edmunds – Principal Ecologist, Australian Marine Ecology Pty. Ltd.

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**Intertidal Reef Monitoring Program:  
Central Victoria  
Marine Protected Areas, June 2013**

**Hugh Brown  
David Donnelly  
Bryan Woods  
Matt Edmunds**

**Australian Marine Ecology Pty. Ltd.**

**June 2013**



## **EXECUTIVE SUMMARY**

Intertidal reefs are present on headlands and points throughout Victoria, providing a variety of different habitats between the marine and terrestrial environments. Intertidal reefs have important social and cultural values and, because of their accessibility and proximity to land, are subject to human pressures including collection, trampling and pollution. To effectively manage and conserve these habitats, the Victorian Government has established a long-term Intertidal Reef Monitoring Program (IRMP). The IRMP provides information on the status of Victorian intertidal reef flora and fauna, as well as the nature and magnitude of trends in species populations and species diversity through time.

Within the Victorian Embayments bioregion, intertidal survey sites were established on reefs in the northern Port Phillip Bay marine sanctuaries at Point Cooke, Jawbone and Ricketts Point. Reference sites were also surveyed in association with each of these sanctuaries.

Along the Central Victorian bioregion, intertidal survey sites were established at Point Addis, Port Phillip Heads and Bunurong Marine National Parks and Point Danger, Barwon Bluff and Mushroom Reef Marine Sanctuaries. Reference sites were also surveyed in association with each of these locations.

The IRMP uses standardised visual census methods for surveying invertebrates and macroalgae on intertidal reefs. The standard operating procedures were modified in consultation with Parks Victoria after the first survey of reefs in 2003. The northern Port Phillip Bay sites and the Mushroom Reef Marine Sanctuary were resurveyed in 2004 using the revised standard operating procedures. All monitoring sites were resurveyed in the summer of 2004/2005. In addition, 4 new sites were established and surveyed inside and outside Bunurong Marine National Park (Eagles Nest) and Port Phillip Heads Marine National Park (Point Lonsdale). Another survey of the sites along the open coast (i.e. excluding those in Port Phillip Bay) was done in summer 2005/2006. All sites were surveyed in autumn 2007, autumn to early winter in 2009, autumn 2010, autumn 2011, February and early March 2012 and the most recent survey in autumn 2013

The objectives of this report are to:

1. provide an overview of the methods used for the IRMP;
2. provide general descriptions of the biological communities and species populations at each monitoring site;
3. describe changes and trends that have occurred over the monitoring period;
4. identify any unusual biological phenomena, interesting or unique communities or species; and
5. identify any introduced species at the monitoring locations.

Surveys occur at a single reef during a single low tide and target the predominant substratum type. Five fixed transects, each running from high to low shore, are positioned at equal distance across the intertidal area to be surveyed, which is 30-100 m in length. Surveys of biota occur in quadrats at sample locations along each transect and are surveyed for: (1) the density of mobile invertebrates; and (2) the percentage cover of macroalgae and aggregated sessile invertebrates.

There were considerable differences in the intertidal flora and fauna between the Port Phillip Bay and the open coast sites. The open coast sites had greater species richness and diversity, along with a much higher cover of the alga *Hormosira banksii* and higher abundances of the snail *Austrocochlea constricta*, and the limpet *Siphonaria* spp. Port Phillip Bay sites are Point Cooke MS, Jawbone MS and Ricketts MS along with their respective reference sites, while the remaining sites are open coast sites.

Key observations made at each pair of sites during the monitoring program were as follows.

### **Point Cooke MS**

- At both sites mobile species diversity during 2013 was at the highest level recorded during the monitoring program.
- At Altona, sessile species diversity dropped from a peak in 2012 back to typical levels.
- At both sites there was a trend of increasing *Ulva* green algal cover since 2010.
- The seagrass *Zostera muelleri* decreased in cover at Point Cooke in 2013 following a five year long trend of increasing cover.

- The dominant gastropod *Austrocochlea porcata* peaked in abundance at both sites from 2009 to 2011.
- There was qualitative evidence of harvesting of the limpet *Cellana tramoserica* at the Altona reference site.

### **Jawbone MS**

- In 2013, mobile species richness at Jawbone MS was the highest recorded.
- A trend of increasing sessile species diversity is evident at Jawbone MS.
- The cover of the algal seaweed *Hormosira banksii* at Williamstown has been increasing since the start of the monitoring period.
- At Jawbone MS, the density of the limpet *Cellana tramoserica* in 2013 was the lowest recorded in the monitoring period, however sizes have increased.
- There was a trend of increasing total grazer density at the Williamstown reference site.

### **Ricketts Point MS**

- The mobile invertebrate community structures of both sites have variation between surveys compared with other monitoring locations.
- The cover of the alga *Hormosira banksii* increased steadily at Ricketts Point from 2005 to 2013.
- At Ricketts Point, the density of the gastropods *Austrocochlea porcata* and *Bembicium* spp. had marked increases in 2007 and 2011 respectively.
- At Halfmoon Bay, the density of the limpet *Cellana tramoserica* was low from 2010 to 2012.

### **Port Phillip Heads MNP**

- Algal and aggregating sessile invertebrate community structure at Point Lonsdale was relatively variable over time, but with no consistent trajectory in changes.
- The cover of the alga *Hormosira banksii* has remained relatively high and stable at both sites over the monitoring period.
- Mobile species diversity had a downward trend over the monitoring period for both sites, with lowest levels recorded in 2012 and 2013.
- The mean density of the coniwink *Bembicium nanum* at both sites had a downward trend over the monitoring period.

- The Cheviot Bay reference area was disturbed by other scientific activity during the 2013 survey.

### **Mushroom Reef MS**

- Mobile species diversity declined markedly at both sites from 2009 and is presently at relatively lowest levels.
- The coverage of the alga *Hormosira banksii* has been increasing steadily at both sites since 2009.
- Densities of the gastropods *Bembicium nanum* and *Austrocochlea constricta* have declined at Mushroom Reef MS since 2007, with a corresponding increase in size.

### **Bunurong MNP**

- Algal and aggregating sessile invertebrate species richness at both sites was considerably variable over time, but with no consistent trajectory in changes.
- Mobile species diversity at both sites appeared to have an increasing trend and was at highest levels in 2013.
- Sessile species diversity at both sites appeared to be cyclical over time and was at a low in 2013.
- The cover of the alga *Hormosira banksii* was generally low with no distinct trends.
- There was a substantial upward trend in the mean size of the limpet *Cellana tramoserica* at both sites from 2006, with mean sizes increasing from approximately 20 mm to 35 mm by 2013.

### **Point Addis MNP**

- In 2013, species richness at Winkipop was the lowest recorded in the monitoring period;
- Species diversity generally changed little over the monitoring period, with the exception of a spike in sessile species diversity at Point Addis MNP in 2013..
- The cover of the alga *Hormosira banksii* was persistently high at both sites in comparison to other monitored sites in the Central Victorian Bioregion. There was a dip to record low levels at Point Addis MNP in 2013.

- Although present in low densities, the mean size of the limpet *Cellana tramoserica* has steadily increased at both sites over the monitoring period.

### Point Danger MS

- The community structure within the Point Danger MS varied considerably since 2011.
- There was little change in species richness and diversity, with the exception of a spike in mobile species diversity at the reference site in 2013.
- The abundance of the alga *Hormosira banksii* was relatively constant at both sites over the monitoring period.
- The slit limpet *Montfortula rugosa* was the most abundant gastropod but was highly variable in abundance between times.
- There was a strong peak in the abundance of the conniwick *Bembicium nanum* in 2007.
- The mean size of the limpet *Cellana tramoserica* was relatively stable over the monitoring period. The mean size of the conniwink *Bembicium nanum* was highly variable until 2010; subsequently there was an upward trend at both sites.

### Barwon Bluff MS

- Community structure at both sites was similar and showed similar variation over time.
- There were no marked changes in species richness and diversity;
- The average abundance of the alga *Hormosira banksii* increased over the monitoring period and was at highest levels at both sites in 2011 and 2012, however there were dips in abundance at both sites during the 2009 and 2013 surveys.
- In 2013, the limpet *Cellana tramoserica* increased in density markedly in both sites to the highest levels recorded during the monitoring period.

- There was a slight increasing trend in the size of the limpet *Cellana tramoserica* inside the marine sanctuary. Sizes outside the sanctuary were more variable with no clear trends.
- Turfing algae had a decreasing trend at both sites, from over 10 % cover at both sites in 2004 to virtually no cover in 2013.
- Sediment cover appears to vary cyclically, with a peak of 10-20 % cover in 2006-2007 and a low of around 5 % in 2004 and 2013.

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# 1 INTRODUCTION

## 1.1 Intertidal Reef Ecosystems

Rocky intertidal reefs are restricted to a narrow fringe between fully terrestrial environments on land and fully submerged subtidal environments further offshore. Intertidal reefs in Victoria are generally restricted to points and headlands, and are often isolated from each other by stretches of sandy intertidal habitats. Victorian intertidal reefs vary in structure from steep sloping rock faces to relatively flat or gently sloping boulder fields and rock platforms. Geomorphology and weathering create features on intertidal reefs including cobble fields, vertical steps, undulations in the reef, crevices, sand patches and rock pools. The influence of semi-diurnal tide is the most important determinant of the types of biota inhabiting rocky reefs. Intertidal reefs tend to experience rapid and extreme changes in environmental conditions including temperature, salinity and desiccation stress through exposure to air.

Common algae on intertidal reefs include the mat forming brown algae Neptune's Necklace *Hormosira banksii* and the green algae *Ulva* spp. Other small turfing species are also often present. Less conspicuous is a thin layer of microscopic algae growing directly on the surface of the reef, which is an important food source for species of grazing molluscs.

Molluscs tend to be the dominant faunal component on intertidal reefs. Herbivorous species include the limpet *Cellana tramoserica*, as well as other species such as top shells *Austrocochlea* spp. and coniwinks *Bembicium* spp. Molluscan predators include *Cominella lineolata* and *Lepsiella vinosa*. The small mussel *Limnoperna pulex* and tubeworms such as *Galeolaria caespitosa* create encrusting mats on the surface of the reef. Other invertebrates on intertidal reefs include small crustaceans such as crabs, as well as sessile animals including anemones. Fishes move in over the reef as the tide rises and can be important structuring components of intertidal reef communities.

Intertidal reefs are the most accessible component of marine environments and consequently these habitats have important social and cultural values. Due to their accessibility, intertidal reefs are sometimes subject to human pressures, including collection of animals for food and fishing bait, trampling, and pollution from catchment discharges. To effectively manage and conserve these habitats, the Victorian Government, through Parks Victoria, has established the Intertidal Reef Monitoring Program (IRMP).

## 1.2 Intertidal Reef Monitoring Program

### 1.2.1 Objectives

Assessing the condition of marine ecosystems and how this changes over time is an important aspect of management and conservation of Victorian marine natural resources and assets. Combined with an understanding of ecosystem processes, this information can be used to manage threats or pressures on the environment to ensure ecosystem sustainability.

Consequently, Parks Victoria established a long-term Intertidal Reef Monitoring Program (IRMP). The primary objective of the IRMP is to provide information on the status of Victorian reef flora and fauna. This includes monitoring the nature and magnitude of trends in species abundances, species diversity and community structure. This will be achieved through regular surveys at locations throughout Victoria, encompassing both representative and unique habitats and communities.

Information from the IRMP allows managers to better understand and interpret long-term changes in the population and community dynamics of Victoria's reef flora and fauna. As a longer time series of data is collected, the IRMP will allow managers to:

- compare changes in the status of species populations and biological communities between highly protected marine national parks and marine sanctuaries and other Victorian reefs;
- determine associations among species and between species and environmental parameters (*e.g.* exposure, reef topography) and assess how these associations vary through space and time;
- provide benchmarks for assessing the effectiveness of management actions, in accordance with international best practice for quality environmental management systems; and
- provide baseline data to detect the responses of species and communities to unforeseen and unpredictable events such as marine pest invasions, mass mortality events, oil spills, severe storm events and climate change.

Monitoring surveys give an estimate of population abundance and community structure for a small window in time. Patterns seen in data from annual surveys are unlikely to exactly match changes in the real populations over time or definitively predict the size and nature of future variation. Plots of changes over time are unlikely to match the changes in real populations because changes over shorter time periods and actual minima and maxima may not be adequately sampled (Figure 1.1).

Furthermore, because the nature and magnitude of environmental variation is different over different time scales, variation over long periods may not be adequately predicted from shorter-term data. Sources of environmental variation can operate at the scale of months (*e.g.* seasonal variation), years (*e.g.* El Niño), decades (*e.g.* extreme storm events) or even centuries (*e.g.* global warming).

However, long-term monitoring data such as those collected in the IRMP are extremely valuable for identifying natural variation and potential anthropogenic change. This monitoring program has allowed trends and patterns to be identified and the power of these data will increase as the surveys continue.

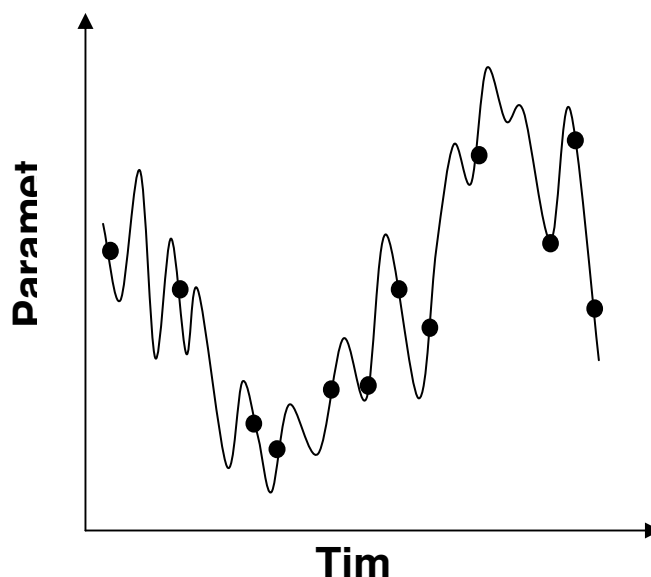


**Figure 1.1.** An example plot depicting change in an environmental, population or community variable over time (days, months or years). The black circles denote examples of monitoring times. Note how data from these times may not necessarily reflect patterns over shorter time periods, or true maxima or minima over longer time periods. Note further how data from any window of 2 or 3 consecutive monitoring times fails to adequately estimate the patterns or variation over the longer time period.

## 1.2.2 Monitoring Protocols and Locations

The IRMP was initiated in April 2003 with 14 sites established on intertidal reef habitats inside and outside the following marine protected areas:

- Point Addis Marine National Park;
- Point Danger Marine Sanctuary;
- Barwon Heads Marine Sanctuary;
- Point Cooke Marine Sanctuary;
- Jawbone Marine Sanctuary;
- Ricketts Point Marine Sanctuary; and
- Mushroom Reef Marine Sanctuary.

The intertidal reef monitoring program uses standardised visual census methods for surveying invertebrates and macroalgae on intertidal reefs. The initial round of surveys was done using a draft Standard Operating Procedure (Edmunds and Hart 2003; Edmunds *et al.* 2004). These Standard Operating Procedures (SOP) were peer reviewed after the first survey. The SOP was modified in consultation with Parks Victoria and according to recommendations made during the peer review process. Details of the updated standard operational procedures (SOP) and quality control protocols are described in Hart and Edmunds (2005).

Existing monitoring sites in Port Phillip Bay and at the Mushroom Reef Marine Sanctuary were resurveyed in 2004 using the revised standard operating procedures (Hart and Edmunds 2005). At Barwon Heads Marine Sanctuary only Barwon Bluff (Site 4004) was surveyed during Survey 2, May 2004. Weather, tide and logistical limitations prevented the survey of Barwon Beach during this period. All monitoring sites were then surveyed in the summer of 2004/2005. In addition, new sites were established and surveyed inside and outside:

- Bunurong Marine National Park; and
- Port Phillip Heads Marine National Park.

Sites along the central Victorian coast, excluding those within Port Phillip Bay, were surveyed in summer 2005/2006. All monitoring sites were surveyed again in: autumn 2007; autumn to early winter in 2009; autumn 2010; autumn 2011; autumn 2012; and autumn 2013.



**Figure 1.2.** Parks Victoria Ranger Mr Dale Appleton working with a marine biologist during intertidal reef monitoring surveys.

## 1.3 Monitoring Central Victorian Marine Protected Areas

This report describes the intertidal reef monitoring program and general results for all surveys to 2013. The surveys were in the following marine protected areas (and associated reference sites) in central Victoria:

- Point Cooke Marine Sanctuary;
- Jawbone Marine Sanctuary;
- Ricketts Point Marine Sanctuary;
- Port Phillip Heads Marine National Park;
- Mushroom Reef Marine Sanctuary;
- Bunurong Marine National Park;
- Point Addis Marine National Park;
- Point Danger Marine Sanctuary; and
- Barwon Heads Marine Sanctuary.

The objectives of this report were to:

- provide an overview of the methods used for the IRMP;
- provide general descriptions of the biological communities and species populations at each monitoring site;
- describe changes and trends that have occurred over the monitoring period;
- identify any unusual biological phenomena, interesting or unique communities or species; and
- identify any introduced species detected during monitoring.

## 2 METHODS

### 2.1 Site Selection and Survey Times

Intertidal survey sites were established on reefs in nine marine protected areas in the Central Victorian and Victorian Embayments Bioregions. These were:

- Northern Port Phillip Bay (Figure 2.1):
  - Point Cooke MS
  - Jawbone MS; and
  - Ricketts Point MS;
- Central coast of central Victoria (Figure 2.2):
  - Port Phillip Heads MNP; and
  - Mushroom Reef MS;
- Eastern coast of central Victoria (Figure 2.3):
  - Bunurong MNP; and
- Western coast of central Victoria (Figure 2.4):
  - Point Addis MNP;
  - Point Danger MS; and
  - Barwon Heads MS.

Two sites were surveyed in each area, one inside and one outside the MPA. Survey dates are shown in (**Table 2.2**). A description of each intertidal reef and sampling considerations at each site is given separately for each marine sanctuary in Appendix A – Site Details

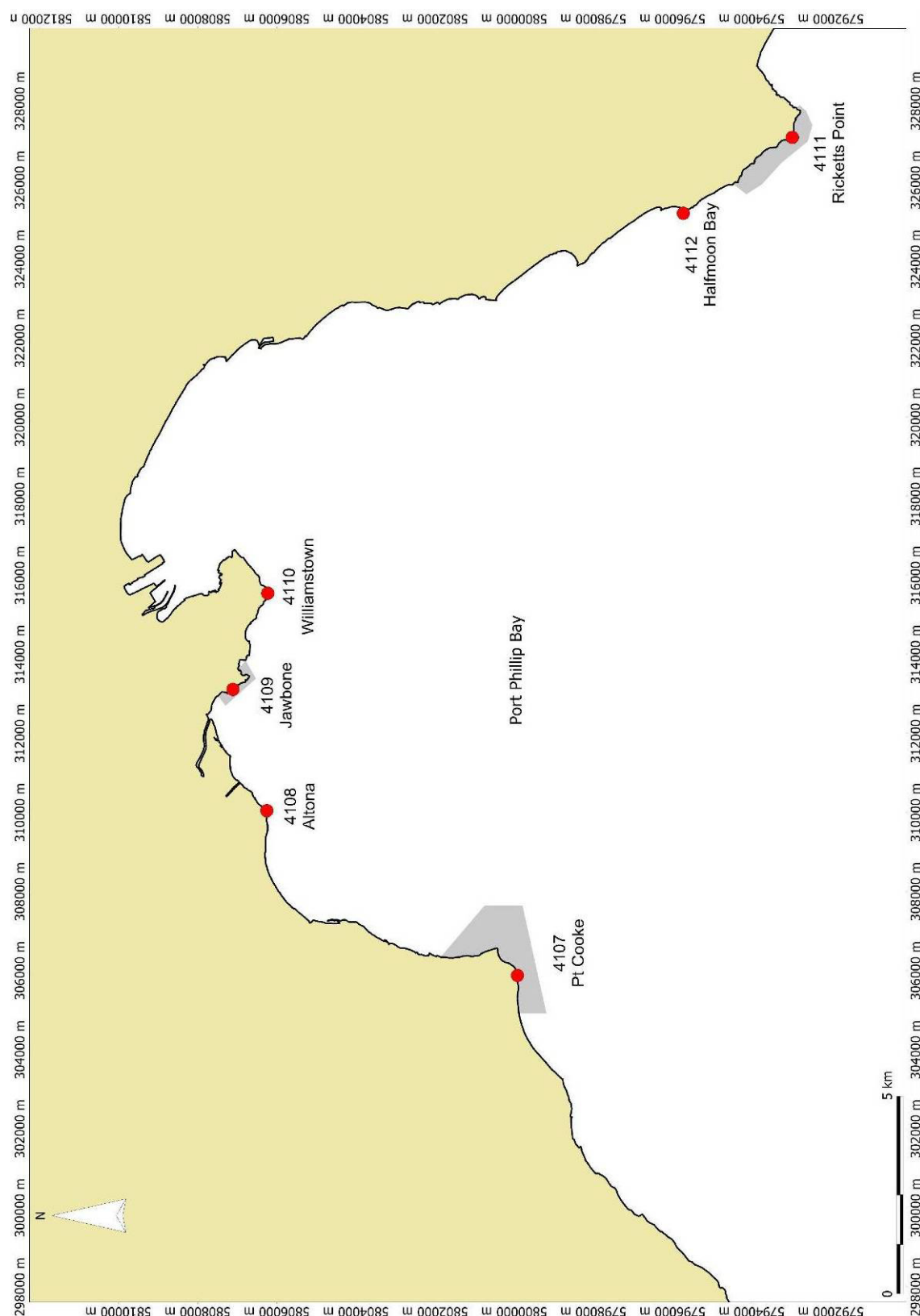


**Figure 2.1.** Location of intertidal monitoring sites in northern Port Phillip Bay. Marine Sanctuary areas are indicated by grey shading.

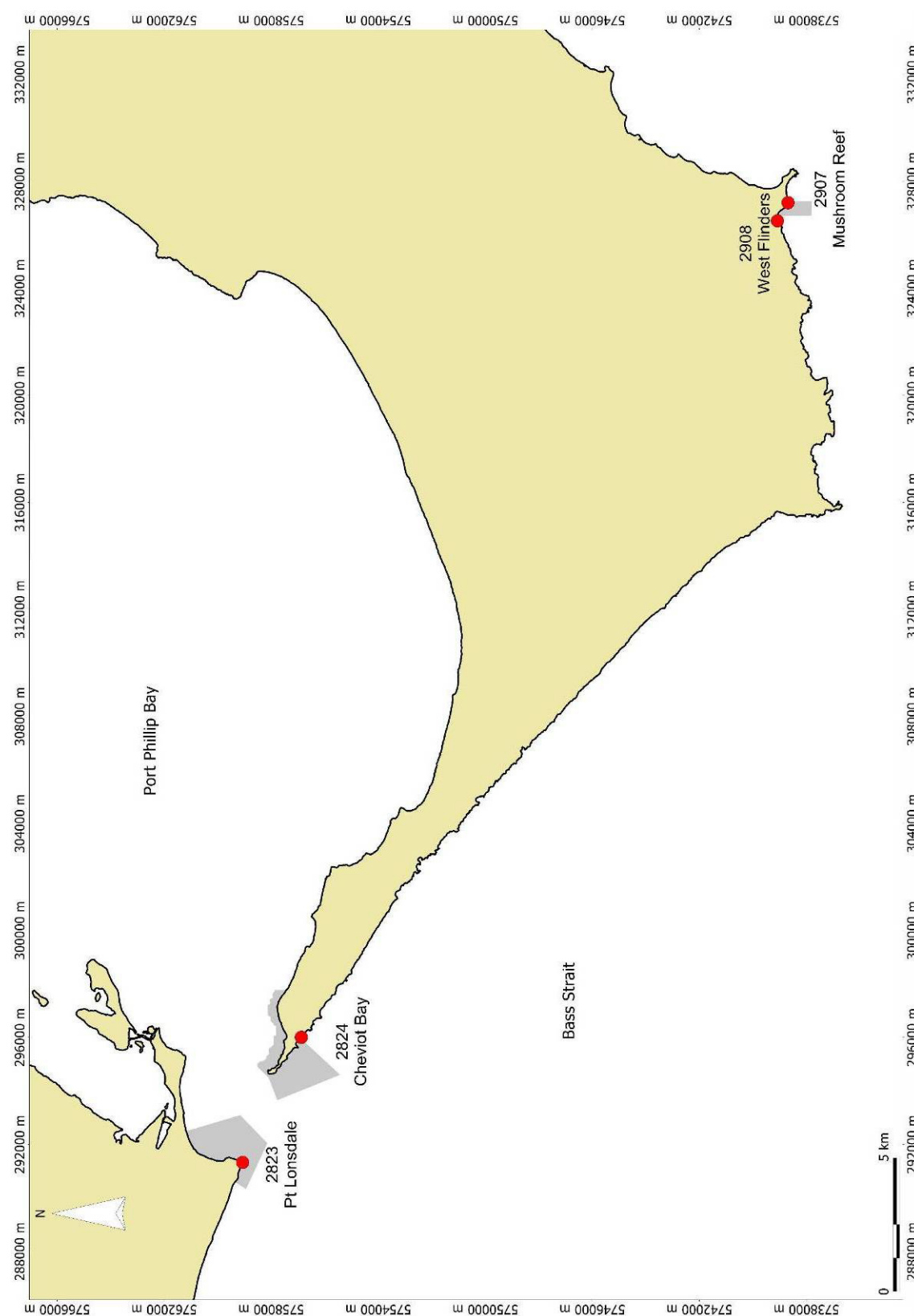


**Figure 2.2.** Location of intertidal monitoring sites along the coastline of central Victoria. Marine protected areas are indicated by grey shading.

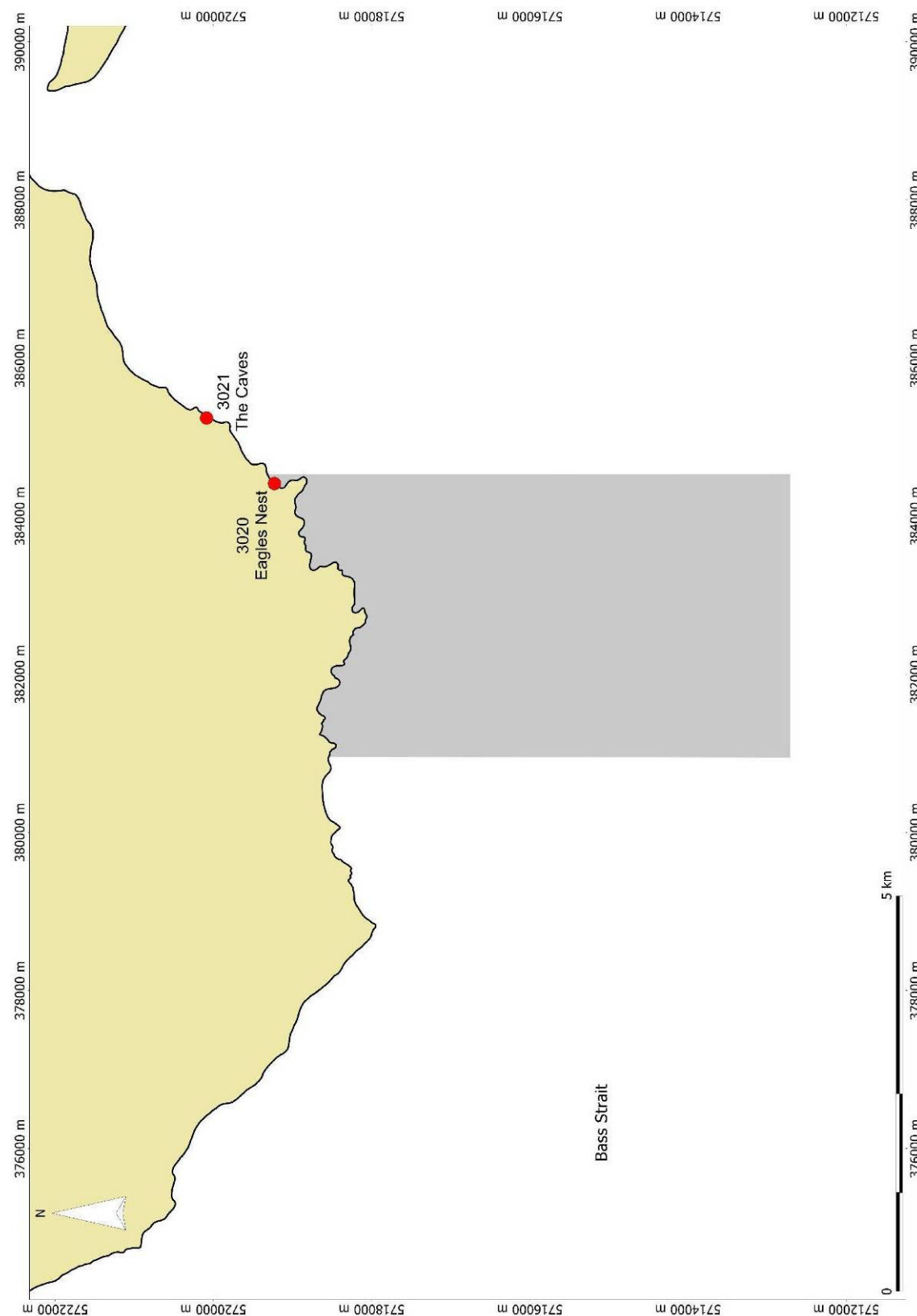


**Figure 2.3.** Location of intertidal monitoring sites at Bunurong Marine National Park. Marine National Park areas are indicated by grey shading.

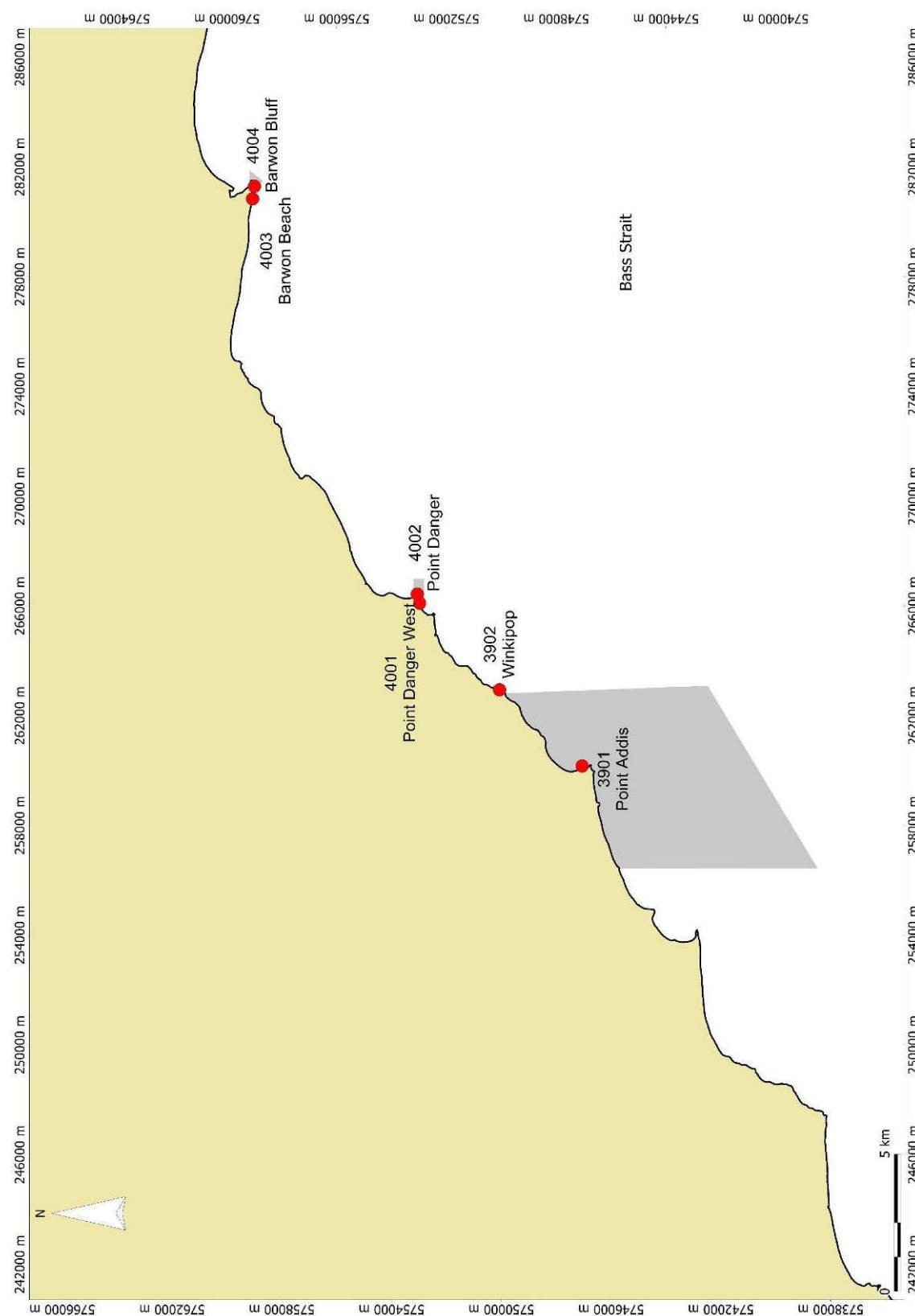


**Figure 2.4.** Location of intertidal monitoring sites along the western coastline of central Victoria. Marine protected areas' boundaries are indicated by grey shading.

**Table 2.1.** Intertidal reef monitoring sites. Coordinates in Map Grid of Australia (Zone 55).

| Site Number                   | Site Name      | Status               | Easting (MGA) | Northing (MGA) |
|-------------------------------|----------------|----------------------|---------------|----------------|
| <b>Point Cooke MS</b>         |                |                      |               |                |
| 4107                          | Point Cooke    | Marine Sanctuary     | 305876        | 5799893        |
| 4108                          | Altona         | Reference            | 310020        | 5806233        |
| <b>Jawbone MS</b>             |                |                      |               |                |
| 4109                          | Jawbone        | Marine Sanctuary     | 313062        | 5807137        |
| 4110                          | Williamstown   | Reference            | 315545        | 5806228        |
| <b>Ricketts Point MS</b>      |                |                      |               |                |
| 4111                          | Ricketts Point | Marine Sanctuary     | 327001        | 5792953        |
| 4112                          | Halfmoon Bay   | Reference            | 325118        | 5795723        |
| <b>Port Phillip Heads MNP</b> |                |                      |               |                |
| 2823                          | Point Lonsdale | Marine National Park | 291321        | 5759033        |
| 2824                          | Cheviot Bay    | Reference            | 295939        | 5756879        |
| <b>Mushroom Reef MS</b>       |                |                      |               |                |
| 2907                          | Mushroom Reef  | Marine Sanctuary     | 327050        | 5738412        |
| 2908                          | West Flinders  | Reference            | 326497        | 5739009        |
| <b>Bunurong MNP</b>           |                |                      |               |                |
| 3020                          | Eagles Nest    | Marine National Park | 384362        | 5719082        |
| 3021                          | The Caves      | Reference            | 385203        | 5719868        |
| <b>Point Addis MNP</b>        |                |                      |               |                |
| 3901                          | Point Addis    | Marine National Park | 260162        | 5746979        |
| 3902                          | Winkipop       | Reference            | 262913        | 5750014        |
| <b>Point Jawbone MS</b>       |                |                      |               |                |
| 4002                          | Point Danger   | Marine Sanctuary     | 266413        | 5753027        |
| 4001                          | Point Danger   | Reference            | 266093        | 5752959        |
| <b>Barwon Bluff MS</b>        |                |                      |               |                |
| 4004                          | Barwon Bluff   | Marine Sanctuary     | 281293        | 5758960        |
| 4003                          | Barwon Beach   | Reference            | 280828        | 5759028        |

**Table 2.2.** Survey periods of intertidal monitoring sites.

| <b>Survey</b> | <b>Period</b>                | <b>Sites</b>                                                                                                |
|---------------|------------------------------|-------------------------------------------------------------------------------------------------------------|
| 1             | April - July 2003            | 4107; 4108; 4109; 4110; 4111; 4112; 2907; 2908; 4001; 4002; 4003; 4004.                                     |
| 2             | May - June 2004              | 4107; 4108; 4109; 4110; 4111; 4112; 2907; 2908; 4004.                                                       |
| 3             | December 2004 - April 2005   | 4107; 4108; 4109; 4110; 4111; 4112; 2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004. |
| 4             | September 2005- January 2006 | 2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004.                                     |
| 5             | May - June 2007              | 4107; 4108; 4109; 4110; 4111; 4112; 2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004. |
| 6             | April - June 2009            | 4107; 4108; 4109; 4110; 4111; 4112; 2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004. |
| 7             | March - May 2010             | 4107; 4108; 4109; 4110; 4111; 4112; 2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004. |
| 8             | March - May 2011             | 4107; 4108; 4109; 4110; 4111; 4112; 2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004. |
| 9             | February – March 2012        | 4107; 4108; 4109; 4110; 4111; 4112; 2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004. |
| 10            | April - May 2013             | 2823, 2824, 2907, 2908, 3020, 3021, 3901, 3902, 4001, 4002, 4003, 4004, 4107, 4108, 4109, 4110, 4111, 4112. |

## 2.2 General Survey Technique

Each site was surveyed during a single low tide. Surveys targeted the predominant substratum type at each intertidal reef (*e.g.* basalt boulder field, flat sandstone reef, basalt reef). The maximum along-shore distance that was practical to sample in a single tide using this method was 100 m.

Within the area to be surveyed, the high and low shore boundaries were identified. On vertically sloping shores, the high shore boundary generally approximated the mean high water level. On relatively flat shores with little variation in vertical height across the shore, the high shore was at the landward edge and the low shore was at the seaward edge of the flat area. A weighted tape measure or numbered transect line was placed along the high shore, beginning at the right hand side of the shore when looking towards the sea. This was the high-shore baseline (A-B, Figure 2.5.). Similarly, a low shore baseline was established by placing a transect line along the low shore. The positions of each end of both baselines were recorded using GPS and photographed (Figure 2.5.). Five fixed transects, each running from high to low shore, were positioned across the intertidal area to be surveyed (Figure 2.5.). Transect 1 was to the right-hand side (looking seaward) and Transect 5 to the left-hand side of the reef (looking seaward). Each transect ran between points on the high and low shore baselines. Adjacent transects were roughly equidistant from each other.

The biota were surveyed using 0.5 x 0.5 m quadrats, randomly placed within 2 x 2 m areas at five fixed sampling along each transect (Figure 2.6). The fixed sampling points were equidistant along each transect (Figure 2.6).

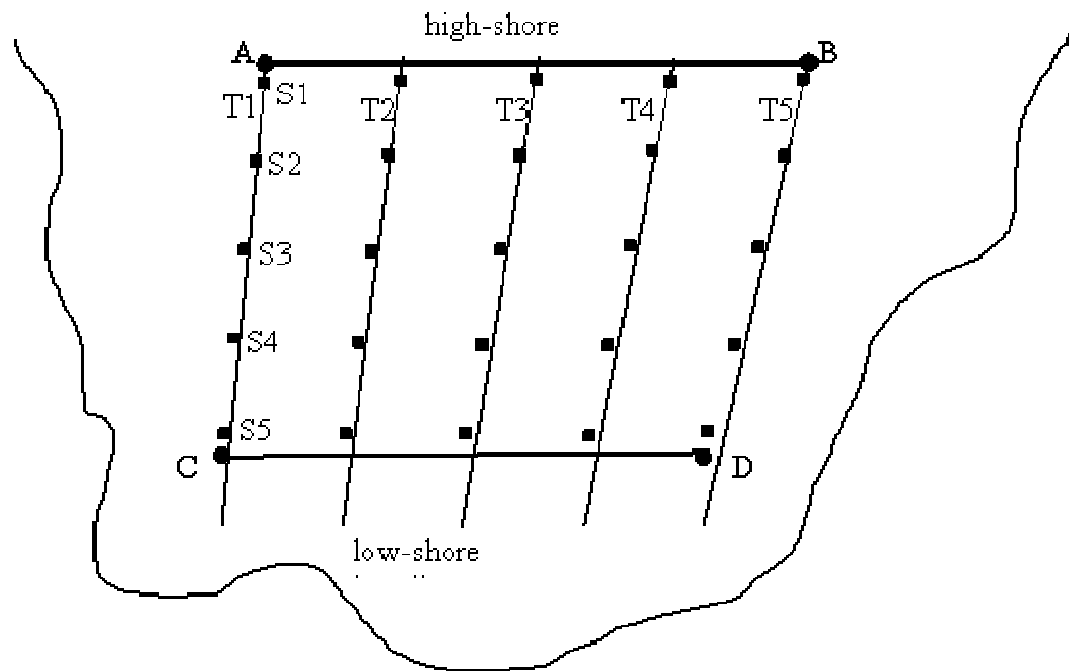


**Figure 2.5.** Example layout of high and low shore baselines and transects on an intertidal reef. Transects (T1-T5) ran across the shore from right to left when looking toward the water. Endpoints of each transect were equidistant along each of the baselines. Sampling locations (S1-S5) are arranged down shore along each transect and encompassed differences in substratum height down the shore.

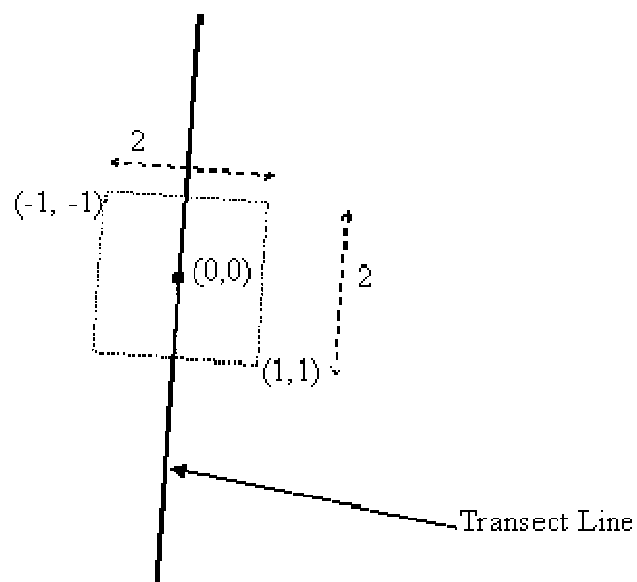


**Figure 2.6.** Configuration of a sampling location along a transect. Each 2 x 2 m sampling location was centred on a point along the transect line. A quadrat was placed randomly within the sampling location using random x- and y-coordinates between -1 and 1 m from the origin.

## 2.3 Visual Census Techniques

### 2.3.1 Method A – Mobile Invertebrates

The density of mobile invertebrates, such as gastropods and sea stars, was measured by counting individuals within the 0.5 x 0.5 m quadrats (Method A: Figure 2.7; Table 2.3). All visible individuals on the rock surface or within crevices and algal fronds were counted. To ensure the monitoring had minimal impact over time, rocks were not overturned or disturbed. Selected specimens were collected for identification and preservation in a reference collection.

The *Bembicium* populations comprise three separate species: *Bembicium nanum*; *B. melanostomum*; and *B. auratum*. Small individuals and those with heavy shell erosion can be difficult to identify in the field (Anderson 1958). Such individuals were grouped at genus level, *Bembicium* spp. Similarly, *Siphonaria* species were often too small to identify reliably in the field and were documented as *Siphonaria* spp. Organisms were identified to species level where possible.

The shell length of 50-100 individuals of abundant species of gastropod was measured at each site. This was done to identify changes in the size structure of commonly collected species over time, which may indicate changes in population dynamics and/or impacts on populations because of illegal shellfish collection. The species selected for measurement were those that are commonly collected on intertidal shores for bait or food, such as *Cellana tramoserica* and *Austrocochlea* spp. as well as non-collected but abundant species, including *Siphonaria* spp, *Cominella lineolata* and *Bembicium* spp. Individuals were selected haphazardly by measuring the first five individuals of each species encountered within each quadrat location. If necessary, at the end of the quadrat sampling, additional size measurements were taken from all individuals within aggregations nearest to the observer.

### 2.3.2 Method B – Macroalgae and Sessile Invertebrates

The abundance of algae and highly aggregated sessile invertebrates, such as tubeworms and mussels, was measured as proportional cover of the substratum (Method B). This was done using a points-intersection method. The 0.5 x 0.5 m quadrat was divided into a grid of 7 x 7 perpendicular wires, giving 50 regularly spaced points (including one corner). Cover was estimated by the number of points directly above each species (Figure 2.7). Selected specimens were collected for identification and preservation in a reference collection.

Some species are known to respond to changes in nutrient and freshwater inputs on Victorian intertidal reefs (e.g. Fox *et al.* 2000). Fluctuations in the population status of these species may indicate changes in nutrient loadings affecting MPAs or other intertidal areas. Species that may respond include the algae *Ulva* spp, *Cladophora subsimplex*, *Capreolia implexia*, *Ceramium flaccidum*, *Corallina officinalis*, *Hormosira banksii* and the tubeworm *Boccardia proboscidea*. The presence/absence of these species within each quadrat was recorded (if present and not detected under any points). Species recorded as present, but not recorded under any points, were only included in the analysis of species richness.

### 2.3.3 Photo Quadrats

During initial surveys, a photograph was taken of the substratum and biota at each quadrat position. This was done to provide a permanent qualitative record of the biota and microhabitat conditions. The photograph was taken such that the minimum dimension is 50 cm (*i.e.* at the scale of a quadrat). This method was not employed during recent surveys.

### 2.3.4 Qualitative Observations

At each site, observers recorded general observations of topography, reef structure (rugosity, relief, boulder sizes, etc.), biogenic habitat structure (*Hormosira*, algal turfs) and a general description of the flora and fauna. Video and photographic records were also taken at each site.

For each quadrat, the substratum microhabitats present were recorded. These were classified as:

- horizontal surface, flat, rock top;
- rock pool;
- rocky rubble or cobble;
- sand; and
- vertical surface, rock side, crevice.

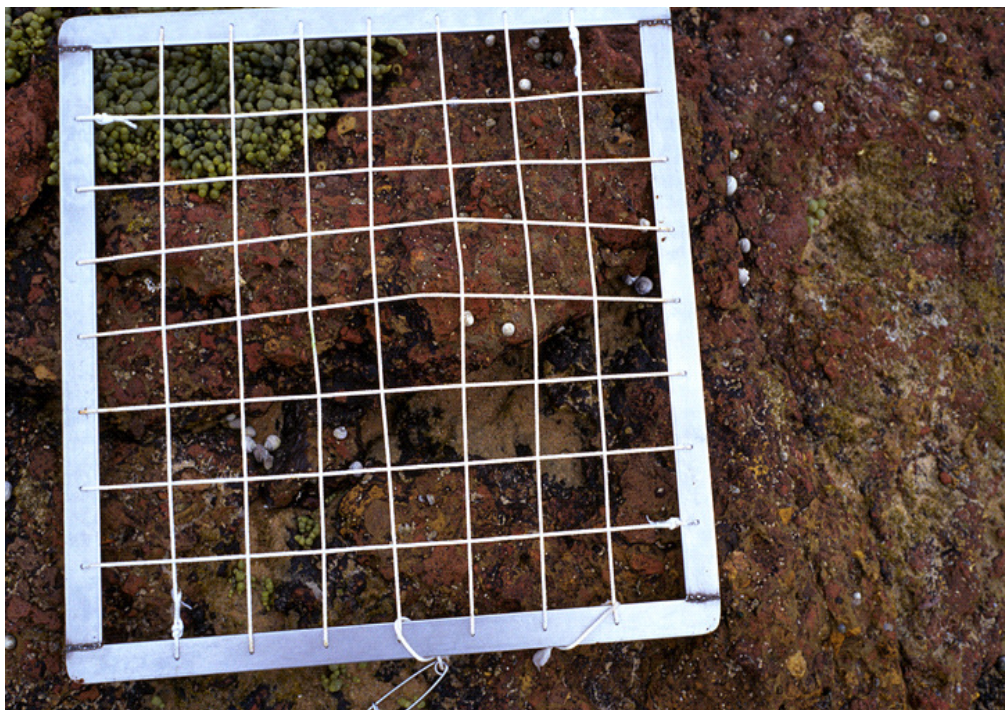


**Figure 2.7.** Quadrat with the alga *Hormosira banksii* and snail *Bembicium nanum*. The abundance of each gastropod was counted within the quadrat. The cover of macrophytes and highly aggregated animals were measured by the number of points intersecting each species on the quadrat grid.



**Figure 2.8.** Marine biologist counting invertebrates within quadrats during intertidal reef monitoring surveys at Point Lonsdale (Site 4112), May 2009.

**Table 2.3.** Intertidal species in south eastern Australia recorded by Methods A and B

| Algae                             | Sessile Invertebrates             | Mobile Invertebrates               |
|-----------------------------------|-----------------------------------|------------------------------------|
| Algal turf                        | Tube Worms                        | Limpets                            |
| Blue-Green Algae                  | <i>Galeolaria caespitosa</i>      | <i>Montfortula rugosa</i>          |
| <i>Rivularia</i> sp.              |                                   | <i>Patella chapmani</i>            |
| <i>Symploca</i> sp.               | Barnacles                         | <i>Cellana tramoserica</i>         |
| Green algae                       | <i>Catomerus polymerus</i>        | <i>Patelloida alticostata</i>      |
| <i>Cladophora prolifera</i>       | <i>Chthamalus antennatus</i>      | <i>Patelloida insignis</i>         |
| <i>Cladophora subsimplex</i>      | <i>Chaemosipho tasmanica</i>      | <i>Patelloida latistrigata</i>     |
| <i>Codium</i> spp.                | <i>Tesseropora rosea</i>          | <i>Notoacmea mayi</i>              |
| <i>Dictyosphaeria serica</i>      | <i>Tetraclitella purpurascens</i> | <i>Notoacmea petterdi</i>          |
| <i>Ulva</i> spp.                  |                                   | <i>Notoacmea</i> spp.              |
| <i>Caulerpa</i> spp.              | Bivalves                          | <i>Siphonaria</i> spp.             |
| <i>Chaetomorpha coliformis</i>    | <i>Limnoperna pulex</i>           |                                    |
| Brown algae                       | <i>Brachidontes rostratus</i>     | Gastropods                         |
| <i>Chordaria cladosiphon</i>      | <i>Mytilus galloprovincialis</i>  | <i>Austrocochlea constricta</i>    |
| <i>Colpomenia sinuosa</i>         |                                   | <i>Austrocochlea porcata</i>       |
| <i>Hormosira banksii</i>          | Anemones                          | <i>Austrocochlea odontis</i>       |
| <i>Leathesia difformis</i>        | <i>Actinia tenebrosa</i>          | <i>Austrocochlea concamerata</i>   |
| <i>Notheia anomala</i>            | <i>Aulactinia veratra</i>         | <i>Turbo undulatus</i>             |
| <i>Scytosiphon lomentaria</i>     | <i>Anthothoe albocincta</i>       | <i>Nerita atramentosa</i>          |
| <i>Lobophora variegata</i>        | <i>Oulactis muscosa</i>           | <i>Bembicium nanum</i>             |
| <i>Cladostephus spongiosus</i>    |                                   | <i>Bembicium</i> spp.              |
| <i>Notheia anomala</i>            |                                   | <i>Bembicium melanostomum</i>      |
| <i>Sargassum</i> spp.             |                                   | <i>Austrolittorina unifasciata</i> |
| <i>Cystophora</i> spp.            |                                   | <i>Nodilittorina acutispira</i>    |
| <i>Zonaria turneriana</i>         |                                   | <i>Dicathais orbita</i>            |
| <i>Halopteris</i> spp.            |                                   | <i>Lepsiella vinosa</i>            |
| <i>Ectocarpus</i> spp.            |                                   | <i>Cominella lineolata</i>         |
| <i>Acrocarpia paniculata</i>      |                                   | <i>Calliostoma armillata</i>       |
| <i>Lobophora variegata</i>        |                                   | <i>Mitra glabra</i>                |
| <i>Padina</i> sp.                 |                                   | <i>Haustrum baileyana</i>          |
| <i>Caulocystis cephalornithos</i> |                                   | <i>Phasianotrochus eximius</i>     |
|                                   |                                   | <i>Pterynotus triformis</i>        |

| Algae                           | Sessile Invertebrates | Mobile Invertebrates           |
|---------------------------------|-----------------------|--------------------------------|
| Red Algae                       |                       | <i>Cypraea angustata</i>       |
| <i>Corallina officinalis</i>    |                       | <i>Batillaria australis</i>    |
| <i>Gracilaria</i> spp.          |                       |                                |
| <i>Laurencia</i> spp.           |                       | Sea stars                      |
| Encrusting coralline algae      |                       | <i>Parvulastra exigua</i>      |
| Erect coralline algae           |                       | <i>Meridiastra calcar</i>      |
| <i>Jania</i> spp.               |                       | <i>Tosia australis</i>         |
| <i>Jania roseum</i>             |                       | <i>Coscinasterias muricata</i> |
| <i>Echinothamnion</i> sp.       |                       |                                |
| <i>Heterosiphonia muelleri</i>  |                       | Sea Slugs                      |
| Seagrass                        |                       | <i>Onchidella nigricans</i>    |
| <i>Zostera muellei</i>          |                       |                                |
| <i>Amphibolis antarctica</i>    |                       | Sea Hares                      |
| Saltbush                        |                       | <i>Aplysia gigantea</i>        |
| <i>Sarcocornia quinqueflora</i> |                       |                                |
|                                 |                       | Crabs                          |
|                                 |                       | <i>Cyclograpsus granulatus</i> |
|                                 |                       | <i>Paragrapsus gaimardii</i>   |
|                                 |                       | <i>Guinusia chabrus</i>        |
|                                 |                       |                                |
|                                 |                       | Nudibranchs                    |
|                                 |                       | <i>Pteraeolidia ianthina</i>   |

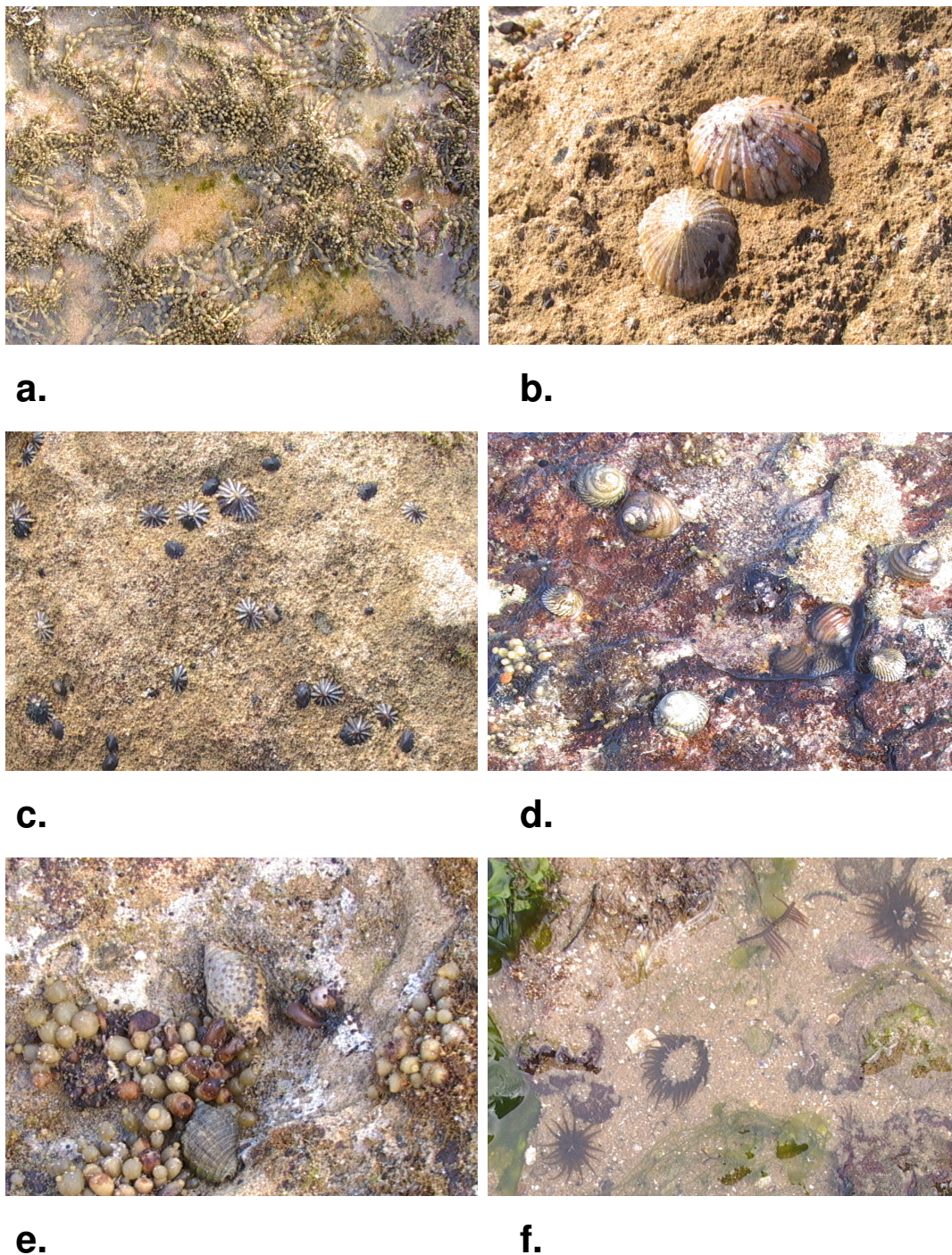


**Figure 2.9.** Examples of typical flora and fauna on intertidal reefs: (a) the brown alga *Hormosira banksii*; (b) the common limpet *Cellana tramoserica*; (c) the limpets *Siphonaria* spp. (centre) and *Notoacmea mayi*; (d) the gastropods *Bembicium nanum* (bottom) and *Austrocochlea constricta*; (e) the gastropods *Cominella lineolata* (top) and *Dicathais orbita*; and (f) the anemone *Aulactinia veratra* and the green alga *Ulva* spp. in standing water.

## **2.4 Data Analysis**

### **2.4.1 Community Structure**

Community structure is a multivariate function of both the type of species present and the abundance of each species. The community structure between pairs of samples was compared using the Bray-Curtis dissimilarity coefficient. This index compares the abundance of each species between two samples to give a single value of the difference between the samples, expressed as a percentage (Faith et al. 1987; Clarke 1993).

Following Sweatman (2008), the count data were log transformed and percent cover values were transformed using the empirical logit transformation (McCullagh and Nelder 1989).

The multivariate information in the dissimilarity matrix was simplified and depicted using non-metric multidimensional scaling (MDS; Clarke 1993). This ordination method finds the low dimensional representation that best depicts the actual high dimension patterns. The MDS results were depicted graphically to show differences between the replicates at each location. The distance between points on the MDS plot is representative of the relative difference in community structure. Data for all intertidal sites and times were included to put relative changes within sites into perspective of all observed changes.

Kruskal stress is an indicator statistic, calculated during the ordination process, which indicates the degree of disparity between the reduced dimensional data set and the original hyper-dimensional data set. A guide to interpreting the Kruskal stress indicator is given by Clarke (1993): ( $< 0.1$ ) a good ordination with no real risk of drawing false inferences; ( $< 0.2$ ) can lead to a usable picture, although for values at the upper end of this range there is potential to mislead; and ( $> 0.2$ ) likely to yield plots which can be misleading to interpret.

### **2.4.2 Species Diversity**

Species diversity involves the consideration of two components: species richness and evenness. Species richness is the number of species present in the community while evenness is the degree of similarity of abundances between species. If all species in a community have similar abundances, then the community has a high degree of evenness. If most of the individuals in a community belong to one species, it has low evenness. Species diversity is a combination of species richness and the

relative abundance of each species, and is often referred to as species heterogeneity. Measures of diversity give an indication of the likelihood that two individuals selected at random from a community are different species.

Species richness (S) was enumerated by the total species count per site, including both the abundance data and the presence data. Species richness from the abundance data alone was used for calculation of evenness and heterogeneity statistics. Species diversity (*i.e.* heterogeneity among species) was described using the reciprocal of Simpson's index ( $1/D_{\text{Simpson}} = \text{Hill's } N_2$ ). This index provides greater weighting for common species, as opposed to the Shannon-Weiner Index (Krebs 1999), which gives greater weighting to rare species. The weighting of common species was considered appropriate for this study, with the sampling being directed towards the enumeration of common species rather than rare ones.

### 2.4.3 Species Populations

The abundances of each species were summarised by calculating the mean density per quadrat ( $0.25 \text{ m}^2$ ) for each site and survey. The abundance of common species, such as *Austrocochlea* spp. and *Cellana tramoserica*, were examined using time series plots. Abundance was not compared for the initial survey because different survey methods were used. The sizes of common species were assessed using time series plots of mean lengths.

## 2.5 Condition Indicators

The monitoring data were used in various ways to provide indicators of reef quality. The development of condition indicators followed the approaches of Stuart-Smith *et al.* (2008) and Porter and Wescott (2010). The indicators are grouped into the categories: biodiversity; introduced species; ecosystem function; climate change; fishing and harvesting; trampling; and environment.

### 2.5.1 Biodiversity

Biodiversity was indicated by community structure; species richness and species diversity, as described in the previous sections.

### 2.5.2 Introduced Species

Indicators of introduced species were:

- the percentage of species that are introduced;

- the percentage of the total abundance of introduced species; and
- the presence of selected invasive pest species.

No introduced species have been observed during the IRMP surveys.

### **2.5.3 Ecosystem Function and Processes**

Biogenic habitat and standing stocks of primary producers was indicated by the average percent cover of the seaweeds:

- *Hormosira banksii*;
- erect coralline algae; and
- algal turfs.

Ecosystem function was also indicated by abundances of other trophic groups:

- the total abundance of grazers; and
- the total abundance of predators.

Other indicators of ecosystem function, including habitat height zonation indices, are being developed.

### **2.5.4 Climate Change**

In Victoria, it is predicted that climate change will cause an influx of species associated with strengthening of warmer current flows, such as the East Australia Current and the Leeuwin Current (which becomes the South Australia Current). Indicators of the effects of climate change examined include:

- the percentage of species at the site that were typically from adjacent bioregions; and
- the percentage of total abundance of species that were typically from adjacent bioregions.

No species typical of adjacent bioregions were detected during this survey.

Climate change is also likely to influence the height zonation of habitats. Indices for this component are being developed.

### **2.5.5 Fishing and Harvesting**

On intertidal rocky shores, gastropods are harvested for food, bait and other uses. Harvesting may reduce abundances and may also change the size distribution of a population through the selective collection of larger individuals.

Indicators of harvesting were the abundances and sizes (mean and proportion of large individuals) of gastropod species targeted by collectors (Porter and Wescott, 2010):

- variegated limpet *Cellana tramoserica*;
- ribbed top snail *Austrocochlea constricta*;
- zebra top snail *Austrocochlea porcata*;
- warrener *Turbo undulatus*; and
- cart-rut whelk *Dicathais orbita*.

### **2.5.6 Environment**

Indicators of environment quality were:

- ratio of algae cover to grazer abundance;
- the total abundance of species indicative of nutrient loading (*e.g.* *Ulva* and *Cladophora* species);
- percentage cover of sediment; and
- the height zonation of habitats (this indicator is being developed).

## **3 POINT COOKE MARINE SANCTUARY**

### **3.1 Site Description and Transect Layout**

#### **3.1.1 Point Cooke Marine Sanctuary (Site 4107)**

The intertidal area at Point Cooke is an extensive basalt rock platform and basalt boulder and cobble field. The Point Cooke Marine Sanctuary also forms part of a Ramsar site and contributes habitat for migratory shorebirds. The intertidal area is 300-400 m long, extending from just north of Point Cooke to the south and west. Patches of sand and intertidal seagrass *Zostera muelleri* occur predominantly across the north-eastern section of the intertidal area, with more continuous patches of reef occurring further south and west. The intertidal reef is generally flat, but minor undulations across the reef mean that tidal inundation is not even across the reef. Strong southerly winds often cause large quantities of subtidal drift algae to be washed onto the intertidal reef area.

The survey site was established on the largest continuous area of reef to the west of Point Cooke (Figure 3.1). During the second survey (May 2004), a large quantity of drift algae was present along the high shore covering a substantial area of intertidal reef.

#### **3.1.2 Altona Reference (Site 4108)**

As habitat similar to that at Point Cooke could not be found nearby, the intertidal area at Altona was established as a reference site for Point Cooke Marine Sanctuary in 2003. The intertidal monitoring site at Williamstown (Site 4110; Section 5.1.2) may also be used as a long-term reference site for Point Cooke.

The intertidal area at Altona consists of basalt reef and boulder fields interspersed with sand and seagrass flats (Figure 3.2). The site was established on a large, continuous area of solid basalt reef and boulders directly adjacent to large patches of sand and seagrass. The intertidal reef is generally flat with most variation in substratum height occurring at the level of individual boulders rather than across the shore. Most boulders in the survey area are substantially bigger (approximately 20-40 cm diameter) than those occurring at Point Cooke. A large number of crevices and a substantial area of vertical substratum exist on the sides of boulders. The survey site has an estuarine influence due to its proximity to Kororoit Creek.



**a.**



**b.**

**Figure 3.1.** Intertidal reef habitat at Point Cooke Marine Sanctuary: (a) 1 June 2007; and (b) 29 April 2009.

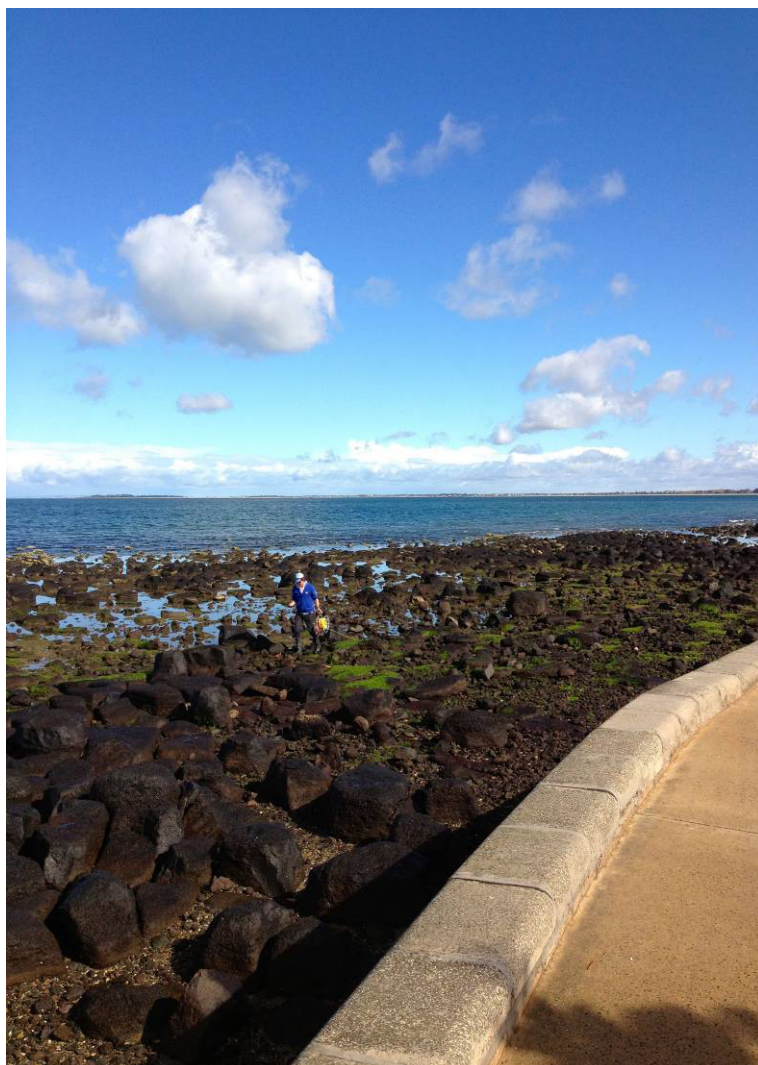


**Figure 3.2.** Intertidal reef at the Altona reference site, 1 April 2013.

### 3.2 Point Cooke Community Structure

The mobile invertebrate community at Point Cooke MS (Site 4107) was dominated by herbivorous gastropods, particularly the top snail *Austrocochlea porcata* and conniwink *Bembicium* spp. Commonly found species at the Altona reference site (Site 4108) were also *A. porcata* and *Bembicium* spp.

The MDS analysis of mobile invertebrate communities showed similar degrees of change between surveys within each site up until 2010. Since that time, Point Cooke MS had a markedly greater degree of variation between surveys (Figure 3.3). The communities at these two sites were relatively dissimilar to each other compared to the other sites as a whole (Figure 3.3). This could be due to the relatively low abundance of *C. tramoserica* at Point Cooke.

The algal/seagrass and aggregating sessile invertebrate community at Point Cooke was largely composed of green algae *Ulva* spp. and seagrass *Zostera muelleri*. At Altona, the community was composed of similar species: *Ulva* spp; *Symploca* sp.; and calcareous tube-worm *Galeolaria caespitosa*. No seagrass was present within the quadrats at Altona.

The MDS analysis of percent cover showed relatively small temporal variation at both Point Cooke and the Altona reference site (Figure 3.4. Three dimensional MDS plot of macroalgae and aggregating sessile invertebrate assemblages on intertidal reefs at Point Cooke and the Altona reference site. The grey lines represent data from all intertidal sites in other MPAS and reference sites used in the MDS analysis. Kruskal stress = 0.18.

Both sites occupied distinctly different spaces in the nMDS plot. This difference in community structure was driven by the greater cover of algae and presence of seagrass within the marine sanctuary. The community at Point Cooke more closely resembled that of the other sites surveyed as a whole compared to the Altona reference site (Figure 3.4. Three dimensional MDS plot of macroalgae and aggregating sessile invertebrate assemblages on intertidal reefs at Point Cooke and the Altona reference site. The grey lines represent data from all intertidal sites in other MPAS and reference sites used in the MDS analysis. Kruskal stress = 0.18.

### 3.3 Point Cooke Diversity

Mobile invertebrate species richness at Point Cooke (Site 4107) and the reference site (Site 4108) was relatively stable over time, apart from a dip in 2007 and a spike in 2009 at the reference and MS sites respectively

Algal and aggregating sessile invertebrate species richness at Point Cooke was relatively stable apart from a small spike in the number of species detected in 2011 (Site 4107; Figure 3.6). Species richness at Altona (Site 4108) was far more variable over time than at the MS, varying between 1 and 13 species over the monitoring period (Figure 3.6).

Mobile invertebrate species diversity at Point Cooke (Site 4107) and the reference site Altona (Site 4108) remained relatively constant until approximately 2011, after which both sites and a consistent upward trend (Figure 3.7).

Species diversity for algae and aggregating sessile invertebrates was generally low and constant at both sites (Figure 3.8). There was elevated sessile species diversity at Altona between 2010 and 2012.

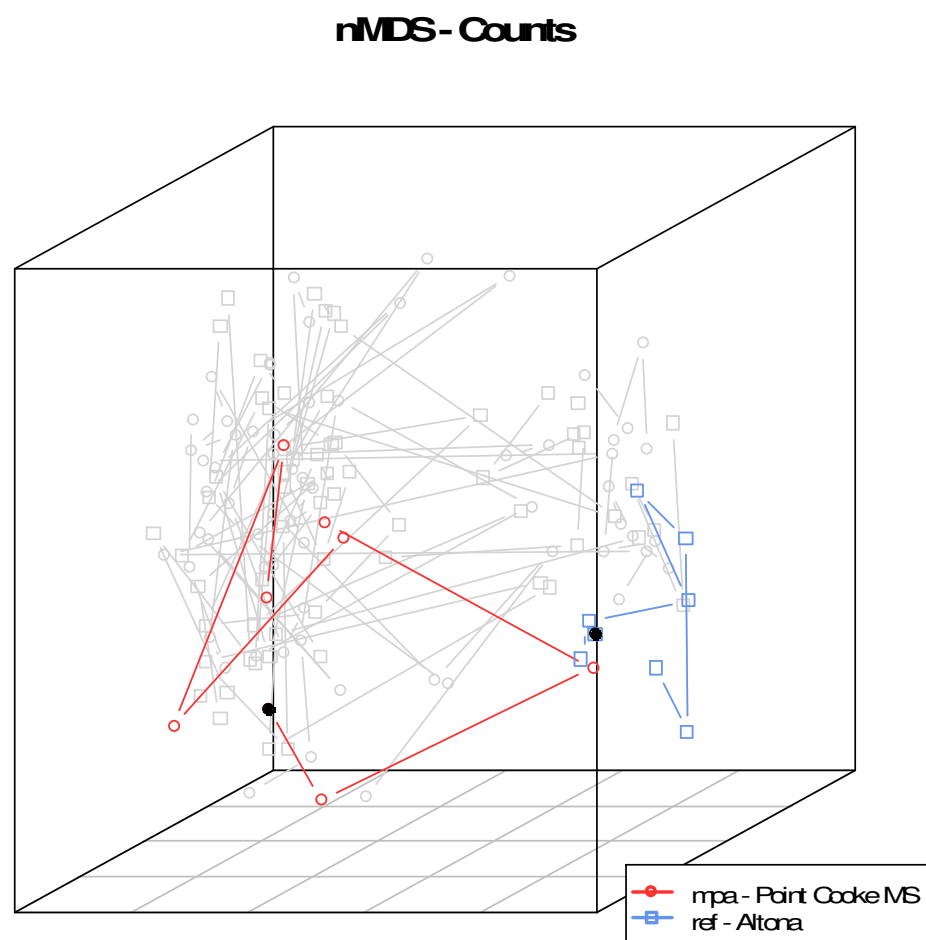


**Figure 3.3.** Three dimensional MDS plot of mobile invertebrates assemblages on intertidal reefs at Point Cooke and the Altona reference site. The grey lines represent data from all intertidal sites in other MPAS and reference sites used in the MDS analysis. Kruskal stress = 0.13.

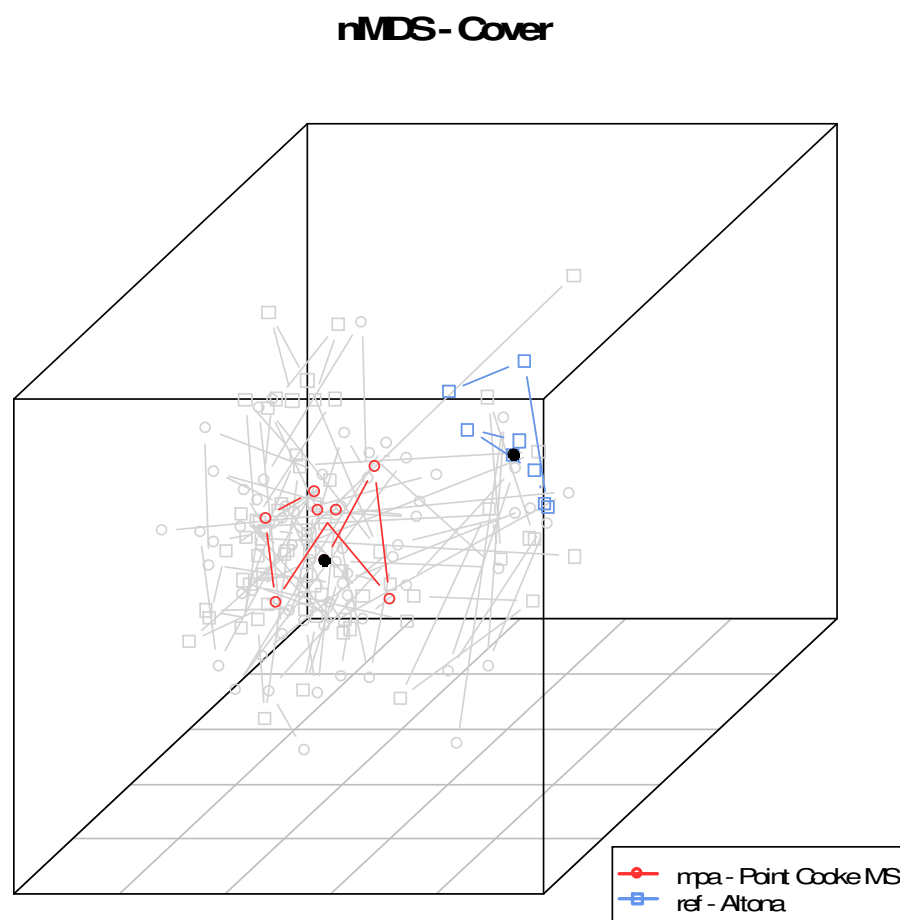


**Figure 3.4.** Three dimensional MDS plot of macroalgae and aggregating sessile invertebrate assemblages on intertidal reefs at Point Cooke and the Altona reference site. The grey lines represent data from all intertidal sites in other MPAS and reference sites used in the MDS analysis. Kruskal stress = 0.18.

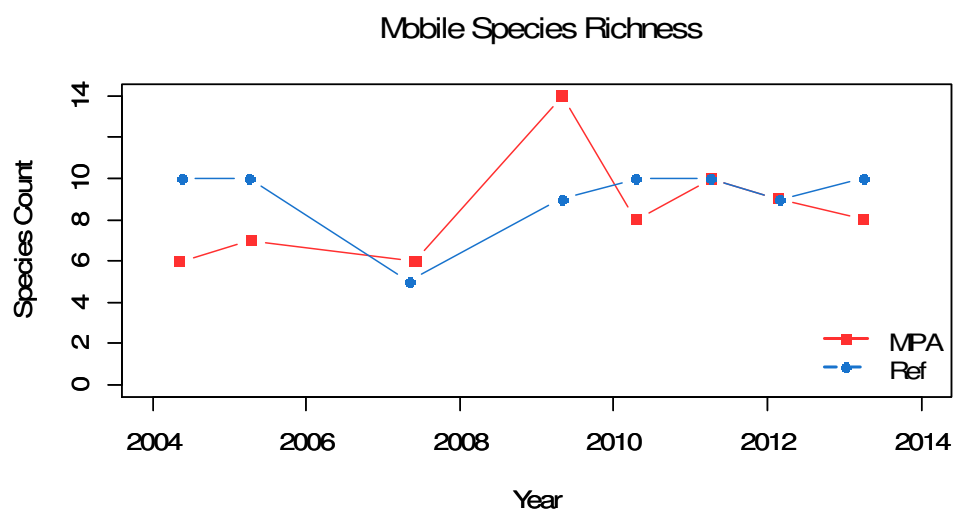


**Figure 3.5.** Mobile invertebrate species richness at Point Cooke and Altona reference site.

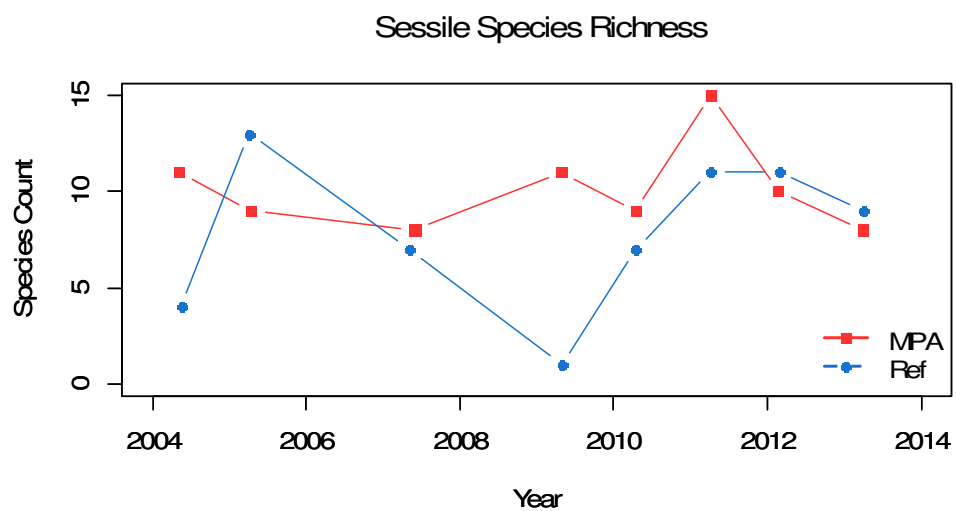


**Figure 3.6.** Algal and aggregating sessile invertebrate species richness of intertidal sites at Point Cooke and the Altona reference site.

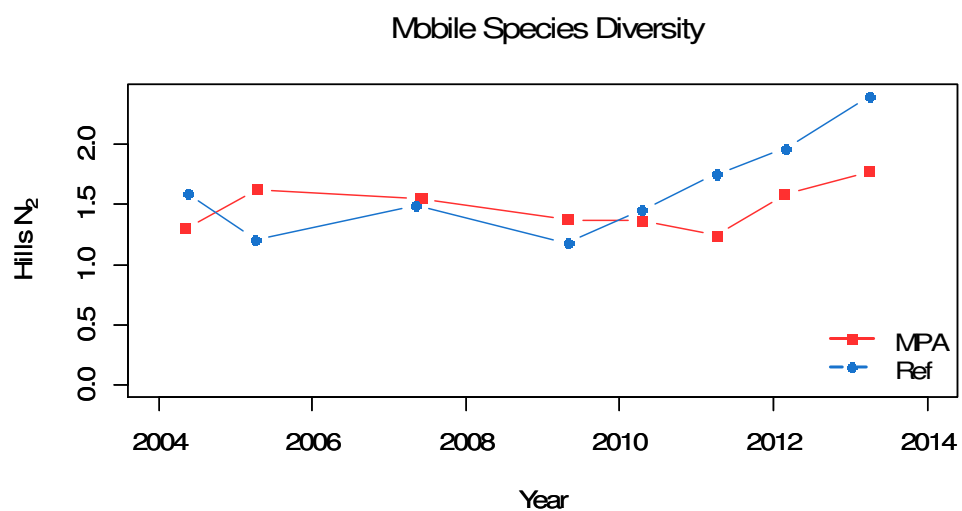


**Figure 3.7.** Mobile invertebrate diversity (Hills  $N_2$ ) of intertidal sites at Point Cooke and the Altona reference site.

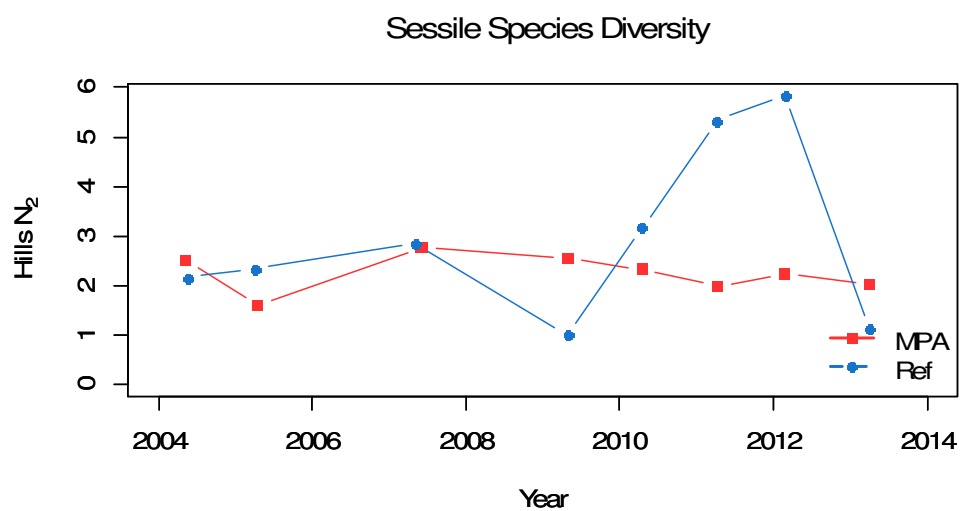


**Figure 3.8.** Algal and aggregating sessile invertebrate diversity (Hill's  $N_2$ ) of intertidal sites at Point Cooke and the Altona reference site.

### 3.4 Point Cooke Macroalgae and Aggregating Sessile Invertebrates

The coverage of the green alga *Ulva* spp. at Point Cooke MS spiked to 60 % cover in April 2005 with a steady upward trend since 2010 (Figure 3.9). Coverage at the reference, Altona site remained low during the monitoring period (Figure 3.9).

*Ulva* spp. (*Enteromorpha* form) was at Point Cooke in moderate quantities (15 %) in 2005, but has since been observed in very low quantities. A previously small patch of sand and *Zostera muelleri* seagrass has gradually extended across a wide band of the reef at Point Cooke, covering 36 % in 2012, before declining to 12 % in the 2013 survey. The coverage of filamentous red algae increased from none to almost 9 % in 2007, dropped to 3 % in 2009 and has not been detected since. Large quantities of drift macroalgae were observed at Point Cooke in 2004, but were sparse during subsequent surveys.

Altona had far less macroalgal cover than Point Cooke. The cover of *Ulva* spp at Altona was generally low (Figure 3.9), and *Ulva* spp. (*Enteromorpha* form) was detected only in 2005 and 2012. Coralline algal species were intermittently detected at very low coverages throughout the monitoring period. *Zostera muelleri* was recorded at Altona during two surveys (3 % in 2011; 0.3 % in 2012).

Aggregating sessile invertebrates did not contribute greatly to the community structure of either reef, although there were small patches of the reef forming tube worm, *Galeolaria caespitosa* on the low shoreline. At Point Cooke, the blue mussel *Mytilus galloprovincialis* was present in low coverage during early surveys, although it was not recorded since 2005.

Waves and currents deposited and eroded sand and shell material in the intertidal zone, periodically inundating and exposing areas of the reefs. The quantity of sand inundation was similar at both sites in 2004, increasing at Point Cooke during subsequent surveys, covering about a quarter of the area between 2007 and 2010. This has subsequently decreased to 9 % in 2013. At Altona, the sediment coverage was more variable between surveys, ranging from 21 % in 2009 to 0.8% in 2013.

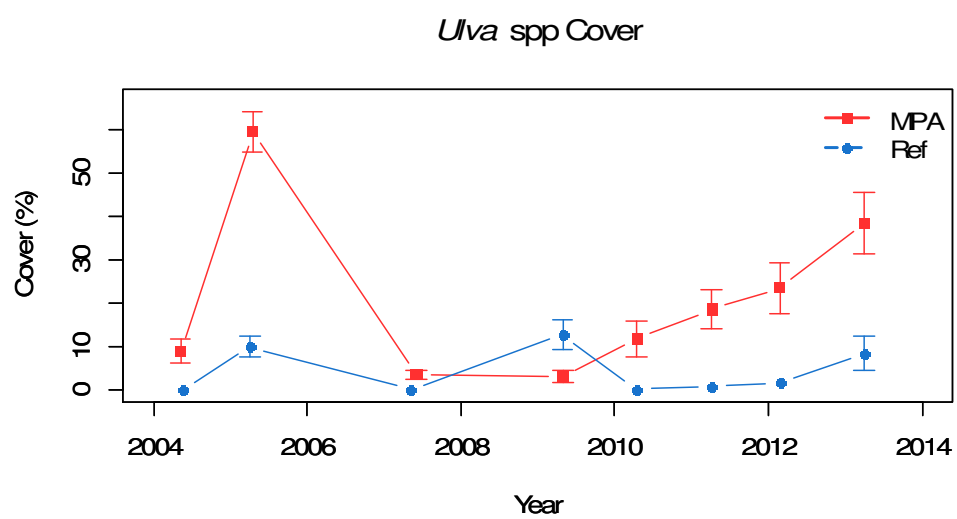


**Figure 3.9.** Mean density ( $\pm$  Standard Error) of *Ulva* spp at Point Cooke and the Altona reference site.

### 3.5 Point Cooke Mobile Invertebrates

Mobile invertebrates appeared consistently lower in density at Point Cooke than Altona. Most mobile invertebrates occurred in greater abundance in the lower areas of the shore.

The herbivorous gastropod *Austrocochlea porcata* was the most abundant invertebrate at both sites. *Austrocochlea porcata* generally occurred in higher densities at Altona. There was a peak in abundances from 2009 to 2011 with a following decline in subsequent years (Figure 3.10a).

Conniwinks, *Bembicium* spp., were generally present in low densities at both sites with the exception of a spike at the reference Altona site in 2011 and 2012 (Figure 3.10b).

The warrener *Turbo undulatus* was recorded in low densities on the low shore at Point Cooke in most surveys, but has only been intermittently recorded in low densities at Altona.

The carnivorous gastropods *Cominella lineolata* and *Lepsiella vinosa* occurred at similarly low densities at Altona as Point Cooke, though the density of *C. lineolata* at Point Cooke appears slightly higher.

The limpet *Cellana tramoserica* was rarely present at Point Cooke throughout the survey period and was consistently present at Altona in low abundances (Figure 3.10c).

A slight declining trend in mean size of *A. porcata* was apparent for Point Cooke and Altona (Figure 3.11a). The mean size of *Cellana tramoserica* was relatively constant at both sites (Figure 3.11b).

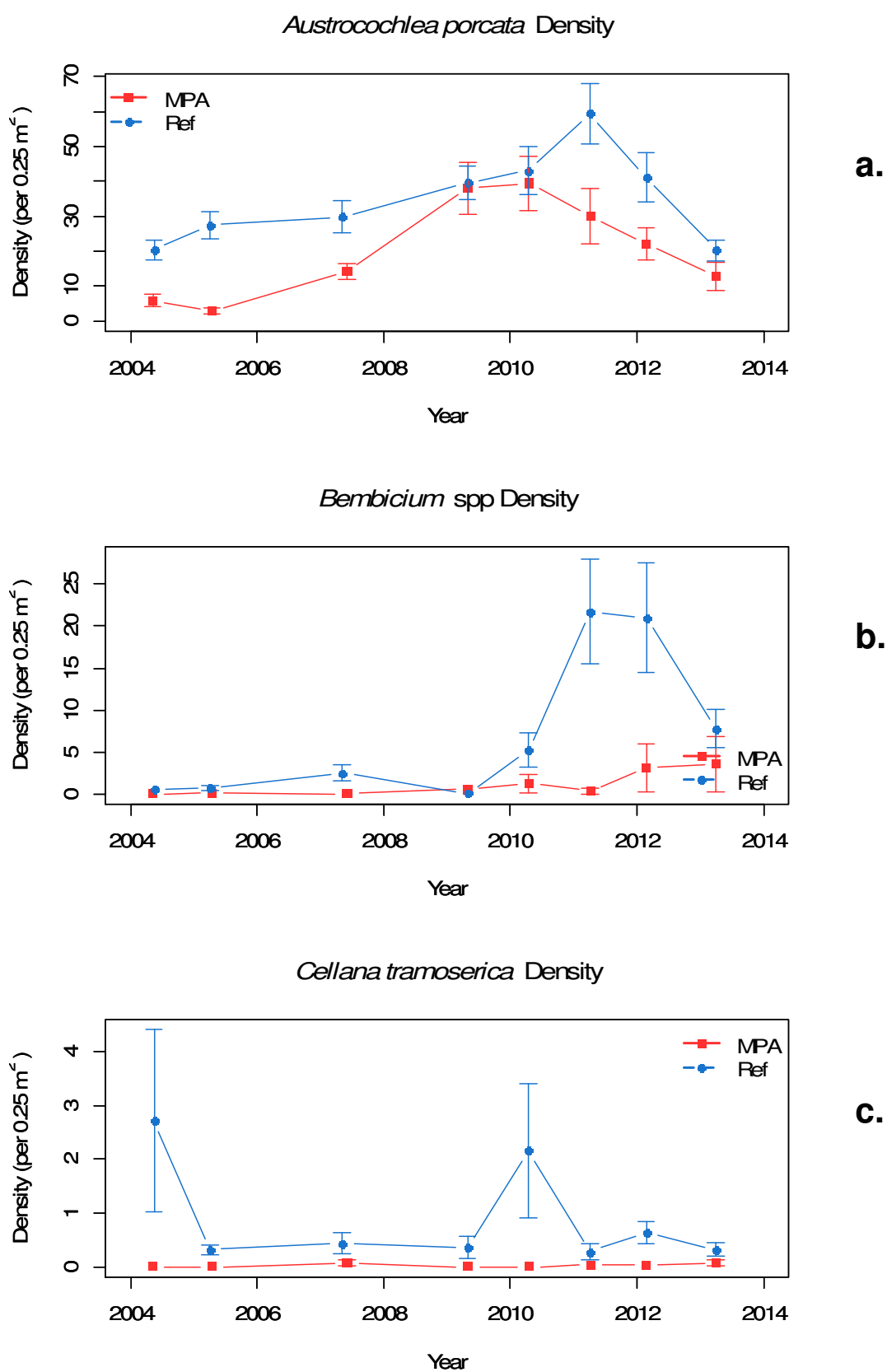


**Figure 3.10.** Mean density ( $\pm$  Standard Error) of dominant mobile invertebrates at Point Cooke and the Altona reference site.

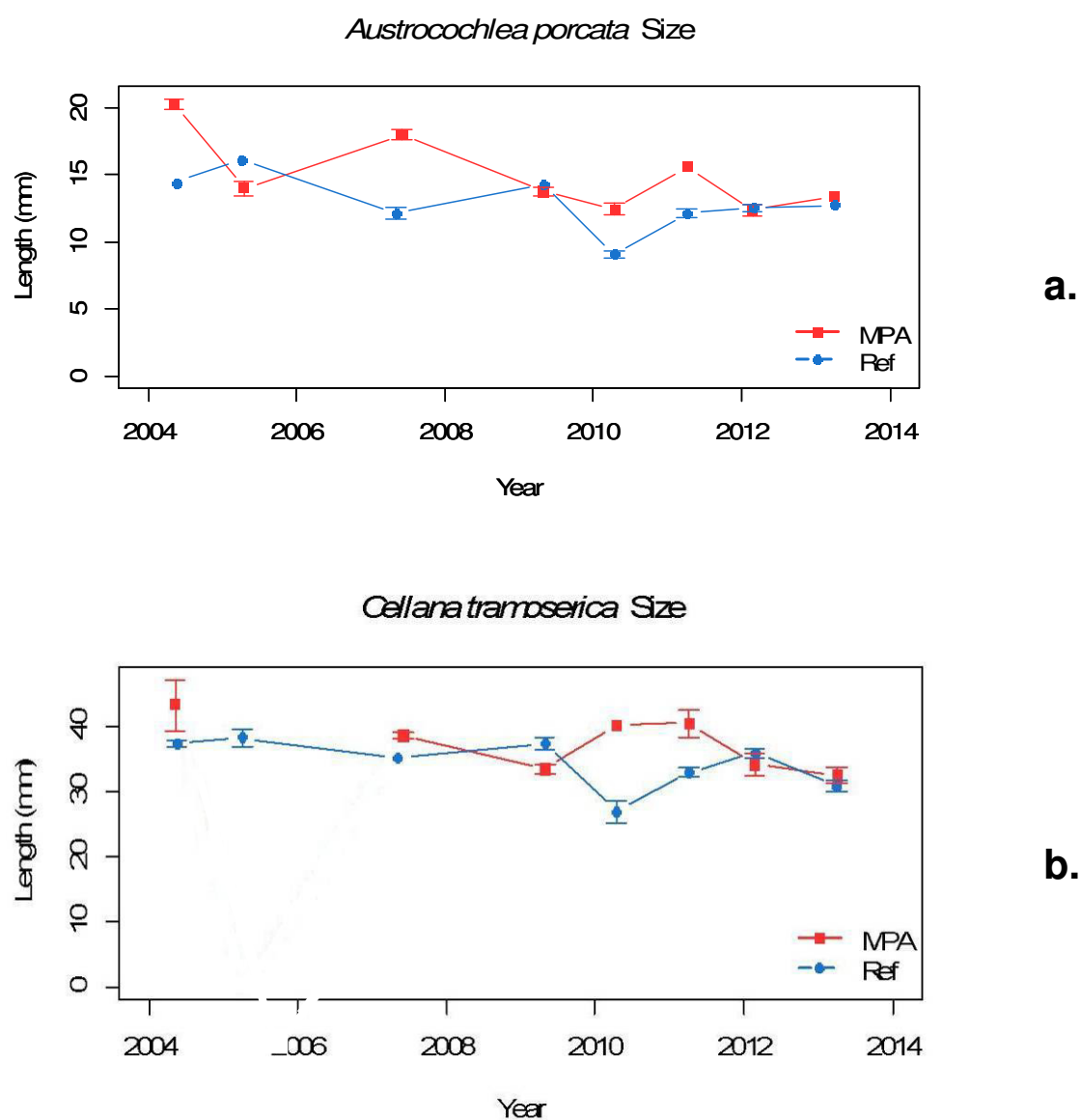


**Figure 3.11.** Mean sizes ( $\pm$  Standard Error) of: (a) *Austrocochlea porcata*, and (b) *Cellana tramoserica* at Point Cooke and the Altona reference site.

## 3.6 Condition Indicators

### 3.6.1 Biodiversity

Community composition was generally within the range of states and changes previously observed. Species richness and diversity levels were moderate to high compared to the rest of the monitoring period.

### 3.6.2 Introduced Species

No introduced species were detected for these sites.

### 3.6.3 Ecosystem Function

Total algal cover generally followed that of *Ulva* spp., with Point Cooke having a spike in 2006 and increasing trend from 2010 (Figure 3.12a). Erect coralline algal cover and turfing algae were low and variable in cover over the monitoring period (Figure 3.12b and Figure 3.12c). Total grazer density was largely driven by the *Austrocochlea porcata* density, with peaks in the latter monitoring period (Figure 3.13a and 4.13b).

### 3.6.4 Climate Change

There were no community shifts towards greater affinities with other bioregions.

### 3.6.5 Harvesting

The mean size and density of *Cellana tramoserica* at both sites have remained relatively low and consistent throughout the monitoring period. At Altona in 2013 there were clusters of numerous empty *C. tramoserica* shells, which were indicative of harvesting activity at this site. There appears to be a slight downward trend in the mean size of *Austrocochlea porcata* and a decrease in density at both sites in the most recent survey, these results were not marked enough to distinguish between any harvesting pressure changes, other potential human disturbances and variations in natural population dynamics, such as recruitment.

### 3.6.6 Trampling

*Hormosira banksii* cover was naturally low at these sites. No evidence of trampling was discernable.

### 3.6.7 Environment

Green algal species cover, sometimes indicative of nutrient loading, was driven by the abundance of *Ulva* spp. As noted above, there was a spike at Point Cooke in 2006 and upward trends at both sites since 2010 (Figure 3.14a).

Sediment cover at both sites has decreased in the last four surveys after an increase from 2005 to 2009. The level of sediment cover in 2013 relatively low compared to the rest of the monitoring period (Figure 3.14b).

*Zostera meulleri* first established within the survey area at Point Cooke in 2005 and has had a marked increase in coverage over subsequent surveys. In 2012, *Z. meulleri* cover had increased to a maximum cover of 36 % before declining to 12 % in 2013 (Figure 3.14c). *Zostera meulleri* was only detected at the Altona reference site in 2011 at very low coverage (Figure 3.14c).

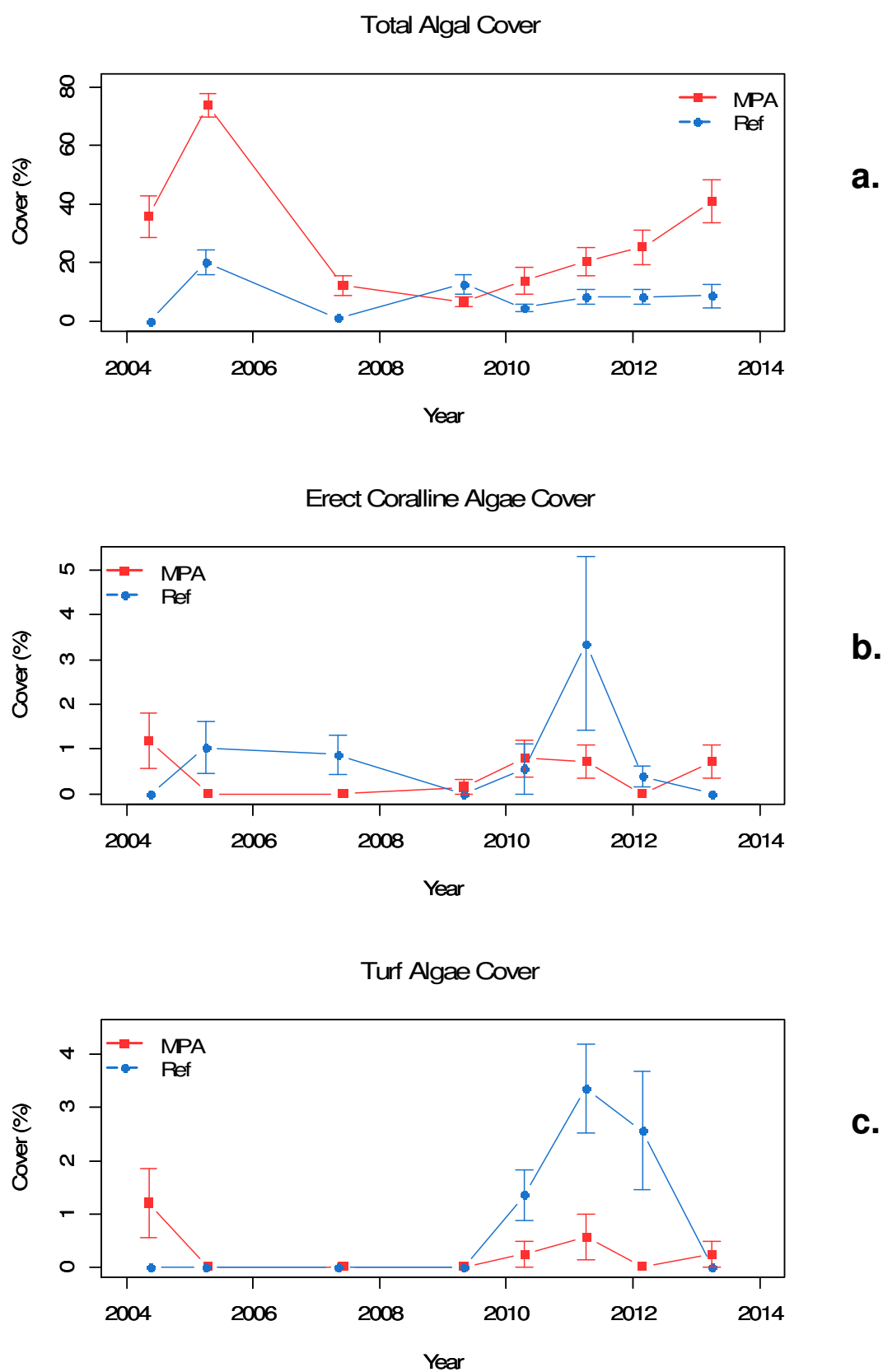


**Figure 3.12.** Mean cover ( $\pm$  Standard Error) of algae at Point Cooke and the Altona reference site.

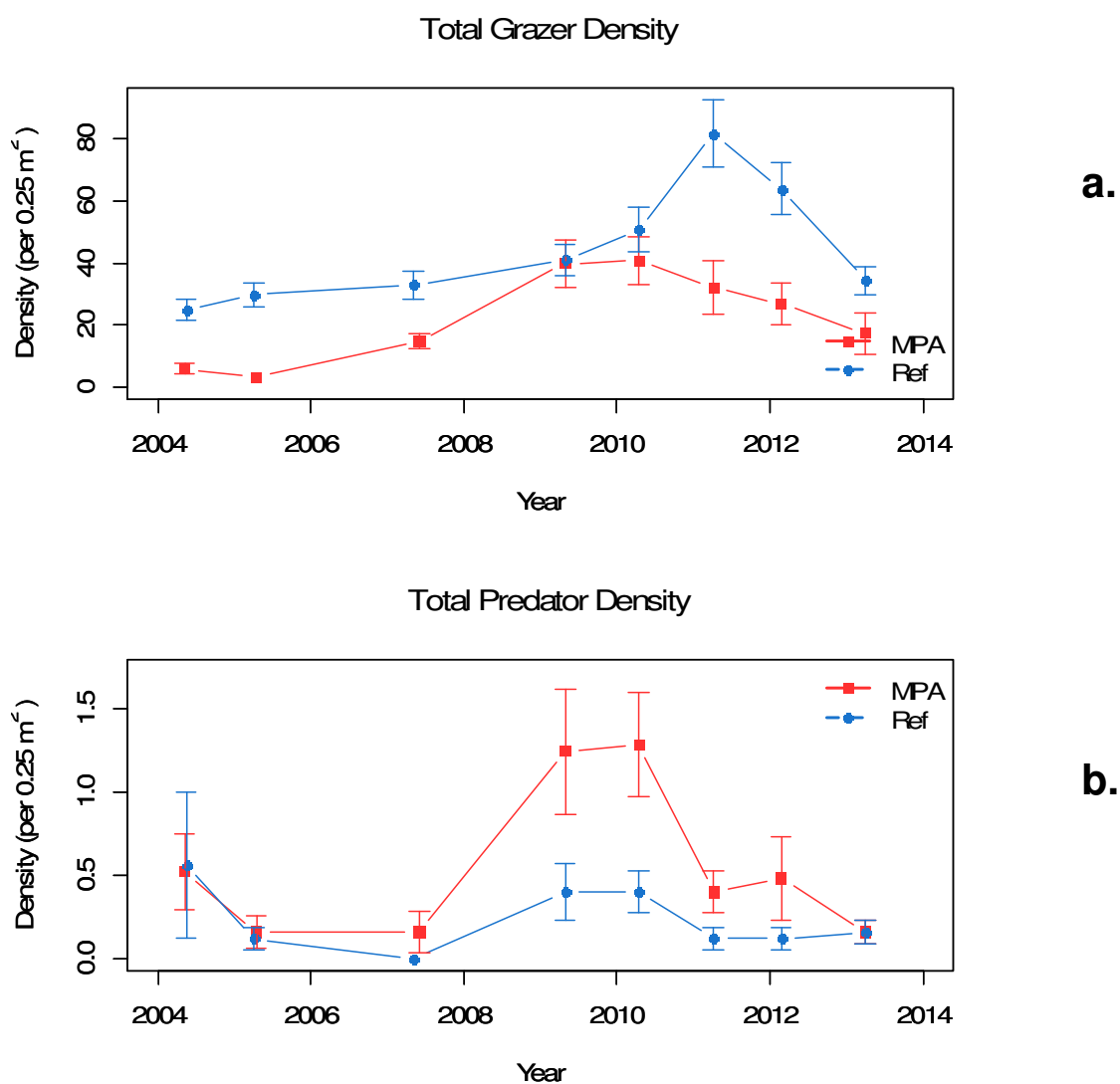


**Figure 3.13.** Mean abundance ( $\pm$  Standard Error) of grazers and predators at Point Cooke and the Altona reference site.

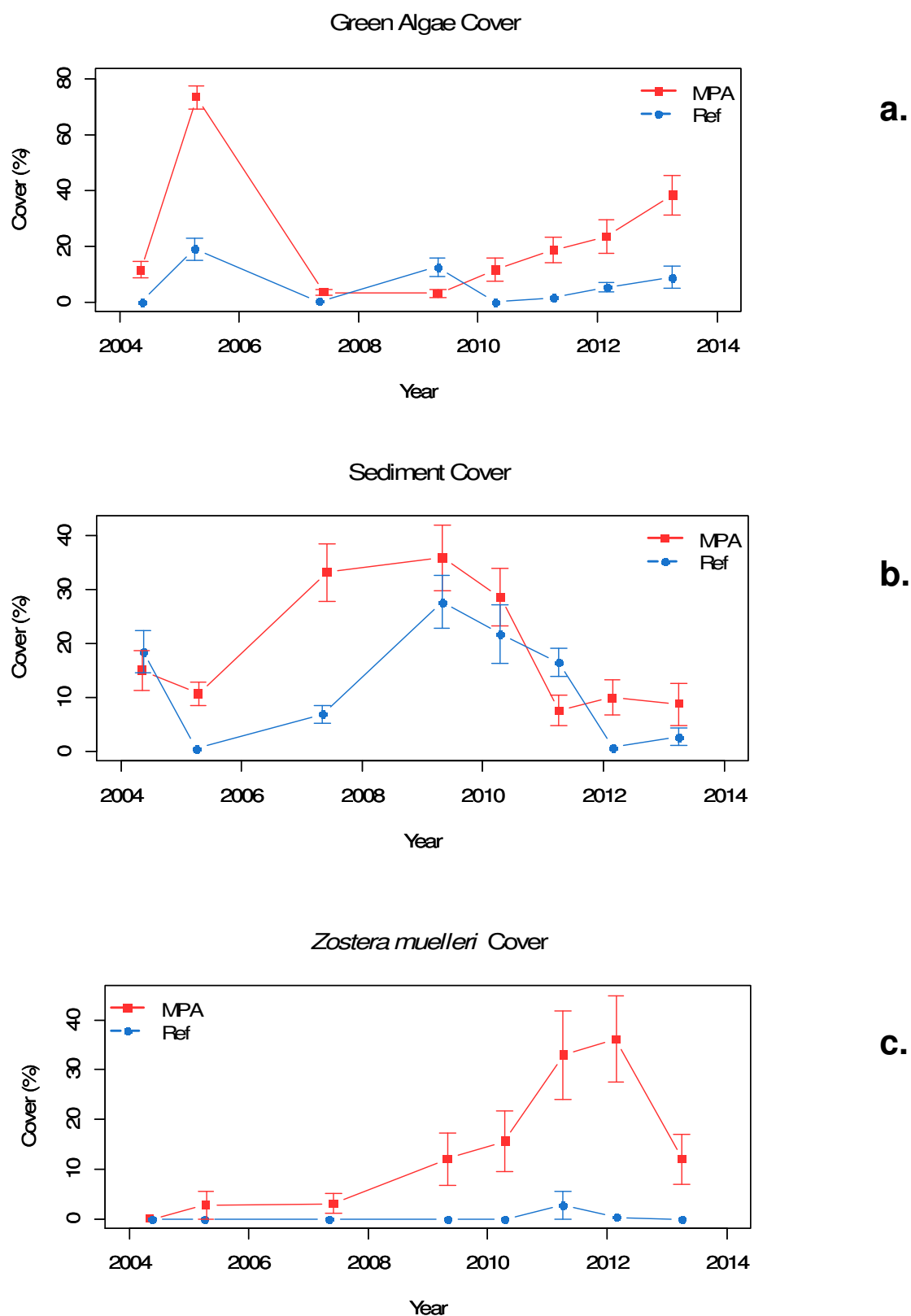


**Figure 3.14.** Mean cover ( $\pm$  Standard Error) of: (a) green algae *Ulva* spp. and *Cladophora* spp.; (b) sediment at Point Cooke; and (c) *Zostera muelleri* at the Altona reference site.

## **4 JAWBONE MARINE SANCTUARY**

### **4.1 Site Description and Transect Layout**

#### **4.1.1 Jawbone Marine Sanctuary (Site 4109)**

The Jawbone Marine Sanctuary has an extensive area of fractured basalt reef and boulders (Site 4109). The reef forms a band up to 30 m wide and extends for several hundred metres along the western portion of the Sanctuary. The fractured basalt create low relief intertidal reef with considerable habitat structure because of the large area of vertical substratum and associated crevices (Figure 4.1). The intertidal reef at Jawbone Marine Sanctuary is subject to the estuarine influence of nearby Kororoit Creek to the west and storm water drainage to the east. An area of mangrove and saltmarsh habitat exists at the eastern end of the sanctuary. This area is a Ramsar site, being an important habitat for migratory shorebirds.

#### **4.1.2 Williamstown Reference (Site 4110)**

The reference site was at Point Gellibrand, Williamstown (Site 4110). As at Jawbone Marine Sanctuary, the intertidal area is a fractured basalt reef and boulder field. The boulders were smaller at Williamstown and consequently there was less vertical structure and fewer crevices (Figure 4.2). The intertidal reef has a southerly aspect.



**Figure 4.1.** Intertidal reef at Jawbone Marine Sanctuary, 14 May 2013.



**Figure 4.2.** Intertidal reef at the Williamstown reference site, 14 May 2013.

## 4.2 Jawbone Community Structure

The mobile invertebrate community at Jawbone MS (4109) was largely composed of the top snail *Austrocochlea porcata*, coniwinks *Bembicium* spp and limpet *Cellana tramoserica*. Common species at Williamstown (Site 4110) were *A. porcata* and coniwinks *Bembicium* spp. The MDS analysis showed that the mobile invertebrate community structure was similar at both sites for most surveys (Figure 4.3). The greatest difference was the first survey conditions at Williamstown.

The algal and aggregating sessile invertebrate community structure differed slightly at Jawbone and the reference Williamstown site. The Jawbone assemblage consisted of predominantly green algae *Ulva* spp, algal turf and the calcareous tube-worm *Galeolaria caespitosa*. In contrast, the cover at Williamstown was mostly *Hormosira banksii*. The MDS analysis, showed that the two sites differed considerably from the other intertidal sites surveyed in central Victoria (Figure 4.4).

## 4.3 Jawbone Diversity

The species richness of mobile invertebrate species was moderately variable with no discernable trends at both sites (Figure 4.5).

Sessile species richness at Jawbone (Site 4009) was also more variable between surveys than over longer time periods (Figure 4.6). Species richness at Williamstown was less variable between and increased gradually up to a maximum recorded in 2010, and has decreased slightly in the last three surveys (Figure 4.6).

Mobile invertebrate diversity (Hills  $N_2$ ) was relatively constant at both sites, with levels consistently higher at Jawbone than Williamstown (Figure 4.7).

Sessile species diversity was relatively stable for Williamstown (Figure 4.8). Within the Jawbone MS, there was a trend of increasing diversity since 2009 (Figure 4.8).

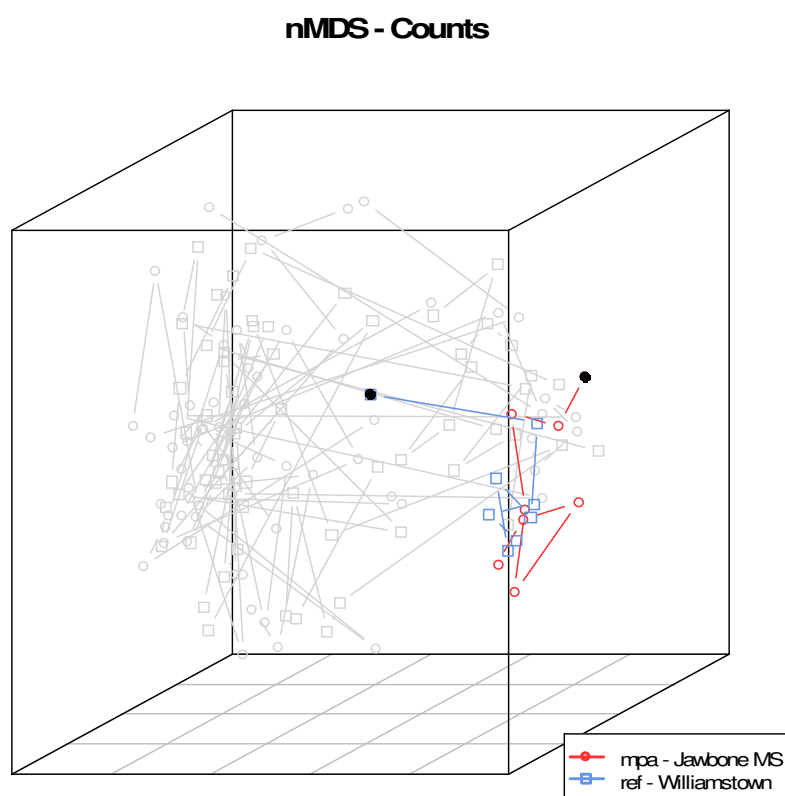


**Figure 4.3.** Three dimensional MDS plot of mobile invertebrate assemblages on intertidal reefs at Jawbone and the Williamstown reference site. The grey lines represent data from all intertidal sites used in the MDS analysis. Kruskal stress = 0.13.

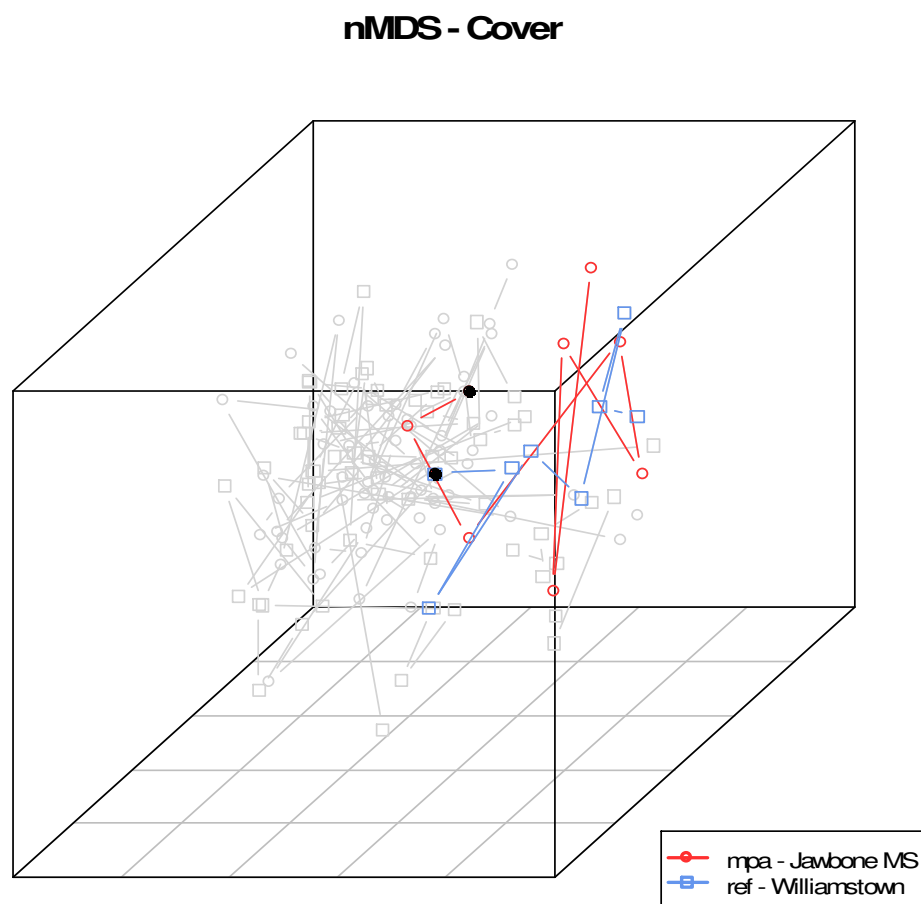


**Figure 4.4.** Three dimensional MDS plot of macroalgae and aggregating sessile invertebrate assemblages on intertidal reefs at Jawbone and the Williamstown reference site. The grey lines represent data from all sites in other MPAS and reference sites used in the MDS analysis. Kruskal stress = 0.18.

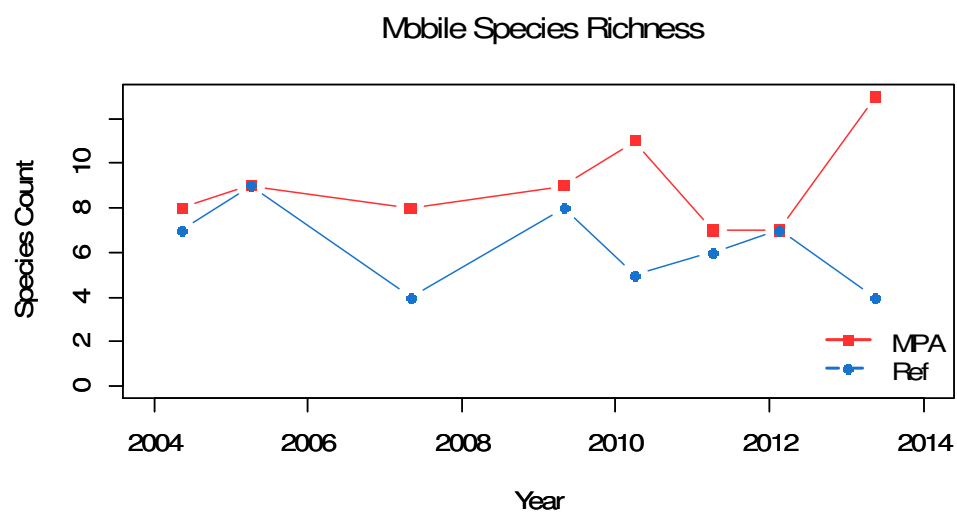


**Figure 4.5.** Mobile invertebrate species richness at Jawbone and the Williamstown reference site.

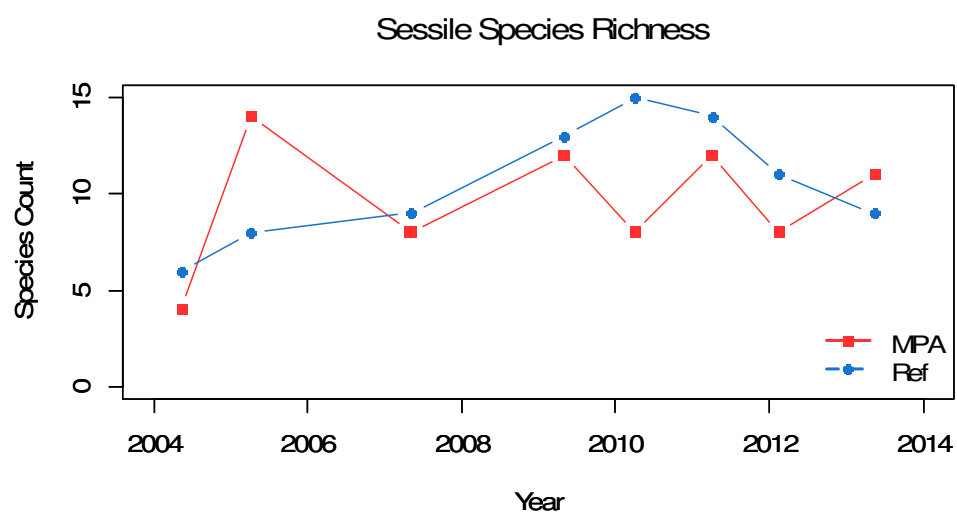


**Figure 4.6.** Algal and aggregating sessile invertebrate species richness of intertidal sites at Jawbone and the Williamstown reference site.

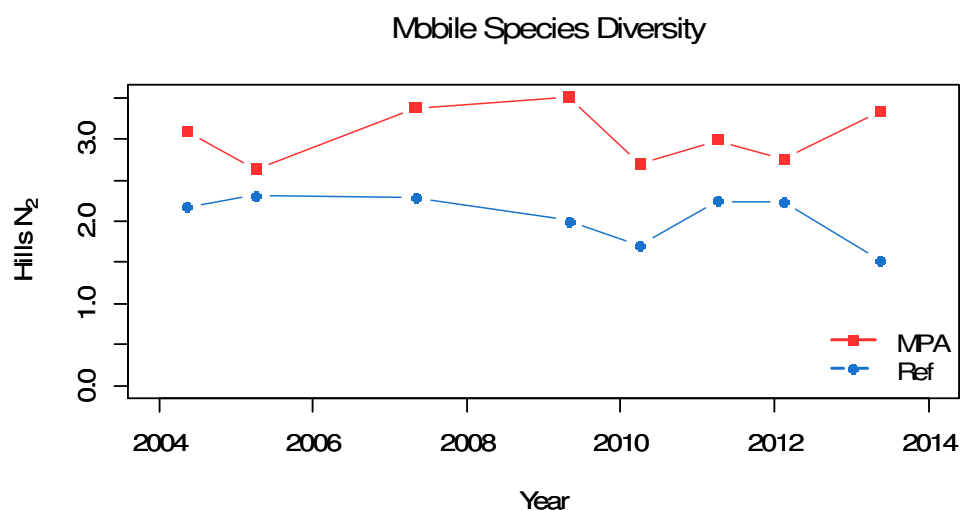


**Figure 4.7.** Mobile invertebrate diversity (Hills  $N_2$ ) of intertidal sites at Jawbone and the Williamstown reference site.

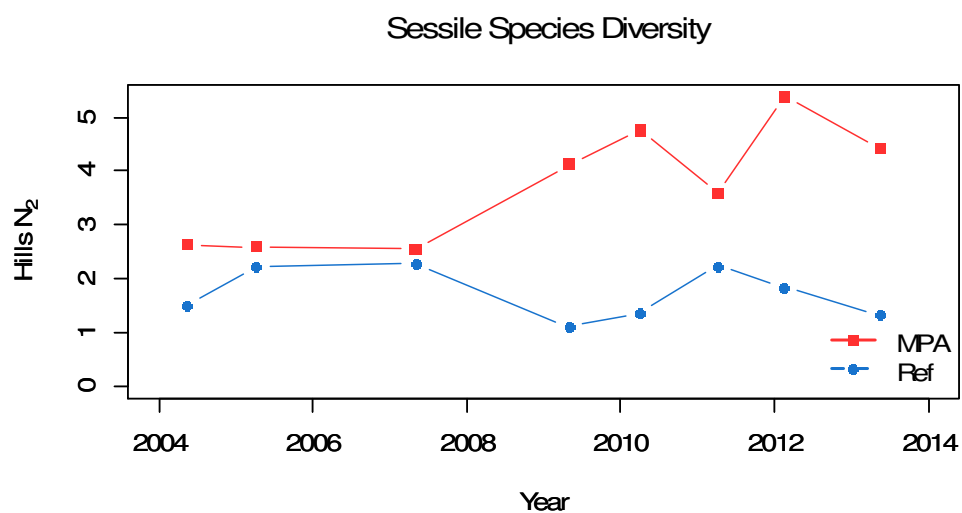


**Figure 4.8.** Algal and aggregating sessile invertebrate diversity (Hill's  $N_2$ ) of intertidal sites at Jawbone and the Williamstown reference site.

## 4.4 Jawbone Macroalgae and Aggregating Sessile Invertebrates

The abundance of all sessile species was very low at Jawbone (Site 4109) throughout the monitoring period. The calcareous tube-worm *Galeolaria caespitose* and the blue mussle *Mytilus galloprovincialis* were present at low densities, low on the intertidal zone. Turfing and coralline algae, the green algae *Ulva* spp and *Codium fragile* were present at the intertidal fringe, at the eastern end of the study area.

Macroalgal cover at Williamstown (Site 4110) was predominantly the brown alga Neptune's Necklace, *Hormosira banksii*, which occurred in patches on the lower region of the shore. The abundance of *H. banksii* has increased steadily at Williamstown throughout the monitoring period (Figure 4.9).

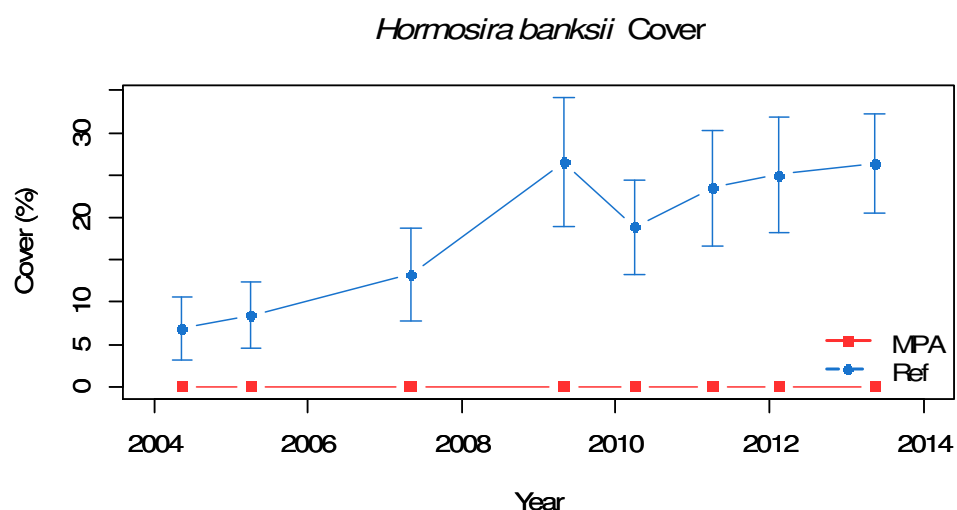


**Figure 4.9.** Mean density ( $\pm$  Standard Error) of Neptune's Necklace *Hormosira banksii* at Jawbone and the Williamstown reference site.

## 4.5 Jawbone Mobile Invertebrates

The mobile invertebrate population structure at Jawbone was dominated by the top shell *Austrocochlea porcata*, conniwinks *Bembicium* spp, the black nerite *Nerita atramentosa* and the variegated limpet *Cellana tramoserica*. At Williamstown, the dominant invertebrates were the herbivorous gastropods *Bembicium* spp and *Austrocochlea porcata*.

The density of *A. porcata* was largely stable at Jawbone MS until 2011, with a subsequent spike in 2012 followed by a low abundance in 2013. The Williamstown reference site had a peak in abundance from 2009 to 2011 (Figure 4.10a).

*Cellana tramoserica* had persistently low densities at Williamstown (Figure 4.10b). At Jawbone MS, *C. tramoserica* densities had a declining trend from 2004 to 2009, with a peak and subsequent decline from 2010 (Figure 4.10b).

The mean size of *A. porcata* was slightly lower and more variable at Jawbone than Williamstown, however there was no trend apparent at either site (Figure 4.11a). The mean size of *C. tramoserica* was very similar between Jawbone and Williamstown and there was little change between 2004 and 2012. In 2013, there was a considerable increase in average *C. tramoserica* size within the Jawbone MS and a corresponding decrease at the Williamstown reference site (Figure 4.11b).

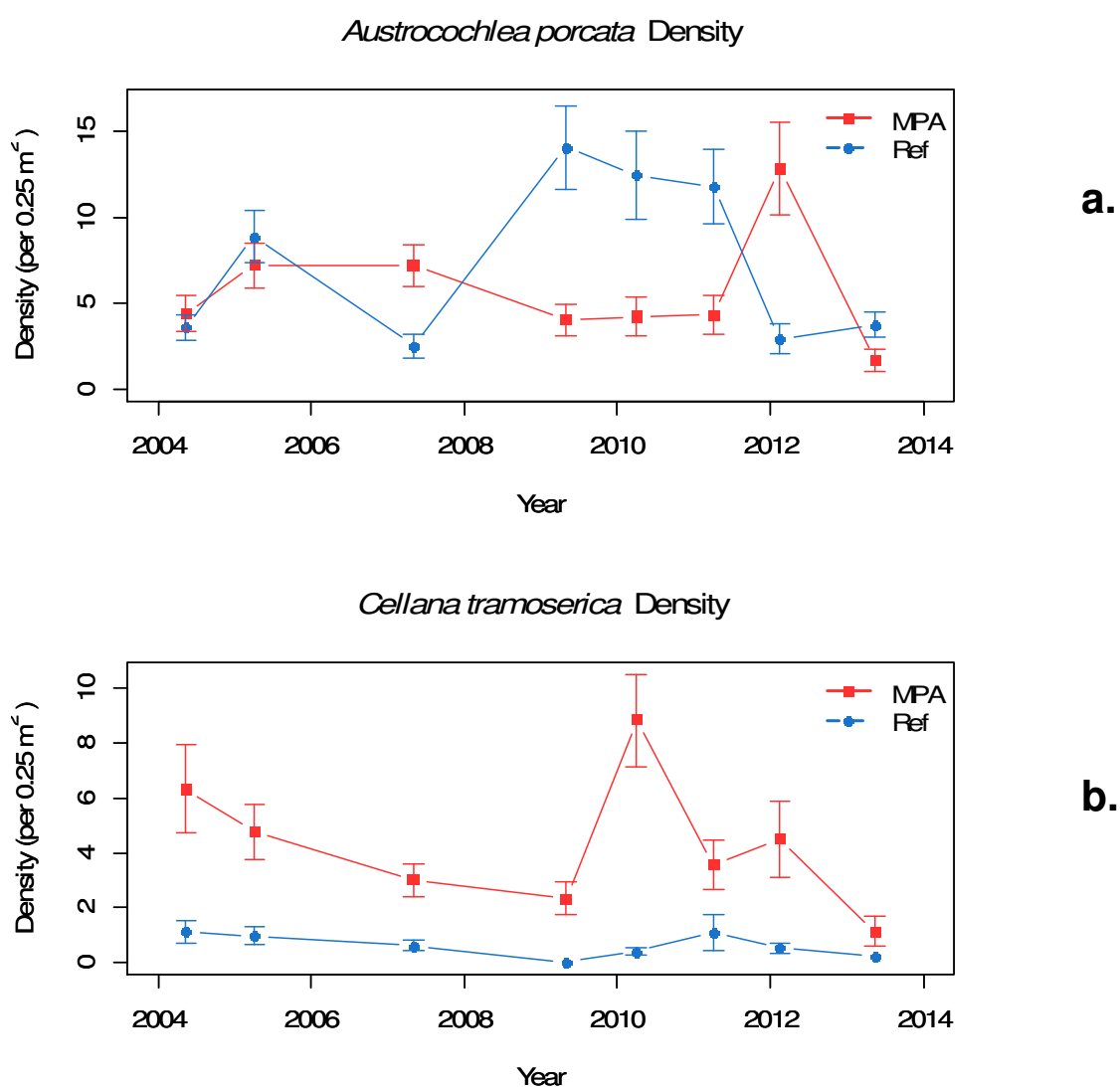


**Figure 4.10.** Mean density ( $\pm$  Standard Error) of dominant mobile invertebrates at Jawbone and the Williamstown reference site.

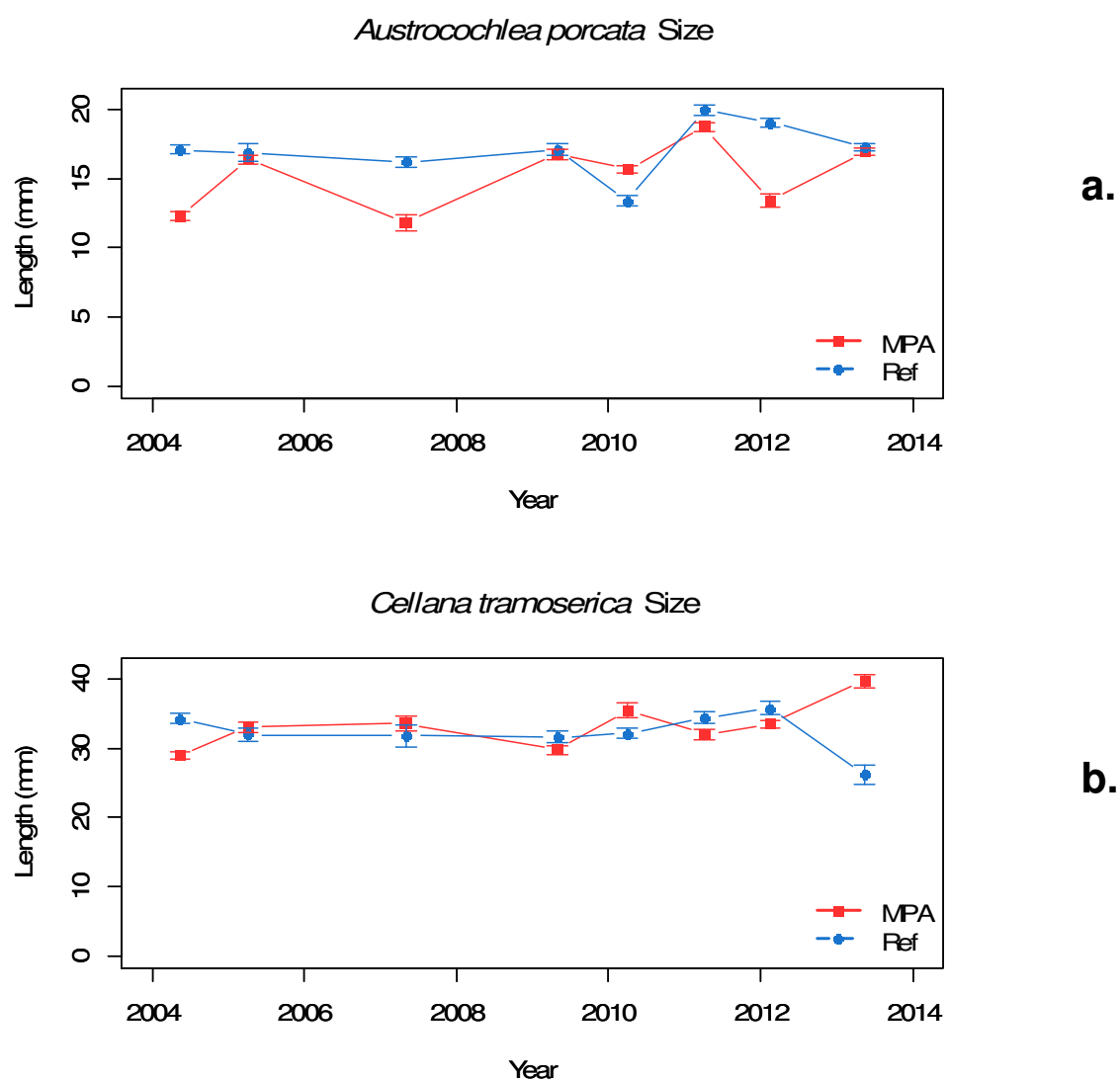


**Figure 4.11.** Mean sizes ( $\pm$  Standard Error) of: (a) *Austrocochlea porcata*, and (b) *Cellana tramoserica* at Jawbone MS and the Williamstown reference site.

## **4.6 Jawbone Condition Indicators**

### **4.6.1 Biodiversity**

Community composition and species richness remained within the range of states and changes observed previously. Species diversity remained steady with the exception of a trend of increasing sessile species diversity within the Jawbone MS.

### **4.6.2 Introduced Species**

No introduced species were detected for these sites.

### **4.6.3 Ecosystem Function**

Total algal cover increased considerably at Williamstown with the increase in *Hormosira banksii* cover. The total algal cover at Jawbone increased through to 2011 and then decreased (Figure 4.12a). Erect coralline algal cover and turfing algae were low and variable in cover over the monitoring period at both sites, with a slight increase in erect coralline algal cover in 2012 (Figure 4.12b and 4.12c). There was a spike in turfing algal cover (13 %) at Williamstown in 2007.

The total abundance of grazers had similar ranges of variation at both sites. There was an apparent increasing trend at the Williamstown site (Figure 4.13a). Total predator densities were low with no clear trends (Figure 4.13b).

### **4.6.4 Climate Change**

There were no community shifts towards greater affinities with other bioregions.

### **4.6.5 Harvesting**

The commonly harvested limpet *Cellana tramosercia* had two peaks of abundance in the Jawbone MS followed by declines in subsequent years. It is not possible to discern any harvesting affects from natural processes from these abundance data. There were no indications of increasing harvesting pressure based on mean sizes.

#### **4.6.6 Trampling**

The increase in cover of *Hormosira banksii* at Williamstown means there was no strong evidence for trampling impacts at that site.

#### **4.6.7 Environment**

The cover of green algal species, sometimes indicative of high nutrient loads, returned to previously observed levels after a marked increase in coverage in the 2010 and 2011 surveys (Figure 4.14a). Apart from a spike in sediment cover in 2007 at both sites, sediment cover remained low at both sites (Figure 4.14b).

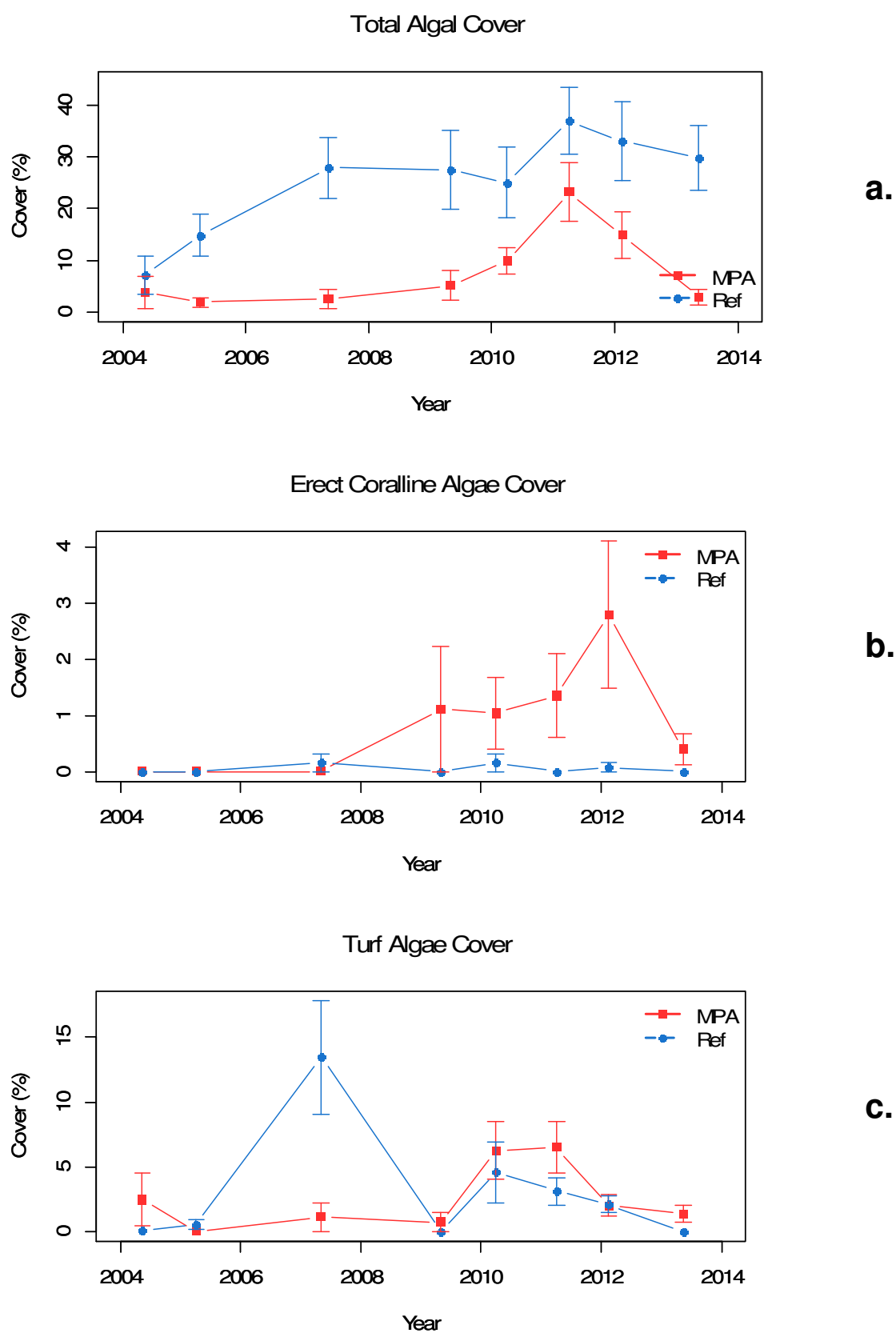


**Figure 4.12.** Mean cover ( $\pm$  Standard Error) of algae at Jawbone MS and the Williamstown reference site.

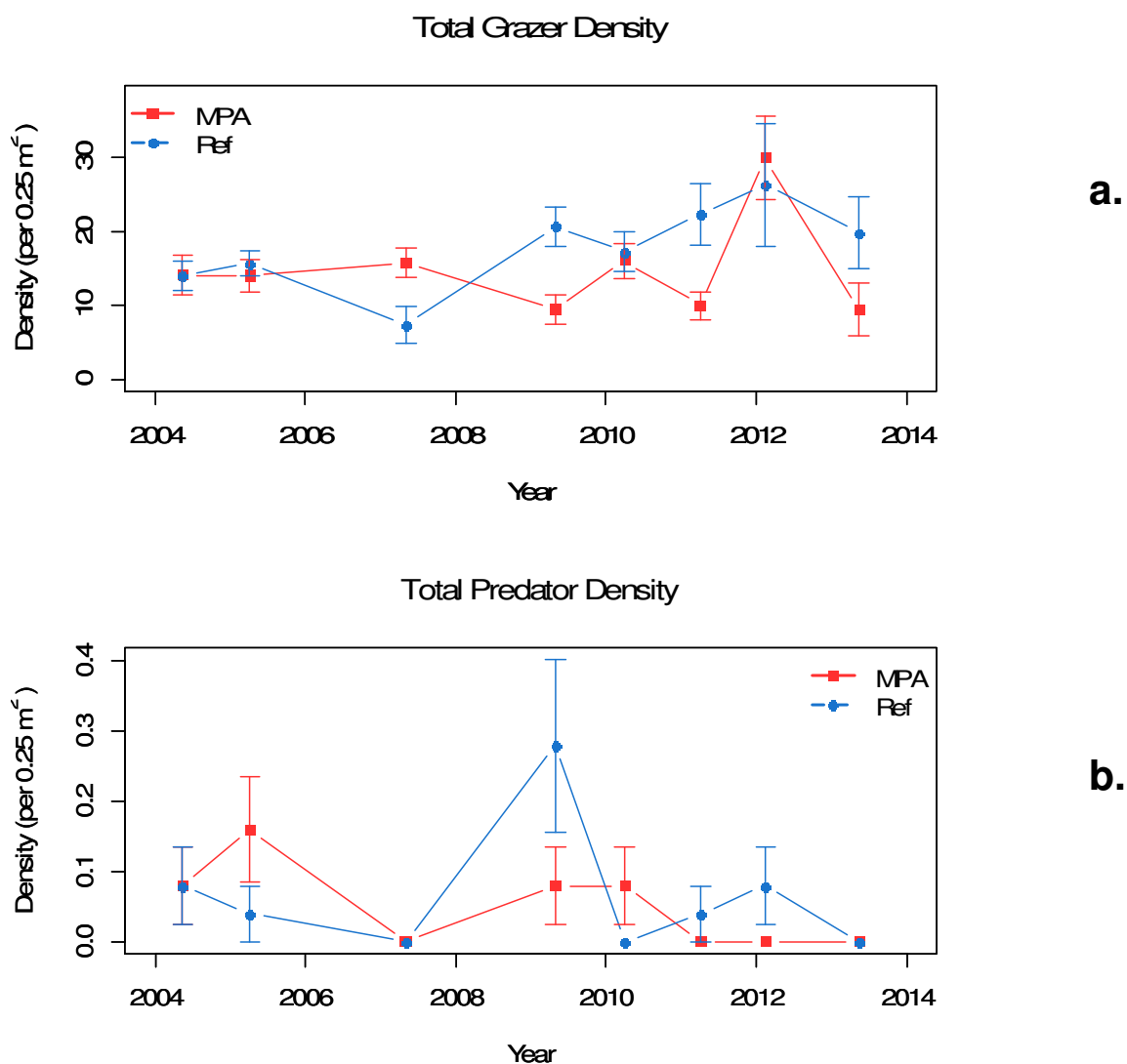


**Figure 4.13.** Mean abundance ( $\pm$  Standard Error) of: (a) all grazers; and (b) all predators at Jawbone MS and the Williamstown reference site.

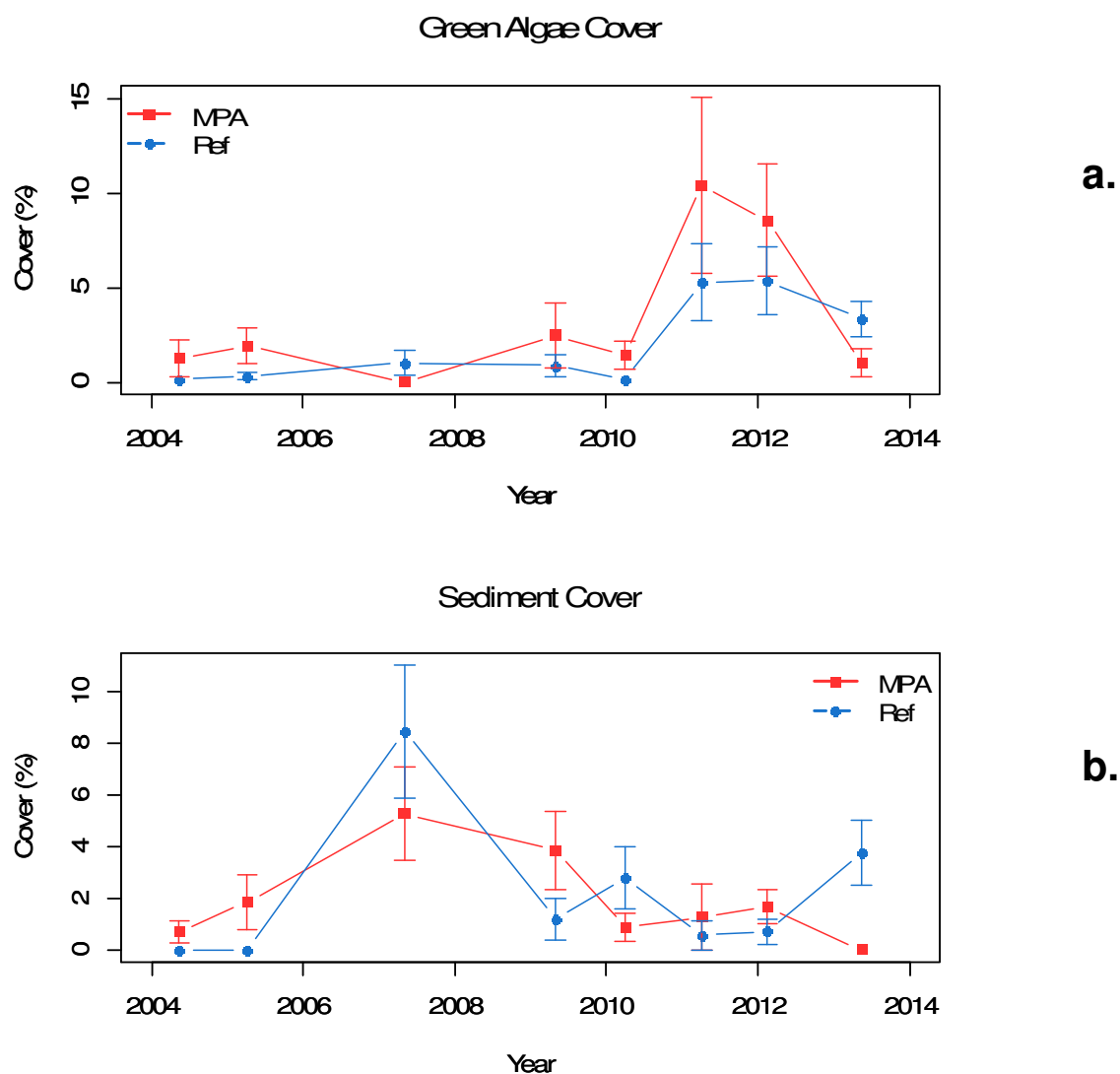


**Figure 4.14.** Mean cover ( $\pm$  Standard Error) of: (a) green algae *Ulva* spp. and *Cladophora* species; and (b) sediment at Jawbone MS and the Williamstown reference site.

## 5 RICKETTS POINT MARINE SANCTUARY

### 5.1 Site description and Transect layout

#### 5.1.1 Ricketts Point Marine Sanctuary (Site 4111)

Several sections of intertidal reef exist in the Ricketts Point Marine Sanctuary. The main intertidal reef is an extension of the Ricketts Point headland. This reef is approximately 60 x 70 m and encompasses several different habitat types, including fractured basalt reef with outcrops and steps, cobble field habitat and areas of intertidal sand and seagrass (Figure 5.1).

The central region of the platform at Ricketts Point is solid basalt reef lying above the high tide mark and supporting patches of the beaded glasswort *Sarcocornia quinqueflora*. There are also small rock pools in this central area. Cobble field and sediment habitats exist to the north and south of the central region. The seaward edge of the platform is fractured basalt with small boulders. Across the intertidal area, low basalt protrusions provide some vertical structure.

The main difficulties in establishing a monitoring site at Ricketts Point were: (1) determining whether the cobble field or the solid basalt reef was the dominant habitat type; and (2) irregularity in height across the intertidal platform. The monitoring site was placed on solid basalt reef at the western seaward edge of the intertidal area.

#### 5.1.2 Halfmoon Bay Reference (Site 4112)

The reference site for Ricketts Point Marine Sanctuary was a small area of intertidal reef at Halfmoon Bay (Site 4112). The main section of this reef is relatively flat basalt extending 20 m north from a high-relief basalt outcrop. This tongue of reef is surrounded by water on three sides.



**Figure 5.1.** Intertidal reef at Ricketts Point Marine Sanctuary, 28 May 2013.



**Figure 5.2.** The intertidal reef monitoring reference site at Halfmoon Bay, 28 May 2013. The high-shore baseline is at the right.

## 5.2 Ricketts Point Community Structure

The two sites differed considerably in mobile invertebrate assemblage structure. The mobile invertebrate community at Ricketts Point (Site 4111) was largely composed of the herbivorous gastropod *Austrocochlea porcata* and coniwink *Bembicium* spp. More common species at the Halfmoon Bay reference site (Site 4112) were the limpet *Cellana tramoserica*, *Siphonaria* spp and the carnivorous gastropods *Lepsiella vinosa*. The MDS analysis showed that both sites were had affinities with the other northern Port Phillip Bay monitoring sites (to the right of the MDS), but there were also substantial between-survey variations (Figure 5.3).

The sessile species community structure also differed substantially between Ricketts Point and Half Moon Bay (Figure 5.4). The Ricketts point assemblage largely consisted of the brown alga *Hormosira banksii*, calcareous tube-worm *Galeolaria caespitosa*, *Symploca* sp. and algal turf. The cover at Halfmoon Bay was mainly composed of *Galeolaria caespitosa*, *Ulva* spp. and algal turf. The MDS analysis showed that the sites were different, but fairly closely related with respect to the total variation from all central Victorian monitoring sites (Figure 5.4).

## 5.3 Ricketts Point Diversity

Mobile invertebrate species richness was consistently lower at Ricketts Point MS than Halfmoon Bay and the temporal variations followed similar trajectories (Figure 5.5).

Sessile species richness was very similar between sites, apart from a disparity in 2009 (Figure 5.6).

Mobile invertebrate species diversity, Hill's  $N_2$ , was relatively constant over time at Ricketts Point MS. At Halfmoon Bay, mobile species diversity was consistently greater and more variable (Figure 5.7).

Sessile species diversity was similar in range and variability between Ricketts Point and Halfmoon Bay throughout the monitoring period (Figure 5.8).

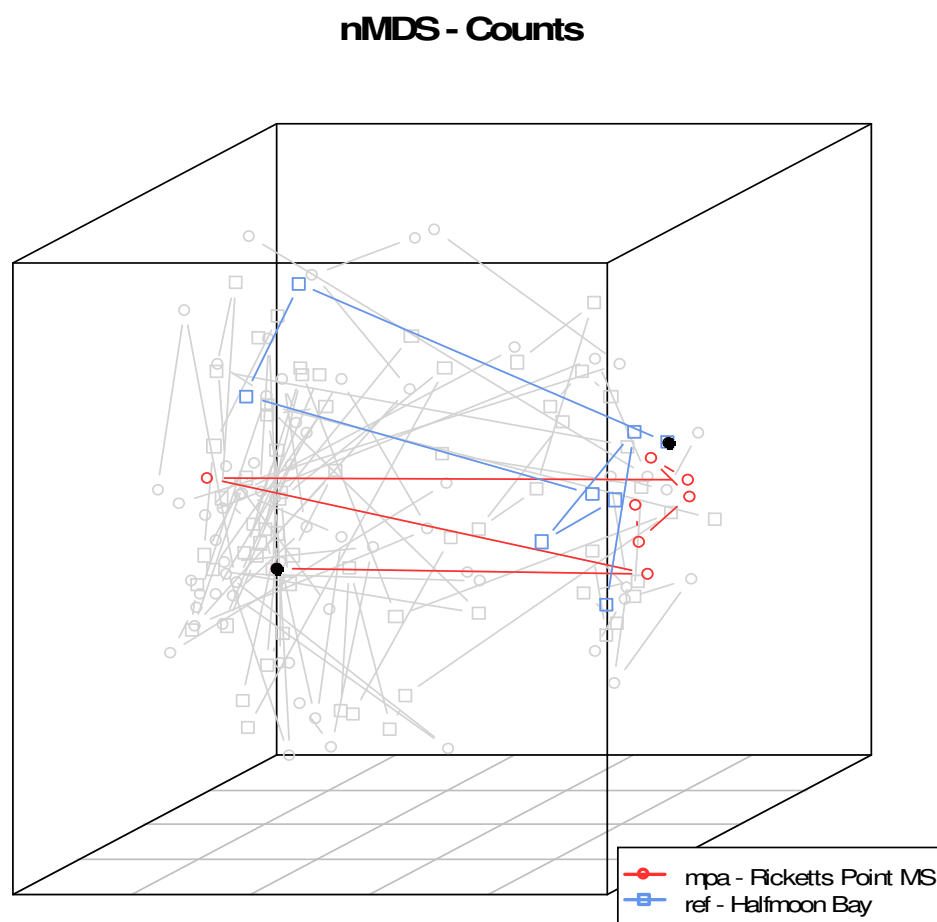


**Figure 5.3.** Three dimensional MDS plot of mobile invertebrate assemblages on intertidal reefs at Ricketts Point and the Half Moon Bay reference site. The grey lines represent data from all other MPA and reference sites used in the MDS analysis. Kruskal stress = 0.13.

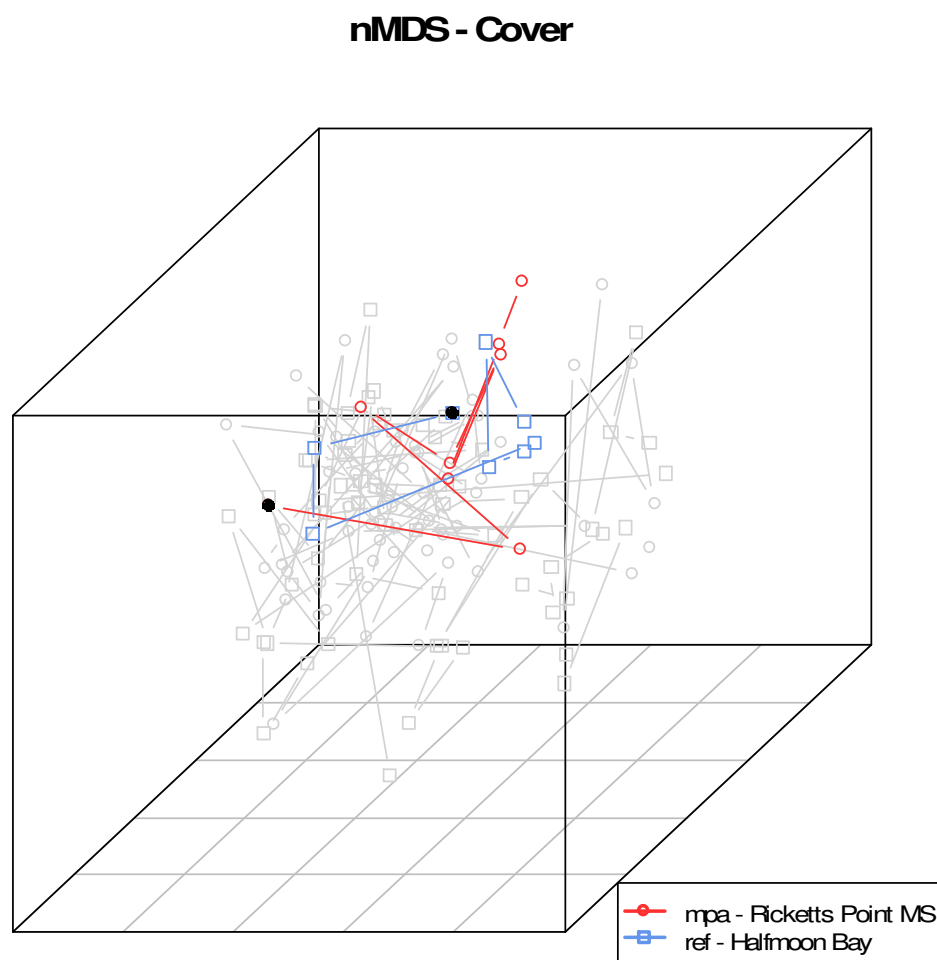


**Figure 5.4.** Three dimensional MDS plot of macroalgae and aggregating sessile invertebrate assemblages on intertidal reefs at Ricketts Point and the Half Moon Bay reference site. The grey lines represent data from all other MPA and reference sites used in the MDS analysis. Kruskal stress = 0.18.

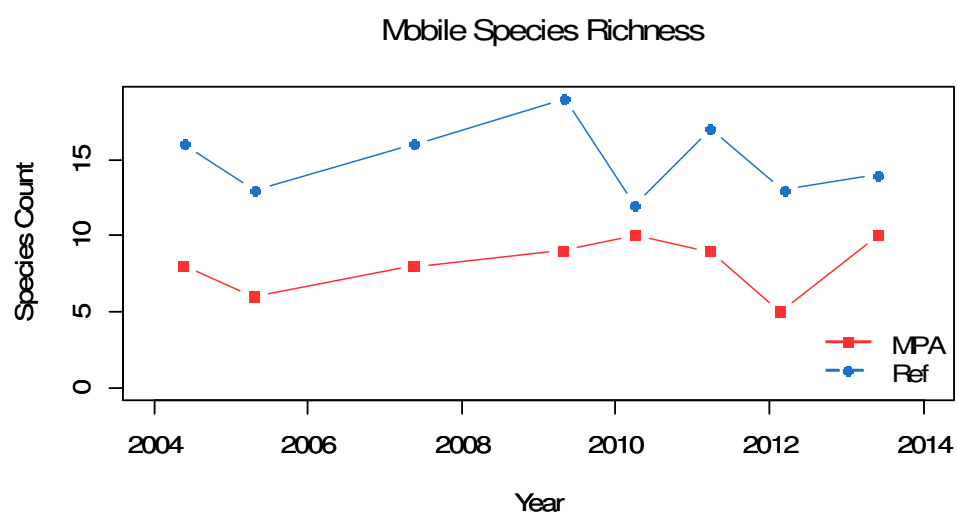


**Figure 5.5.** Mobile invertebrate species richness at Ricketts Point and the Half Moon Bay reference site.

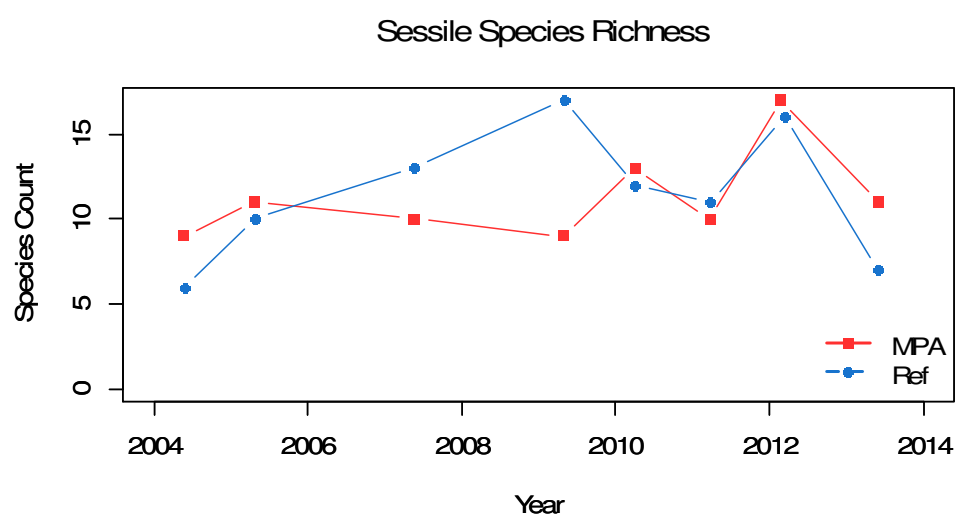


**Figure 5.6.** Algal and aggregating sessile invertebrate species richness of intertidal sites at Ricketts Point and the Half Moon Bay reference site.

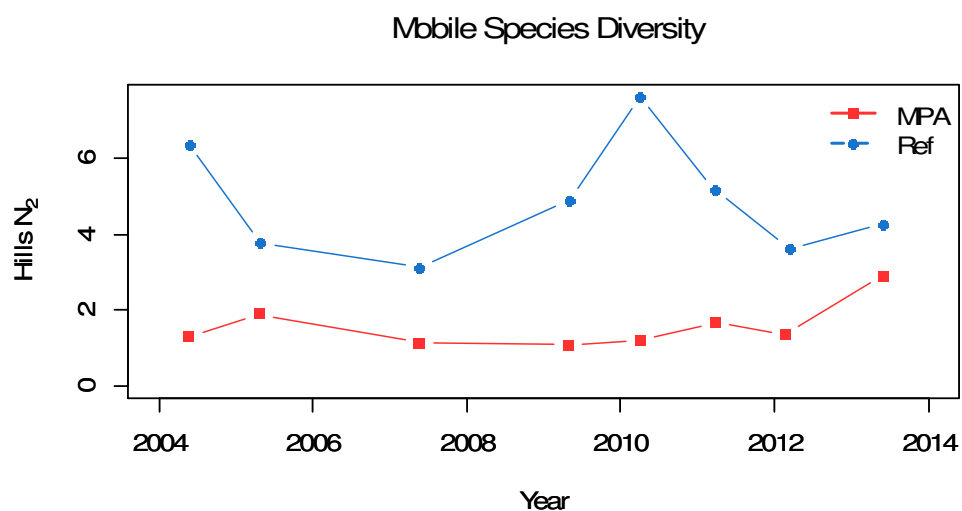


**Figure 5.7.** Mobile invertebrate diversity (Hills  $N_2$ ) of intertidal sites at Ricketts Point and the Half Moon Bay reference site.

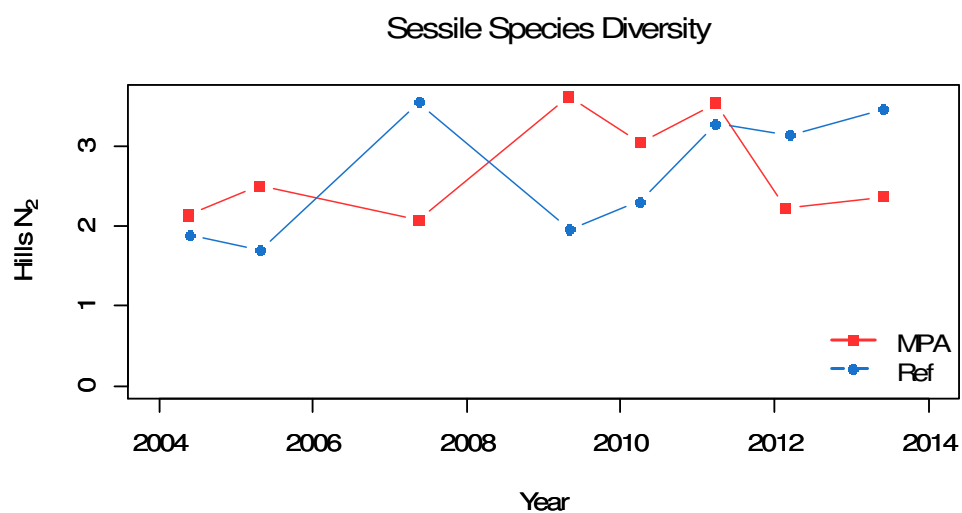


**Figure 5.8.** Algal and aggregating sessile invertebrate diversity (Hill's  $N_2$ ) of intertidal sites at Ricketts Point and the Half Moon Bay reference site.

## 5.4 Ricketts Point Macroalgae and Aggregating Sessile Invertebrates

The high shore area of the Ricketts Point site is exposed for long times between high tide periods resulting in a low algal coverage of the area. Macroalgal cover along the seaward edge of the Ricketts Point platform was predominantly the brown alga Neptune's Necklace *Hormosira banksii*. *Hormosira banksii* coverage at Ricketts Point generally followed an upward trend from 2009 (Figure 5.9). At Halfmoon Bay, coverage was consistently close to zero (Figure 5.9).

Patches of the calcareous tube-worm *Galeolaria caespitosa* were present at Ricketts Point at very low coverage throughout the surveys. There was much higher and more variable coverage at Halfmoon Bay (Figure 5.10).

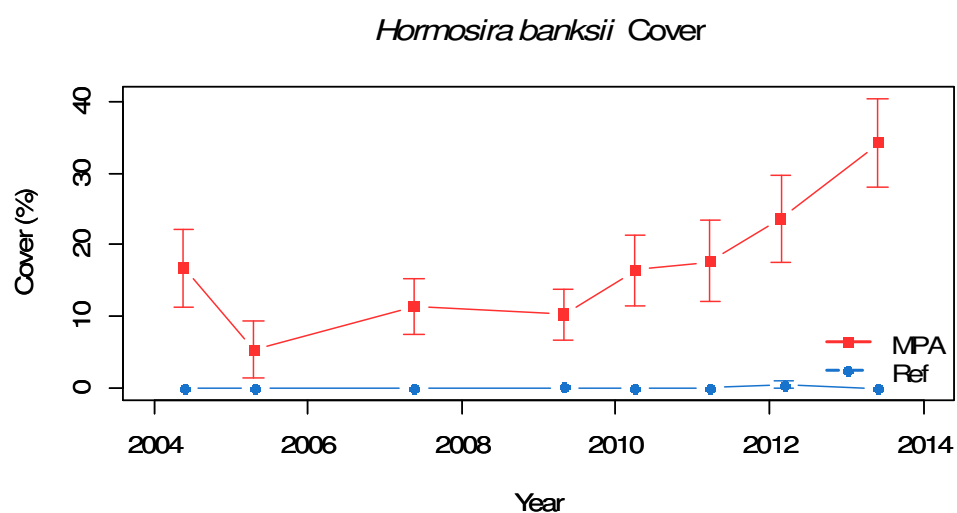


**Figure 5.9.** Mean cover ( $\pm$  Standard Error) of Neptune's Necklace *Hormosira banksii* at Ricketts Point and the Half Moon Bay reference site.

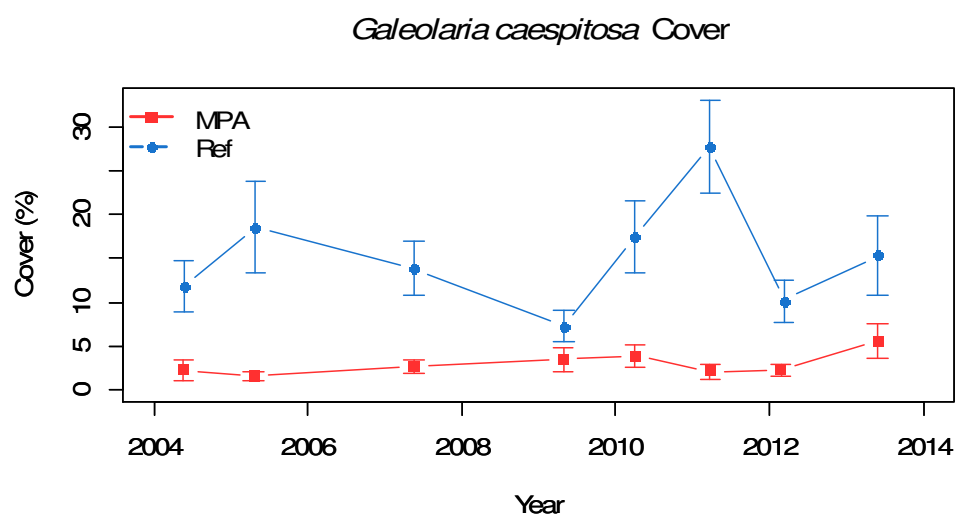


**Figure 5.10.** Mean cover ( $\pm$  Standard Error) of the reef forming tube worm *Galeolaria caespitosa* at Ricketts Point and the Half Moon Bay reference site.

## 5.5 Ricketts Point Mobile Invertebrates

At Ricketts Point MS (Site 4111), the limpet *Cellana tramoserica* was consistently very low in abundance (Figure 5.11a). Densities were consistently higher at Halfmoon Bay, and have increased following a marked decline from 2010 to 2012 (Figure 5.11a).

The gastropod *Austrocochlea porcata* was the most abundant mobile invertebrate at Ricketts Point MS. Higher abundances were observed between 2009 and 2012 (Figure 5.11b). A trend of decreasing abundance was apparnt at Half Moon Bay (Figure 5.11b).

The densities of *Bembicium* spp. were consistently low and steady at both sites untill 2011. Abundances at Ricketts Point subsequently increased (Figure 5.11c).

The mean size of *A. porcata* at both sites had periodic dips through the monitoring period (Figure 5.12a).

The mean size of *Bembicium* spp. followed similar patterns of temporal change at both sites (Figure 5.12b), varying between 5 and 18 mm length (Figure 5.12b).

Anemones, such as *Aulactinia veratra* and *Actinia tenebrosa*, and the seastars *Tosia australis*, *Meridiastra calcar* and *Coscinasterias muricata* were present at Halfmoon Bay in small rock pools on the seaward edge of the intertidal reef.

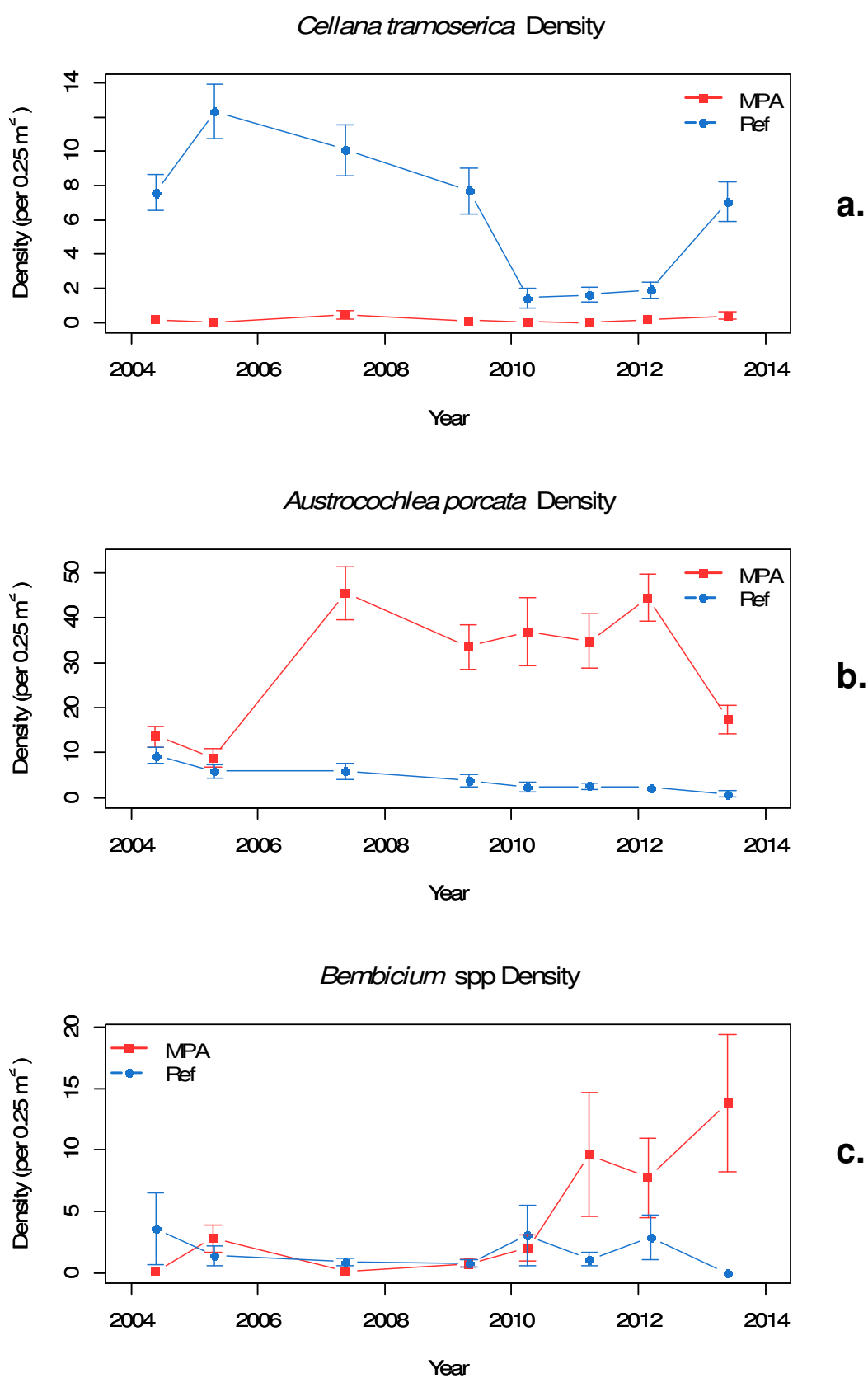


**Figure 5.11.** Mean density ( $\pm$  Standard Error) of dominant mobile invertebrates at Ricketts Point MS and the Half Moon Bay reference site.

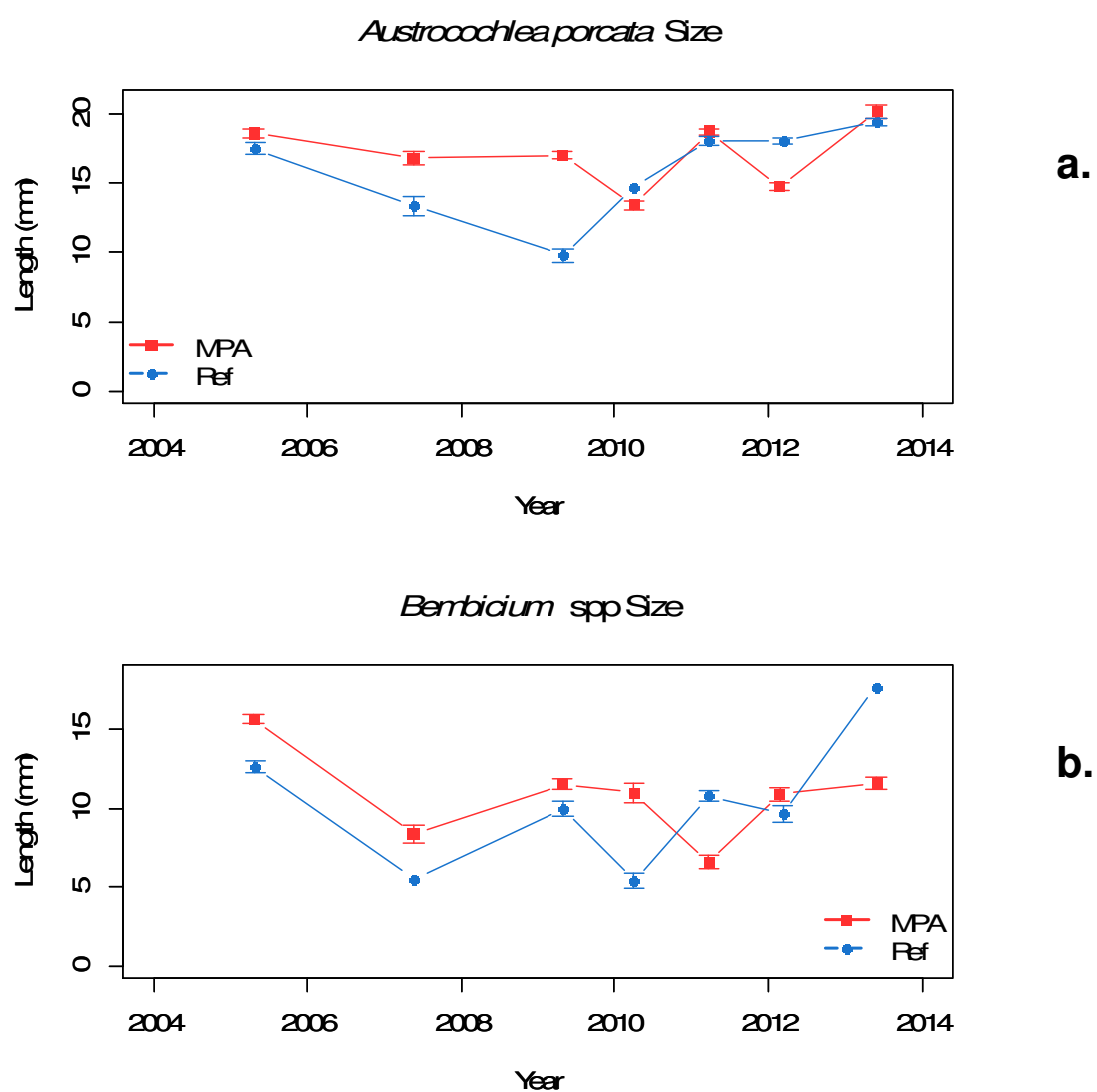


**Figure 5.12.** Mean sizes ( $\pm$  Standard Error) of: (a) the top shell *Austrocochlea porcata*; and (b) the coniwink *Bembicium* spp. at Ricketts Point and the Half Moon Bay reference site.

## 5.6 Ricketts Point Condition Indicators

### 5.6.1 Biodiversity

Community composition, species richness and species diversity in 2012 were within the range of states and changes previously observed.

### 5.6.2 Introduced Species

No introduced species were detected for these sites.

### 5.6.3 Ecosystem Function

The total algal cover has varied considerably over the monitoring period at both sites (Figure 5.13a). Total algae cover at Ricketts Point MS has been relatively high since 2010 (Figure 5.13a).

Erect coralline algal cover was higher at Halfmoon Bay compared to Ricketts Point, although coverage at both sites was similar in 2013 (Figure 5.13b). Turfing algal cover was consistently higher at Halfmoon Bay than at Ricketts Point, and both sites appear to have similar temporal variations (Figure 5.13c).

Grazer density at both sites varied over time with densities markedly greater at Ricketts Point MS since 2009 (Figure 5.14a). Predator density at Ricketts Point MS remained low and steady throughout the monitoring period. Predator abundance remained consistently higher and more variable through time at Halfmoon Bay throughout the monitoring period (Figure 5.14b).

### 5.6.4 Climate Change

There were no community shifts towards greater affinities with other bioregions.

### 5.6.5 Harvesting

The densities of the gastropod *Austrocochlea porcata* and limpet *Cellana tramoserica* did not provide any indications of increased harvesting pressure at Ricketts Point. There were declines in density of both species at Halfmoon Bay, particularly *Cellana tramoserica*. The temporal patterns of mean sizes provided no indications of changes in harvesting pressure.

### 5.6.6 Trampling

The increase in cover of *Hormosira banksii* at Ricketts Point MS over time means there was no strong evidence for trampling impacts.

### **5.6.7 Environment**

The cover of green algal species has been relatively variable with some peaks up to 12 % cover (Figure 5.15a). Sediment cover was low over the monitoring period for both sites (Figure 5.15b).

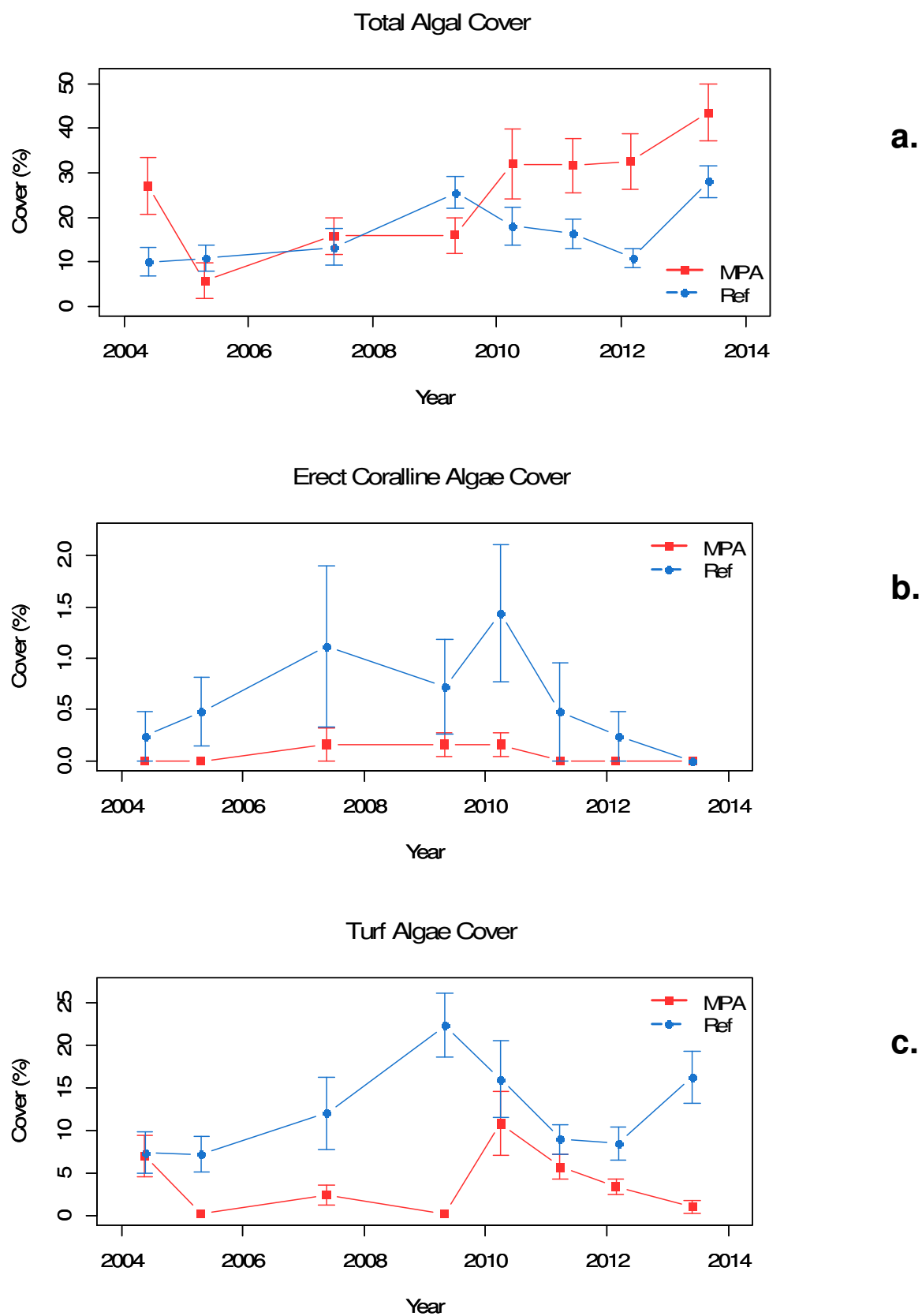


**Figure 5.13.** Mean cover ( $\pm$  Standard Error) of algae within the Ricketts Point MS and the Half Moon Bay reference site.

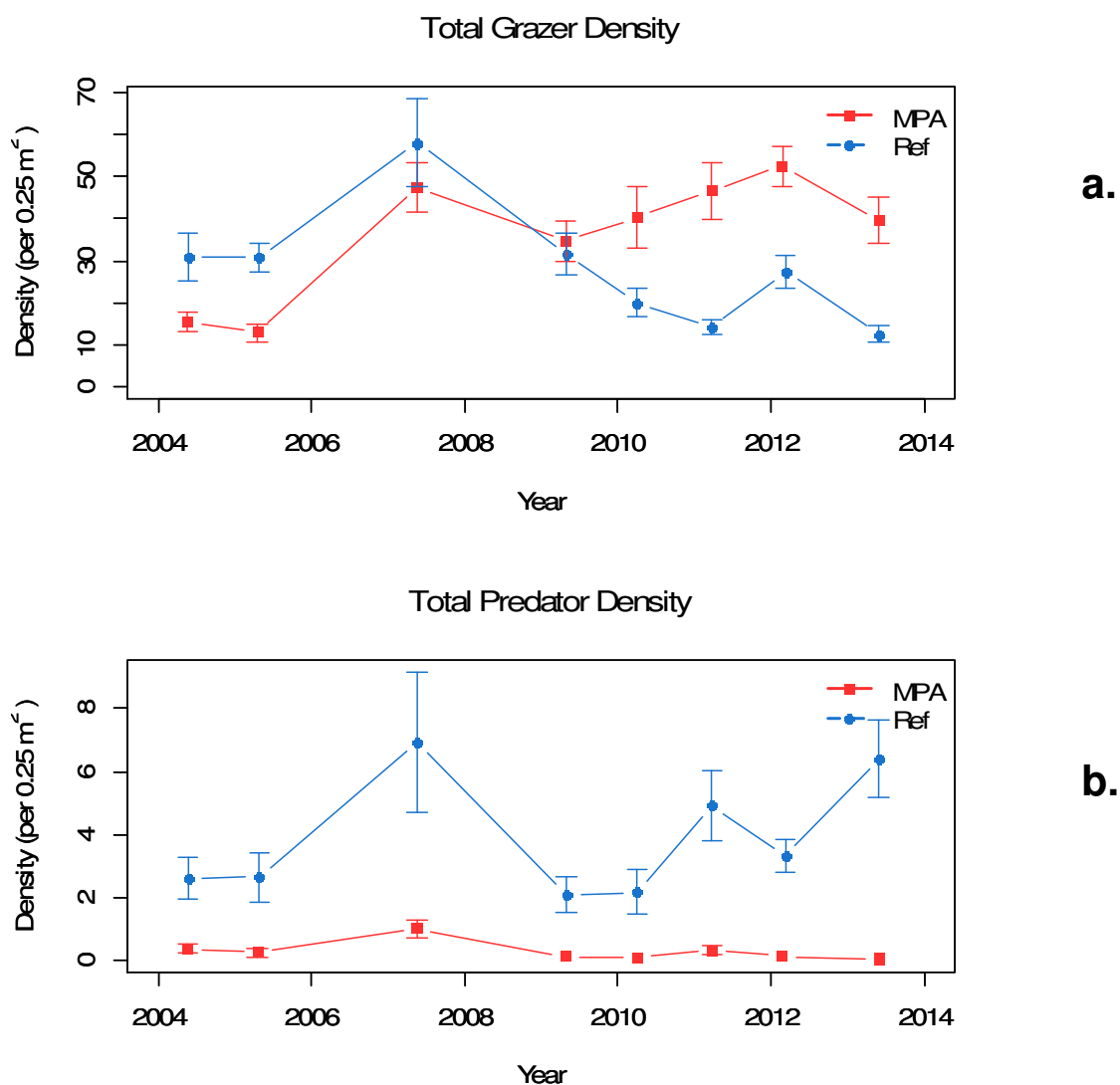


**Figure 5.14.** Mean abundance ( $\pm$  Standard Error) of: (a) all grazers; and (b) all predators within the Ricketts Point MS and the Half Moon Bay reference site.

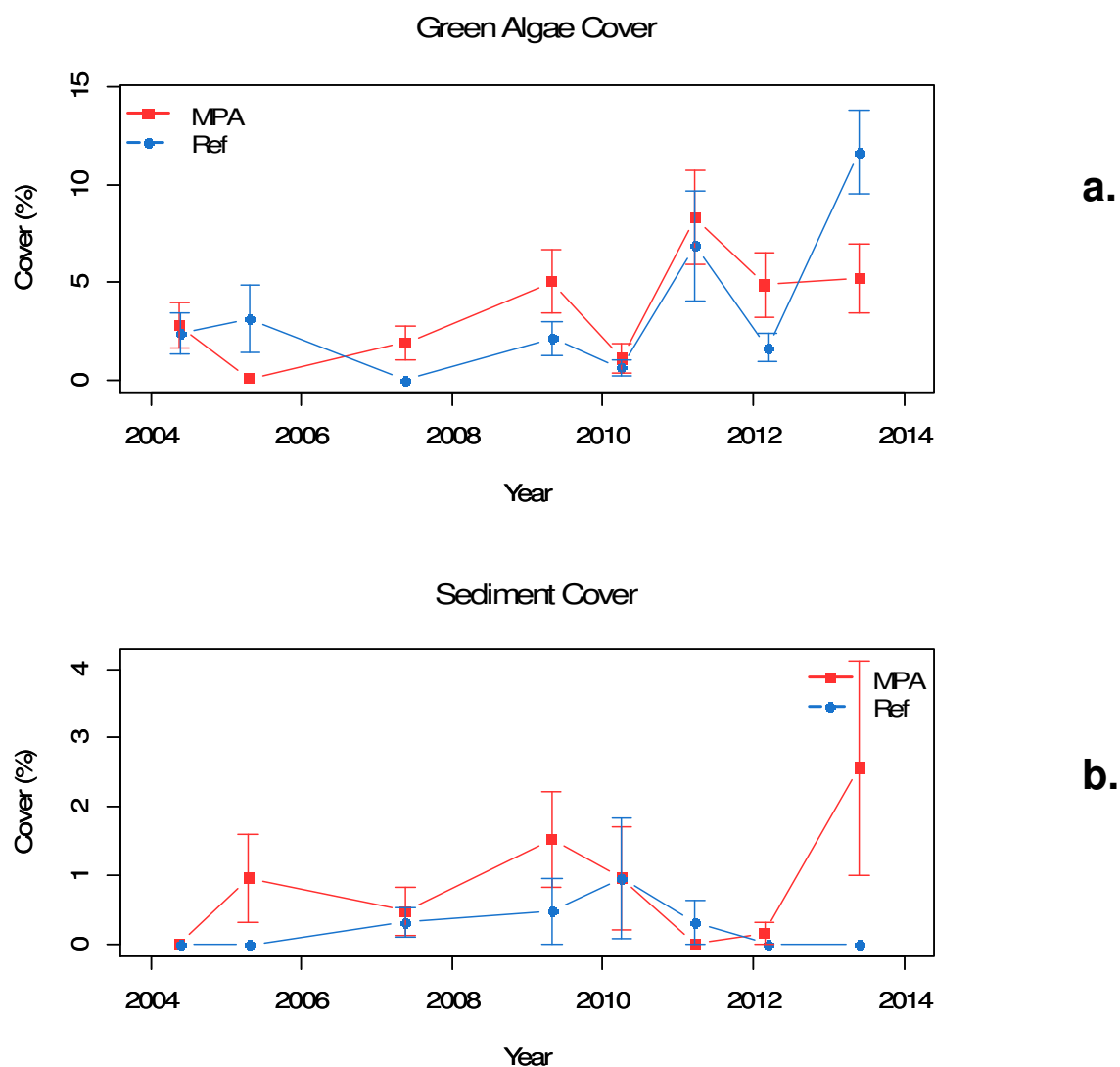


**Figure 5.15.** Mean cover ( $\pm$  Standard Error) of: (a) green algae (*Ulva* spp. and *Cladophora* spp.); and (b) sediment, at Ricketts Point and the Half Moon Bay reference site.

## **6 PORT PHILLIP HEADS MARINE NATIONAL PARK**

### **6.1 Site Description and Transect Layout**

#### **6.1.1 Point Lonsdale (Site 2823)**

The intertidal reef surveyed for the Port Phillip Heads Marine National Park was located at Point Lonsdale, on the western side of Port Phillip Heads. An extensive, triangular intertidal platform projects south and east from the Point Lonsdale headland (Figure 6.1). The calcarenite reef is predominantly flat, with some uneven patches as a result of exposure to strong weather and wave action. The intertidal platform is subject to a high level of trampling by the public. The survey area is on the southern expanse of reef, exposed to swell and wind from the prevailing southern quarter.

#### **6.1.2 Cheviot Bay Reference (Site 2824)**

The intertidal reef is less extensive at Cheviot Bay than at Point Lonsdale and is interrupted by large rock pools and tidal channels (Figure 6.2). The reef at this site is exposed to the prevailing south-westerly weather and sub-maximal wave conditions. The low relief survey area is located immediately to the east of the Point Nepean section of the Port Phillips Heads Marine National Park, with the western end of Cheviot Beach being included within the Marine Park Boundary. Special permission from the management authority (Parks Victoria) is required to access the area because of unexploded ordnance in the vicinity. The intertidal platform is thus not subjected to the high levels of public trampling that occur at Point Lonsdale. In 2013, experimental plots with manipulation were observed within the monitoring area, indicating the monitoring site is being deliberately impacted by research activities.



**Figure 6.1.** Intertidal reef at Point Lonsdale, Port Phillip Heads Marine National Park, 30 May 2013. The photo shows the typical algal assemblage present; *Hormasira banksii* predominates with interspersed patches of *Ulva* spp.



**Figure 6.2.** Intertidal reef at the Cheviot Bay reference site, 1 June 2013.

## 6.2 Port Phillip Heads Community Structure

The mobile invertebrate communities at Point Lonsdale (Site 2823) and the Cheviot Bay reference site (Site 2824) were similar for most surveys (Figure 6.3). The slit limpet *Montfortula rugosa* and false limpet *Siphonaria* spp. were prevalent at both sites. Other limpets *Cellana tramoserica*, *Patelloida alticostata* and *Notoacmea* spp. were also common. The conniwink *Bembicium nanum* was more abundant at Point Lonsdale. The community structure at Point Lonsdale was more variable over time than Cheviot Bay (Figure 6.3).

The sessile species community structure was similar at Point Lonsdale and Cheviot Bay. The brown alga Neptune's Necklace *Hormosira banksii* was the dominant cover, with some *Corallina officinalis*, *Ulva* spp. and algal turf also present. The mat-forming mussel *Limnoperna pulex* occurred at low density at Point Lonsdale and was recorded infrequently at Cheviot Bay. The MDS analysis showed that the community structure at Point Lonsdale was more variable than Cheviot Bay (Figure 6.4).

## 6.3 Port Phillip Heads Diversity

Species richness of mobile invertebrates was relatively stable at both Point Lonsdale and the reference Cheviot Bay, with a very slight decreasing trend apparent at both sites (Figure 6.5).

Sessile species richness at both sites was stable, apart from a spike at both sites in 2006 (Figure 6.5).

Diversity (Hills  $N_2$ ) of mobile invertebrates co-varied at Point Lonsdale and Cheviot Bay since the 2005 survey. There was a decreasing trend and diversity was at the lowest recorded values in 2012 and 2013 (Figure 6.7).

Sessile species diversity at both sites remained low and stable throughout the monitoring period, reflecting the dominance of *H. banksii* at these sites (Figure 6.8).

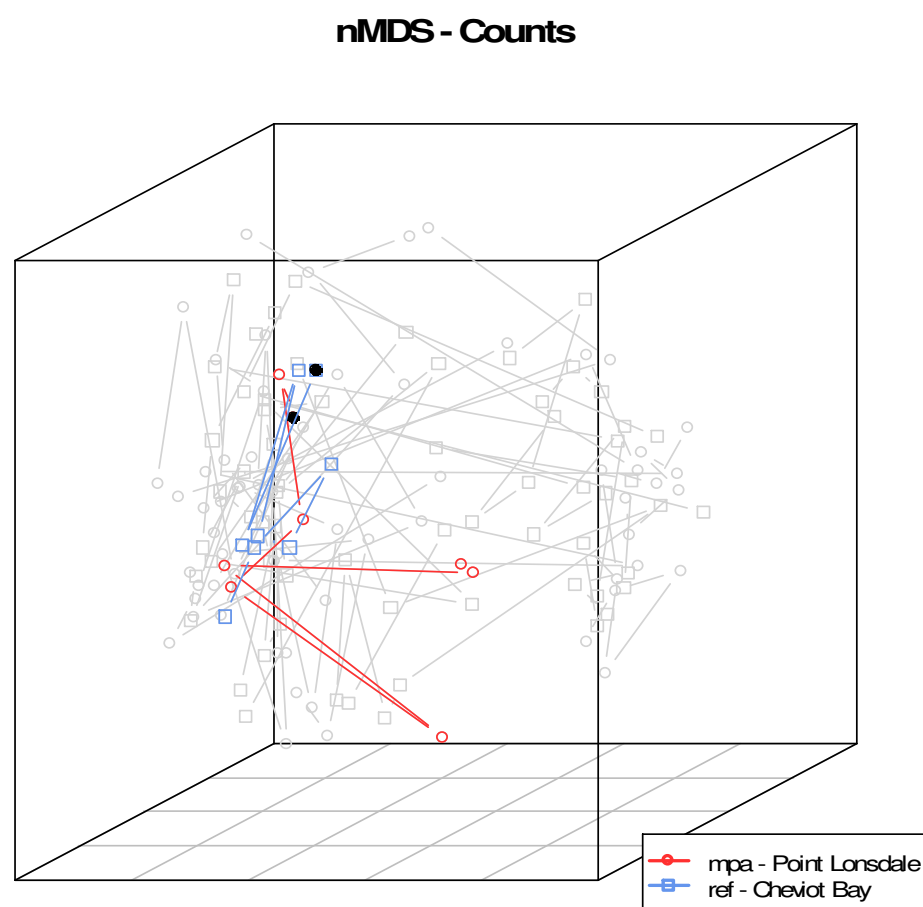


**Figure 6.3.** Three dimensional MDS plot of mobile invertebrate assemblages on intertidal reefs at Point Lonsdale and the Cheviot Bay reference site. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.13.

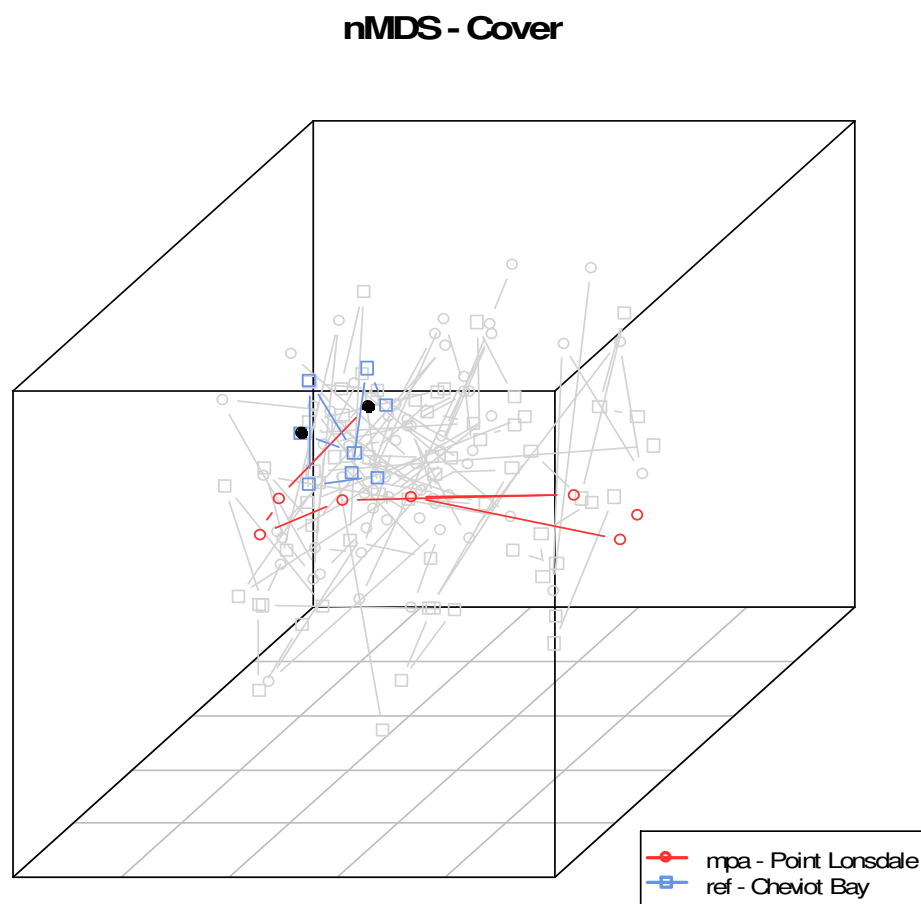


**Figure 6.4.** Three dimensional MDS plot of macroalgae and aggregating sessile invertebrate assemblages on intertidal reefs at Point Lonsdale and the Cheviot Bay reference site. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.18.

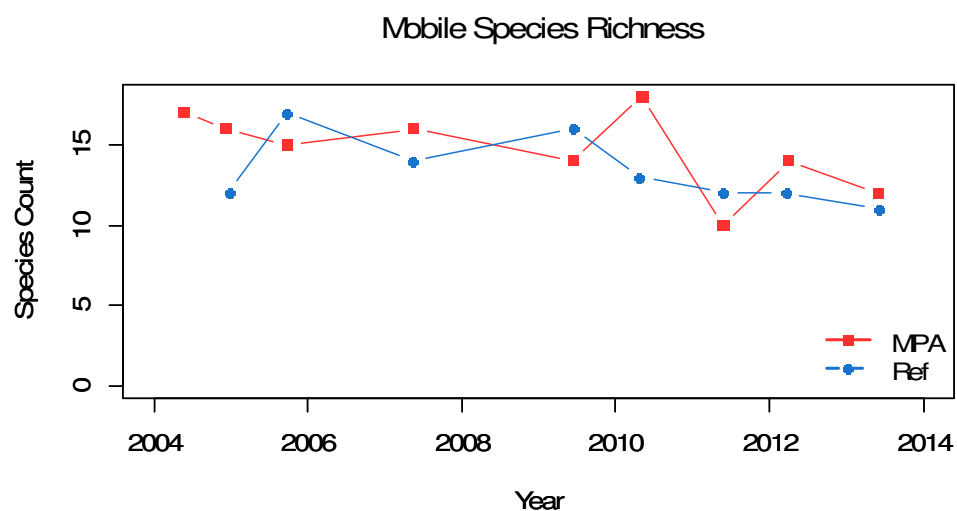


**Figure 6.5.** Mobile invertebrate species richness at Point Lonsdale and the Cheviot Bay reference site.

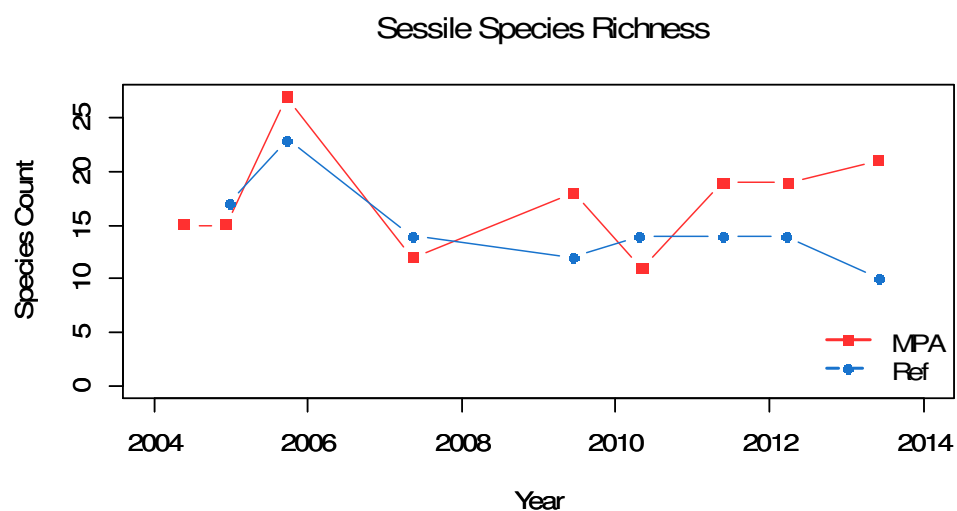


**Figure 6.6.** Algal and aggregating sessile invertebrate species richness of intertidal sites at Point Lonsdale and the Cheviot Bay reference site.

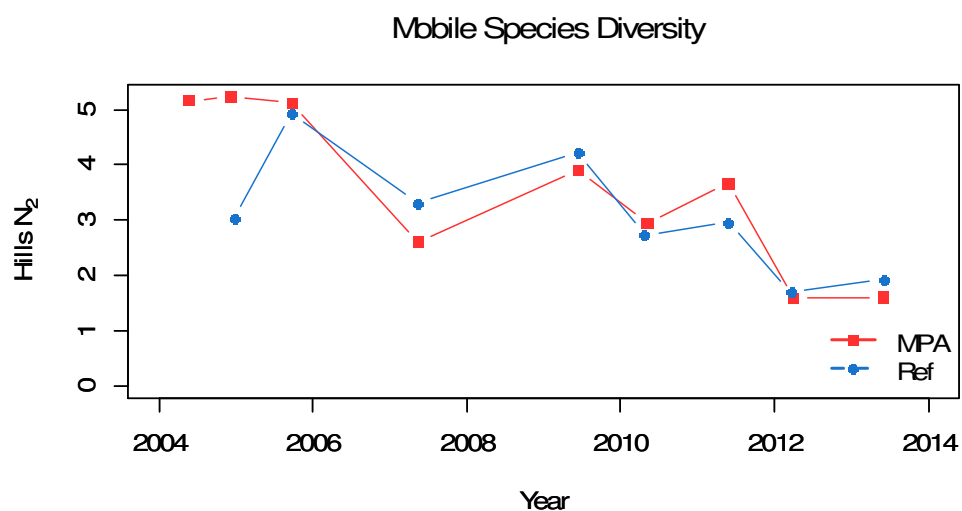


**Figure 6.7.** Mobile invertebrate diversity (Hills  $N_2$ ) of intertidal sites at Point Lonsdale and the Cheviot Bay reference site.

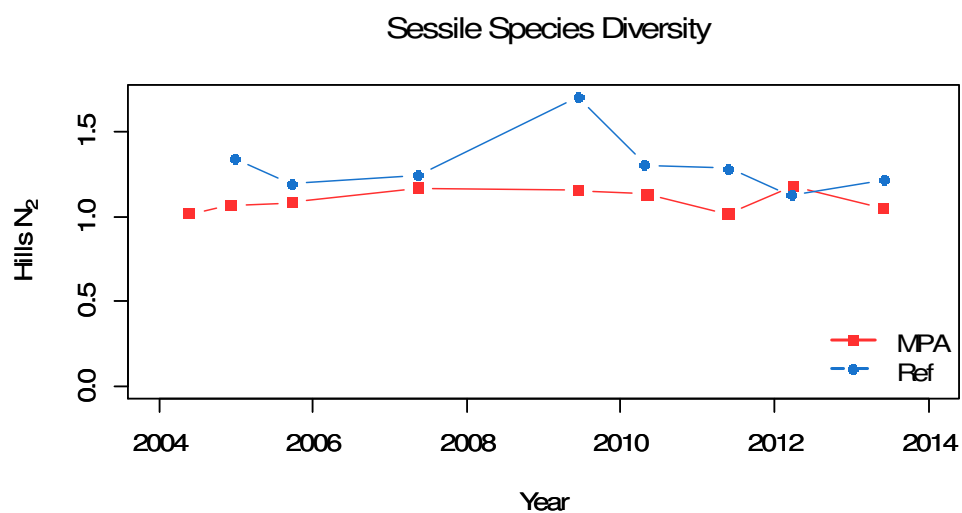


**Figure 6.8.** Algal and aggregating sessile invertebrate diversity (Hill's  $N_2$ ) of intertidal sites at Point Lonsdale and the Cheviot Bay reference site.

## 6.4 Port Phillip Heads Macroalgae and Aggregating Sessile Invertebrates

The small change in shore height across the reef platforms at both sites and the low relief of the reefs resulted in a macroalgal community dominated by Neptune's Necklace *Hormosira banksii*. The cover of *H. banksii* at both sites was high and relatively stable over time (Figure 6.9).

Coralline and turfing algae were generally more abundant at Cheviot Bay, although present in only low densities of less than 5 %.

Sand inundation was generally low and variable at both sites, generally covering between 2 % and 10 % of the reef throughout the monitoring period.

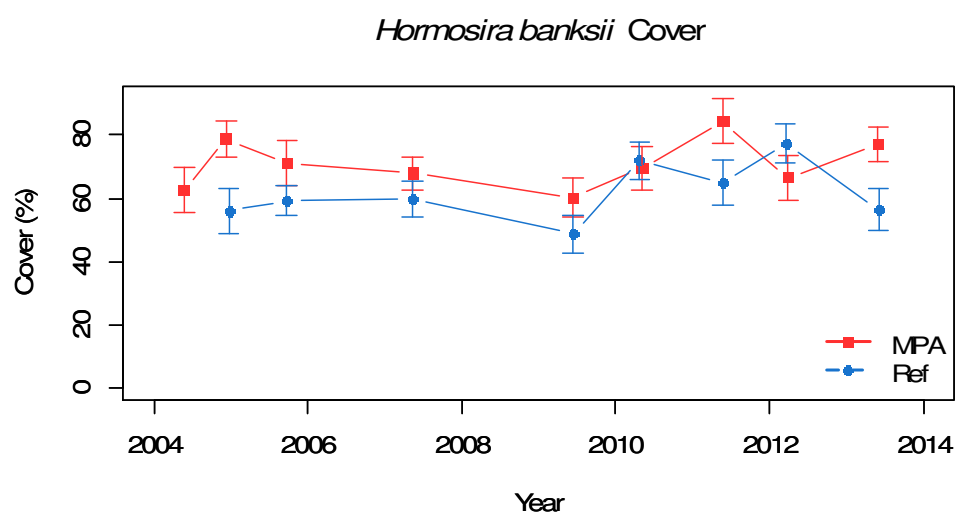
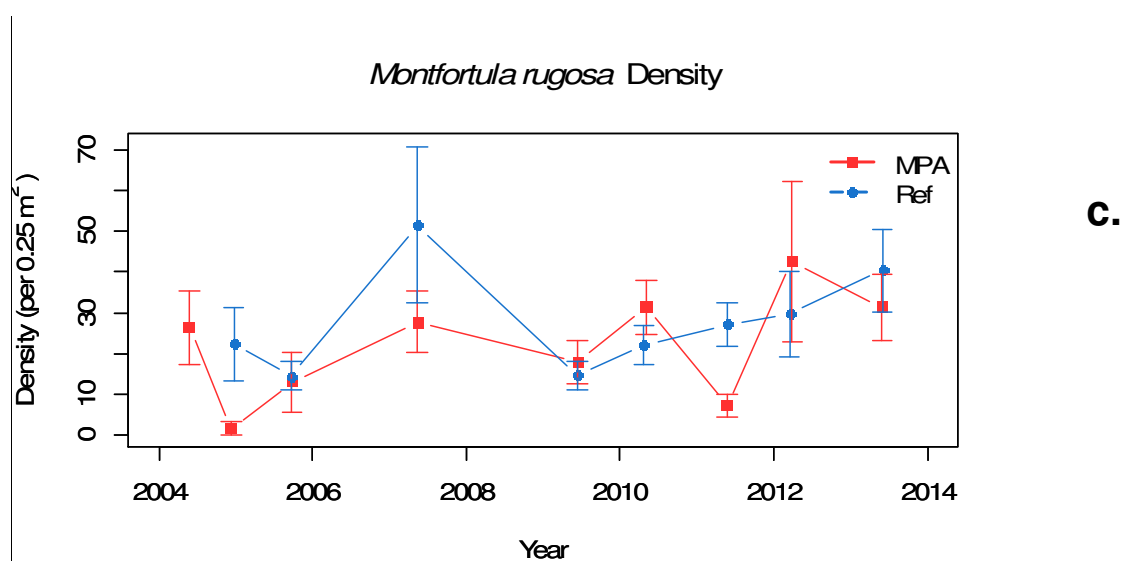
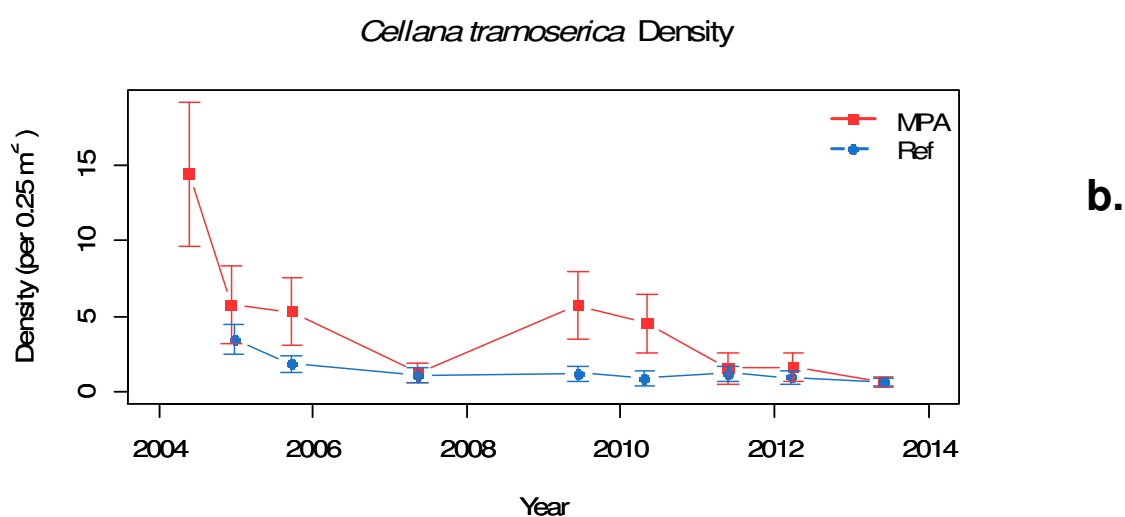
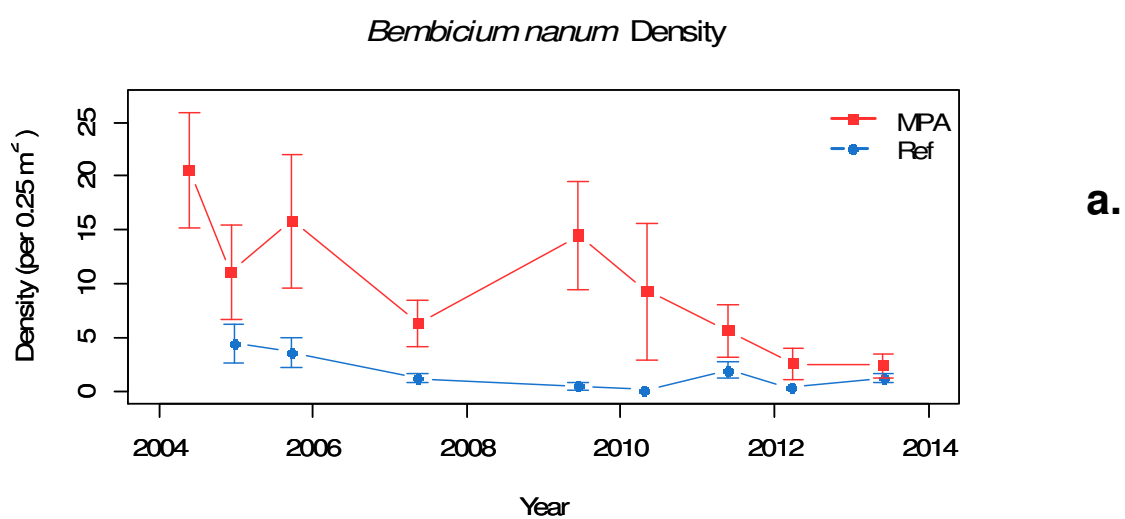


**Figure 6.9.** Mean density ( $\pm$  Standard Error) of Neptune's Necklace *Hormosira banksii* at Point Lonsdale and the Cheviot Bay reference site.

## 6.5 Port Phillip Heads Mobile Invertebrates

The mean density of the limpet *C. tramoserica* at Point Lonsdale decreased from 15 individuals  $0.25 \text{ m}^{-2}$  to  $<1$  individuals  $0.25 \text{ m}^{-2}$  in 2013. Cheviot Bay generally had lower abundances of *C. tramoserica* (Figure 6.10a). The conniwink *Bembicium nanum* density was consistently higher at Point Lonsdale compared with Cheviot Bay until 2010, after which there was a downward trend to densities similar to Cheviot Bay. (Figure 6.10b). *Montfortula rugosa* was the most abundant mobile invertebrate species at both sites and densities were considerably variable between surveys with no apparent longer term trends (Figure 6.10c). The limpets *Siphonaria* spp. were frequently at reasonably high densities at both sites, but were not observed during the last two surveys (Figure 6.10d).

The mean length of the limpet *C. tramoserica* has been relatively stable at both Point Lonsdale and Cheviot Bay with similar mean lengths at both sites for the past few years (Figure 6.11).



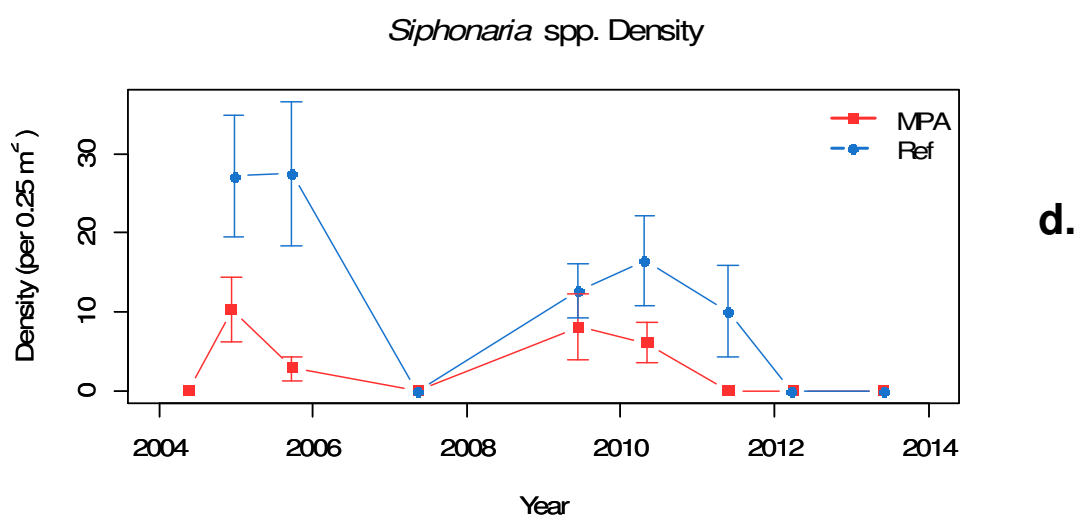


**Figure 6.10.** Mean density ( $\pm$  Standard Error) of dominant mobile invertebrates at Point Lonsdale and the Cheviot Bay reference site.

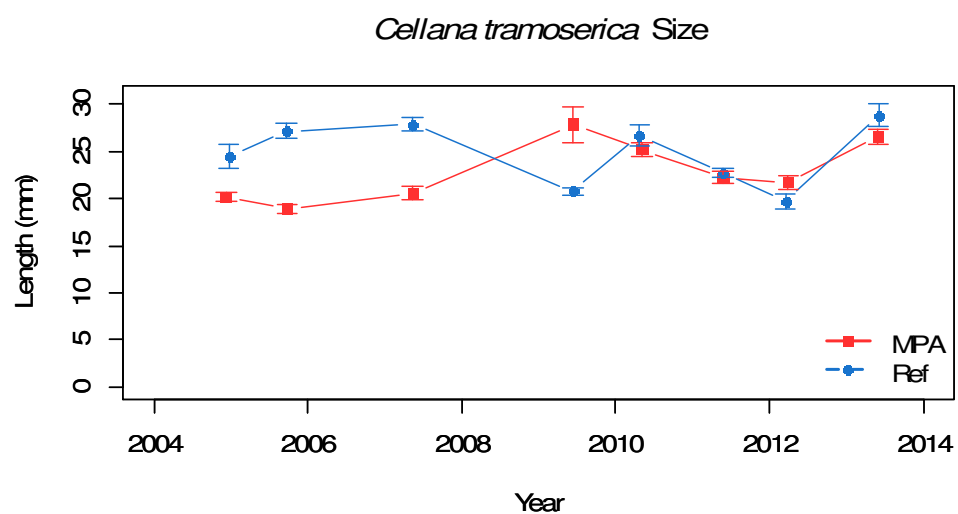


**Figure 6.11.** Mean sizes ( $\pm$  Standard Error) of the limpet *Cellana tramoserica* at Point Lonsdale and the Cheviot Bay reference site.

## 6.6 Port Phillip Heads Condition Indicators

### 6.6.1 Biodiversity

The community structure at Point Lonsdale is presently outside previously observed community assemblage states. Species richness and species diversity were within the range of states and changes previously observed, apart from mobile species diversity, which was at the lowest levels for both sites.

### 6.6.2 Introduced Species

No introduced species were detected for these sites.

### 6.6.3 Ecosystem Function

Total algae cover was stable and remained high at both sites, being driven by *Hormosira banksii* abundance (Figure 6.13a).

Erect coralline algae and turfing algae cover was generally higher and more variable at Cheviot Bay (Figure 6.13b and 6.13c).

The total grazer density was generally stable at both sites apart from a spike at Cheviot Bay in 2007 (Figure 6.14a). Total predator density was low and stable at both sites (Figure 6.14b).

### 6.6.4 Climate Change

There were no community shifts towards greater affinities with other bioregions.

### 6.6.5 Harvesting

Mean size of *Cellana tramoserica* has been relatively stable at both sites, fluctuating by approximately 5 mm, and provides no indications of any change to harvesting pressure.

### 6.6.6 Trampling

There is restricted access to the Cheviot Bay reference site and public trampling pressure is considered negligible and this is reflected in the presently high *H. banksii* coverage. Recent scientific disturbances were observed in the monitoring area in 2013. Point Lonsdale is a popular location amongst the general public and education groups and there is likely to be some level of trampling pressure, particularly over holiday periods. There was no apparent impact of this trampling on the survey area, as the cover of *H. banksii* was generally higher at Point Lonsdale than Cheviot Bay and showed similar variations through time.

### 6.6.7 Environment

The cover of green algal species was relatively low at these sites (Figure 6.15a).

Sediment cover was generally low and variable at both sites. There was a peak of 10 % cover in 2009 (Figure 6.15b).



**Figure 6.12.** Photograph of Point Lonsdale at high tide 2013.

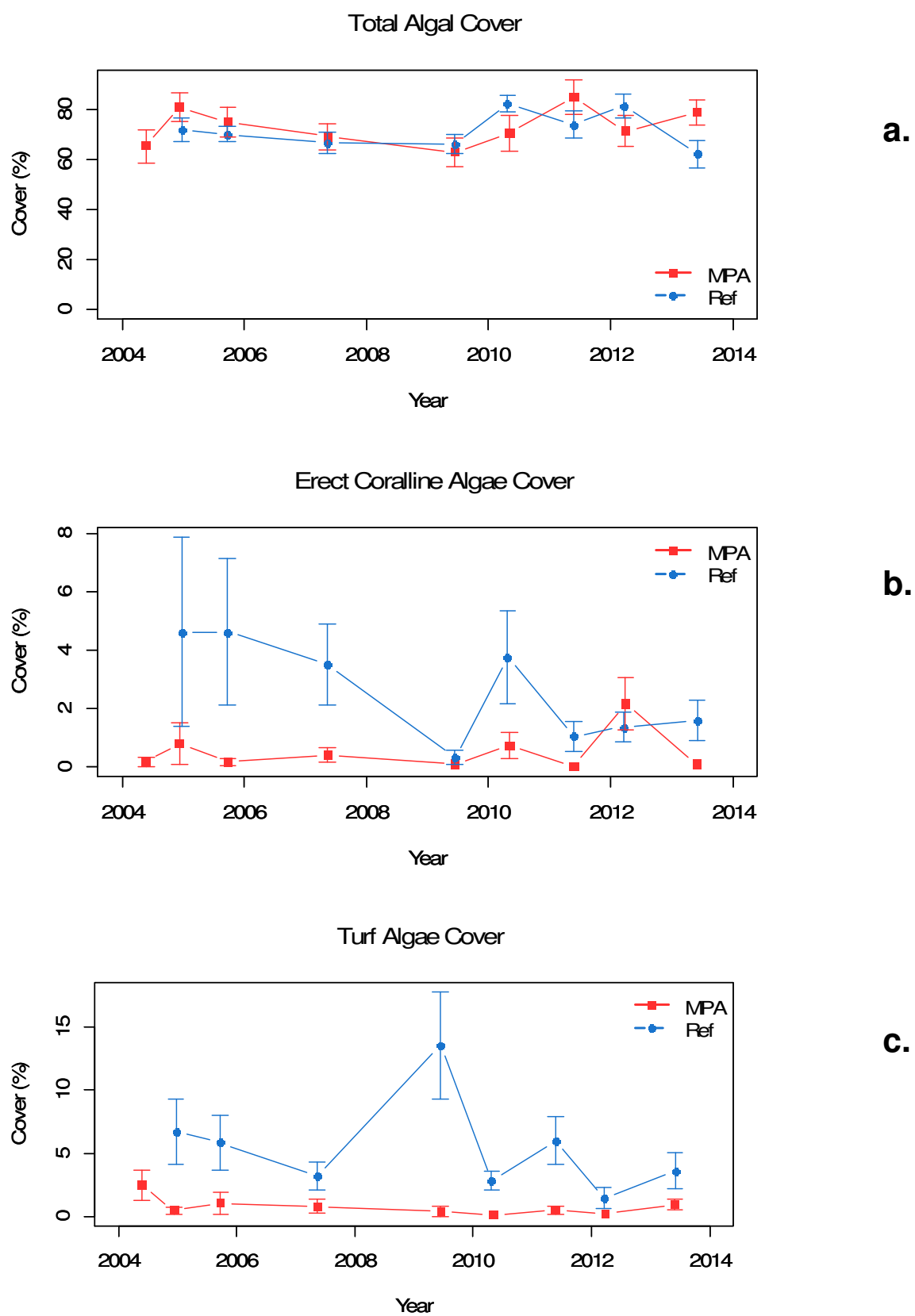


**Figure 6.13.** Mean cover ( $\pm$  Standard Error) of algae at Point Lonsdale and the Cheviot Bay reference site.

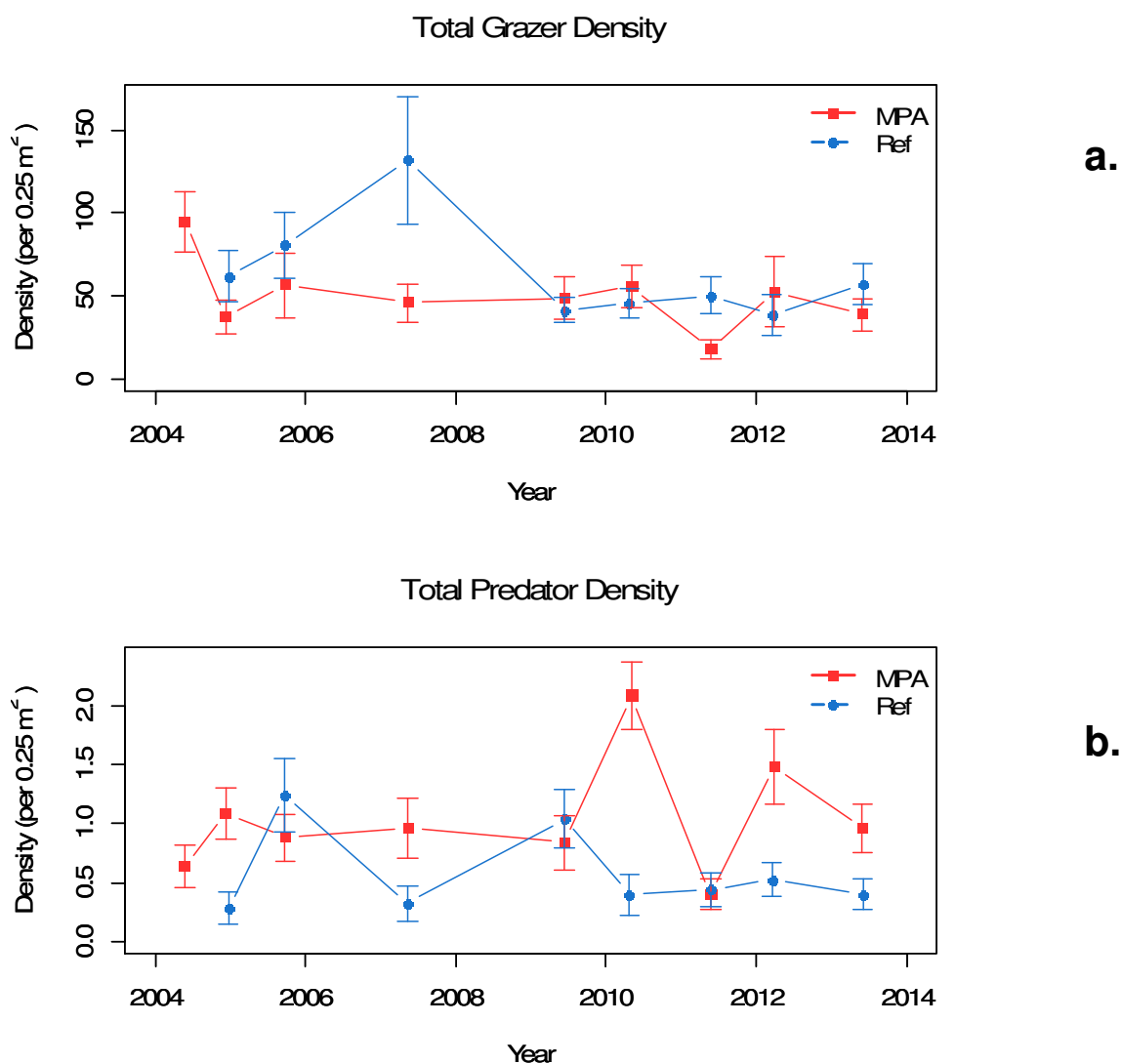


**Figure 6.14.** Mean abundance ( $\pm$  Standard Error) of: (a) all grazers; and (b) all predators at Point Lonsdale and the Cheviot Bay reference site.

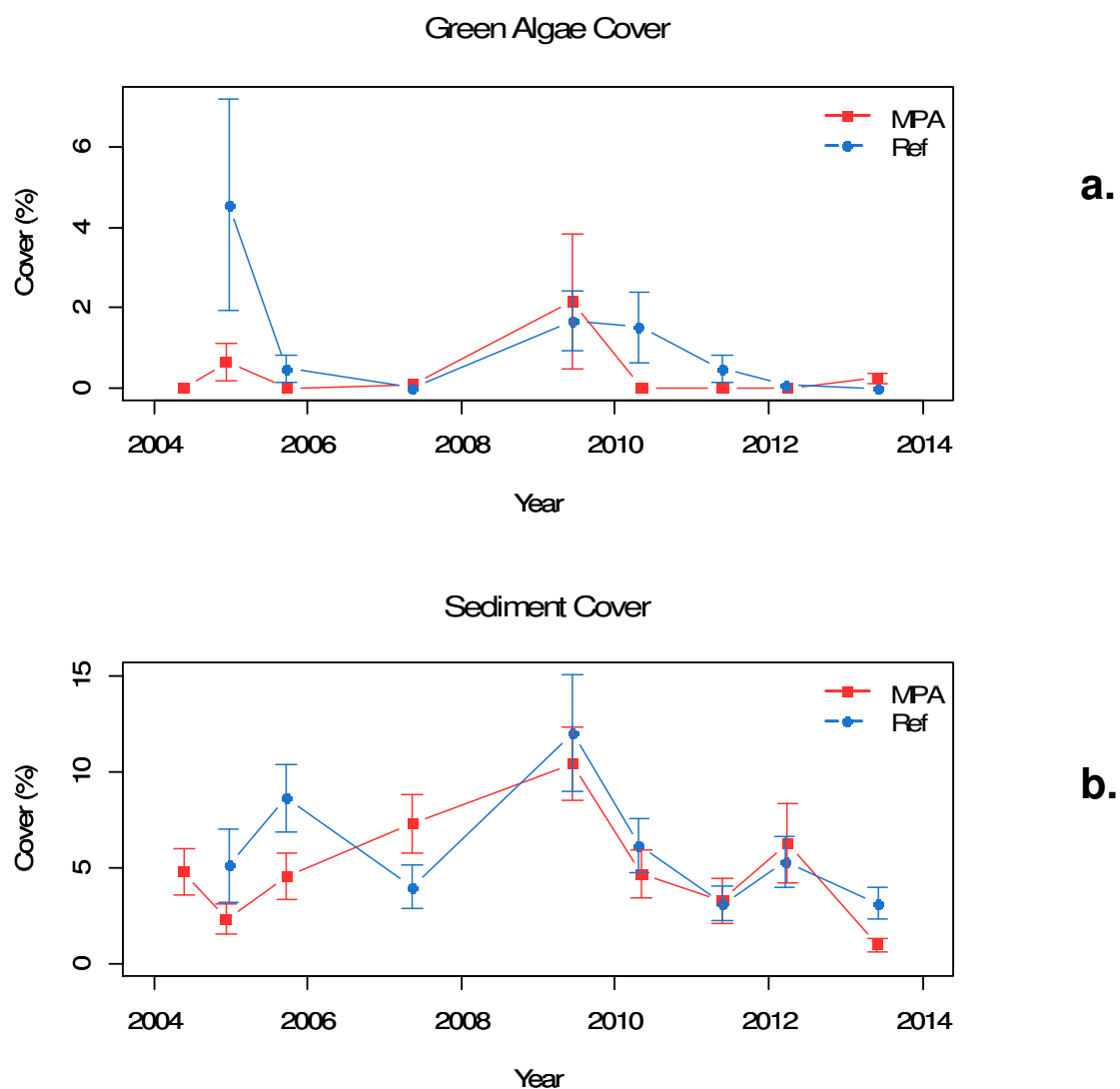


**Figure 6.15.** Mean cover ( $\pm$  Standard Error) of: (a) green algae (*Ulva* spp. and *Cladophora* spp.); and (b) sediment at Point Lonsdale and the Cheviot Bay reference site.

## **7 MUSHROOM REEF MARINE SANCTUARY**

### **7.1 Site Description and Transect Layout**

#### **7.1.1 Mushroom Reef Marine Sanctuary (Site 2907)**

Located near Flinders, Mushroom Reef is a basalt intertidal reef in the shape of a mushroom. There is a large intertidal isthmus (the stem of the mushroom) that is composed of basalt pebbles and boulders (Figure 7.1). Sections of the isthmus tend to inundate with water soon after the tide begins to rise. The head of the mushroom is low-relief, uneven basalt reef with some pebbles and boulders (Figure 7.1). The highest section of the reef is the centre of the head of the mushroom. This area slopes away gently to the subtidal at its outer edge. Mushroom Reef is exposed on all sides, but is protected from large swell by a shallow reef further offshore.

The survey site at Mushroom Reef was positioned at the south eastern side of the reef as this is representative of the predominant intertidal habitat.

#### **7.1.2 Flinders West Reference (Site 2908)**

The reference site for Mushroom Reef was on the nearest intertidal platform to the west of the marine sanctuary. The intertidal area at Flinders West is a low-relief, gently sloping basalt reef with occasional small steps and boulder outcrops (Figure 7.2). Patches of sand covered areas at the lowest reef extent. As with Mushroom Reef, Flinders West has a south-easterly aspect and is moderately sheltered from wind and waves from the southwest. It is also protected from large swell by a shallow reef further offshore.



**Figure 7.1.** Intertidal reef at Mushroom Reef Marine Sanctuary: 8 June 2004



**Figure 7.2.** Intertidal reef at the Flinders West reference site, 31 May 2013.

## 7.2 Mushroom Reef Community Structure

The mobile invertebrate community at Mushroom Reef (Site 2907) was dominated by the top shell *Austrocochlea constricta*, conniwink *Bembicium* spp., and the pulmonate limpets *Siphonaria* spp. Commonly found species at the reference West Flinders site (Site 2908) were the top shell *A. constricta*, *Lepsiella vinosa*, the black nerite *Nerita atramentosa* and *Siphonaria* spp. The MDS analysis showed large variations in community structure through time at both sites compared to sites elsewhere in central Victoria (Figure 7.3). The sites were relatively dissimilar to each other (Figure 7.3).

The sessile species observed were similar between Mushroom Reef and the reference West Flinders site. The assemblage consisted of predominantly the brown alga Neptune's Necklace *Hormosira banksii*, pink coralline alga *Corallina officinalis*, encrusting coralline algae and algal turf. The MDS analysis showed both sites had relatively large variation in community structure through time and that the two sites were different for most times (Figure 7.4).

## 7.3 Mushroom Reef Diversity

The species richness of mobile invertebrate species at both sites had only minor variations over time, but had a downward trend from 2009 (Figure 7.5).

Algal and aggregating sessile invertebrate species richness at both sites showed fluctuations through time with no apparent trends (Figure 7.6).

Mobile invertebrate Hills diversity ( $H_2$ ) was initially high for both sites. This decreased markedly at West Flinders in 2009 and at Mushroom Reef in 2010 and remained low since (Figure 7.7).

Sessile species diversity was more variable at West Flinders than Mushroom Reef (Figure 7.7). Sessile species diversity was similar at both sites in 2013 (Figure 7.7).

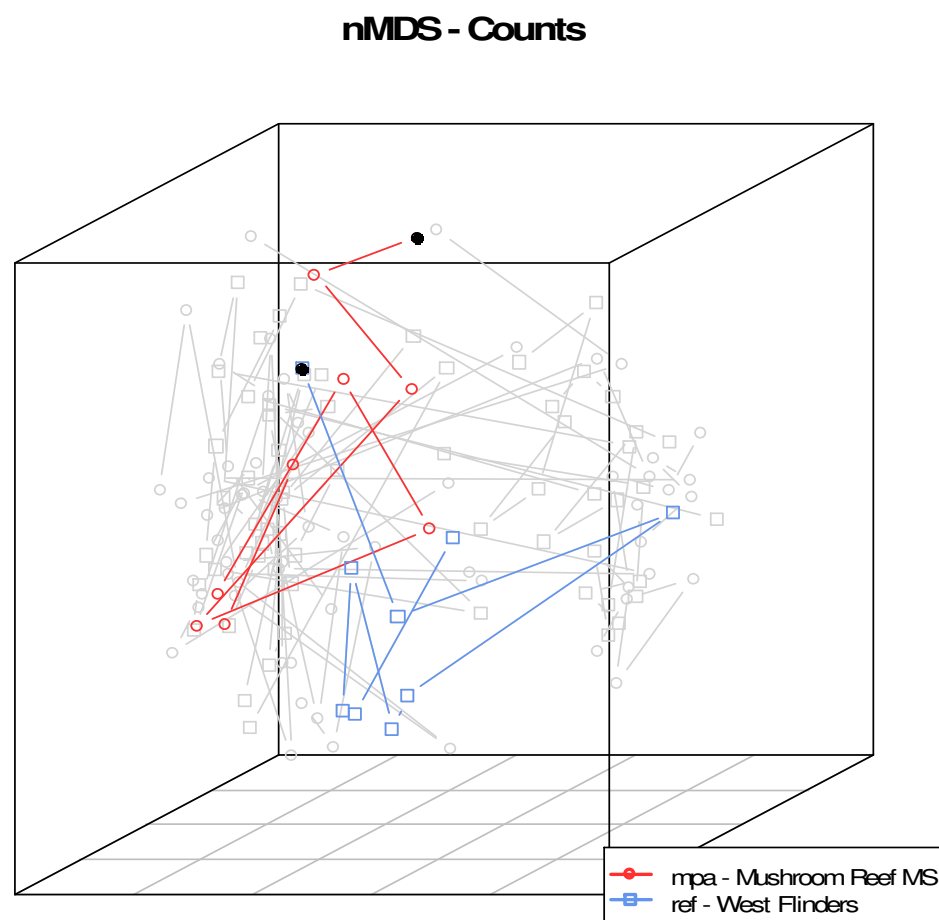


**Figure 7.3.** Three dimensional MDS plot of mobile invertebrate assemblages on intertidal reefs at Mushroom Reef and the West Flinders reference site. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.13.

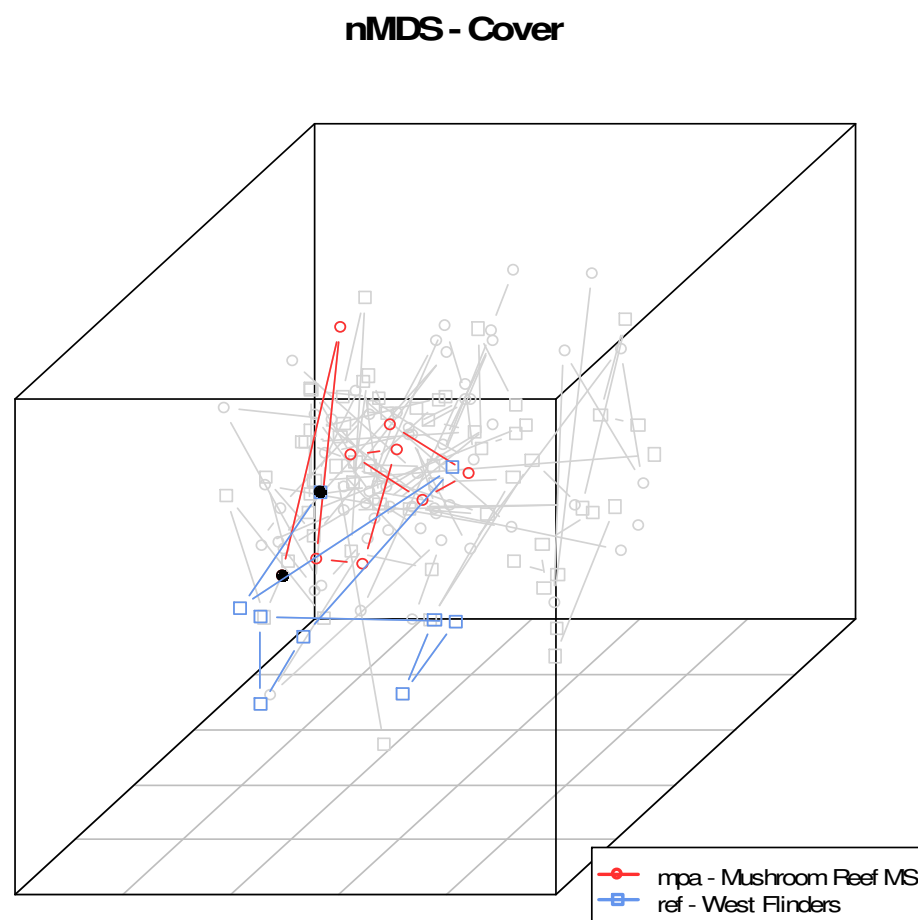


**Figure 7.4.** Three dimensional MDS plot of macroalgae and aggregating sessile invertebrate assemblages on intertidal reefs at Mushroom Reef and the West Flinders reference site. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.18.

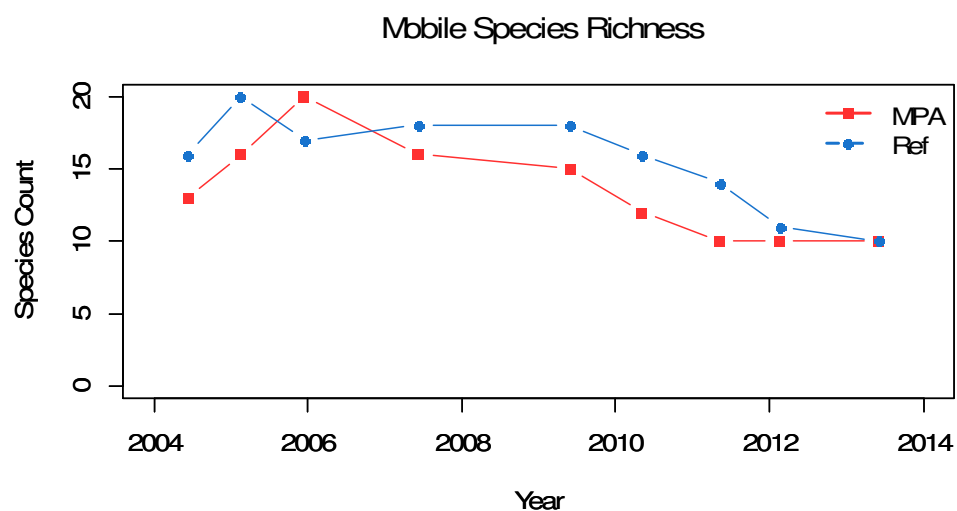


**Figure 7.5.** Mobile invertebrate species richness at Mushroom Reef and the West Flinders reference site.

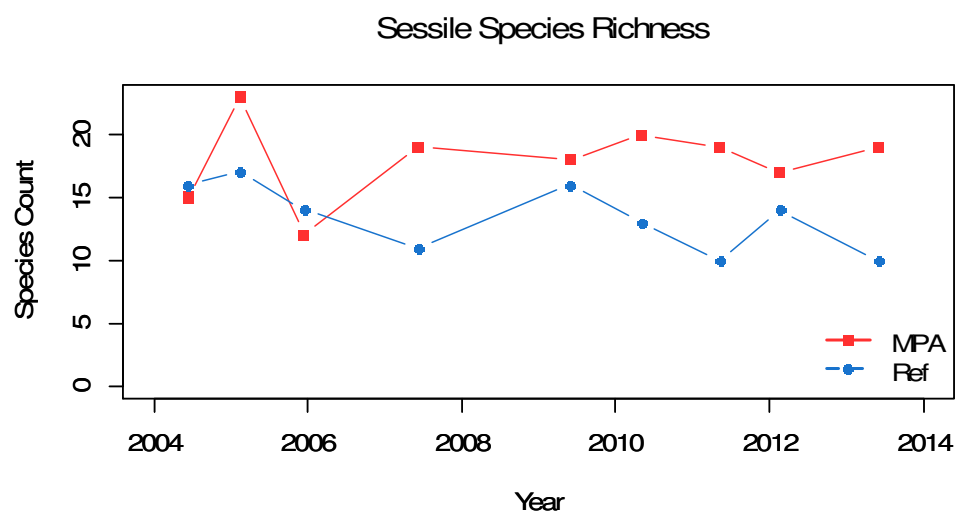


**Figure 7.6.** Algal and aggregating sessile invertebrate species richness of intertidal sites at Mushroom Reef and the West Flinders reference site.

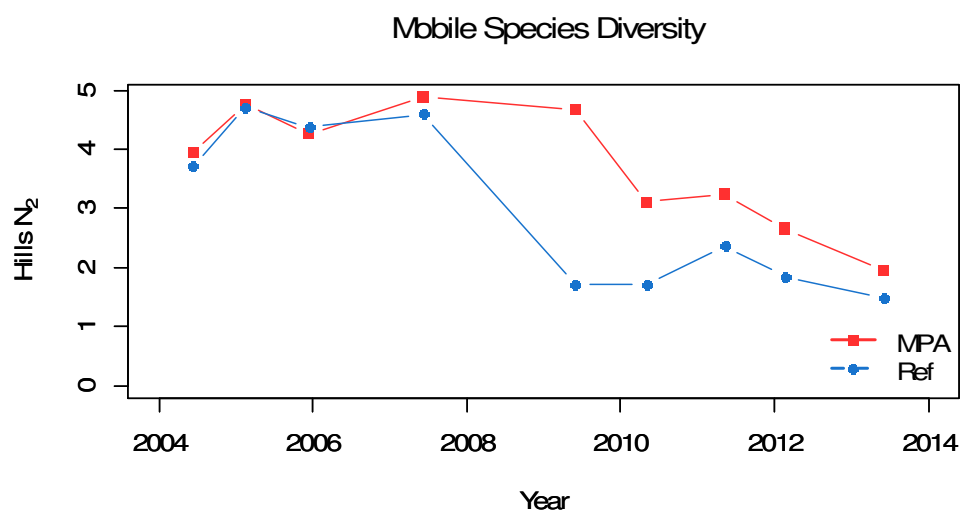


**Figure 7.7.** Mobile invertebrate diversity (Hills  $N_2$ ) of intertidal sites at Mushroom Reef, and the West Flinders reference site.

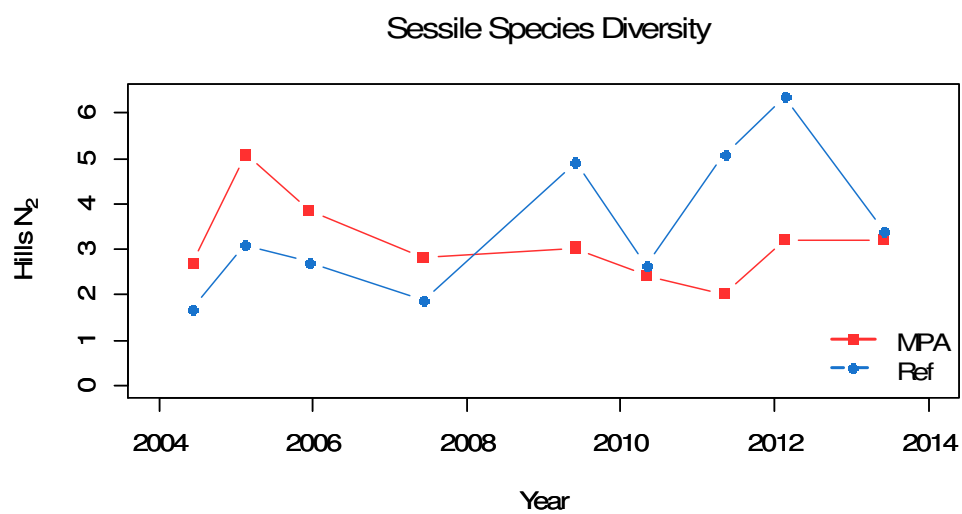


**Figure 7.8.** Algal and aggregating sessile invertebrate diversity (Hill's  $N_2$ ) of intertidal sites at Mushroom Reef and the West Flinders reference site.

## 7.4 Mushroom Reef Macroalgae and Aggregating Sessile Invertebrates

Macroalgal and sessile invertebrate cover was relatively low at Mushroom Reef (Site 2907). Neptune's Necklace *Hormosira banksii* and crustose coralline algae were the dominant species, with *Ulva* spp., and the mat forming mussel *Limnoperna pulex* occurring in low densities. The cover of *H. banksii* was variable, ranging between 1 and 16 % cover over time (Figure 7.9).

Macroalgal cover at West Flinders (Site 2908) was variable through surveys. After a substantial decrease in cover of *H. banksii* between 2005 and 2007, the cover of *H. banksii* in subsequent surveys fluctuated between 6 and 15 % (Figure 7.9). The seagrass *Zostera muelleri* was intermittently detected at Flinders West from 2004, in low coverages.

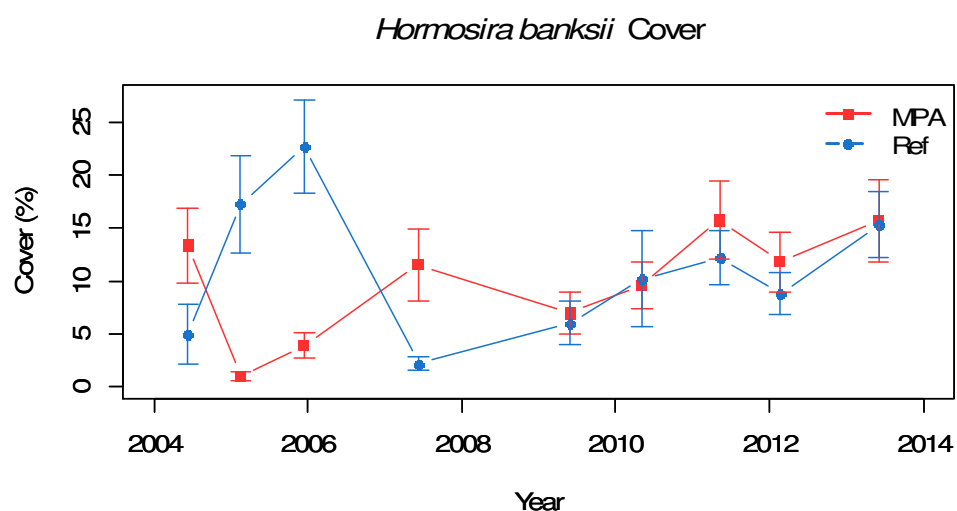


**Figure 7.9.** Mean density ( $\pm$  Standard Error) of Neptune's Necklace *Hormosira banksii* at Mushroom Reef and the West Flinders reference site.

## 7.5 Mushroom Reef Mobile Invertebrates

The mobile invertebrate population structure at both Mushroom Reef (Site 2907) and the reference West Flinders site (Site 2908) was dominated by the top shell *Austrocochlea constricta*, occurring in dense patches across the shoreline. Other species contributing to the communities were the striped conniwink *Bembicium nanum*, black nerite *Nerita atrimentosa* and the pulmonate limpet *Siphonaria* spp. The seastar *Meridiastra exigua* was common in shallow stands of water on the reef.

Densities of *A. constricta* were consistently higher at Mushroom Reef than at Flinders West (Figure 7.10a). Abundances peaked in 2007 with 27 individuals  $0.25 \text{ m}^{-2}$ , decreasing during subsequent surveys to 6 individuals  $0.25 \text{ m}^{-2}$  in 2013. Densities at West Flinders were low and relatively stable over time (Figure 7.10a).

*Bembicium nanum* densities were likewise consistently higher at Mushroom Reef, although densities at both sites have declined substantially since 2006 (Figure 7.10b).

The mean size of *B. nanum* followed similar patterns through time at both sites (Figure 7.11a). There was an upward trend since 2007 (Figure 7.11a).

The mean size of *A. constricta* was stable through time, showing no clear patterns (Figure 7.11b).

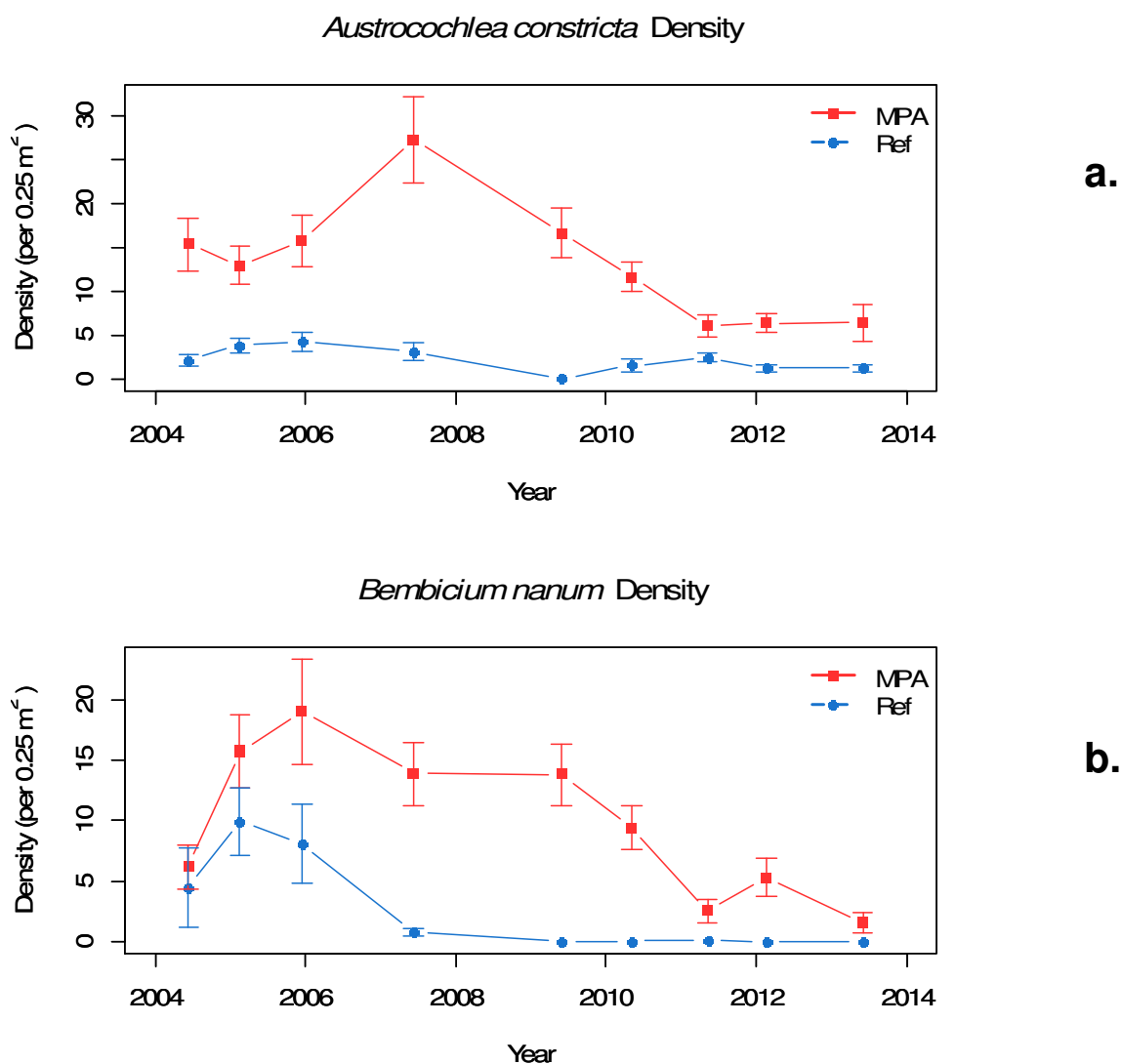


**Figure 7.10.** Mean density ( $\pm$  Standard Error) of dominant mobile invertebrates at Mushroom Reef and the West Flinders reference site.

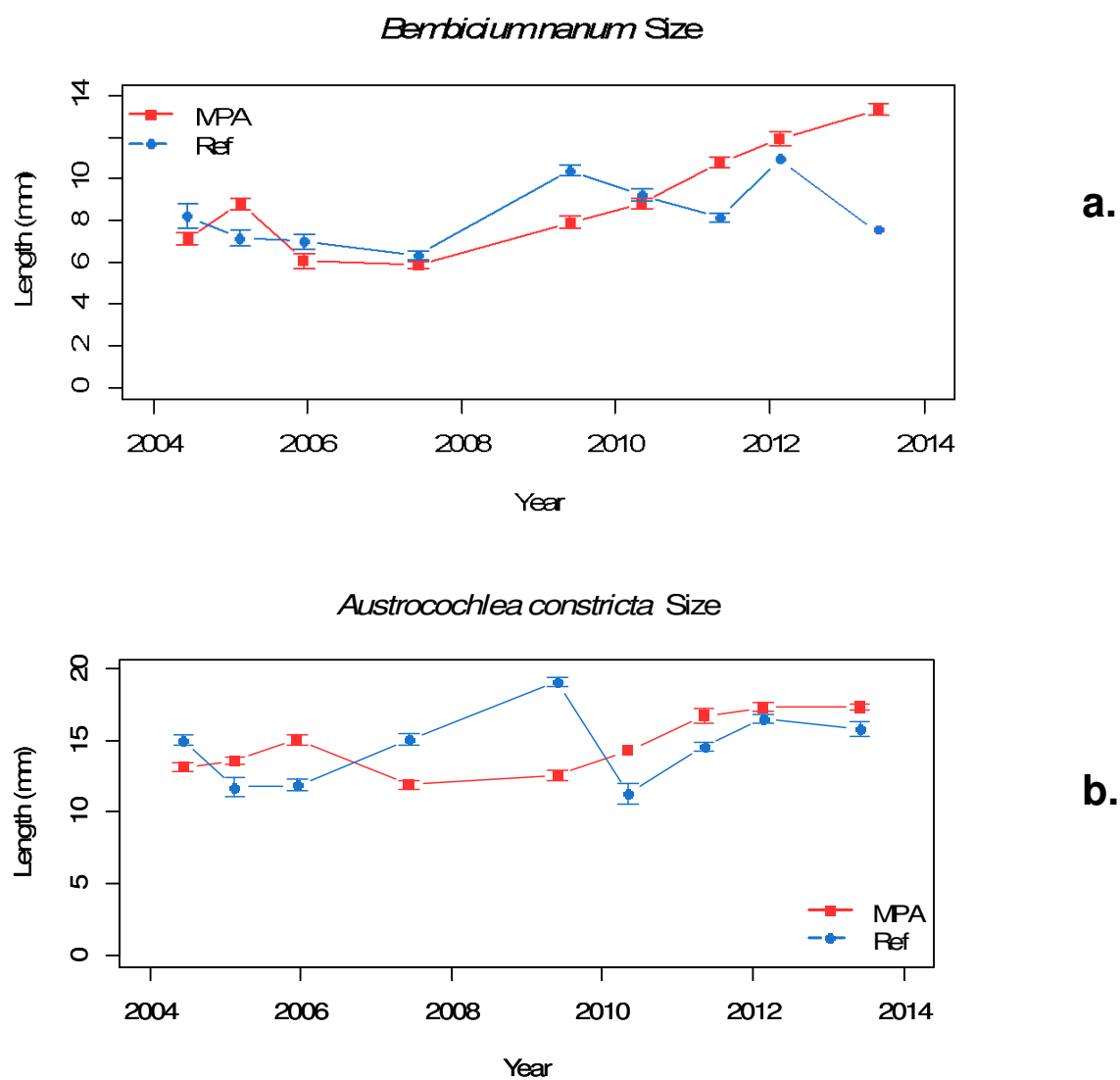


**Figure 7.11.** Mean sizes ( $\pm$  Standard Error) of: (a) the coniwink *Bembicium* spp. And (b) the top shell *Austrocochlea constricta* at Mushroom Reef and the West Flinders reference site.

## 7.6 Mushroom Reef Condition Indicators

### 7.6.1 Biodiversity

Community composition and species richness remained within the range of states and changes previously observed although community composition was considerably variable. Mobile species diversity had declined to lowest levels by 2012 and 2013 at both sites. Sessile species diversity changed little over the monitoring period.

### 7.6.2 Introduced Species

No introduced species were observed during the intertidal reef surveys in this area.

### 7.6.3 Ecosystem Function

Total algae cover was relatively stable at both sites, with cover being consistently higher at West Flinders (Figure 7.12a). Erect coralline and turfing algal coverages were more variable at West Flinders, ranging from about 0 to 30 % during the monitoring period (Figure 7.12b-c). Erect coralline and turfing algal cover was consistently low at Mushroom Reef MS (Figure 7.12b-c).

Total grazer abundance was initially greater at Mushroom Reef compared to West Flinders, but reduced to similar levels in more recent years (Figure 7.13a). Total predator density at both sites appeared to have cyclic increases and decreases over three year periods (Figure 7.13b).

### 7.6.4 Climate Change

There were no community shifts towards greater affinities with other bioregions.

### 7.6.5 Harvesting

Although not typically harvested species, there was a decline over recent years in the density of *Bembicium nanum* and *Austrocochlea porcata* (Figure 7.11b). These results did not provide evidence that could distinguish harvesting pressure from natural population dynamics.

### 7.6.6 Trampling

There were no major changes in *Hormosira banksii* cover at both sites in recent surveys..

### 7.6.7 Environment

The cover of green algal species at Mushroom Reef was very low and variable, fluctuating between 2 and 8 %. The cover remained very low at West Flinders

(Figure 7.14a).

Sediment cover was very low (< 3 %) over the monitoring period at both sites

(Figure 7.14b).

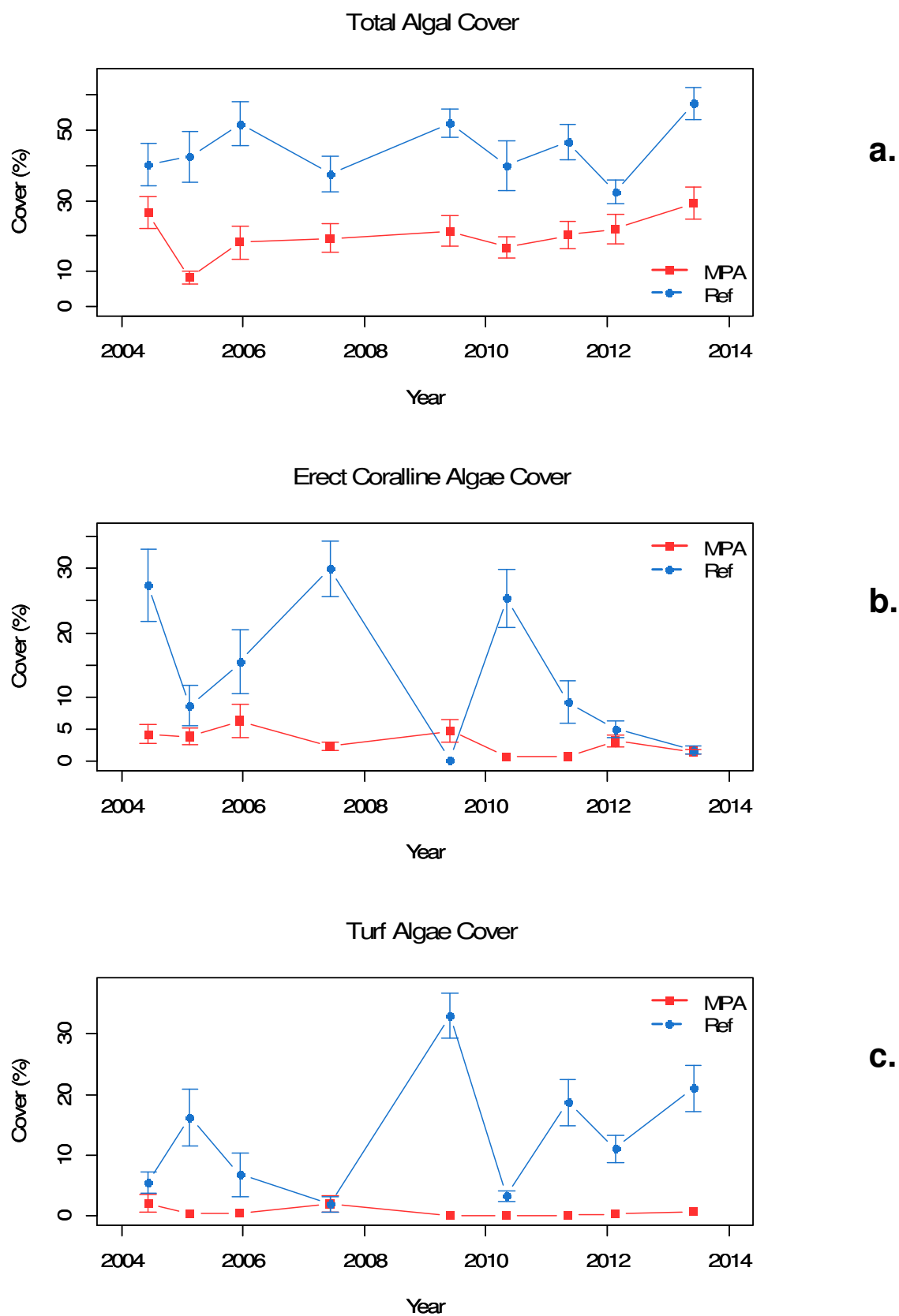


**Figure 7.12.** Mean cover ( $\pm$  Standard Error) of algae at Mushroom Reef and the West Flinders reference site.

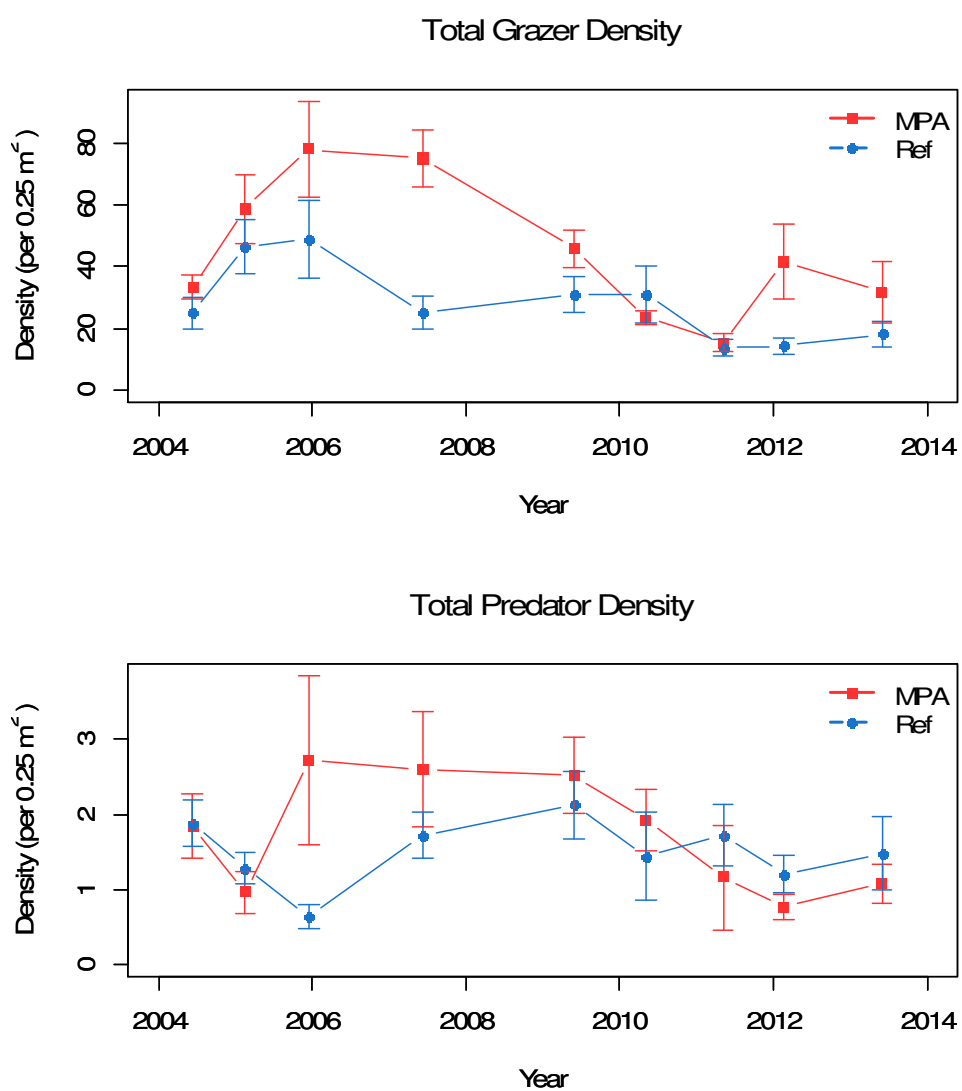


**Figure 7.13.** Mean abundance ( $\pm$  Standard Error) of: (a) all grazers; and (b) all predators at Mushroom Reef and the West Flinders reference site.

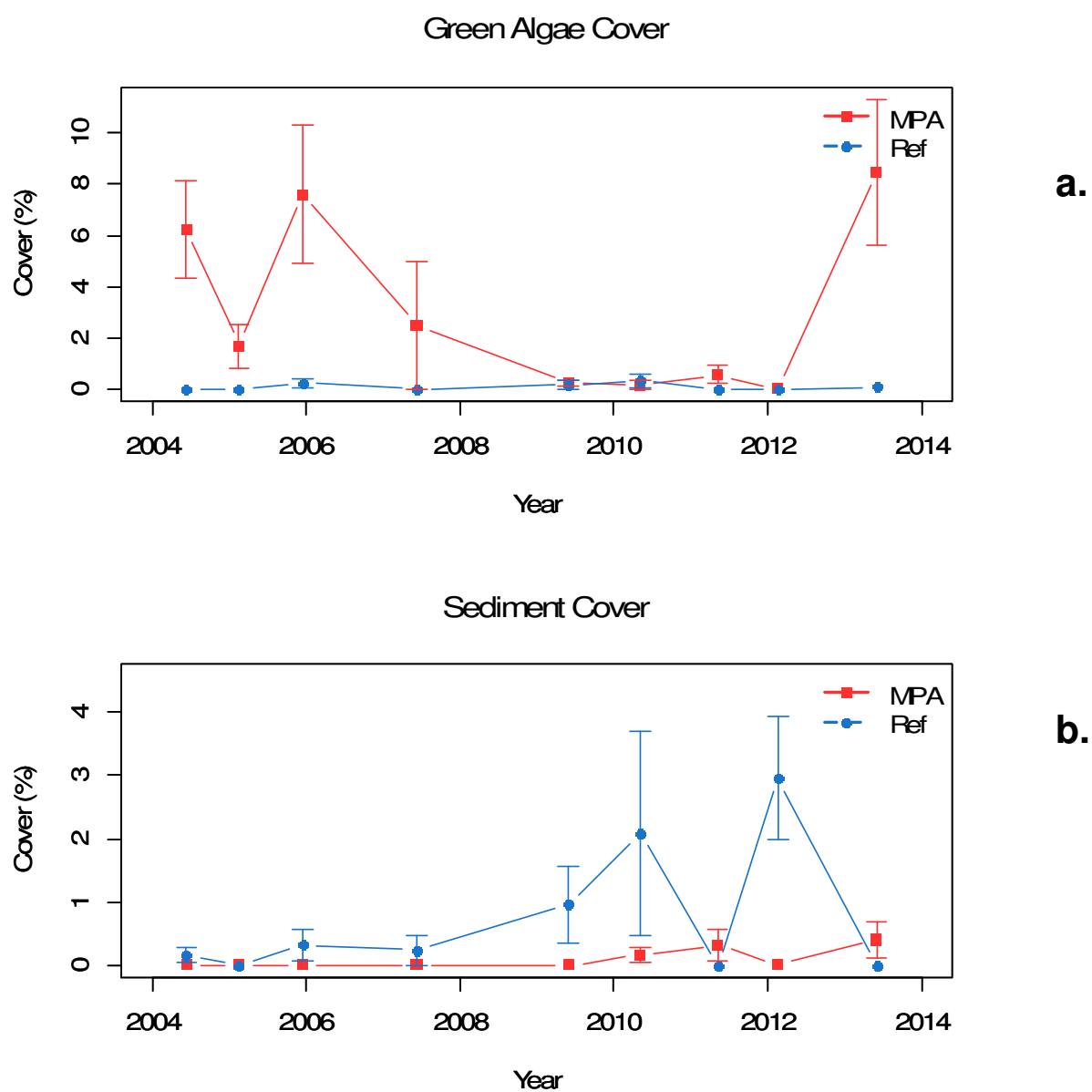


**Figure 7.14.** Mean cover ( $\pm$  Standard Error) of: (a) green algae (*Ulva* spp. and *Cladophora* spp.); and (b) sediment at Mushroom Reef and the West Flinders reference site.

## **8 BUNURONG MARINE NATIONAL PARK**

### **8.1 Site Description and Transect Layout**

#### **8.1.1 Eagles Nest (Site 3020)**

Many intertidal reefs exist within the Bunurong Marine National Park that are suitable as monitoring sites. The mudstone reefs of the area form large intertidal platforms. Located on the eastern side of the Eagles Nest headland, Site 3020 was selected as being representative of the dominant habitat type of the area. Keough and King (1991) studied visitor traffic to the Bunurong area and found the intertidal reefs at Eagles Nest had the highest visitation rates. Combined with easy access from the Eagles Nest carpark, this site was the most suitable for long-term intertidal studies.

The site is on the eastern side of the Marine National Park. It has an east facing aspect with the Eagles Nest headland sheltering it from the north and west. It is exposed to swells from the southeast, but sheltered from the prevailing south and southwest swell. The reef platform is relatively flat with little relief (Figure 8.1).

#### **8.1.2 Caves Reference (Site 3021)**

The reference site is at the Caves (Site 3021), located to the east of Bunurong Marine National Park. The site is directly below the access stairs from the Caves carpark. As with Eagles Nest, the reef substratum is mudstone, has a southeast facing aspect and is sheltered from the north and west by the Caves headland. The reef is exposed to southeast and southerly swell but is more sheltered from direct exposure to the prevailing southwest swell. The reef platform has a large area with little rugose structure or relief (Figure 8.2). The eastern end of the survey area (Transect 5) has more structure with large rocky outcrops towards the high shore level.



**Figure 8.1.** Intertidal reef at Eagles Nest, Bunurong Marine National Park, 7 June 2007.



**Figure 8.2.** Intertidal reef at the Caves reference site, 13 June 2013.

## 8.2 Bunurong Community Structure

The mobile invertebrate species at Eagles Nest (3020) and the reference Caves (Site 3021) are similar. The communities were largely composed of the conniwink *Bembicium nanum*, periwinkles *Nodilittorina acutispira* and *Austrolittorina unifasciata*, and limpets *Siphonaria* spp. and *Cellana tramoserica*. The snail *Austrocochlea constricta*, and limpets *Notoacmea mayi* and *Patelloida alticostata* were also common. The MDS analysis of mobile invertebrate communities showed that both sites were similar with moderate variations in community structure over time (Figure 8.3).

The sessile species were also consistent between Eagles Nest and the Caves. The community was dominated by the mat forming mussel *Limnoperna pulex*, the brown alga Neptune's Necklace *Hormosira banksii* and algal turf. The MDS plot illustrates non-overlapping variation between survey times at both sites, and the trajectory of change in community structure at Eagles Nest appears to differ from that at the Caves (Figure 8.4).

## 8.3 Bunurong Diversity

Mobile species richness at Eagles Nest appeared to have a downward trend. Conversely, mobile species richness at The Caves exhibited no clear trends (Figure 8.5).

Shifts in sessile species richness at Eagles Nest and the Caves varied very similarly through time at both sites in a cyclical pattern of approximately 4 years (Figure 8.6).

Mobile invertebrate diversity (Hills  $N_2$ ) exhibited low between-survey variability and an increasing trend at both sites (Figure 8.7).

There were no clear trends in sessile species diversity with both sites varying considerably throughout the monitoring period. In 2013 sessile species diversity was similar at both sites and in the lower range of observed values (Figure 8.8).

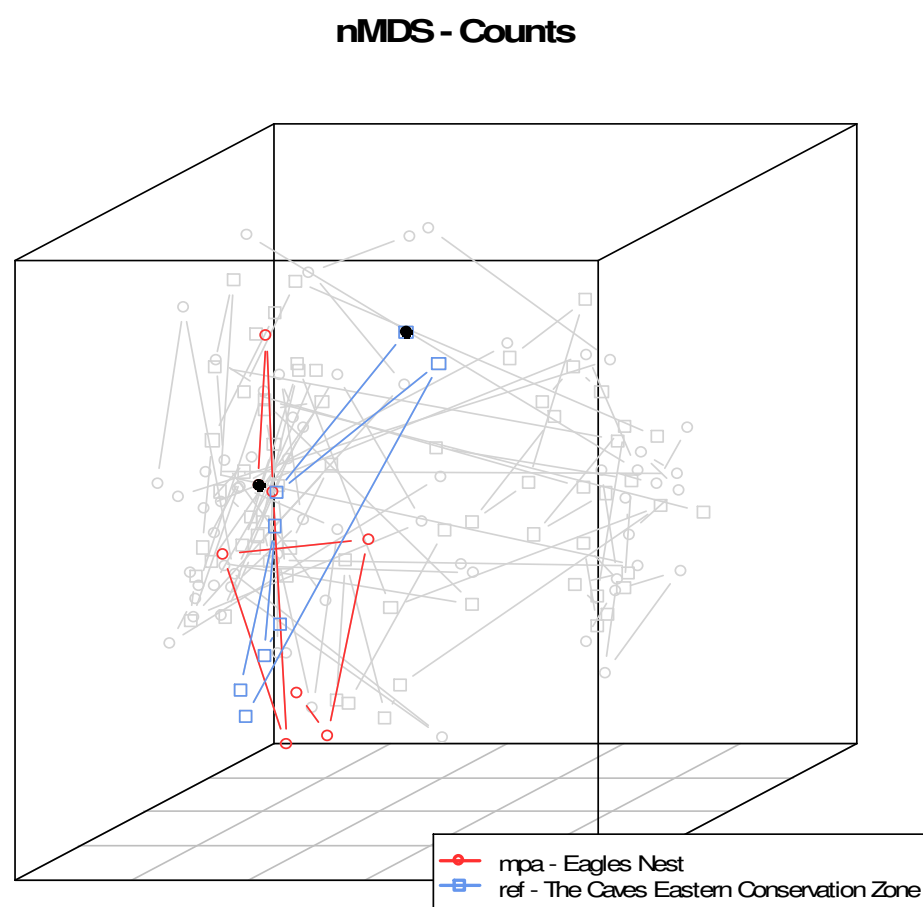


**Figure 8.3.** Three dimensional MDS plot of mobile invertebrate assemblages on intertidal reefs at Eagles Nest and the Caves reference site. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.13.

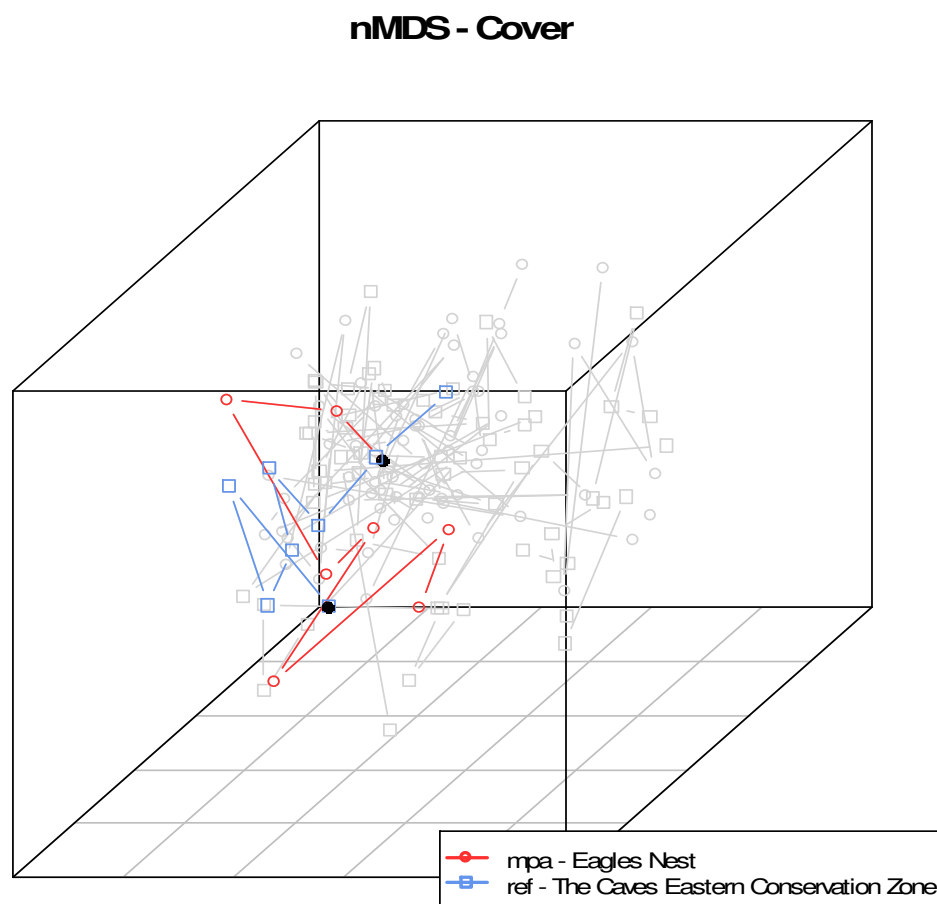


**Figure 8.4.** Three dimensional MDS plot of macroalgae and aggregating sessile invertebrates assemblages on intertidal reefs at Eagles Nest and the Caves reference site. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.18.

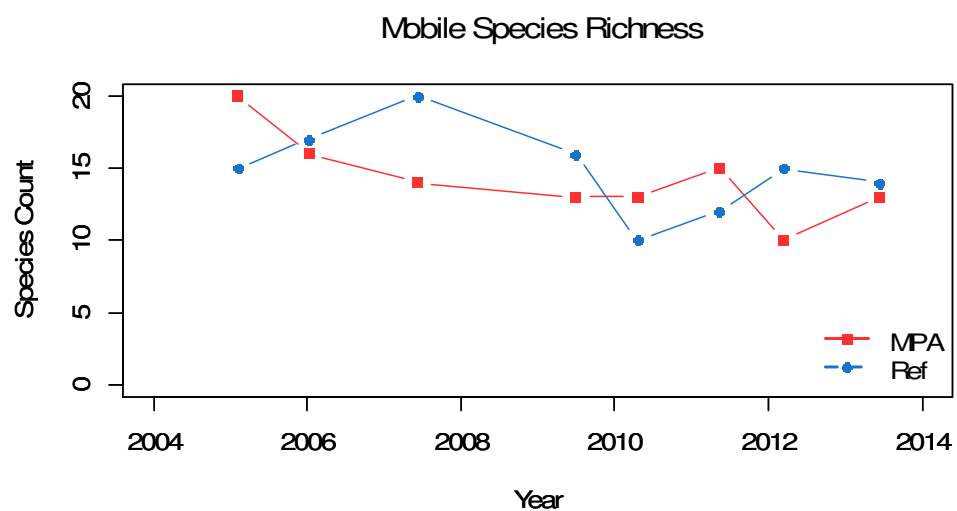


**Figure 8.5.** Mobile invertebrate species richness at Eagles Nest and the Caves reference site.

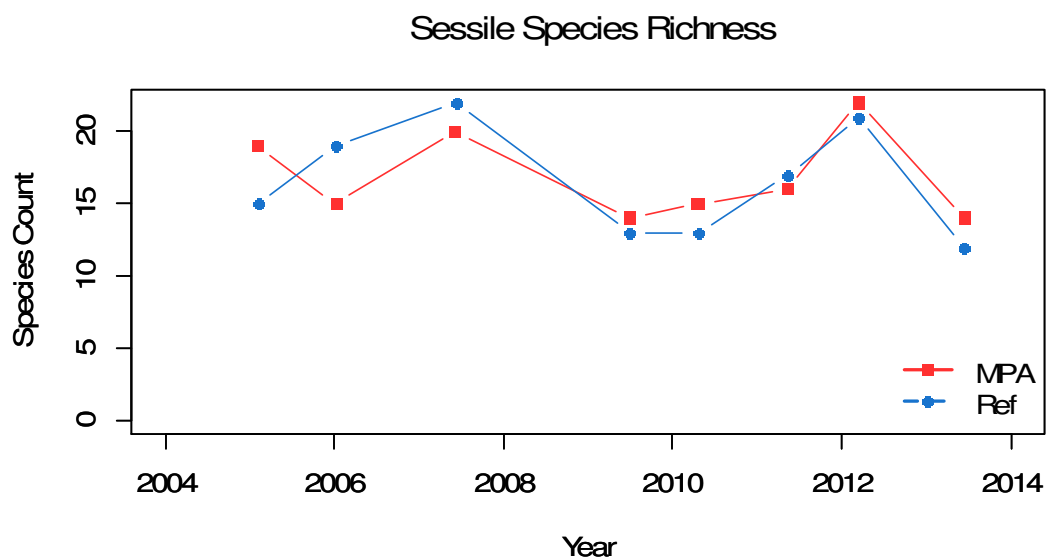


**Figure 8.6.** Algal and aggregating sessile invertebrate species richness of intertidal sites at Eagles Nest and the Caves reference site.

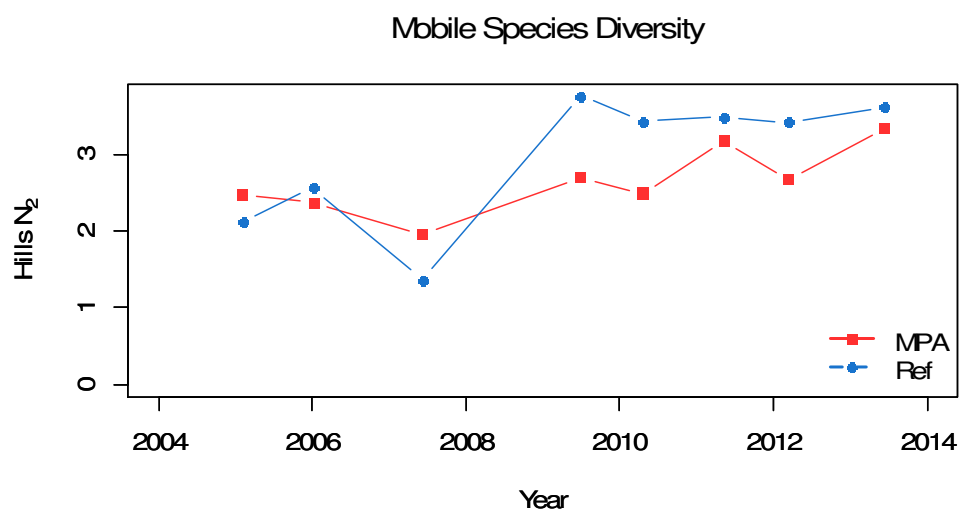


**Figure 8.7.** Mobile invertebrate diversity (Hills  $N_2$ ) of intertidal sites at Eagles Nest and the Caves reference site.

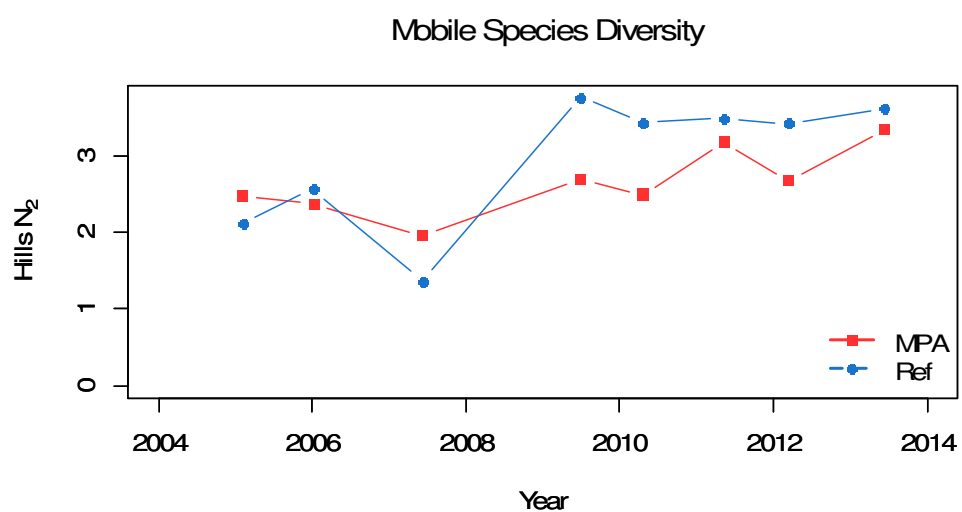


**Figure 8.8.** Algal and aggregating sessile invertebrate diversity (Hill's  $N_2$ ) of intertidal sites at Eagles Nest and the Caves reference site.

## 8.4 Bunurong Macroalgae and Aggregating Sessile Invertebrates

The cover of the brown alga Neptune's Necklace *Hormosira banksii* was relatively stable through time with consistently low cover at both sites (Figure 8.9). The mat-forming mussel *Limnoperna pulex* cover was variable and low. Sand cover at both sites was variable through time with no consistent patterns.

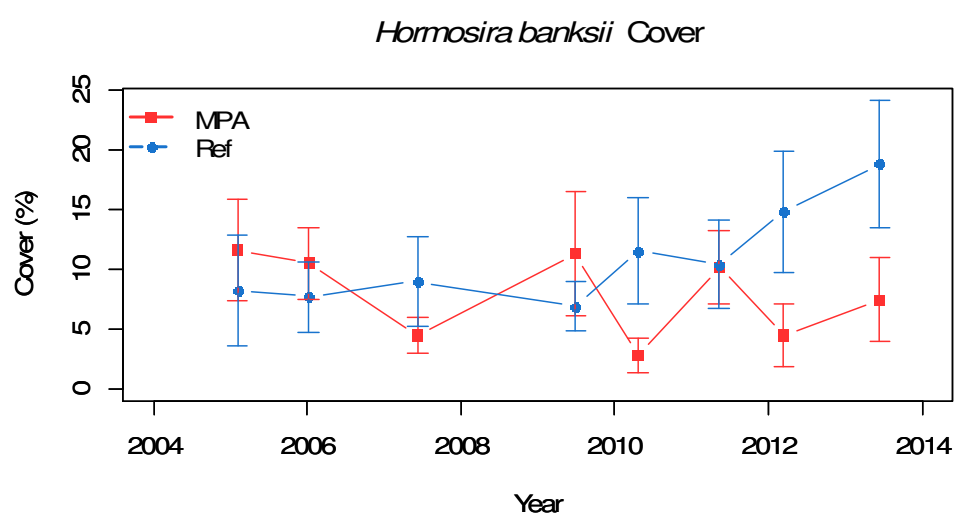


**Figure 8.9.** Mean density ( $\pm$  Standard Error) of Neptune's Necklace *Hormosira banksii* at Eagles Nest and the Caves reference site.

## 8.5 Bunurong Mobile Invertebrates

The mean densities of *A. unifasciata* at both sites were quite variable over time, with both sites having similar temporal variability apart from a spike at Eagles Nest in 2010 (Figure 8.10a).

*Bembicium nanum* densities at both sites were also variable over time, with a spike at the Caves in 2006 and one at Eagles Nest in 2010 (Figure 8.10b).

*Cellana tramoserica* occurs in consistently low densities at the two sites (Figure 8.10c).

The mean size of *C. tramoserica* was similar at both sites. There was a substantial upward trend from 2009, with mean sizes increasing from approximately 20 mm to 35 mm by 2013 (Figure 8.11).

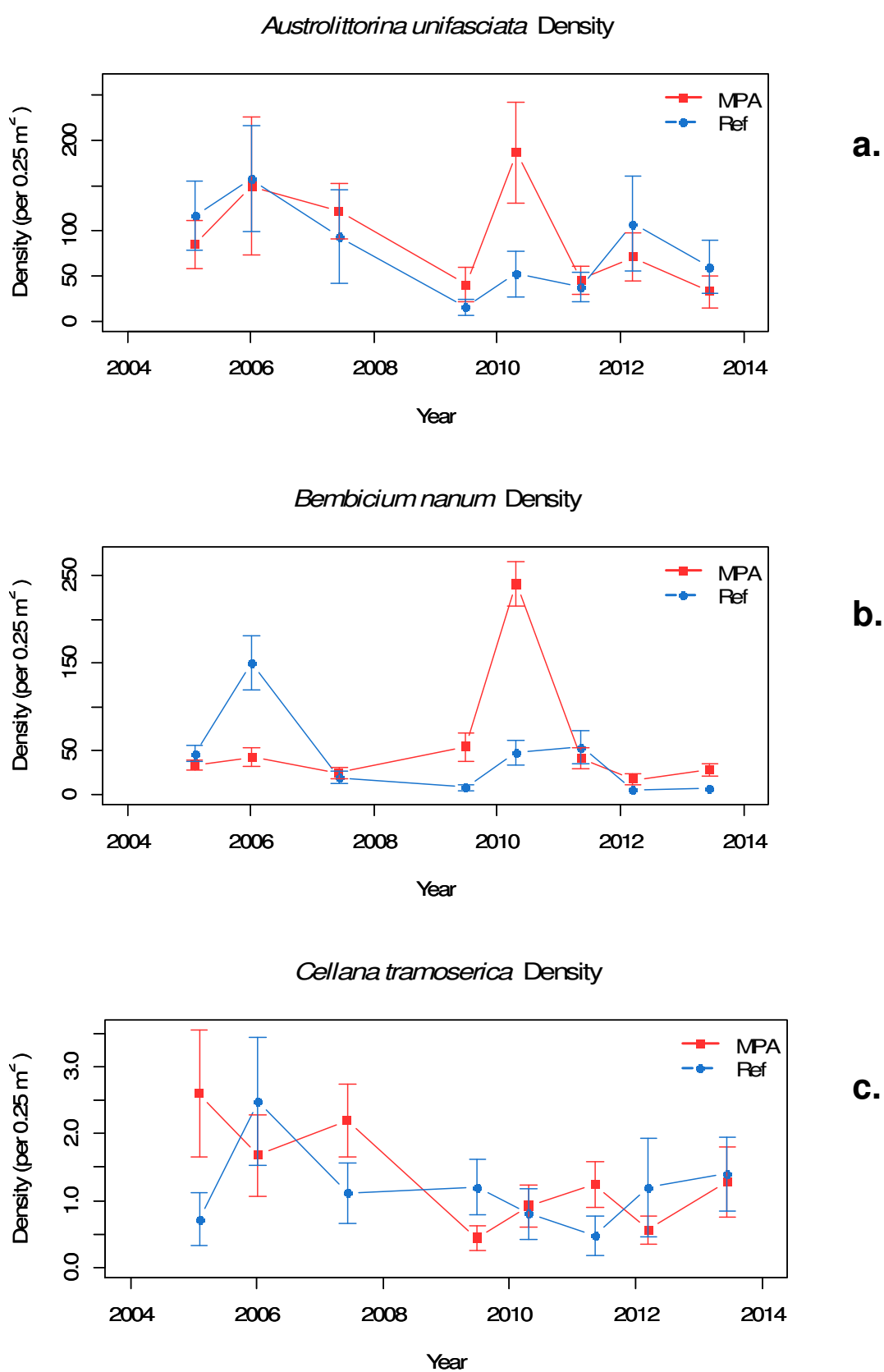


**Figure 8.10.** Mean density ( $\pm$  Standard Error) of dominant mobile invertebrates at Eagles nest and the Caves reference site.

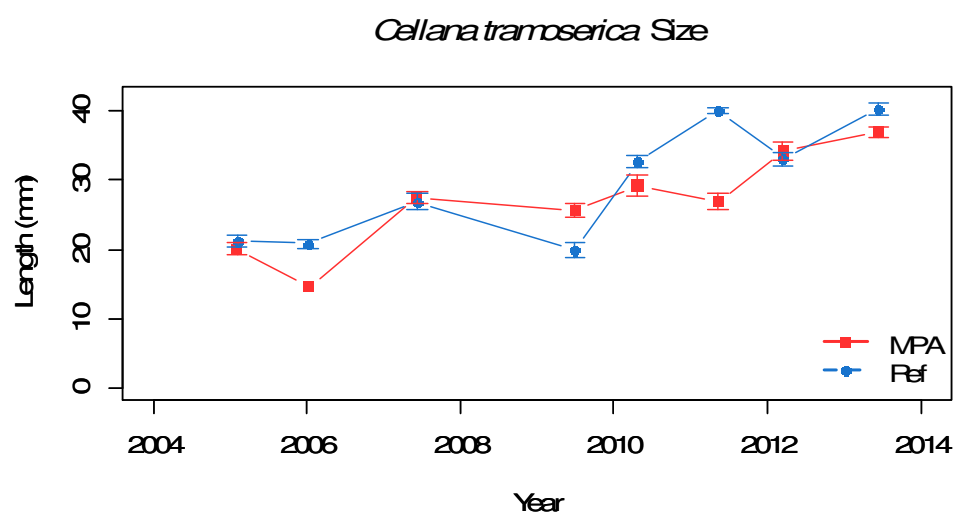


**Figure 8.11.** Mean sizes ( $\pm$  Standard Error) of the limpet *Cellana tramoserica* at Eagles Nest and the Caves reference site.

## 8.6 Bunurong Condition Indicators

### 8.6.1 Biodiversity

Community composition and species richness remained within the range of states and changes previously observed. In 2013, mobile species diversity was at highest recorded levels at both sites.

### 8.6.2 Introduced Species

No introduced species were observed during the intertidal reef surveys in this area.

### 8.6.3 Ecosystem Function

Total algal coverage was consistently greater at Eagle Rock than at the Caves. Both sites had little change over time (Figure 8.12a).

Erect coralline algal cover was only present in low coverage at The Caves reference site (Figure 9.12b).

Turfing algal cover peaked at both sites in 2009 with a subsequent decline (Figure 9.12c).

Total grazer density was very high at both sites. There was a spike in grazer density at the Caves in 2007, after which densities dropped down to 200 per 0.25 m<sup>2</sup> (Figure 8.13a). Total predator abundance was very low at both sites and appeared to have slight downward trends (Figure 8.13b).

### 8.6.4 Climate Change

There were no community shifts towards greater affinities with other bioregions.

### 8.6.5 Harvesting

The increasing trend of mean sizes of *C. tramoserica* possibly indicates there is not targeted harvesting of larger limpets, however this may also be a population response to other environmental parameters (Figure 8.11).

### 8.6.6 Trampling

There was no declining trend of *Hormosira banksii* densities (Figure 8.9) and therefore no indication of trampling impacts.

### **8.6.7 Environment**

The mean cover of green algal species at both sites was in very low throughout the monitoring period (Figure 8.14a). Sediment cover at both sites was variable but generally low over time, ranging from 0 to 13 % cover (Figure 8.14b).

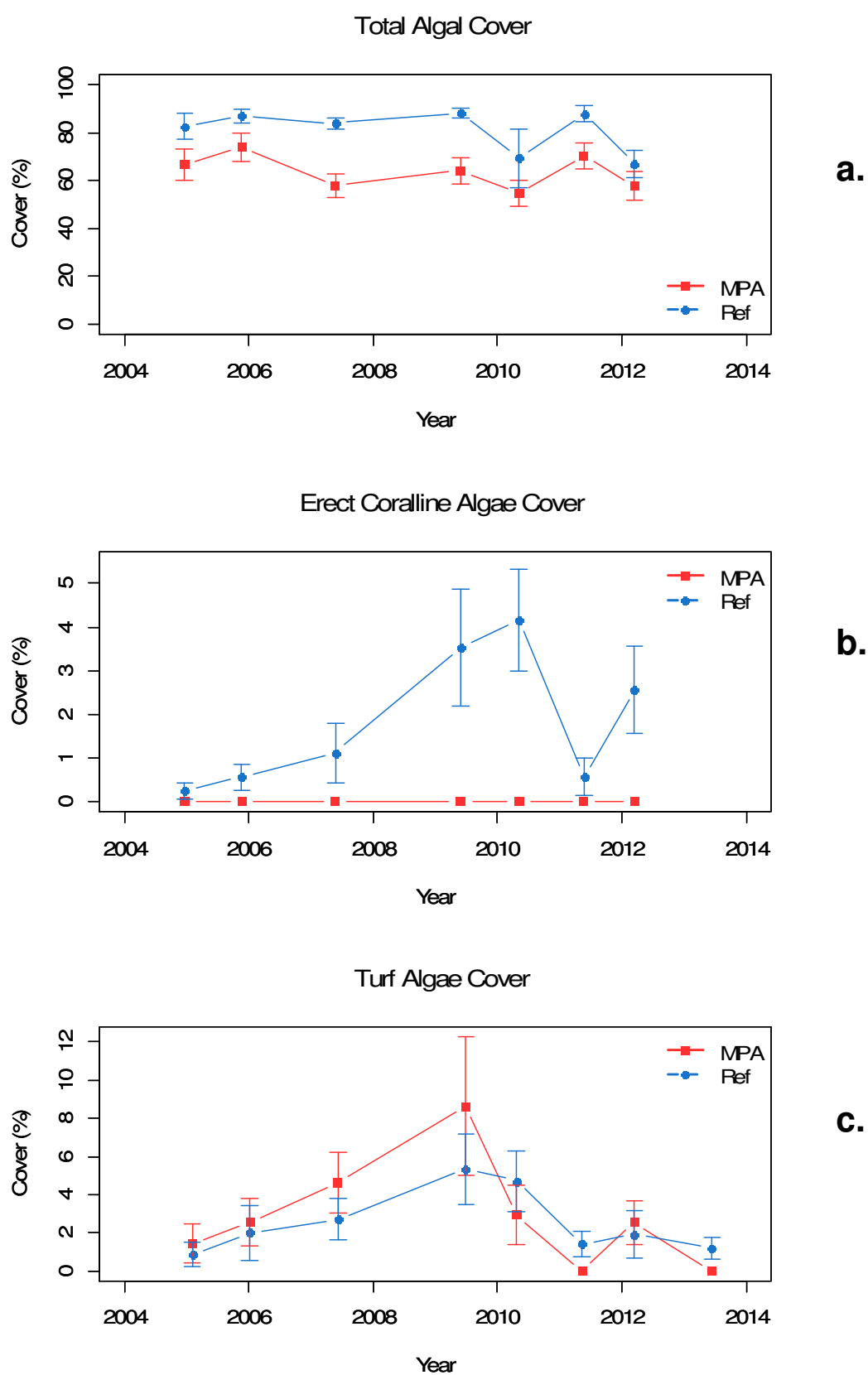


**Figure 8.12.** Mean cover ( $\pm$  Standard Error) of algae at Eagles Nest and the Caves reference site.

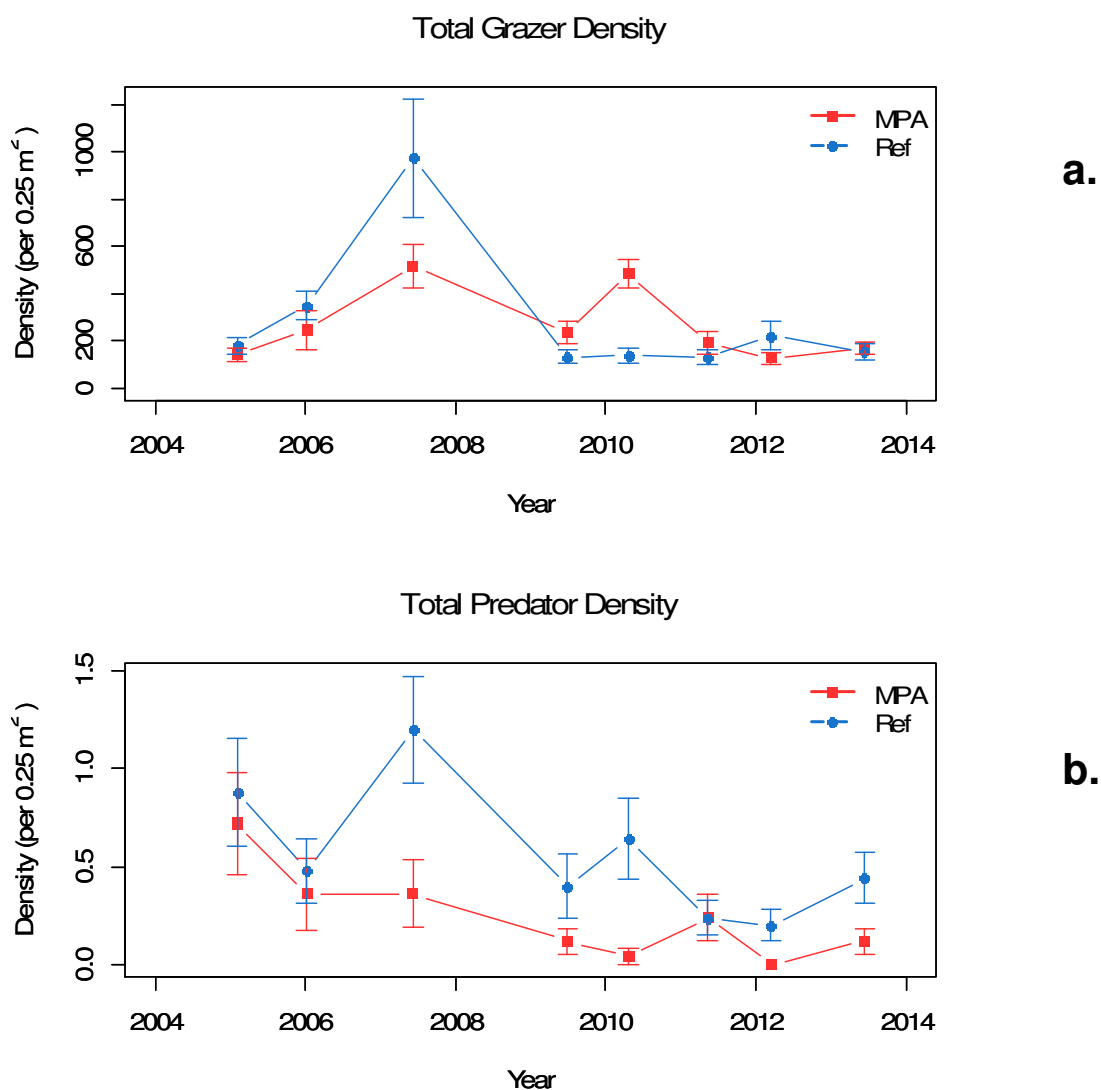


**Figure 8.13.** Mean abundance ( $\pm$  Standard Error) of: (a) all grazers; and (b) all predators at Eagles Nest and the Caves reference site.

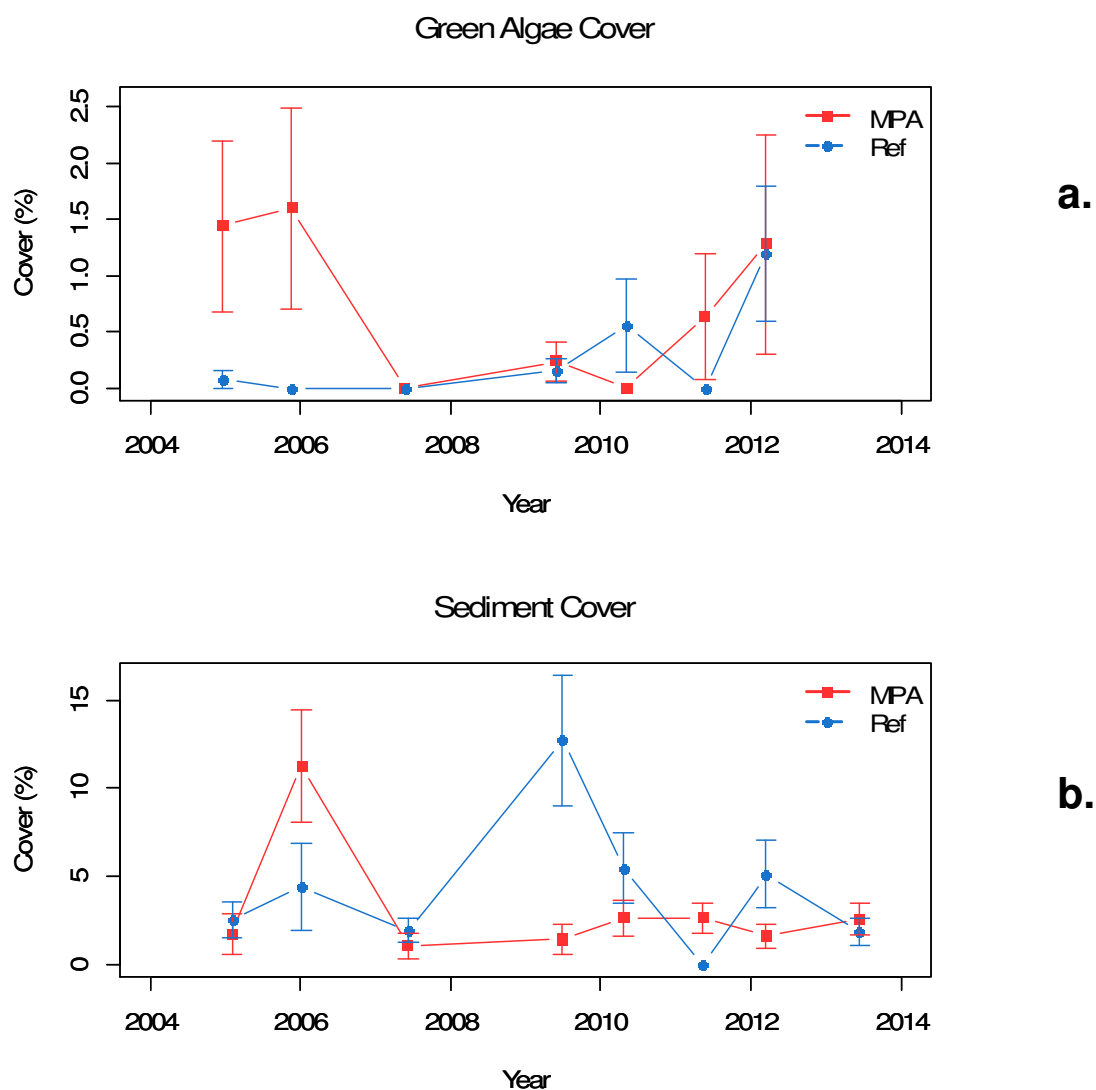


**Figure 8.14.** Mean cover ( $\pm$  Standard Error) of: (a) green algae (*Ulva* spp. and *Cladophora* spp.); and (b) sediment at Eagles Nest and the Caves reference site.

## **9 POINT ADDIS MARINE NATIONAL PARK**

### **9.1 Site Description and Transect Layout**

#### **9.1.1 Point Addis Marine National Park (Site 3901)**

The main intertidal reef at Point Addis is a large and prominent tongue of intertidal platform that extends east from the base of cliffs northeast of Point Addis. This reef is long and undulating in places. The platform is relatively low and large areas of this reef remain inundated during some tidal cycles. It is relatively exposed to wave action. The survey site is on a smaller patch of reef that fringes the coastal cliffs. It is a low-relief, uneven reef that drops steeply at the seaward edge into subtidal habitat (Figure 9.1). Undulations in the reef caused by weathering create patches of standing water.

The intertidal reefs are exposed to swell from the south and east. The Point Addis headland provides some protection from southwest winds and swell, although large waves from the southwest can wrap around Point Addis onto these reefs.

#### **9.1.2 Winkipop Reference (Site 3902)**

The reference site for Point Addis Marine National Park was located to the east of the park at Winkipop reef. The intertidal area at Winkipop is a very low-relief, gently sloping reef (Figure 9.2). The area exposed at low tide is 30 to 50 m wide. This area is exposed to large southerly swells. A narrow band of sandy beach exists on the landward side of the reef. As at Point Addis, pools of standing water were common in low lying undulations in the reef surface. This reef may be periodically subject to some sand inundation.

During the 2013 survey, scientific experiments set up by other institutions were observed within the sampling area at Winkipop.



**Figure 9.1.** Intertidal reef at Point Addis Marine National Park, 3 April 2013.



**Figure 9.2.** Intertidal reef at the Winkipop reference site, 3 April 2013.

## 9.2 Point Addis Community Structure

The types of mobile invertebrate species present at Point Addis and Winkipop were generally similar, but more species rich at Winkipop. Abundances of the false limpet *Siphonaria* spp., and limpets *Cellana tramoserica*, *Notoacmea* spp. and *Patelloida alticostata* were greater at Point Addis. Anemones (*Anthothoe albocincta*, *Actinia tenebrosa*, *Oulactis muscosa* and *Aulactinia veratra*) were observed regularly at Winkipop in small patches of standing water or buried in wet sand beneath *H. banksii*. Anemones have only been observed intermittently at Point Addis.

The MDS analysis placed Point Addis and Winkipop as distinct from one another but within the same cluster of open coast sites. There was generally only a very small variation in community structure over time (Figure 9.3).

The sessile species communities at Point Addis and the reference site Winkipop were dominated by the brown algae *Hormosira banksii* and brown algal turf. The MDS analysis showed that both sites were similarly grouped, with some overlap in assemblage structure, but Point Addis was more variable over time than Winkipop (Figure 9.4).

## 9.3 Point Addis Diversity

Mobile invertebrate species richness was relatively stable through time at both sites, though there appeared to be a slight downward trend at Winkipop (Figure 9.5).

Sessile species richness was similar at Point Addis and Winkipop, with very little variation over time (Figure 9.6).

Mobile invertebrate diversity (Hills  $N_2$ ) was more variable at Winkipop compared to Point Addis, with a peak in 2011 followed by a marked decline in 2012 to the lowest recorded in the monitoring period (Figure 9.7). Both sites did not have any marked trend over time (Figure 9.7).

Algal and aggregating sessile invertebrate species diversity remained low at both sites over the monitoring period (Figure 9.8).

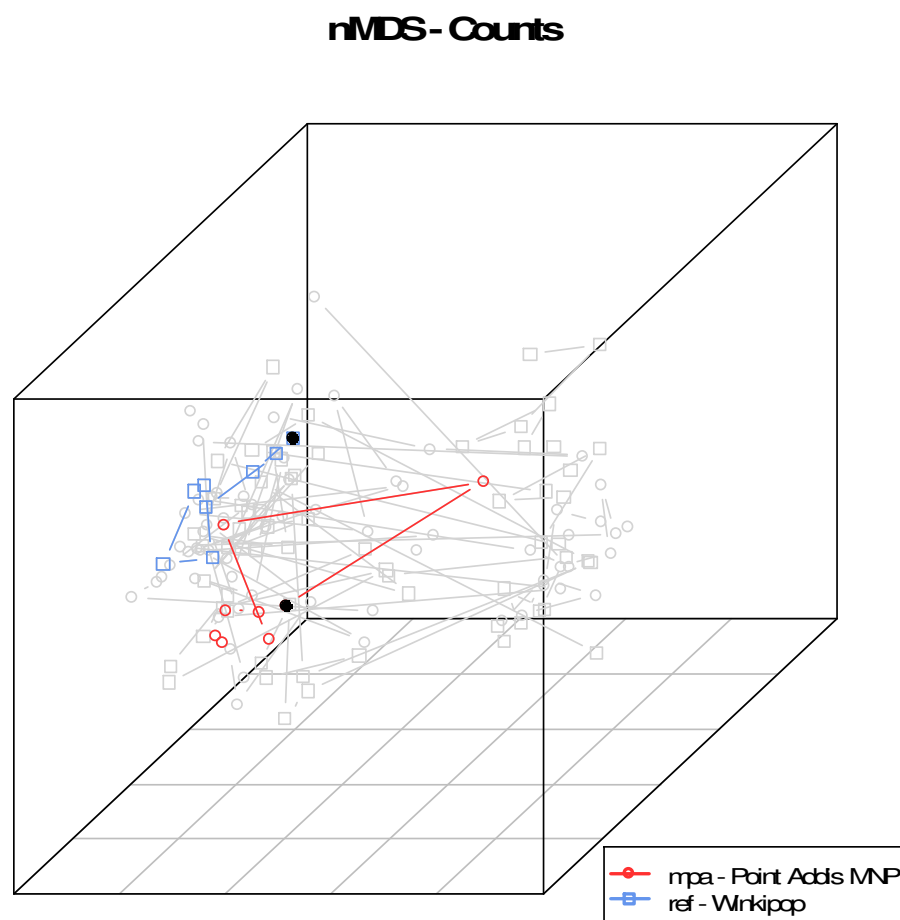


**Figure 9.3.** Three dimensional MDS plot of mobile invertebrate assemblages on intertidal reefs at Point Addis and the Winkipop reference site. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.13.

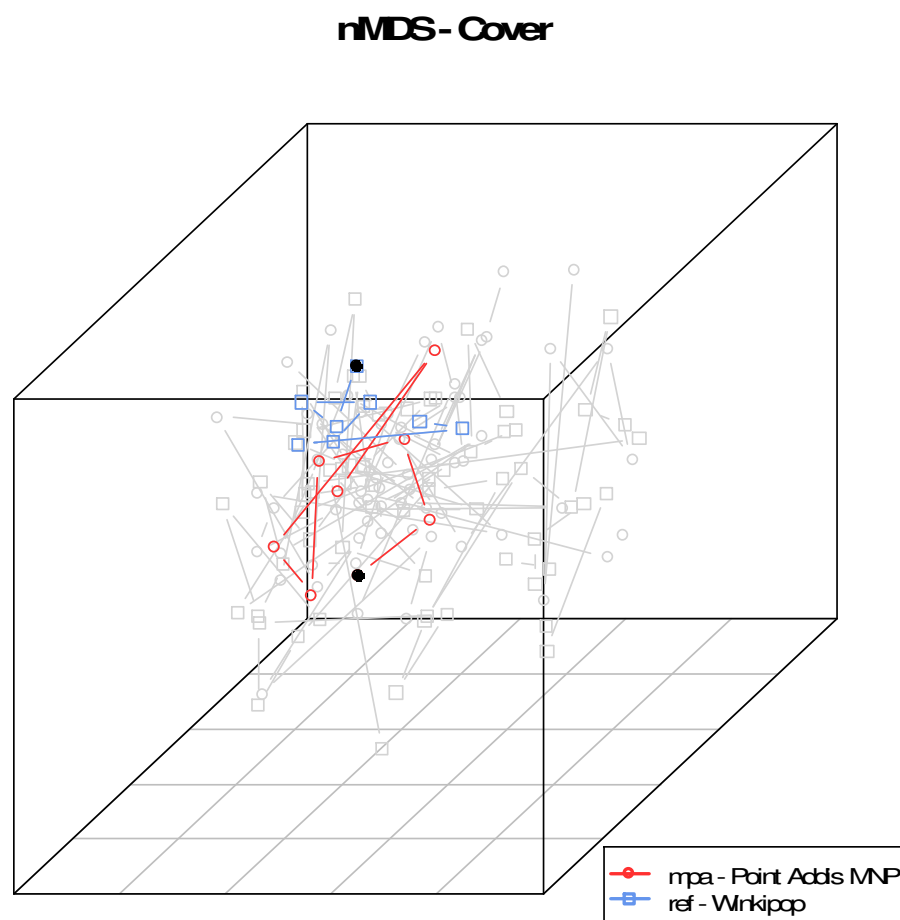


**Figure 9.4.** Three dimensional MDS plot of macroalgae and aggregating sessile invertebrates assemblages on intertidal reefs at Point Addis and the Winkipop reference site. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.18.

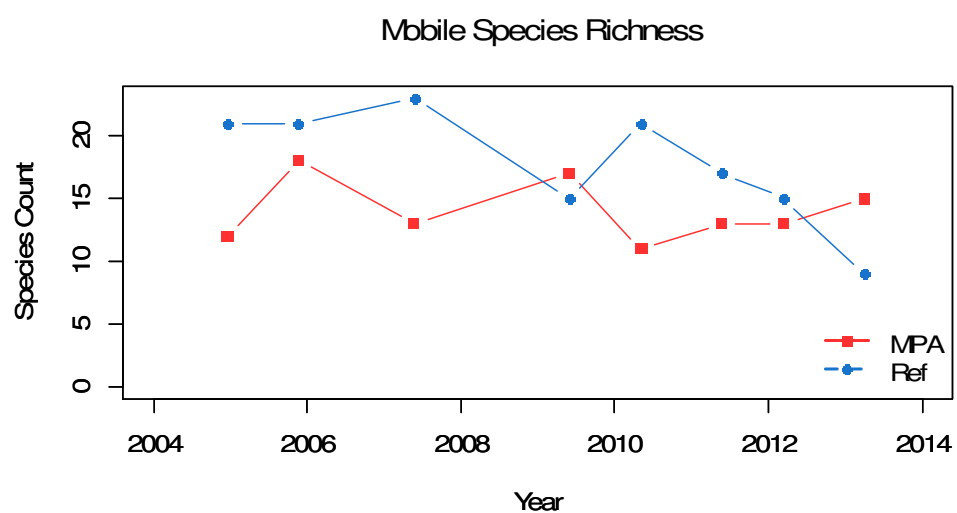


**Figure 9.5.** Mobile invertebrate species richness at Point Addis and the Winkipop reference site.

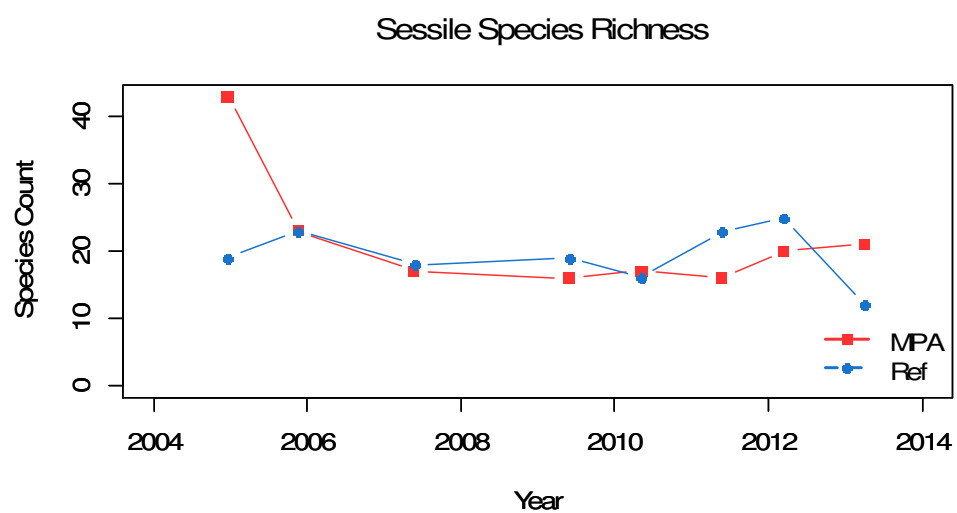


**Figure 9.6.** Algal and aggregating sessile invertebrate species richness of intertidal sites at Point Addis and the Winkipop reference site.

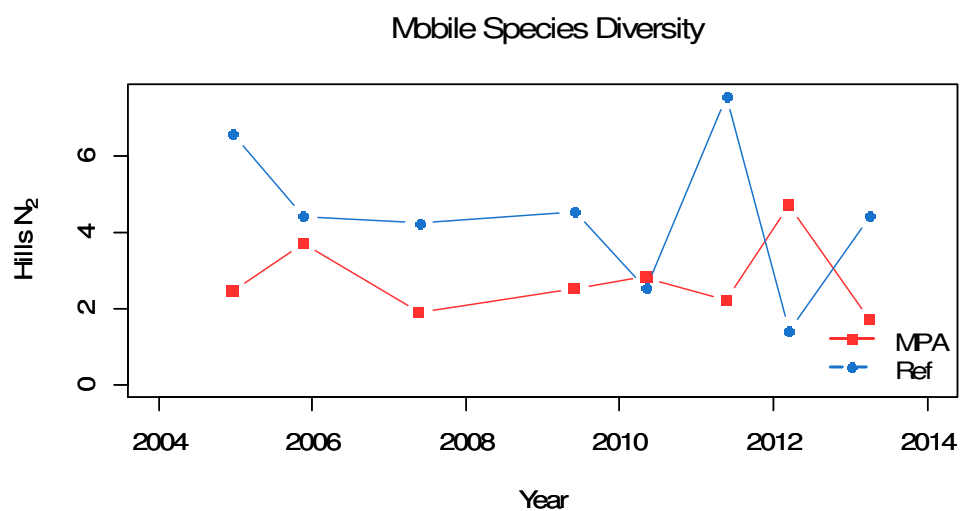


**Figure 9.7.** Mobile invertebrate diversity (Hills  $N_2$ ) of intertidal sites at Point Addis and the Winkipop reference site.

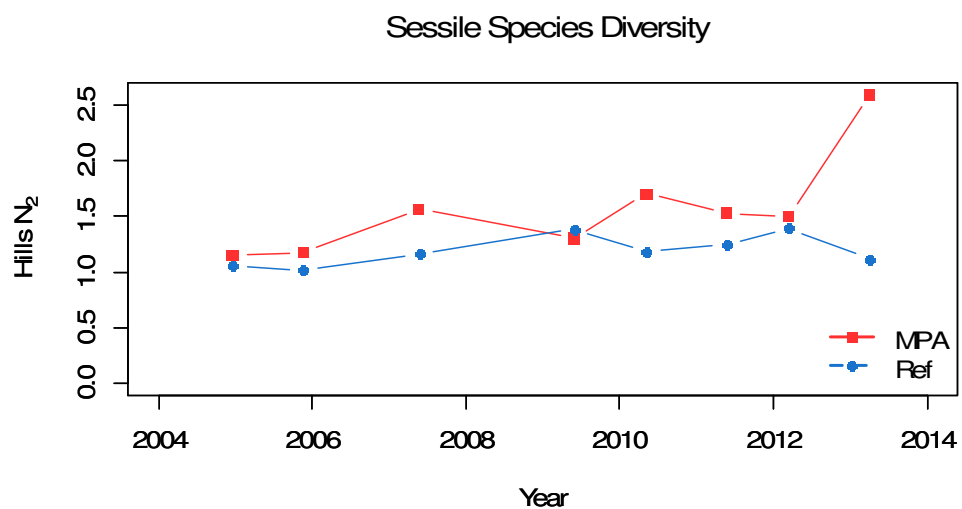


**Figure 9.8.** Algal and aggregating sessile invertebrate diversity (Hill's  $N_2$ ) of intertidal sites at Point Addis and the Winkipop reference site.

## 9.4 Point Addis Macroalgae and Aggregating Sessile Invertebrates

The brown alga *Hormosira banksii* was the dominant cover at both sites, with cover consistently 20-30 % higher at the Winkipop reference site. The cover of *H. banksii* at both sites had similar temporal variations and appeared stable over time. There was an uncharacteristic dip in *H. banksii* abundance to 2013 (Figure 9.9). Algal turf cover was consistently higher at Point Addis (5-15 %) than Winkipop (0-3 %).

There were no marked trends in the abundances of the sessile animals over time. The tube worm *Galeolaria caespitosa*, barnacle *Chthamalus antennatus* and mussel *Limnoperna pulex* have been observed intermittently at both sites.

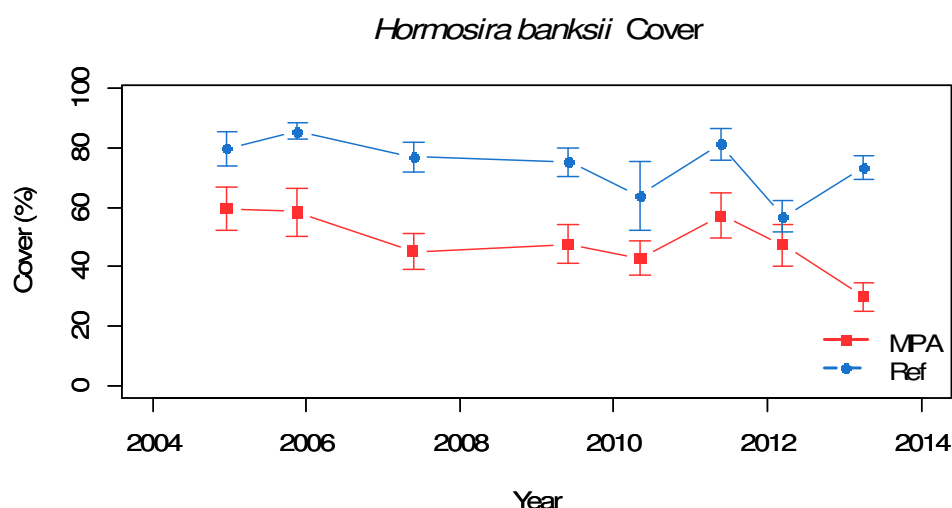


**Figure 9.9.** Mean density ( $\pm$  Standard Error) of Neptune's Necklace *Hormosira banksii* at Point Addis and the Winkipop reference site.

## 9.5 Point Addis Mobile Invertebrates

The limpet *Montfortula rugosa* density was generally low at both sites, apart from a couple of spikes at Winkipop in 2010 and 2012 (Figure 9.10a).

The densities of *B. nanum* and *C. tramoserica* were generally low and variable through all surveys (Figure 9.10b-c). *Bembicium nanum* was generally more abundant at Winkipop than at Point Addis (Figure 9.10b) and *C. tramoserica* was more abundant at Point Addis than at Winkipop (Figure 9.10c).

The mean size of *C. tramoserica* at Point Addis and the reference Winkipop site was similar over time. There was an upward trend at both sites (Figure 9.11).

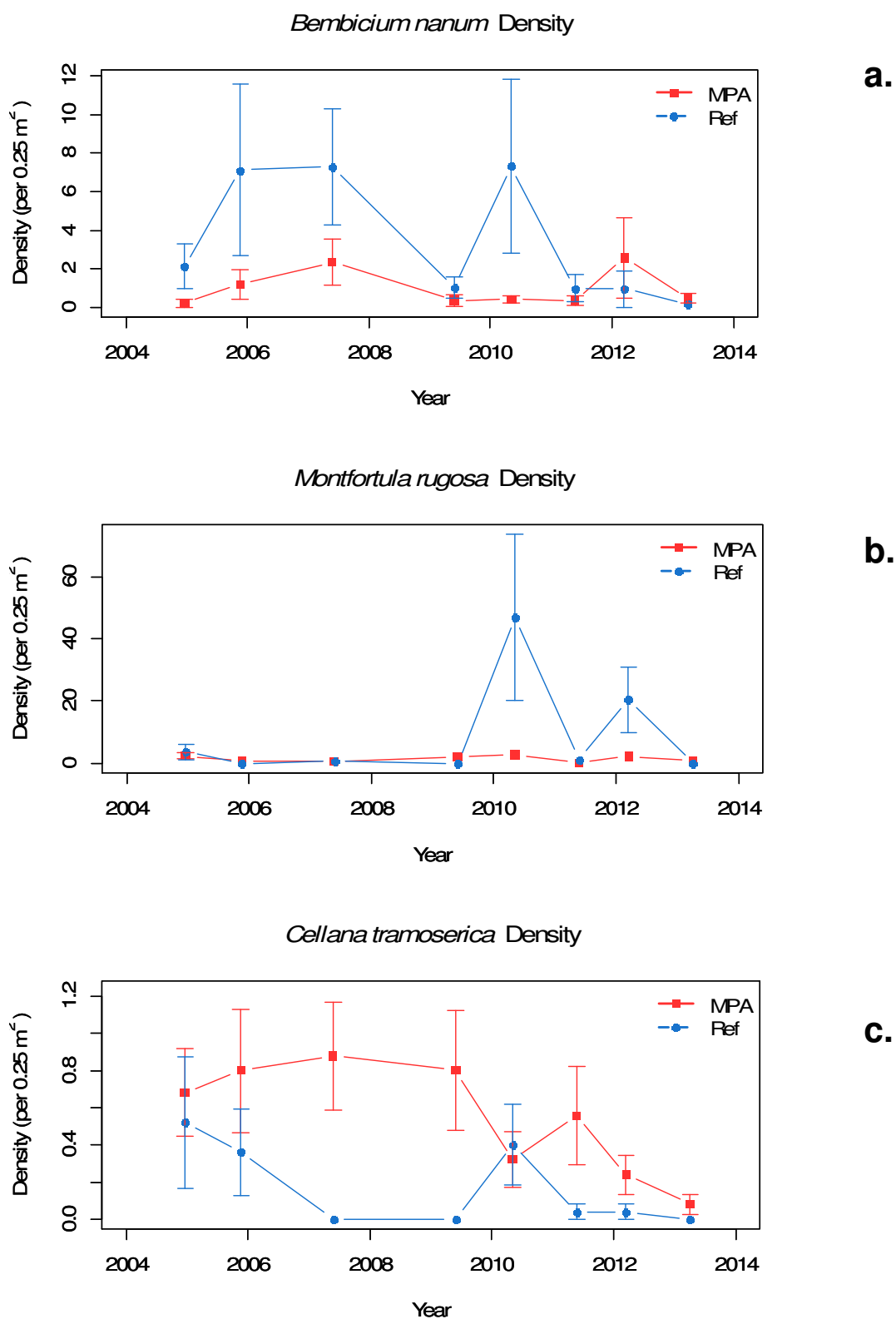


**Figure 9.10.** Mean density ( $\pm$  Standard Error) of dominant mobile invertebrate species at Point Addis and the Winkipop reference site.

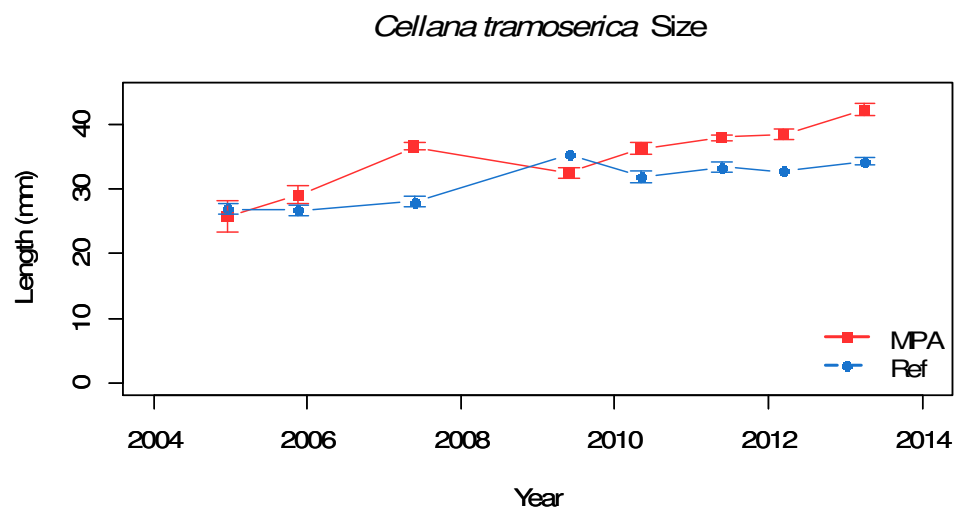


**Figure 9.11.** Mean sizes ( $\pm$  Standard Error) of harvested invertebrates at Point Addis and the Winkipop reference site.

## 9.6 Point Addis Condition Indicators

### 9.6.1 Biodiversity

The community structure at Point Addis was more variable than that at Winkipop. Species richness and diversity at Point Addis in 2013 was within the range of states and changes previously observed, however species richness at Winkipop was at the lowest recorded level in 2013. The scientific experiments present at Winkipop during the 2013 were located nearby but outside the monitoring area. It is unlikely the experiments are related to the low species richness and diversity observed during 2013.

### 9.6.2 Introduced Species

No introduced species were detected at these sites.

### 9.6.3 Ecosystem Function

Total algal cover was very high and generally stable at both sites (Figure 9.12a). Erect coralline algal cover at Point Addis was consistently close to zero. It varies moderately at Winkipop, where there appeared to be a general upward trend since the start of the monitoring period (Figure 9.12b). Turfing algae cover was consistently higher and more variable at Point Addis than Winkipop throughout the monitoring period (Figure 9.12c).

Total grazer density remained stable throughout the monitoring period, apart from a spike at Point Addis in 2007 (Figure 9.13a). Total predator density at both sites was low, variable and with no clear trends (Figure 9.13b).

### 9.6.4 Climate Change

There were no community shifts towards greater affinities with other bioregions.

### 9.6.5 Harvesting

*Cellana tramoserica* occur at very low densities at these sites, <1 individuals 0.25 m<sup>-2</sup> quadrat. There were no indications of increased harvesting pressure based on densities, however mean sizes increased, indicating there is no significant harvesting pressure which would be selective for larger animals.

### 9.6.6 Trampling

The cover of the alga *Hormosira banksii* was persistently high at both sites in comparison to other monitored sites in the Central Victorian Bioregion. There was a

general trend of decreasing abundance inside the MNP since 2011. It is difficult to discern whether this is an impact of any trampling or other environmental influences (Figure 9.9).

### **9.6.7 Environment**

The cover of green algal species, sometimes indicative of nutrient loading, was low and highly variable at these sites (Figure 9.14a). Sediment cover at both sites was relatively low until an increase up to 20% cover in 2013 (Figure 9.14b).

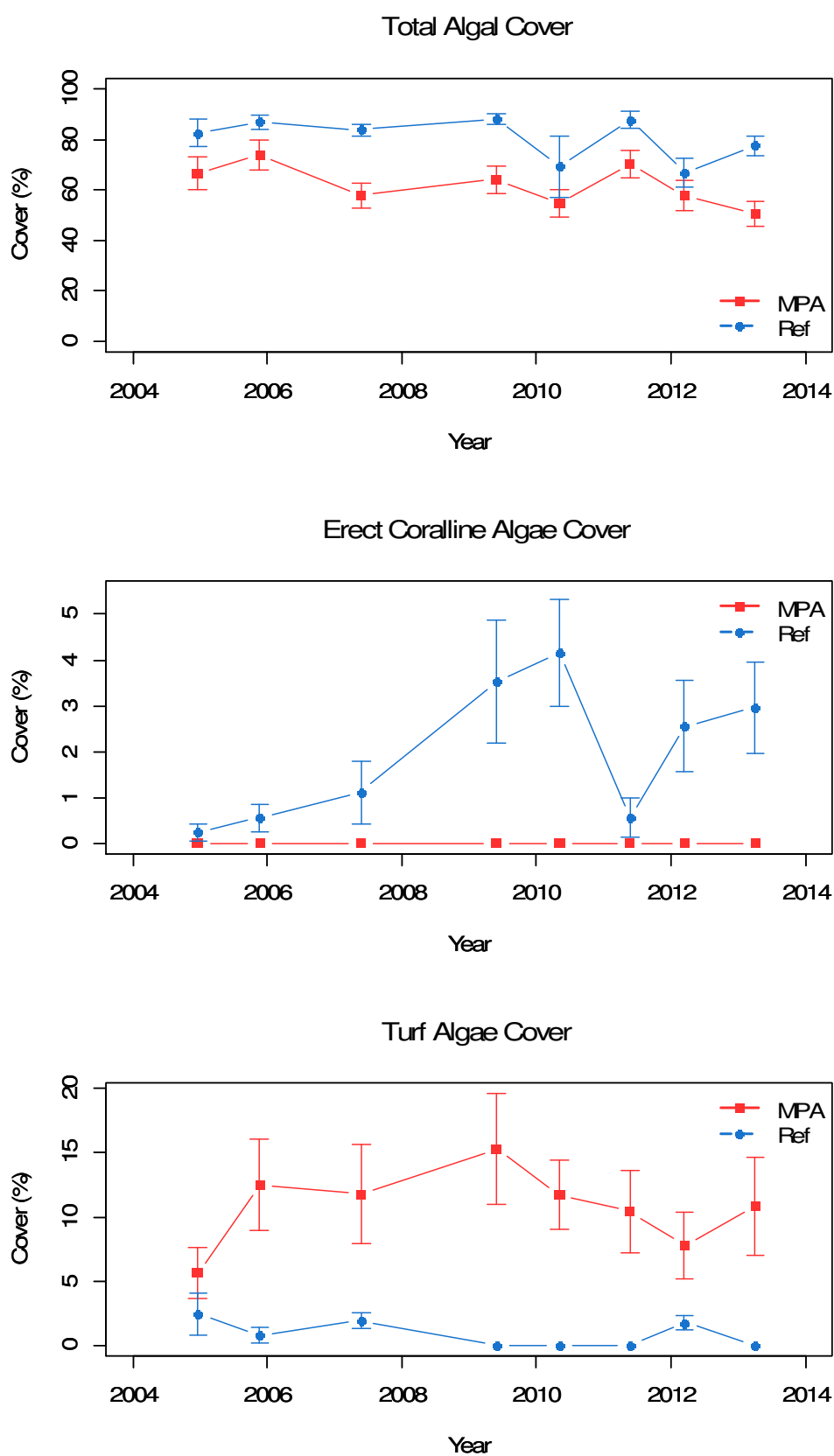


**Figure 9.12.** Mean cover (± Standard Error) of algae at Point Addis and the Winkipop reference site.

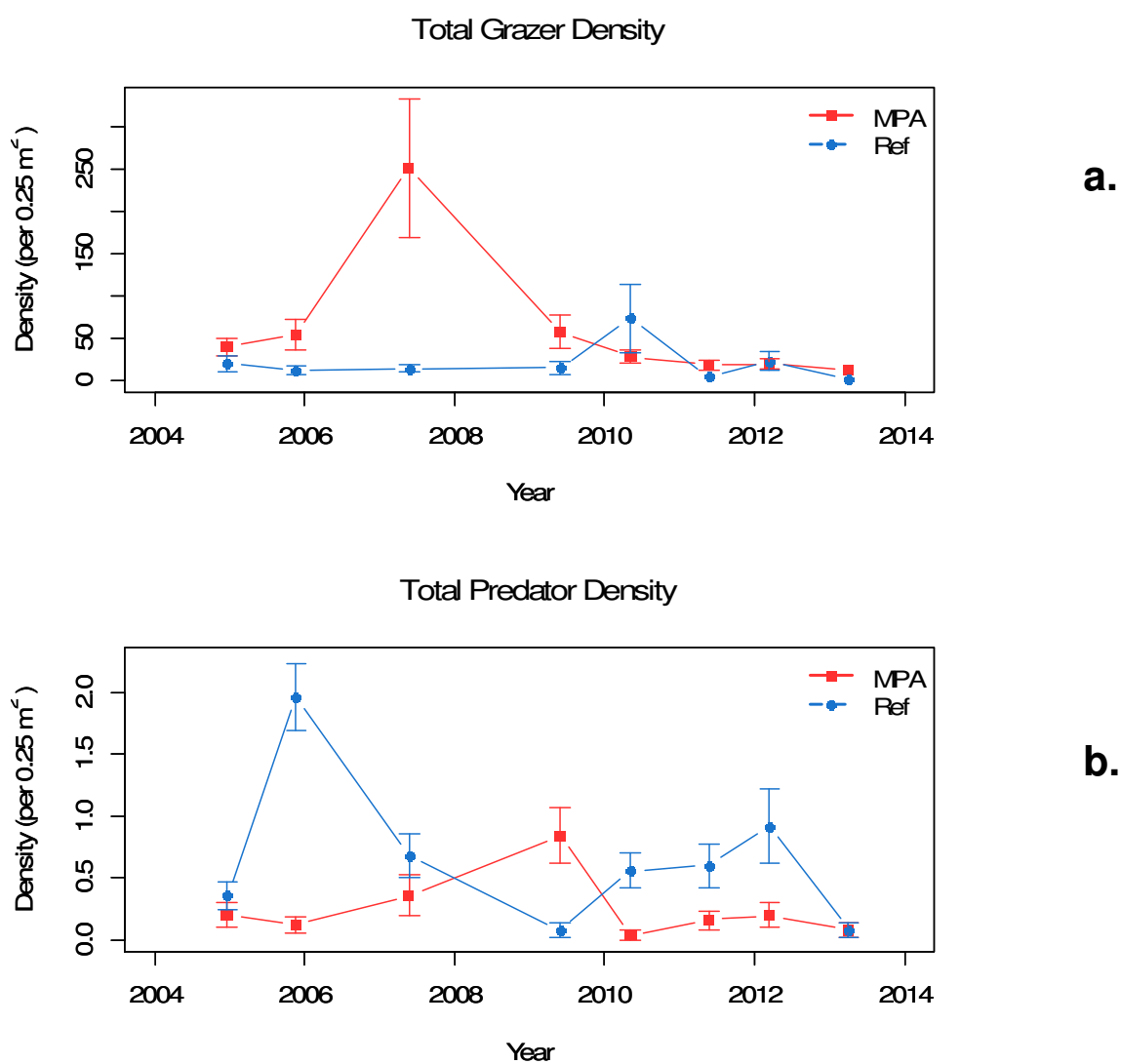


**Figure 9.13.** Mean abundance ( $\pm$  Standard Error) of: (a) all grazers; and (b) all predators at Point Addis and the Winkipop reference site.

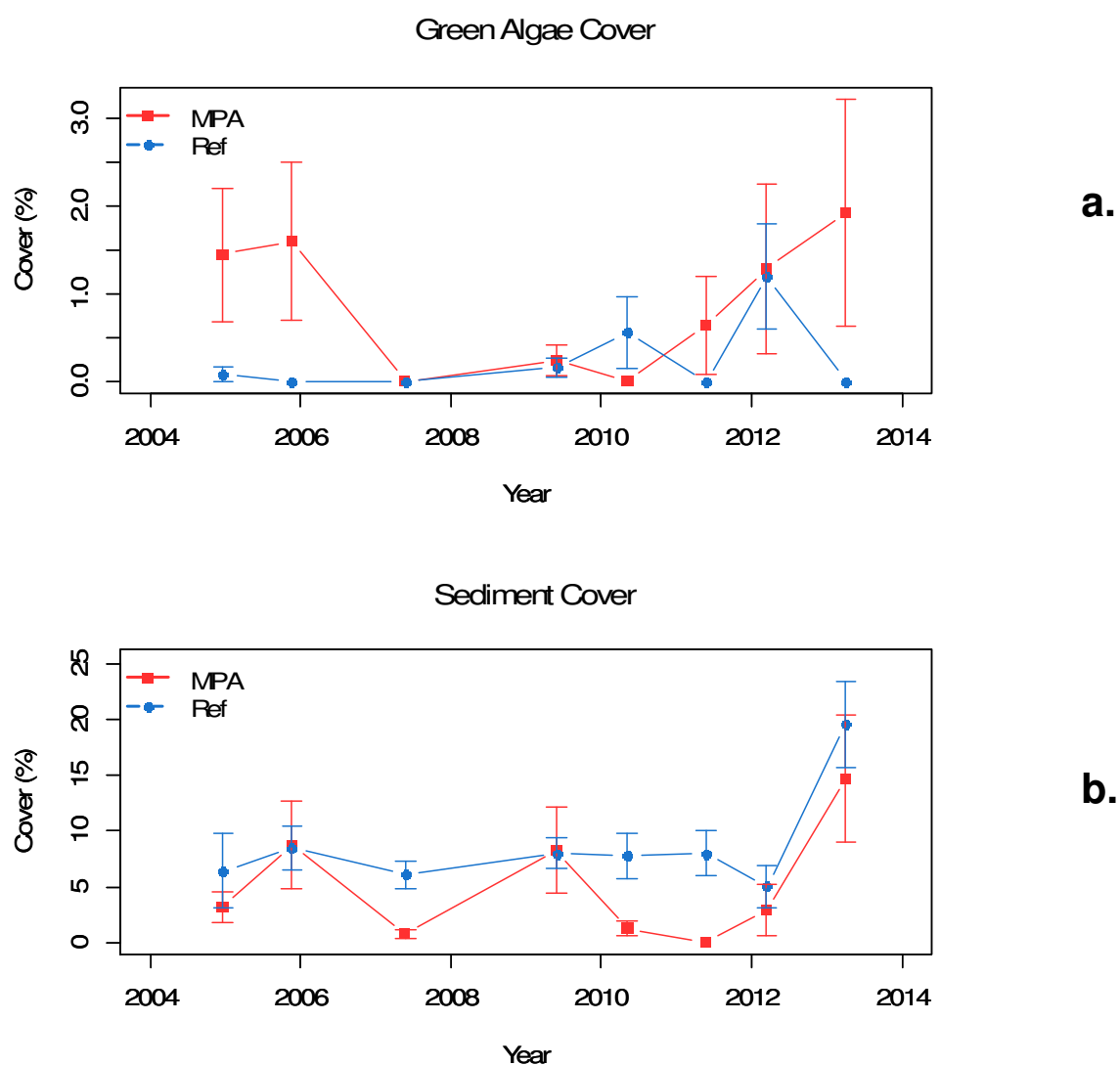


**Figure 9.14.** Mean cover ( $\pm$  Standard Error) of: (a) green algae (*Ulva* spp. and *Cladophora* spp.); and (b) sediment at Point Addis and the Winkipop reference site.

## **10 POINT DANGER MARINE SANCTUARY**

### **10.1 Site Description and Transect Layout**

#### **10.1.1 Point Danger Marine Sanctuary (Site 4002)**

The intertidal area at Point Danger is a large sandstone reef platform that is an extension of the Point Danger headland (Figure 10.1). The reef is exposed to the north, east and south, however most of the prevailing weather and waves are from the southwest to southeast. Large areas of sandy beach lie to the west and north of the platform.

The reef is a relatively flat sandstone platform which drains and floods quickly with the tide. The reef has been eroded to a rugose surface, with relief features of 10-15 cm height. Most of the reef is affected by sand inundation, with a thin layer of sand being present in many quadrats.

The survey site is in the near shore region of the platform towards the south/west border of the sanctuary. The high and low-shore baselines are approximately transverse to the headland.

#### **10.1.2 Point Danger West Reference (Site 4001)**

The reference site, Point Danger West, is separated from the Point Danger intertidal platform by a short section of sandy beach. As with Point Danger, the sandstone platform has been eroded to create an uneven surface at the scale of tens of centimetres. This reef is subject to significant sand inundation (Figure 10.2).



**Figure 10.1.** Intertidal reef at Point Danger Marine Sanctuary: 30 April 2013.



**Figure 10.2.** Intertidal reef at the Point Danger West reference site: 30 April 2013.

## Point Danger Community Structure

The mobile invertebrate community structures at Point Danger (4002) and the reference site Point Danger West (Site 4001) were similar. The community is dominated by the conniwink *Bembicium nanum*., periwinkle *Nodilittorina acutispira* and limpets *Siphonaria* spp and *Montfortula rugosa*. Snails *Dicathais orbita*, *Lepsiella vinosa*, *Turbo undulatus* and limpet *Patelloida alticostata* contributed to the community structure although occurring at lower densities.

The MDS analysis showed a similar degree of variation in both sites during much of the monitoring period. This variation was large compared with other monitoring areas (Figure 10.3). This variation was largely because of decreases in abundance of *Bembicium nanum* and corresponding increases in *Nodilittorina acutispira*.

The sessile species community structure was also similar between Point Danger the Point Danger West. The most common species were the brown alga Neptune's Necklace *Hormosira banksii*, mat-forming mussel *Limnoperna pulex* and algal turf. .

The calcareous tube-worm *Galeolaria caespitosa* was present at Point Danger West, but not at the Point Danger marine sanctuary site. The MDS analysis showed the Point Danger marine sanctuary site generally had smaller variations between times than the reference site and that both sites had departed away from previous conditions (Figure 10.4). In 2013, the two sites were distinctly different due to a reduction in *Hormosira banksii* at the Point Danger West site and an increase in *Limnoperna pulex* at the Point Danger Marine Sanctuary site.

## 10.2 Point Danger Diversity

Species richness of mobile invertebrates was relatively stable over the monitoring period at both Point Danger (Site 4002) and the reference site at Point Danger West (Site 4001; Figure 10.5).

Sessile species richness fluctuated at both Point Danger and Point Danger West , however no obvious trends were apparent (Figure 10.6).

Mobile invertebrate diversity (Hills  $N_2$ ) fluctuated considerably at both sites with no apparent trends, in 2013, there was a spike to the highest recorded level at Point Danger West (Figure 10.7). Sessile species diversity was also comparatively stable over the monitoring period and there was an increase at Point Danger MS in 2013 (Figure 10.8).

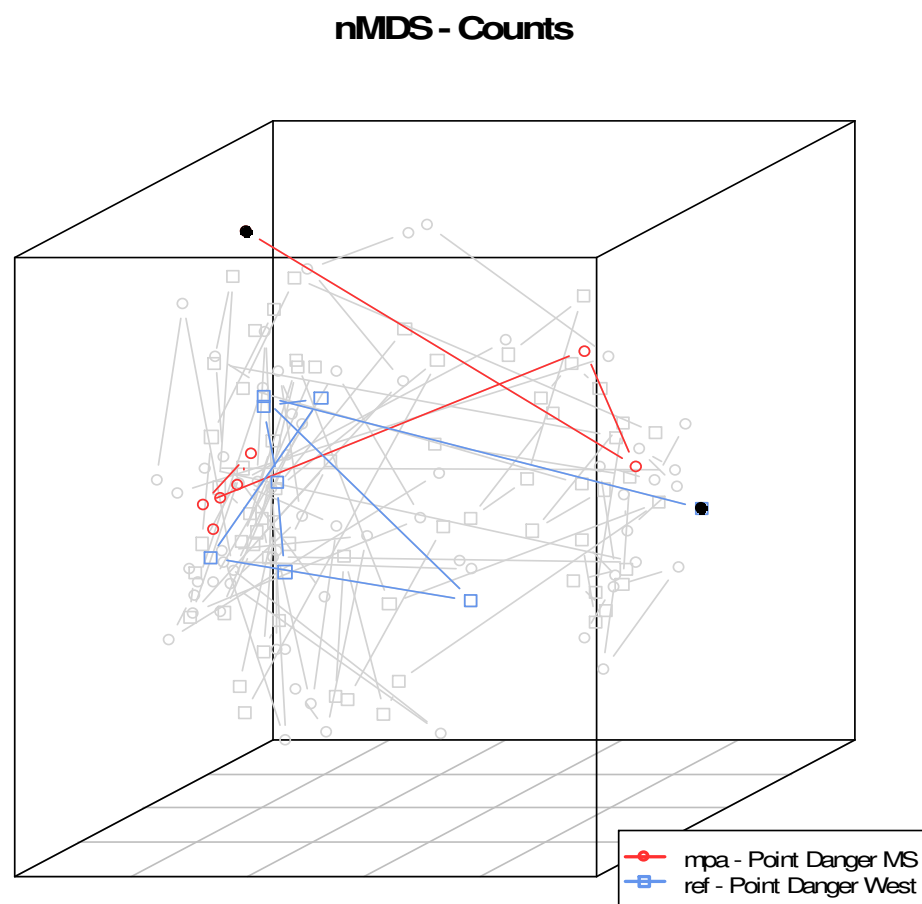


**Figure 10.3.** Three dimensional MDS plot of mobile invertebrate assemblages on intertidal reefs at Point Danger. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.13.

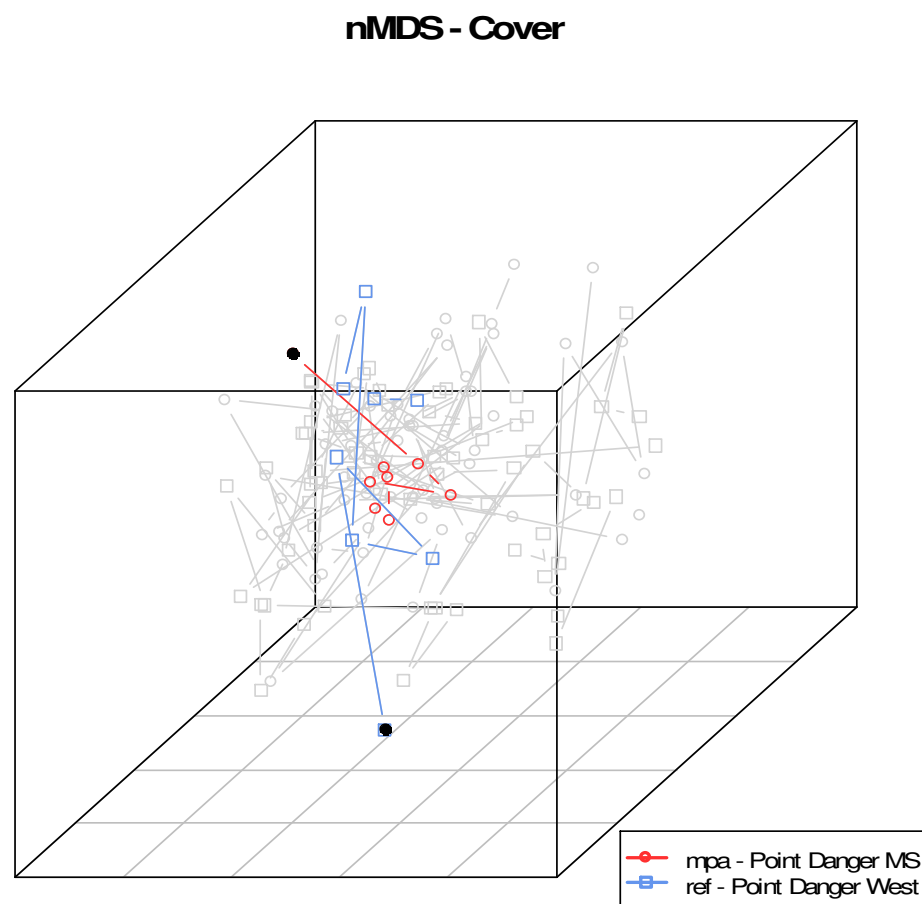


**Figure 10.4.** Three dimensional MDS plot of sessile assemblages on intertidal reefs at Point Danger. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.18.

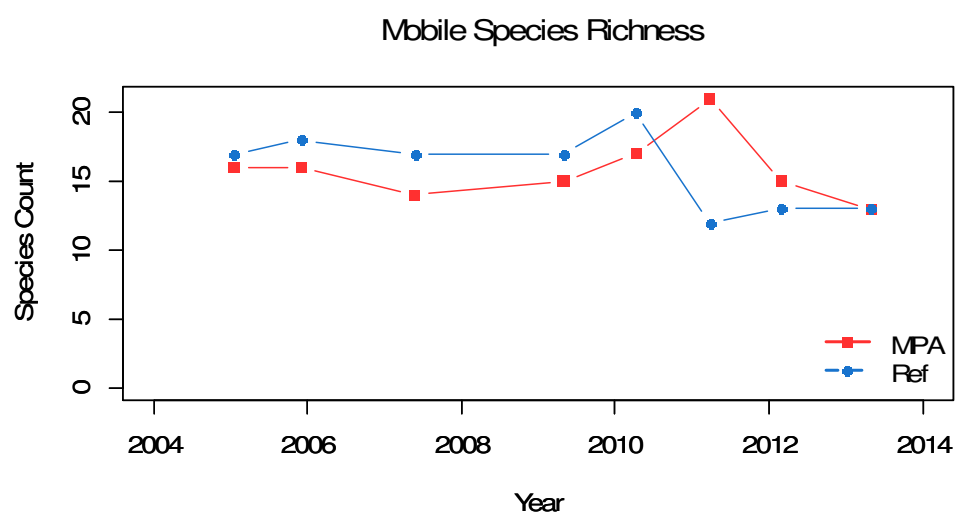


**Figure 10.5.** Mobile invertebrate species richness at Point Danger sites.

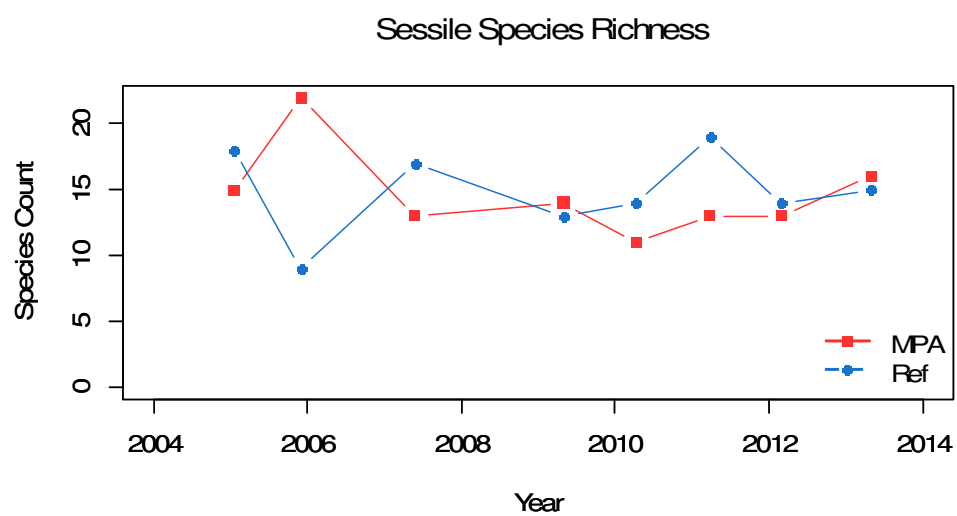


**Figure 10.6.** Sessile species richness of intertidal sites at Point Danger sites.

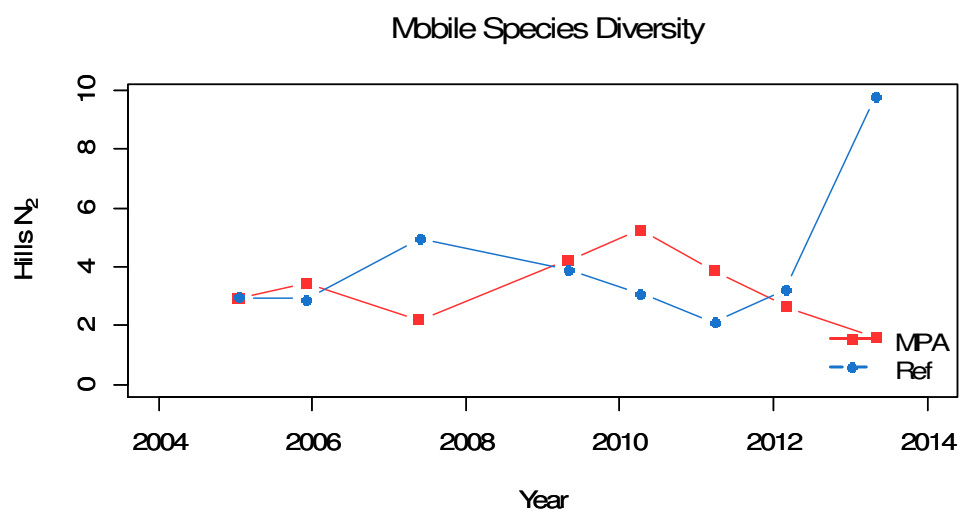


**Figure 10.7** Mobile invertebrate diversity (Hills  $N_2$ ) of intertidal sites at Point Danger sites.

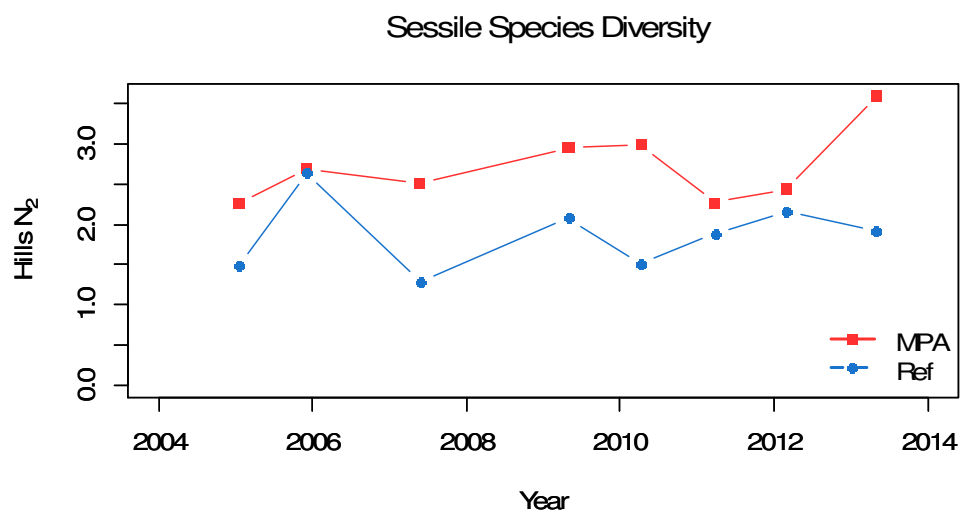


**Figure 10.8.** Sessile species diversity (Hill's  $N_2$ ) of intertidal sites at Point Danger sites.

### 10.3 Point Danger Sessile Species

The cover of *H. banksii* was similar at both sites and remained relatively stable over the monitoring period (Figure 10.9).

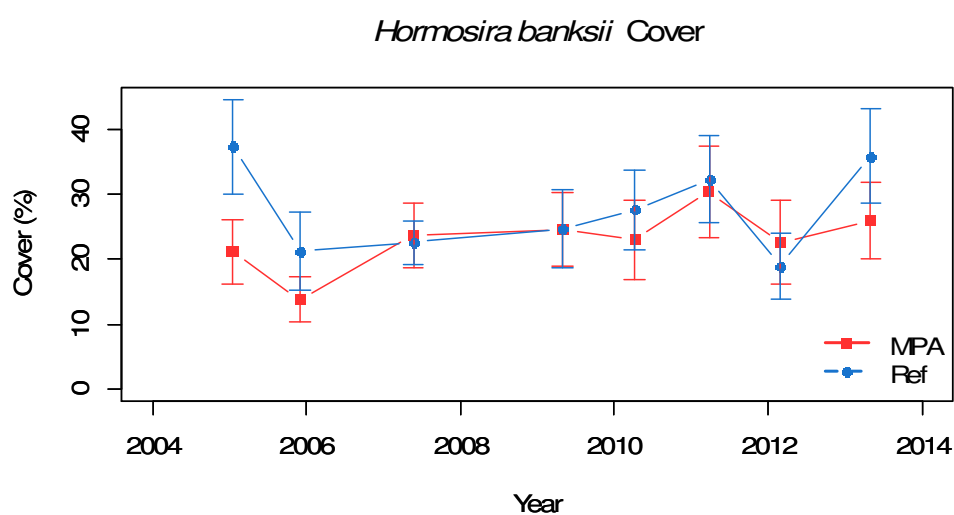


**Figure 10.9.** Mean density ( $\pm$  Standard Error) of Neptune's Necklace *Hormosira banksii* at Point Danger.

## 10.4 Point Danger Mobile Invertebrates

The abundance of *Montfortula rugosa* fluctuated considerably between survey times with abundances in 2013 far greater at Point Danger (Figure 10.10a).

For *Bembicium nanum*, there was a strong peak in abundance in 2007 at Point Danger MS. This peak was not reflected at the reference site, and abundances in the MS subsequently fell to reference site levels by 2009 (Figure 10.10b).

The limpet *Cellana tramoserica* was present in low densities at both sites over the monitoring program (Figure 11.10c).

Mean sizes of *Bembicium nanum* fluctuated considerably through time with an increasing trend apparent at both sites since 2010 (Figure 10.11a). Mean sizes of *C. tramoserica* were relatively stable through time with a slight upward trend (Figure 10.11b).

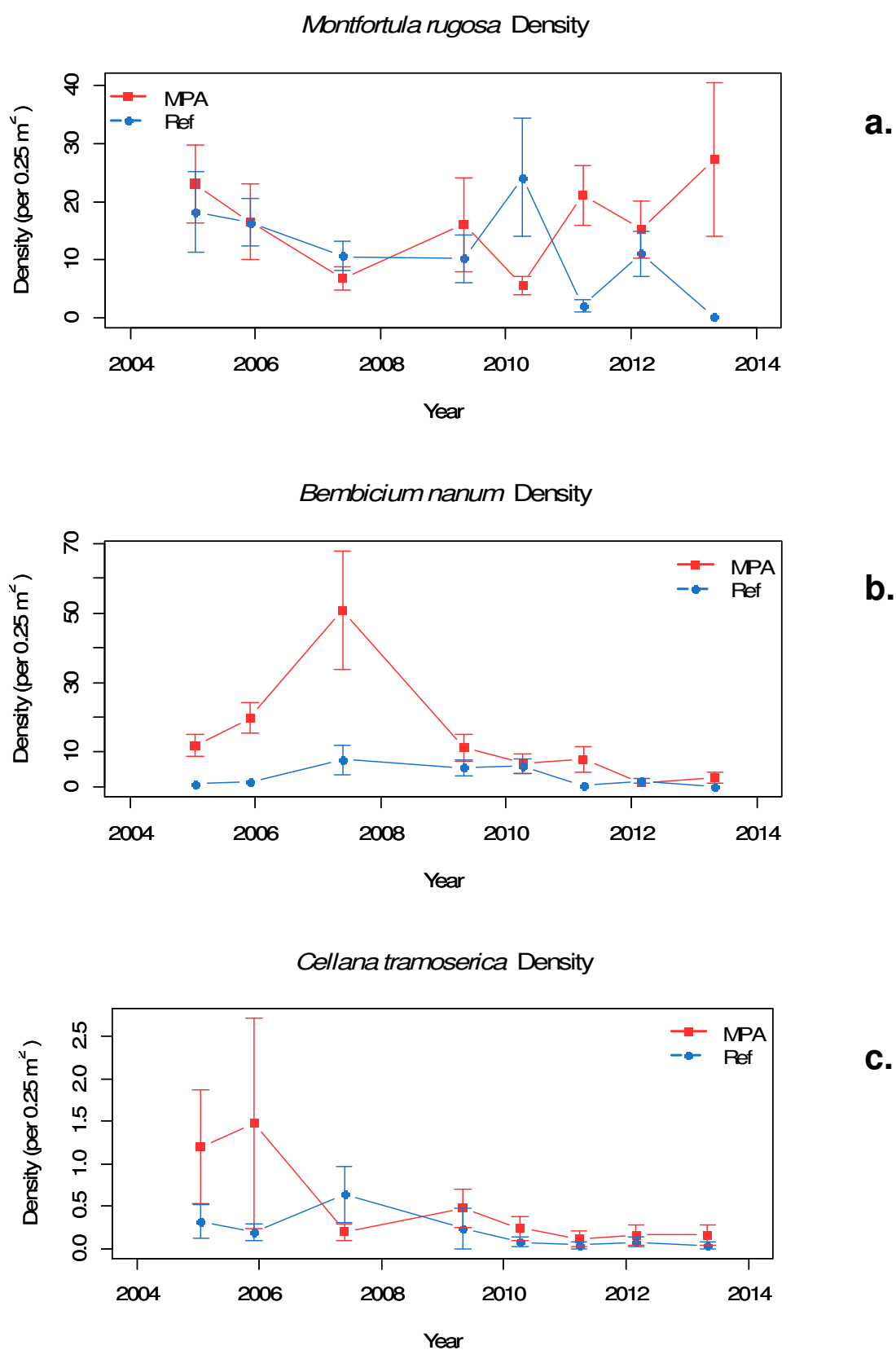


**Figure 10.10.** Mean Density ( $\pm$  Standard Error) of dominant mobile invertebrates at Point Danger.

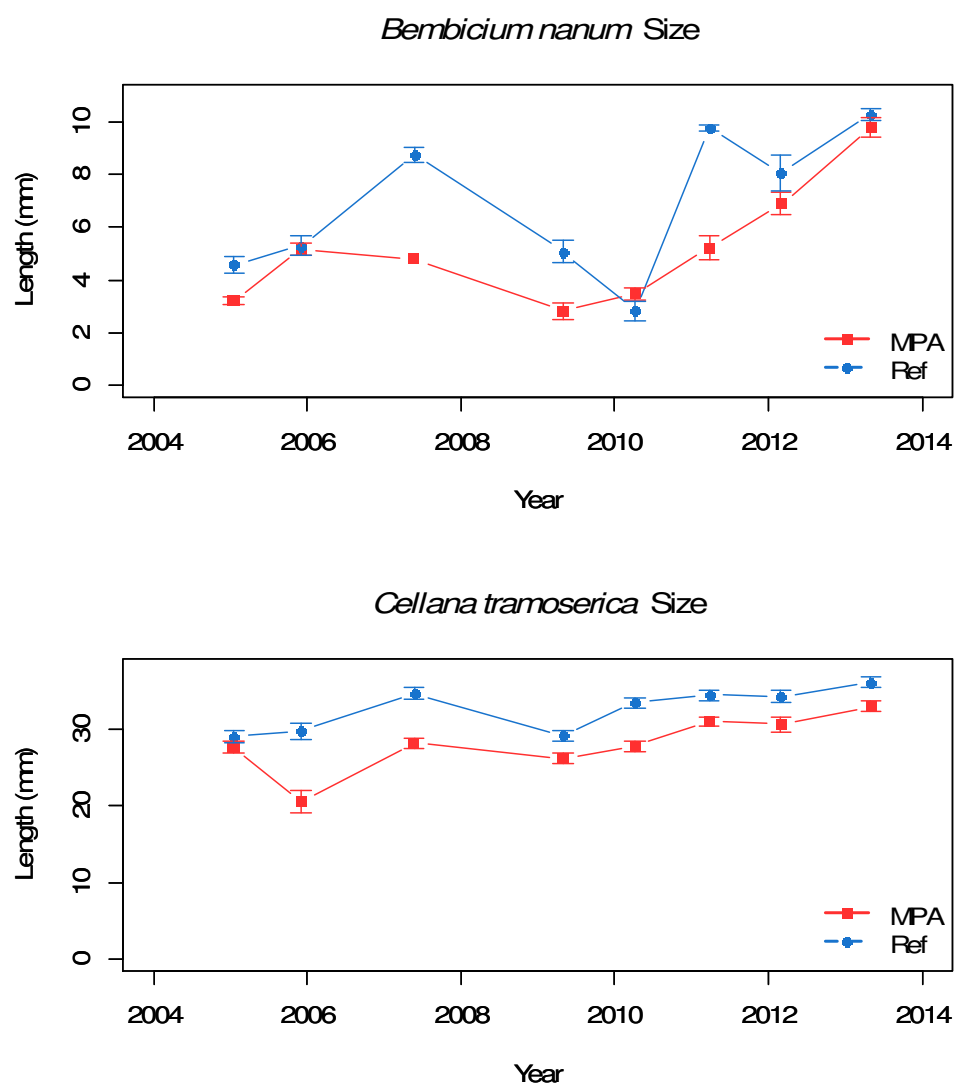


**Figure 10.11.** Mean sizes ( $\pm$  Standard Error) of invertebrates at Point Danger.

## **10.5 Point Danger Condition Indicators**

### **10.5.1 Biodiversity**

Community composition and species richness were within the range of states previously observed. There was a peak in mobile species diversity at Point Danger MS in 2013. .

### **10.5.2 Introduced Species**

No introduced species were observed during the intertidal reef surveys in this area.

### **10.5.3 Ecosystem Function**

Total algal cover varied cyclicly over time – the 2013 state was with higher algal cover than previously recorded (Figure 10.11a). The cover of erect coralline algae was very low during all surveys (Figure 10.11b). The cover of algal turf at both sites was low and variable over time with no clear patterns (Figure 10.11c).

The abundance of grazers was variable between survey times, with similar variations at both sites (Figure 10.12a). Predator abundances were greater within the sanctuary until 2009, with a drop to similar densities as the reference site (Figure 10.12b).

### **10.5.4 Climate Change**

There were no community shifts towards greater affinities with other bioregions.

### **10.5.5 Harvesting**

There were no indications of harvesting based on gastropod abundances, although there were some declines apparent, and increases in mean sizes. The indicators did not provide evidence that could distinguish harvesting pressure from natural population dynamics.

### **10.5.6 Trampling**

The stable abundances of *H. banksii* indicated there were no trampling impacts.

### **10.5.7 Environment**

The cover of green algal species increased over recent years, potentially indicating increased nutrient loading (Figure 10.14a).

Sediment cover had a large range of 30 % at both sites during the monitoring program. High coverages were observed in 2011 and in 2013 in the reference site, but was correspondingly low at Point Danger MS (Figure 10.14b).

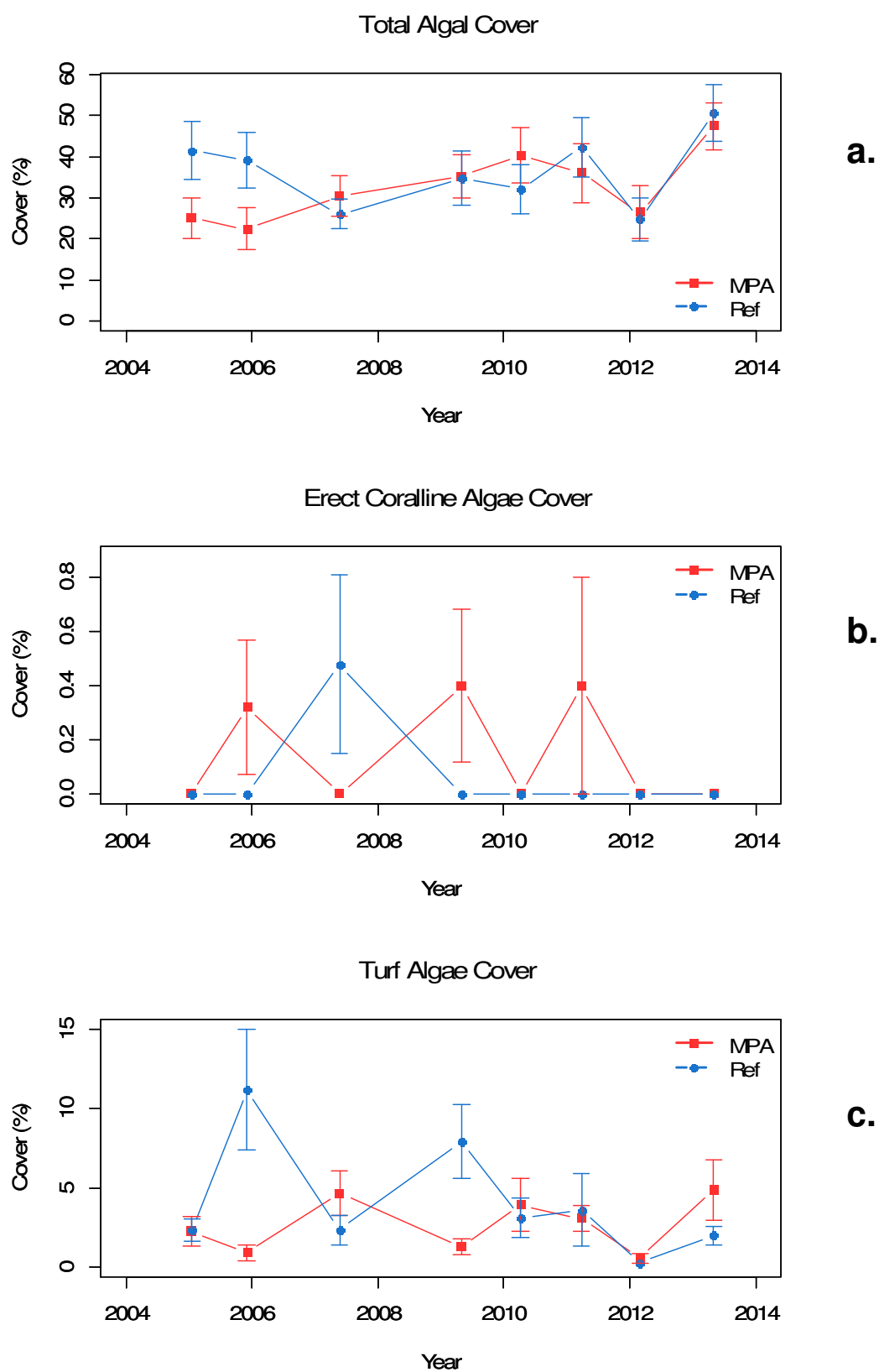


**Figure 10.12.** Mean cover ( $\pm$  Standard Error) of functional algal groups at Point Danger.

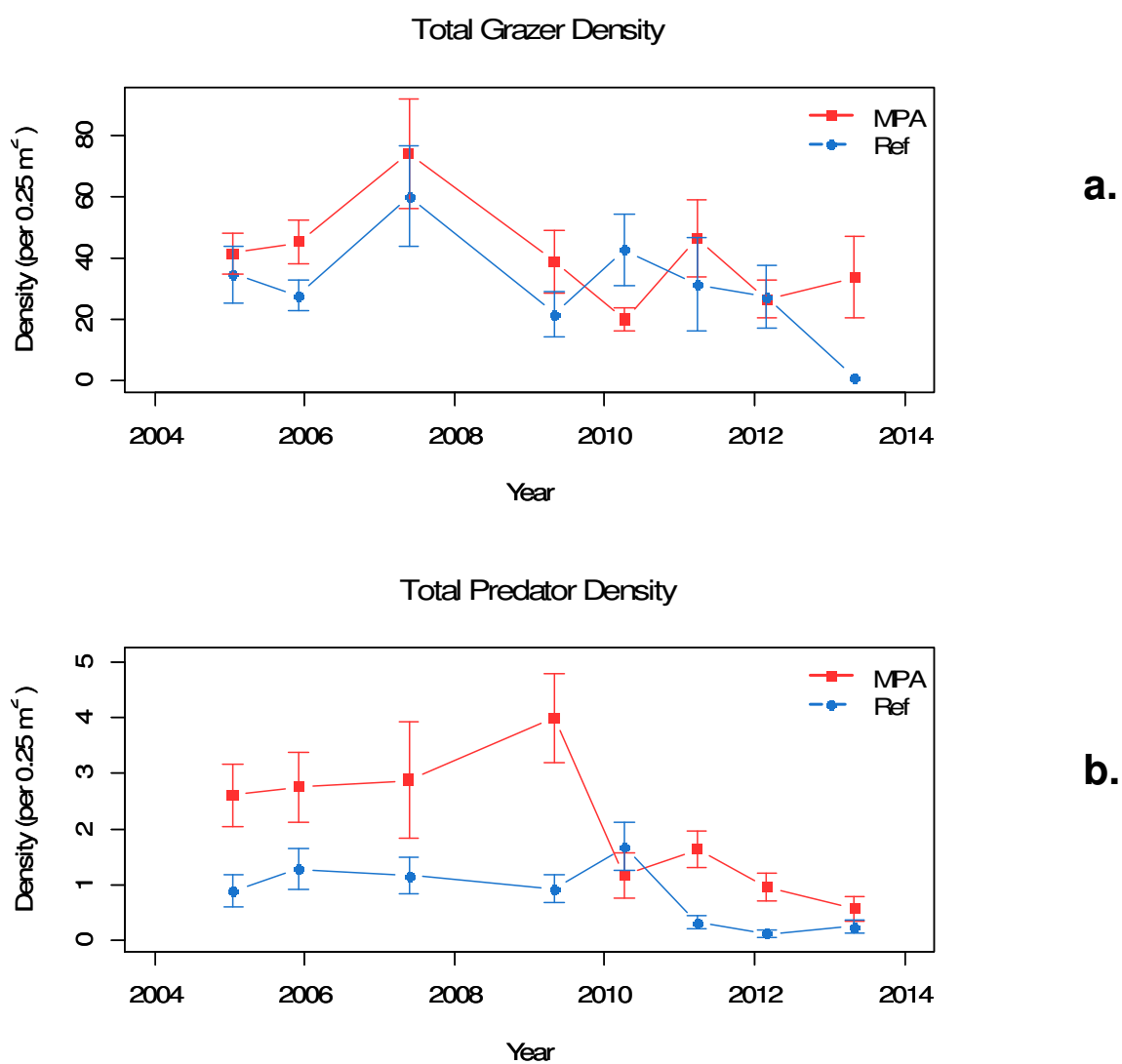


**Figure 10.13.** Mean abundance ( $\pm$  Standard Error) of: (a) all grazers; and (b) all predators at Point Danger.

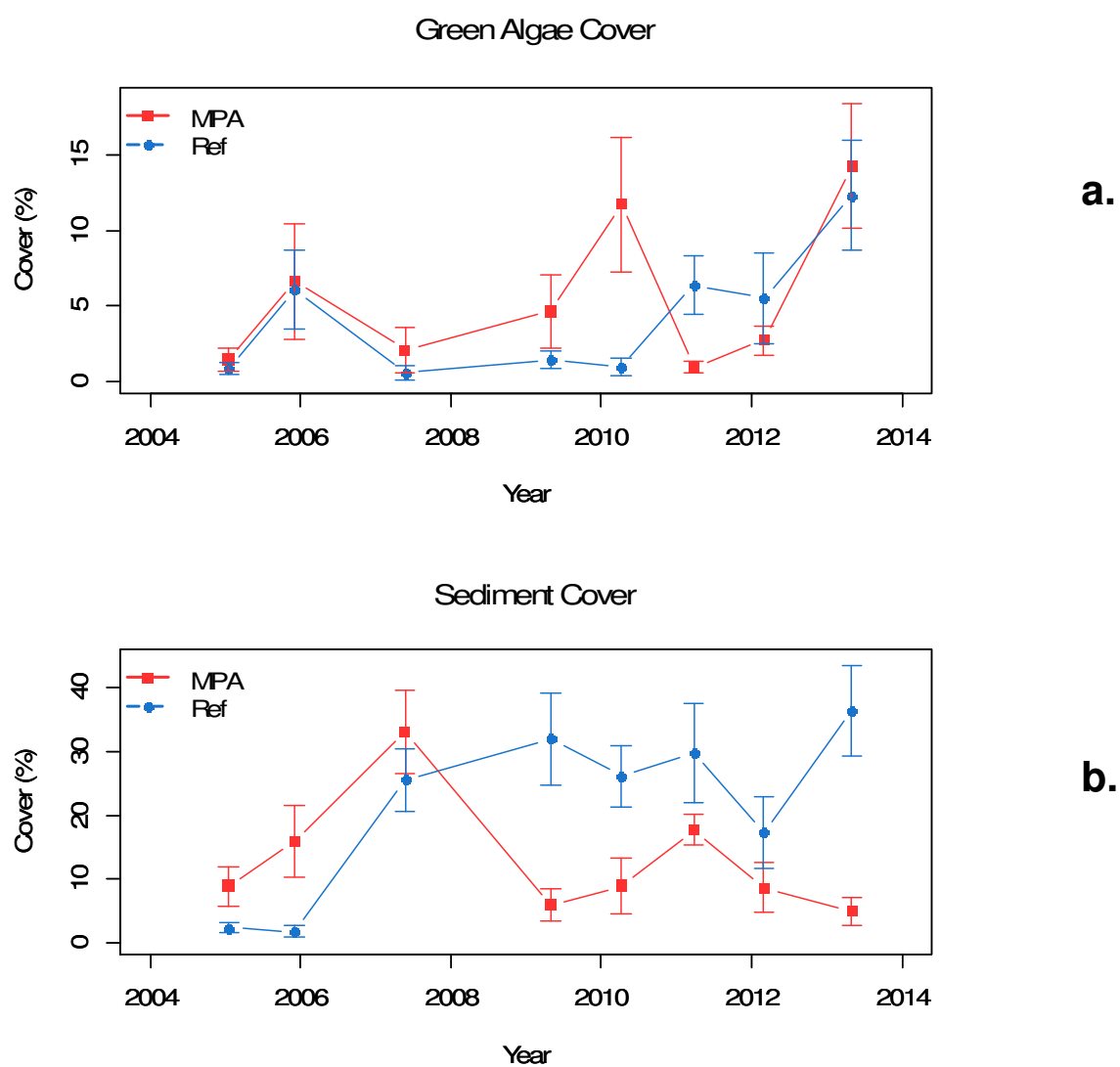


**Figure 10.14.** Mean cover ( $\pm$  Standard Error) of: (a) green algae (*Ulva* spp. and *Cladophora* spp.); and (b) sediment at Point Danger.

# **11 BARWON BLUFF MARINE SANCTUARY**

## **11.1 Site Description and Transect Layout**

### **11.1.1 Barwon Bluff Marine Sanctuary (Site 4004)**

The intertidal reef at Barwon Bluff is composed of sections of sandstone and basalt reef. The intertidal rock platform extends from the end of Barwon Bluff as a pincer-shaped reef. The north-eastern section of the pincer is a basalt platform and boulder reef. This section of the reef is relatively protected from swell but has a large estuarine influence from the adjacent mouth of the Barwon River. The south-western section of the reef is a relatively flat sandstone reef, which is more exposed to large swells and sand inundation due to its exposure towards the south, proximity to an adjacent surf beach and strong cross-shore currents. The survey site is on the sandstone section of the reef (Figure 12.1).

The sandstone platform has three large rockpools in the centre of the survey area. The transects do not intercept any of these pools. Relief is present as 5-10 cm high ripples in the platform. These ripples act as traps for cross-shore sand movement. The edge of the platform drops sharply into subtidal habitat. At the high shore end of the platform there is a distinctive rise in shore height.

### **11.1.2 Barwon Beach Reference (Site 4003)**

To the west of the intertidal platform at Barwon Bluff are several smaller isolated patches of intertidal sandstone reef. These reefs are directly exposed to large southerly swells and sand inundation due to their proximity to the adjacent surf beach and strong longshore currents. The reef surface has been weathered to create an uneven surface at the scale of 10s of centimetres. The reference site is on one of these reefs, approximately 400 m west of Barwon Bluff, directly below a set of access stairs. These stairs are the closest access point and are the first set west of Barwon Bluff.

The reef structure is rugose, with many depressions and rock pools approximately 20 cm in depth and 20-100 cm in diameter. It is more rugose than the Barwon Bluff site (Site 4004).

The Barwon Beach reference site (Site 4003) was not surveyed during Survey 2, May 2004, because of sand inundation.



**a.**



**b.**

**Figure 11.1** Intertidal reef at Barwon Bluff Marine Sanctuary: (a) and Barwon Beach reference site (b) 29 May 2013.

## 11.2 Barwon Bluff Community Structure

The mobile invertebrate communities at Barwon Bluff (Site 4004) and the reference site Barwon Beach (Site 4003) are largely composed of top shells *Austrocochlea constricta*, conniwinks *Bembicium* spp. limpets *Cellana tramoserica* and *Notoacmea* spp., periwinkles *Nodilittorina acutispira*, and slit limpets *Montfortula rugosa*.

The MDS analysis of mobile invertebrate community structure indicated both sites were similar to each other with a similar level of variation between times, placing them close together within the same cluster on the MDS plot (Figure 11.2). In 2013 there was a marked shift in community structure away from previous conditions at Barwon Beach reference site. This was attributed to a drop in density of *Montfortula rugosa* and *Cellana tramoserica* density (Figure 11.2).

The sessile species communities at Barwon Bluff and the Barwon Beach reference site are dominated by the brown algae Neptune's Necklace *Hormosira banksii*. The mat-forming mussel *Limnoperna pulex*, the calcareous tube-worm *Galeolaria caespitosa* and algal turf were also present at low abundances. The MDS analysis located the two sites closely together on the MDS plot for most years, indicating their similarity with each other throughout the monitoring program (Figure 11.3). The MDS also illustrated a similar degree of variation between times for both sites. In 2013, there was a marked shift in community structure at the reference site was attributed to an increase in sand and sediment cover.

## 11.3 Barwon Bluff Diversity

Mobile invertebrate species richness has been stable at the Barwon Beach reference site (Site 4003), ranging from 13 to 17 species per survey (Figure 11.2). Species richness was more variable at Barwon Bluff Marine Sanctuary (Site 4004), peaking at 22 species in late 2005 before dropping to 10 in 2007 and subsequently increasing again (Figure 12.4).

The species richness of the algal and sessile invertebrate communities at Barwon Bluff and Barwon Beach remained similar to each other through time, varying between 15 and 20 species. There was a dip at both sites to lowest recorded levels in 2013 (Figure 11.5).

Mobile invertebrate diversity (Hills  $N_2$ ) was reasonably variable at both Barwon Heads sites, with intermediate levels observed in 2013 (Figure 11.5).

Algal and aggregate sessile invertebrate diversity remained low and relatively stable, between 1 and 1.5, throughout the monitoring program (Figure 11.5).

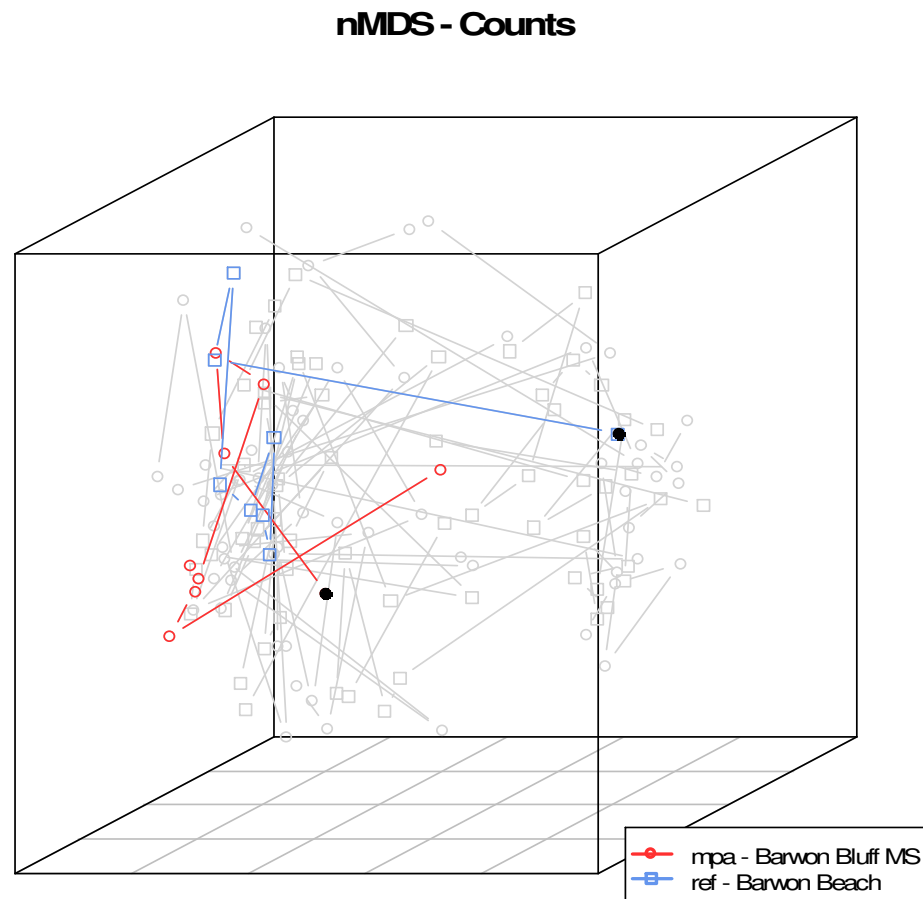


**Figure 11.2** Three dimensional MDS plot of mobile invertebrate assemblages on intertidal reefs at Barwon Bluff. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.13.

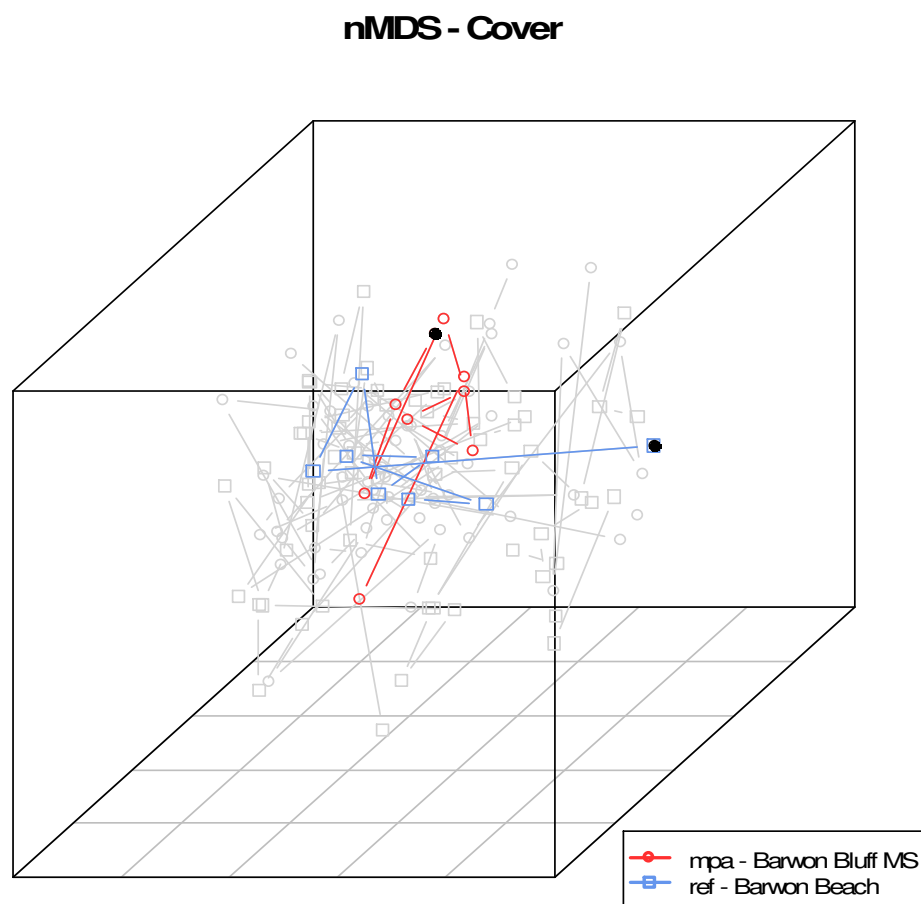


**Figure 11.3** Three dimensional MDS plot of sessile species assemblages on intertidal reefs at Barwon Bluff. The grey lines represent data from all other MPA and reference sites used in the MDS ordination. Kruskal stress = 0.18.

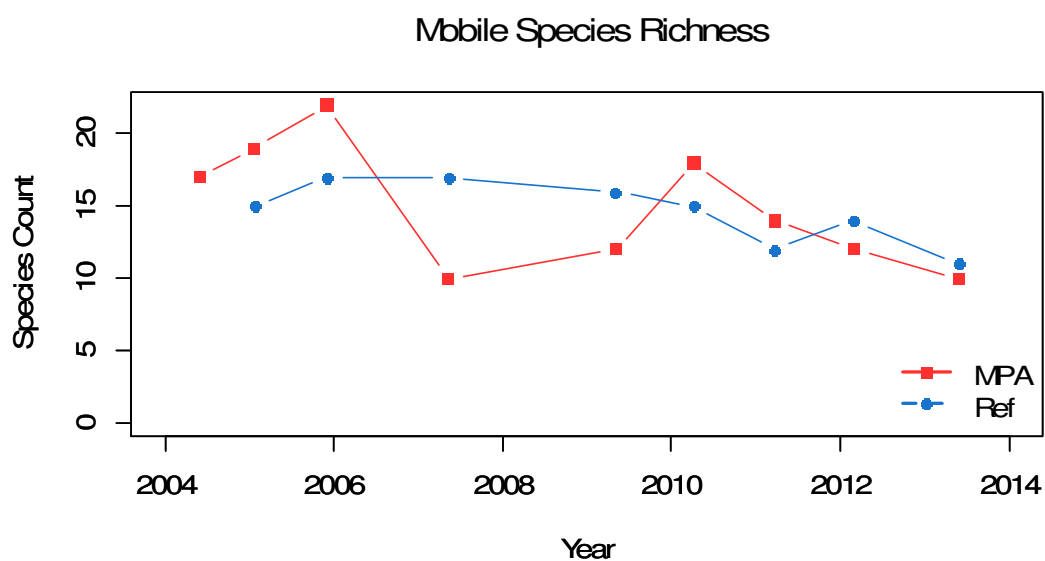


**Figure 11.4** Mobile invertebrate species richness at Barwon Bluff sites.

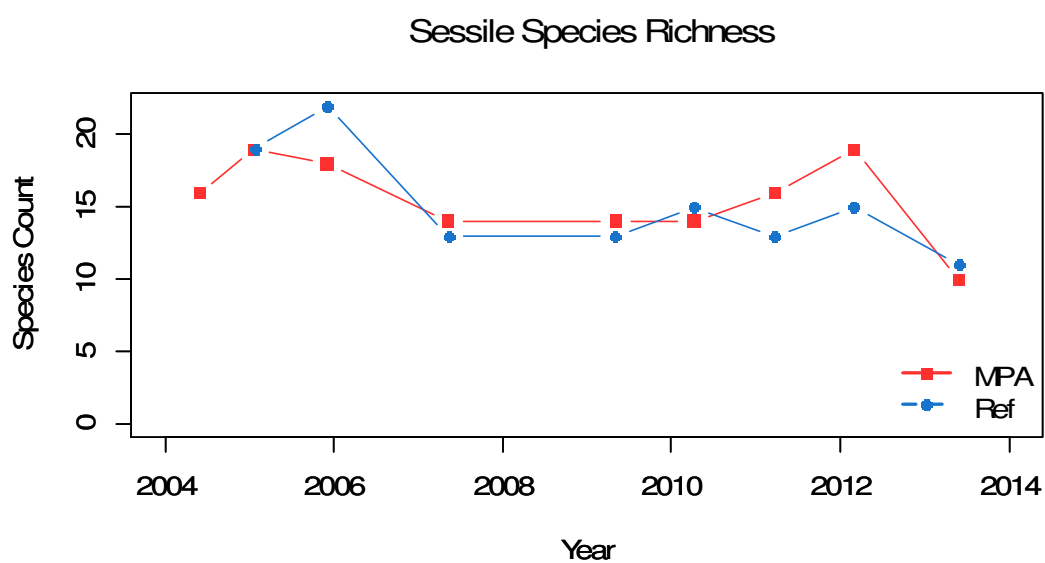


**Figure 11.5** Sessile species richness of intertidal sites at Barwon Bluff sites.

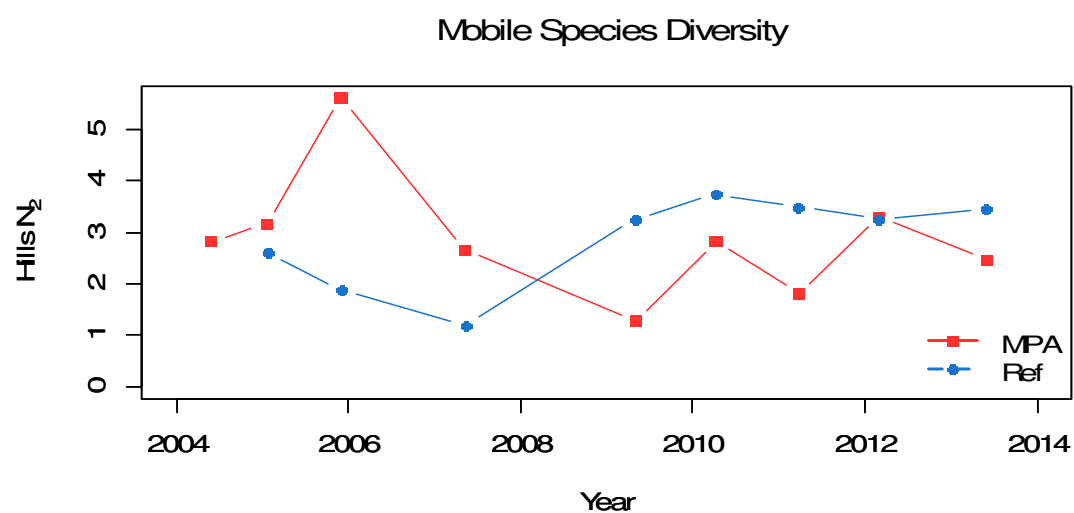


**Figure 11.6** Mobile invertebrate diversity (Hills  $N_2$ ) of intertidal sites at Barwon Bluff sites.

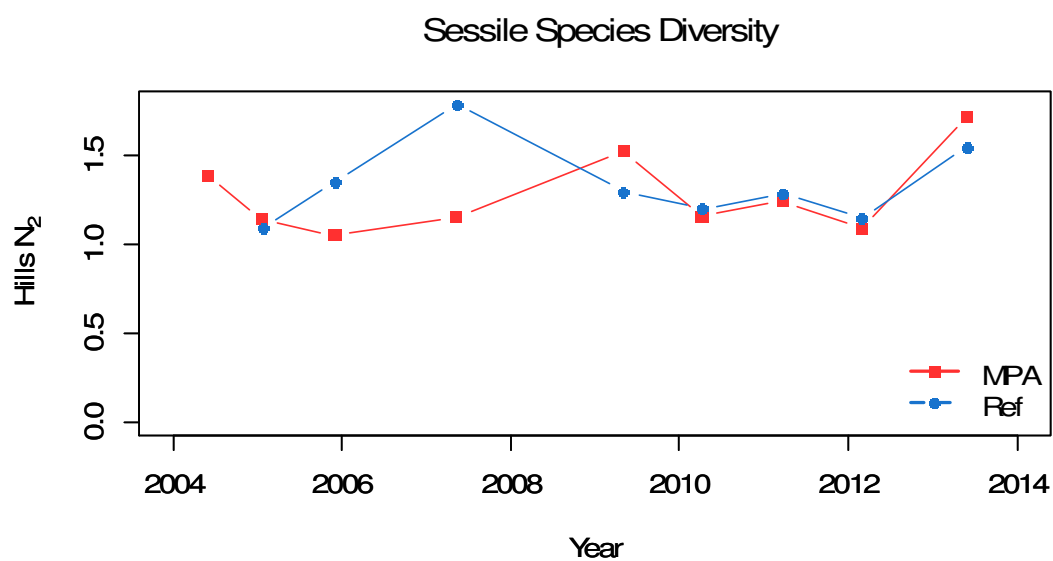


**Figure 11.7** Sessile species diversity (Hill's  $N_2$ ) of intertidal sites at Barwon Bluff sites.

## 11.4 Barwon Bluff Sessile Species

The cover of *H. banksii* was typically 15-20 % higher at Barwon Bluff than at the reference site, except for 2009 and 2013 when cover decreased significantly at the Barwon Bluff MS site (Figure 11.8). In 2011 and 2012, both sites had the highest levels of cover of *H. banksii* since surveys started.

Erect coralline algae are present at Barwon Bluff in highly variable abundances and were largely absent in 2011 and 2012. In 2013 there were marked increases in green algal cover at both sites. The only other macroalgae which occurred in appreciable quantities on the shore were turf forming species. Although variable, there was a general decrease in algal turf cover at both sites over the monitoring period.

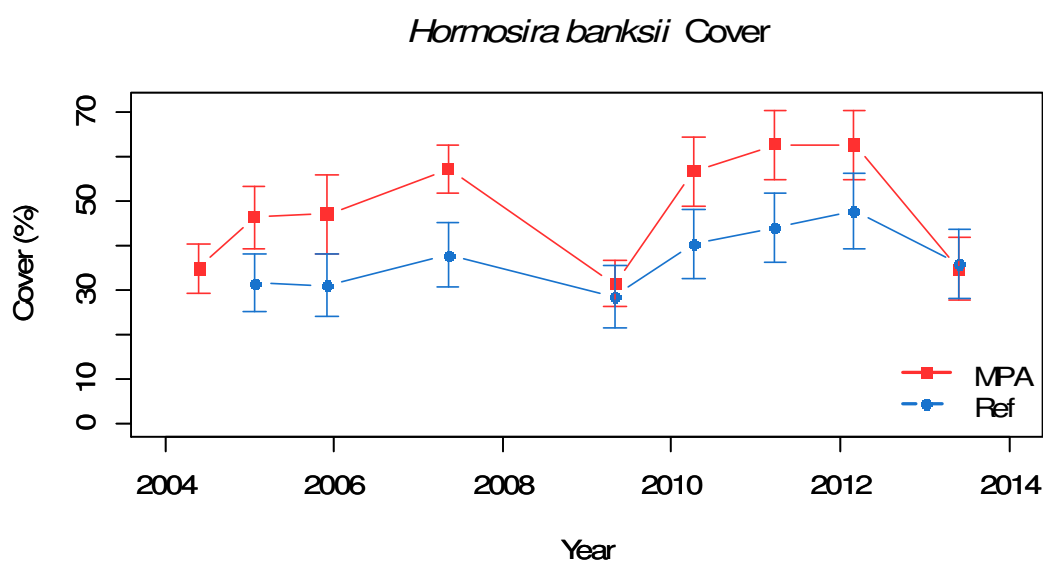


**Figure 11.8** Mean percent cover ( $\pm$  Standard Error) of Neptune's Necklace *Hormosira banksii* at Barwon Bluff sites.

## 11.5 Barwon Bluff Mobile Invertebrates

The periwinkle *N. acutispira* was present in high densities at both sites in 2007, particularly at Barwon Beach, in the mid to low region of the intertidal platforms. Since this time the abundance of *N. acutispira* decreased substantially and was absent in the 2013 survey (Figure 11.9a).

The limpet *M. rugosa* was the most abundant species at both sites, although abundances were highly variable. No individuals were recorded at either site in 2013 (Figure 11.9b).

*Cellana tramoserica* densities increased markedly in 2013 at Barwon Bluff and Barown Beach with values of 14 and 31 per 0.25m<sup>2</sup> respectively (Figure 11.9c).

There were no apparent patterns in mean length of *C. tramoserica*. There were similar ranges of variation over the monitoring period at both sites (Figure 11.10).

The predatory gastropods *Cominella lineolata* and *Dicathais orbita* occurred in low abundances at both sites during all surveys.

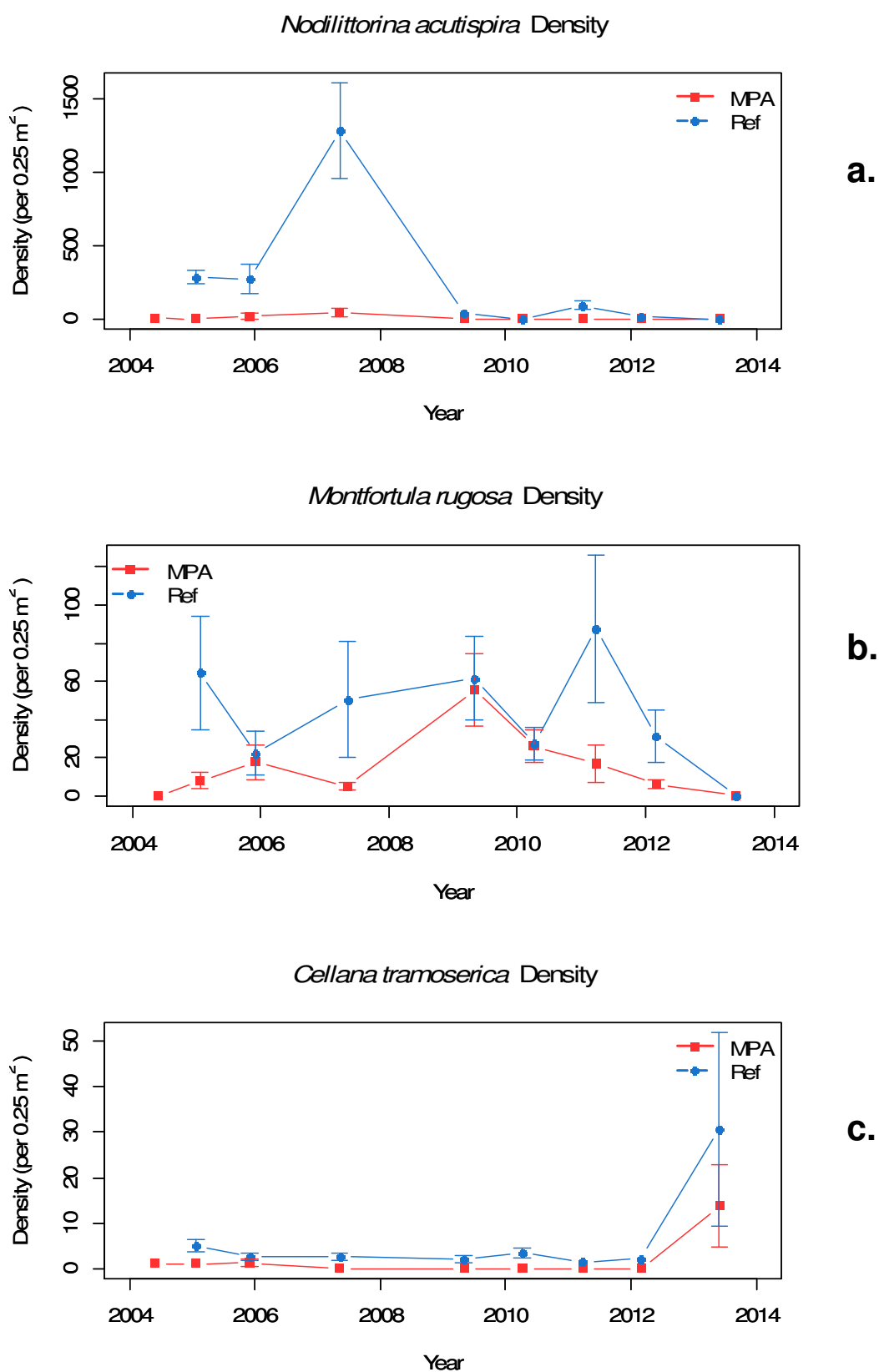


**Figure 11.9** Mean Density ( $\pm$  Standard Error) of dominant mobile invertebrates at Barwon Bluff sites.

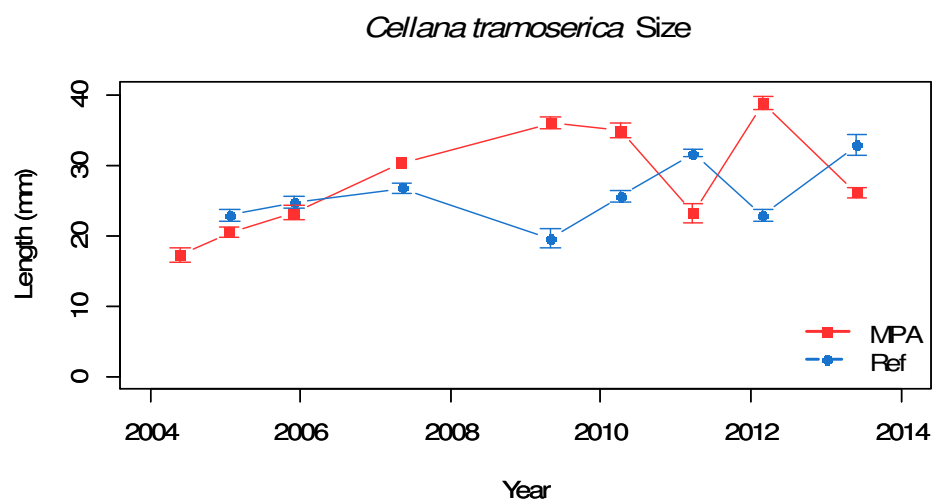


**Figure 11.10** Mean sizes ( $\pm$  Standard Error) of the limpet *Cellana tramoserica* at Barwon Bluff, within the Barwon Bluff MS, and the Barwon Beach reference site.

## 11.6 Barwon Bluff Condition Indicators

### 11.6.1 Biodiversity

Community composition, species richness and diversity levels were all within the range previously observed at these sites. There was a marked decrease in sessile species richness driven by a drop in the number of algal species present in 2013.

### 11.6.2 Introduced Species

No introduced species were detected for these sites.

### 11.6.3 Ecosystem Function

Total algal cover reflected *H. banksii* cover and was at its highest from 2010 to 2012 (Figure 11.11a). Erect coralline algae cover was low and variable at both sites, approaching zero coverage since 2011 (Figure 11.11b). Turfing algae had a generally decreasing trend over the monitoring period, with very little cover observed in 2013 (Figure 11.11c).

The total abundance of grazers at both sites varied substantially (Figure 11.12a). This was primarily due to changes in the abundance of the periwinkle *Nodilittorina acutispira*.

Total predator abundances were low and variable at both sites, however a general decreasing trend was apparent over the monitoring period (Figure 11.12b).

### 11.6.4 Climate Change

There were no community shifts towards greater affinities with other bioregions.

### 11.6.5 Harvesting

The density of *Cellana tramoserica* was low at Barwon Bluff MS before a marked spike in both sites in 2013. Mean sizes had a general increasing trend over the monitoring period. These changes may be indicative a reduction in any harvesting pressure and/or changes in natural influences on population dynamics.

### **11.6.6 Trampling**

There were dips in abundance of *Hormosira banksii* cover during 2009 and 2013, at both sites. It is difficult to discern whether this is an impact of any trampling or other environmental influences.

### **11.6.7 Environment**

The cover of green algal species can sometimes be indicative of nutrient loading. This was relatively low (< 2 %) at both sites for the majority of surveys (Figure 11.13a).

Sediment cover appears to vary cyclically at Barwon Heads, with peaks of 10-20 % cover. Low cover periods were in 2004 to 2005 and in 2011 (Figure 11.13b).

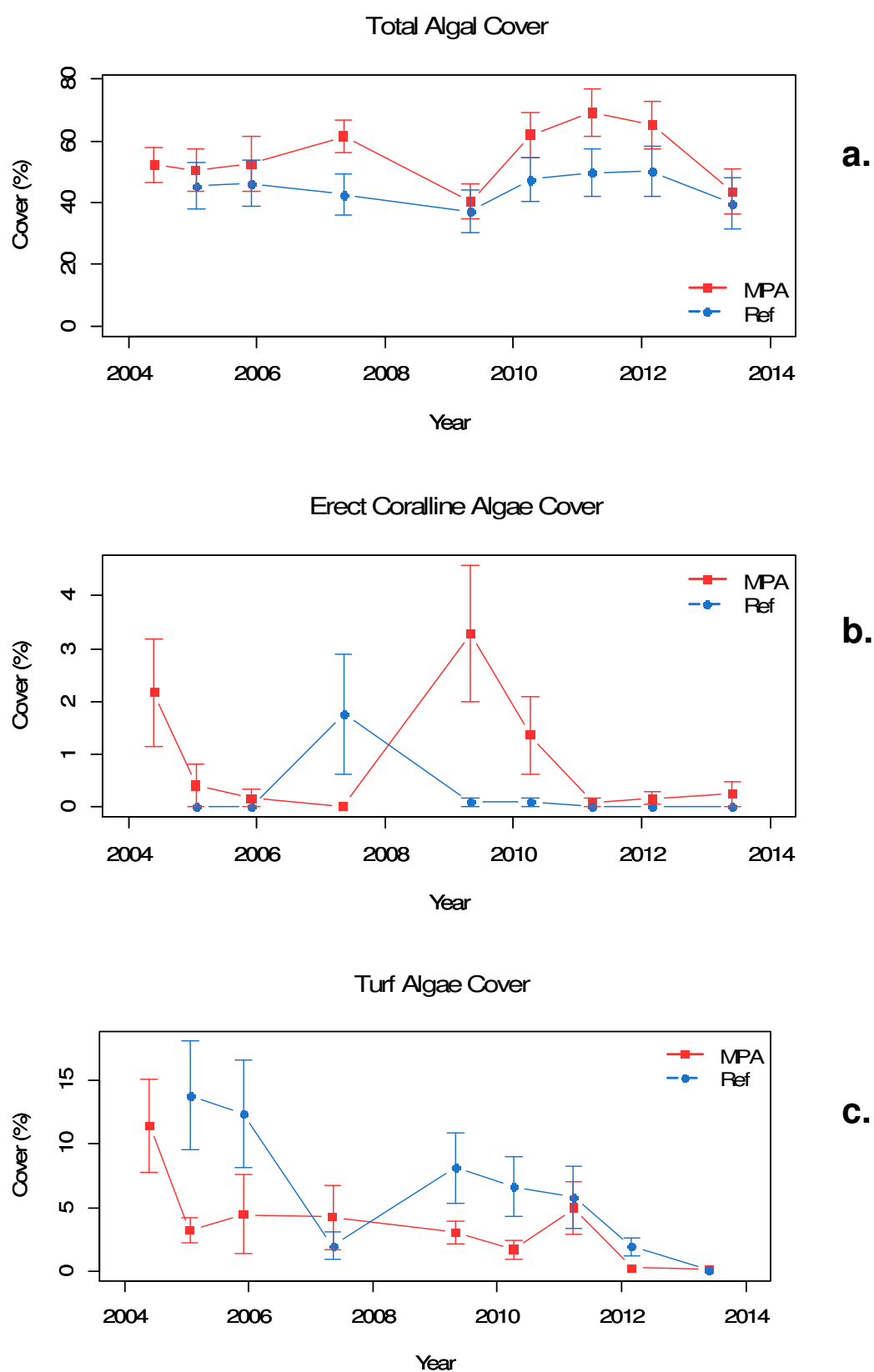


**Figure 11.11** Mean cover ( $\pm$  Standard Error) of algae within the Barwon Bluff MS, and the Barwon Beach reference site.

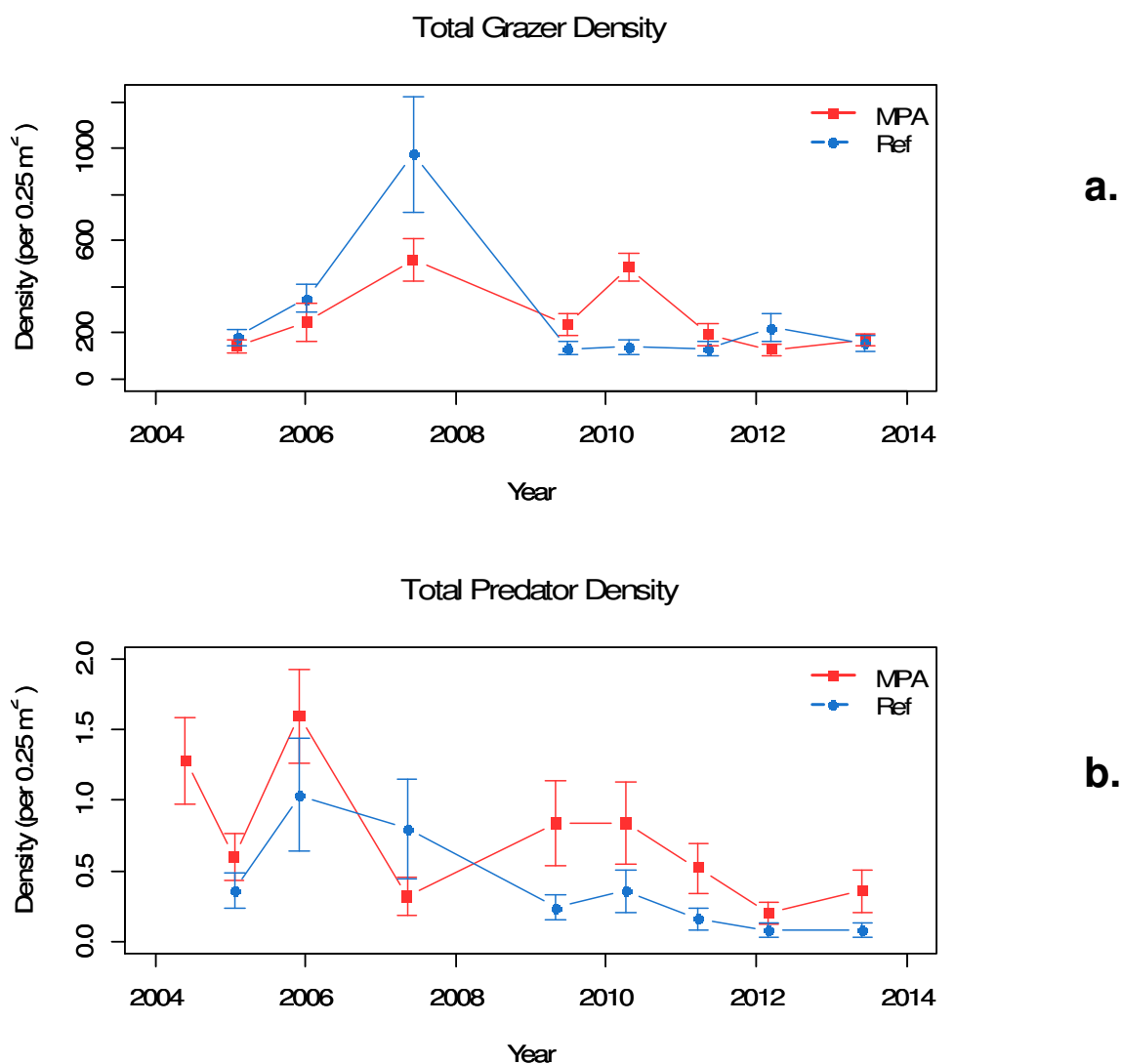


**Figure 11.12** Mean abundance ( $\pm$  Standard Error) of: (a) all grazers; and (b) all predators at Barwon Bluff sites.

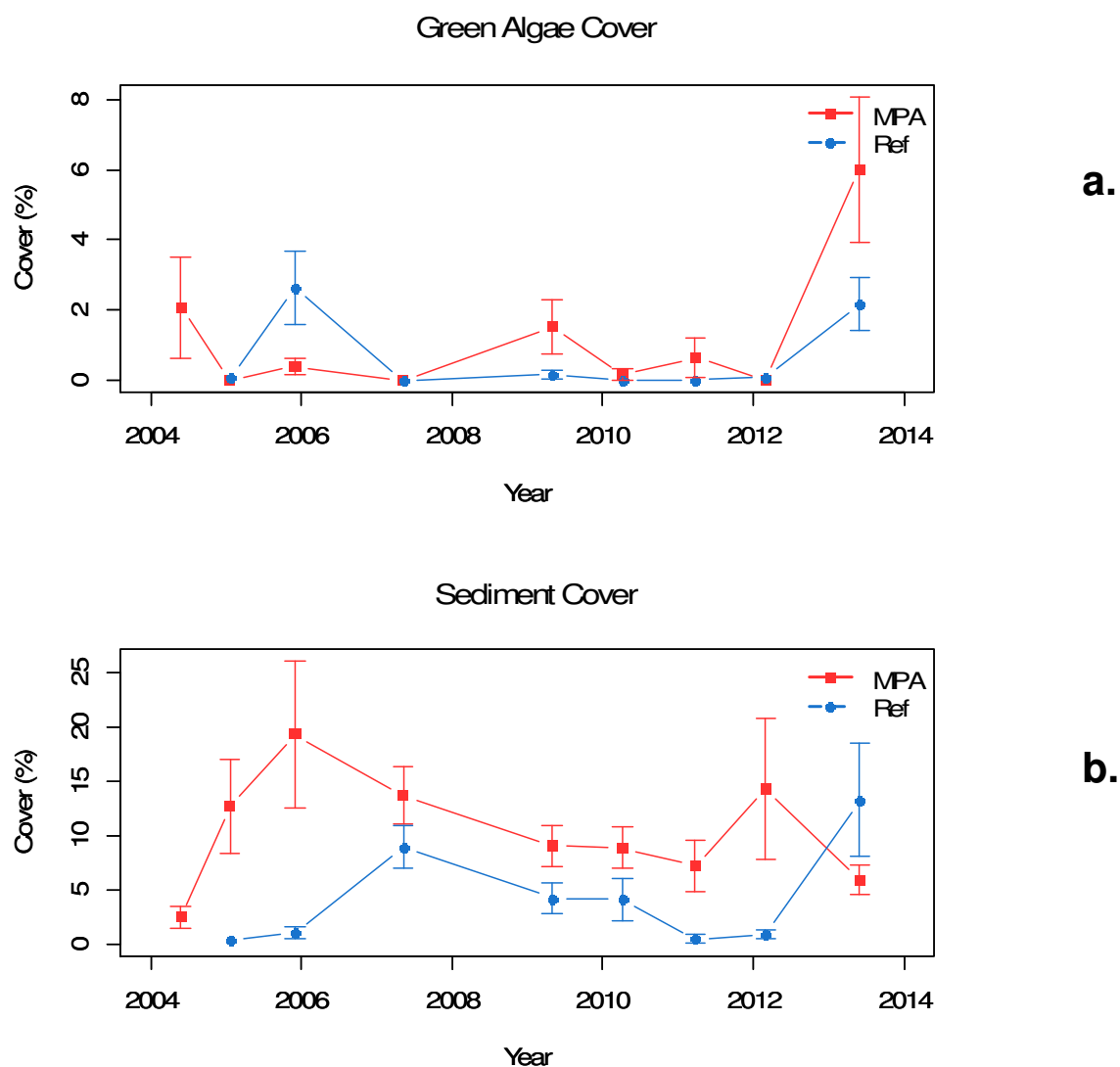


**Figure 11.13** Mean cover ( $\pm$  Standard Error) of: (a) green algae (*Ulva* spp. and, *Cladophora* spp.); and (b) sediment at Barwon Bluff sites.

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## 14 APPENDICES – Site Details

### 14.1 Point Cooke Marine Sanctuary

#### 14.1.1 Point Cooke – Site 4107

##### Site Description

The intertidal area at Point Cooke is an extensive basalt rock platform and basalt boulder and cobble field. The Point Cooke Marine Sanctuary also forms part of a RAMSAR site and contributes habitat for migratory shorebirds. The intertidal area is 300-400 m long, extending from just north of Point Cooke to the south and west. Patches of sand and intertidal seagrass *Zostera muelleri* occur predominantly across the north-eastern section of the intertidal area, with more continuous patches of reef occurring further south and west. The intertidal reef is generally flat. However, small undulations across the reef mean that tidal inundation does not occur evenly across the reef. Strong southerly winds may cause large amounts of subtidal drift algae to be washed onto the intertidal reef area.

##### Transect Layout

The survey site was established on the largest continuous area of reef to the west of Point Cooke (Figure 4.1). Both the high-shore and low-shore baselines were 95 m long and were approximately parallel. The five transects between the baselines and were between 30 m and 35 m long.

**Table 14.1** Site details for Point Cooke (Site 4107) in Point Cooke MS.

|                   |                  |             |              |            |            |
|-------------------|------------------|-------------|--------------|------------|------------|
| Site:             | 4107 Point Cooke |             |              |            |            |
| MPA/Ref:          | MPA              |             |              |            |            |
| Site coordinates  |                  |             |              |            |            |
| Baseline position | MGA Zone         | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55               | 305876      | 5799893      | 144.791251 | -37.927817 |
| B                 | 55               | 305965      | 5799917      | 144.792270 | -37.927620 |
| C                 | 55               | 305890      | 5799858      | 144.791401 | -37.928136 |
| D                 | 55               | 305965      | 5799881      | 144.792271 | -37.927945 |

## 14.1.2 Altona – Site 4108

### Site Description

Altona, site 4108, is the reference site for Point Cooke MS. The intertidal area at Altona consists of basalt reef and boulder fields interspersed with sand and seagrass flats. The survey site was established on a relatively large and continuous area of solid basalt reef and basalt boulders directly adjacent to large patches of sand and seagrass. The intertidal reef is generally flat with most variation in substratum height occurring at the level of individual boulders rather than across the shore. Most boulders in the survey area are substantially bigger (approximately 20-40 cm diameter) than those occurring at Point Cooke. Consequently, there are a large number of crevices and a substantial area of vertical substratum on the sides of boulders. The survey site has an estuarine influence because of its proximity to Kororoit Creek.

### Transect Layout

The high-shore baseline was straight, and did not follow the curve of the coastal defence wall. The high-shore baseline was 70 m long. The low-shore baseline was 69 m long. Transects ranged from 28 m at the eastern end of the site to 38 m at the western end.

**Table 14.2** Site details for Altona (Site 4108), the reference site for Point Cooke MS.

|                   |             |             |              |            |            |
|-------------------|-------------|-------------|--------------|------------|------------|
| Site:             | 4108 Altona |             |              |            |            |
| MPA/Ref:          | Reference   |             |              |            |            |
| Site coordinates  |             |             |              |            |            |
| Baseline position | MGA Zone    | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55          | 310019      | 5806233      | 144.840041 | -37.871591 |
| B                 | 55          | 310076      | 5806270      | 144.840687 | -37.871269 |
| C                 | 55          | 310035      | 5806204      | 144.840204 | -37.871855 |
| D                 | 55          | 310091      | 5806245      | 144.840851 | -37.871497 |

## 14.2 Jawbone Marine Sanctuary

### 14.2.1 Jawbone – Site 4109

#### Site Description

There is an extensive area of fractured basalt reef and boulder field at Jawbone Marine Sanctuary (Site 4109). The reef forms a band up to 30 m wide and extends for several hundred metres from the point at Jawbone, to the southwest boundary of the Sanctuary. The large basalt boulders create medium to high relief intertidal reef with considerable habitat structure because of the large amount of vertical substratum and crevices (Figure 5.1). The intertidal reef at Jawbone Marine Sanctuary has a large estuarine influence because of the proximity of Kororoit Creek and there is an area of mangrove and salt marsh habitat at the eastern end of the sanctuary. This area is also a Ramsar site and is an important habitat for migratory shorebirds.

#### Transect Layout

The survey site was established on a continuous area of reef. The high-shore and low-shore baselines were 100 m in length and were parallel to shore. The five transects placed between the baselines were 6-18 m in length.

**Table 14.3** Site details for Jawbone (Site 4109) in Jawbone MS.

|                   |              |             |              |            |            |
|-------------------|--------------|-------------|--------------|------------|------------|
| Site:             | 4109 Jawbone |             |              |            |            |
| MPA/Ref:          | MPA          |             |              |            |            |
| Site coordinates  |              |             |              |            |            |
| Baseline position | MGA Zone     | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55           | 313062      | 5807137      | 144.874838 | -37.864078 |
| B                 | 55           | 313136      | 5807068      | 144.875662 | -37.864715 |
| C                 | 55           | 313046      | 5807118      | 144.874652 | -37.864246 |
| D                 | 55           | 313123      | 5807057      | 144.875511 | -37.864811 |

## 14.2.2 Williamstown – Site 4110

### Site Description

The reference site for the Jawbone Marine Sanctuary was intertidal reef at Point Gellibrand, Williamstown (Site 4110). As at the Jawbone Marine Sanctuary, the intertidal area is a fractured basalt reef and boulder field. However, the boulders were smaller at Williamstown and consequently there was less vertical structure and fewer crevices (Figure 5.2). The intertidal reef has a south-westerly aspect.

### Transect Layout

The high-shore baseline was 23 m. The low-shore baseline was 44 m in length. The five transects established were 50 - 65 m in length.

**Table 14.4** Site details for Williamstown (Site 4110), the reference site for Jawbone MS.

|                   |                   |             |              |            |            |
|-------------------|-------------------|-------------|--------------|------------|------------|
| Site:             | 4110 Williamstown |             |              |            |            |
| MPA/Ref:          | Reference         |             |              |            |            |
| Site coordinates  |                   |             |              |            |            |
| Baseline position | MGA Zone          | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55                | 315545      | 5806228      | 144.902817 | -37.872772 |
| B                 | 55                | 315531      | 5806210      | 144.902653 | -37.872931 |
| C                 | 55                | 315579      | 5806185      | 144.903192 | -37.873165 |
| D                 | 55                | 315618      | 5806206      | 144.903640 | -37.872985 |

## 14.3 Ricketts Point Marine Sanctuary

### 14.3.1 Ricketts Point – Site 4111

#### Site Description

There are several sections of intertidal reef in the Ricketts Point Marine Sanctuary. The main intertidal reef is an extension of the Ricketts Point Headland. This reef is large (approximately 60 x 70 m) and encompasses several different habitat types including fractured basalt reef with prominent outcrops and steps, cobble field habitat and areas of intertidal mud and seagrass.

The central region of the platform at Ricketts Point is solid basalt reef that is above the high tide mark and supports patches of the beaded glasswort *Sarcocornia quinqueflora*. To the north and south of the central region are cobble field and sediment habitats. The monitoring site was placed on solid basalt reef at the western seaward edge of the intertidal area, where the reef is fractured basalt with small boulders.

#### Transect Layout

The high shore baseline was 45 m long and ran north-south above a rock step. Below the rock step the shore sloped away more gradually. The low shore baseline was 46 m long and ran parallel to the high shore baseline. The low-shore baseline traversed Neptune's Necklace *Hormosira banksii* habitat and some shallow rock pools. There were also small basalt boulders towards the low tide mark. The five transects were between the baselines and were approximately 18 m long.

**Table 14.5** Site details for Ricketts Point (Site 4111) in Ricketts Point MS.

|                   |                     |             |              |            |            |
|-------------------|---------------------|-------------|--------------|------------|------------|
| Site:             | 4111 Ricketts Point |             |              |            |            |
| MPA/Ref:          | MPA                 |             |              |            |            |
| Site coordinates  |                     |             |              |            |            |
| Baseline position | MGA Zone            | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55                  | 327001      | 5792953      | 145.029804 | -37.994596 |
| B                 | 55                  | 327034      | 5792922      | 145.030172 | -37.994882 |
| C                 | 55                  | 326994      | 5792949      | 145.029723 | -37.994631 |
| D                 | 55                  | 327019      | 5792910      | 145.029998 | -37.994987 |

### 14.3.2 Halfmoon Bay – Site 4112

#### Site Description

The reference site for Ricketts Point Marine Sanctuary was on a small area of intertidal reef at Halfmoon Bay (Site 4112). The main section of this reef is relatively flat basalt extending 20 m north from a high-relief basalt outcrop. This tongue of reef is surrounded by water on three sides.

#### Transect Layout

The high shore baseline was placed along the eastern edge of the platform which is slightly higher than the western edge. The upper baseline was 25 m long and was laid parallel to the 30 m long lower baseline. Transects running between the baselines were approximately 6 m.

**Table 14.6** Site details for Halfmoon Bay (Site 4112), the reference site for Ricketts Point MS.

|                   |                   |             |              |           |           |
|-------------------|-------------------|-------------|--------------|-----------|-----------|
| Site:             | 4112 Halfmoon Bay |             |              |           |           |
| MPA/Ref:          | Reference         |             |              |           |           |
| Site coordinates  |                   |             |              |           |           |
| Baseline position | MGA Zone          | MGA Easting | MGA Northing | Longitude | Latitude  |
| A                 | 55                | 325118      | 5795720      | 145.00905 | -37.96931 |
| B                 | 55                | 325097      | 5795736      | 145.00880 | -37.96170 |
| C                 | 55                | 325114      | 5795717      | 145.00900 | -37.96934 |
| D                 | 55                | 325093      | 5795731      | 145.00876 | -37.96921 |

## 14.4 Point Addis Marine National Park

### 14.4.1 Point Addis – Site 3901

#### Site Description

The main intertidal reef at Point Addis is a large and prominent tongue of intertidal platform that extends east from the base of cliffs northeast of Point Addis. This reef is long and is undulating in places. The platform is relatively low and large areas of this reef remain inundated during some tidal cycles. It is relatively exposed to wave action. The survey site is on a smaller patch of reef that fringes the coastal cliffs. It is a low-relief, uneven reef that drops steeply at the seaward edge into subtidal habitat. Undulations in the reef caused by weathering create patches of standing water.

The intertidal reefs are exposed to the south and east. The Point Addis headland provides some protection from southwest winds and swell, although large waves from the southwest can wrap around Point Addis onto these reefs.

The survey area bridges a large channel that intersects the baselines. Additional coordinates of this were recorded and the affected transects shifted appropriately.

#### Transect Layout

The high and low baselines were 74 m and 81 m in length respectively. Transects range in length from 16 m at Transect 1 to 22 m at Transect 5.

**Table 14.7** Site details for Point Addis (Site 3901) in Point Addis MNP.

|                   |                  |             |              |            |            |
|-------------------|------------------|-------------|--------------|------------|------------|
| Site:             | 3901 Point Addis |             |              |            |            |
| MPA/Ref:          | MPA              |             |              |            |            |
| Site coordinates  |                  |             |              |            |            |
| Baseline position | MGA Zone         | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55               | 260162      | 5746979      | 144.253788 | -38.393261 |
| B                 | 55               | 260166      | 5747053      | 144.253859 | -38.392596 |
| C                 | 55               | 260177      | 5746972      | 144.253957 | -38.393329 |
| D                 | 55               | 260185      | 5747055      | 144.254077 | -38.392583 |

## 14.4.2 Winkipop – Site 3902

### Site Description

The reference site for Point Addis Marine National Park was located to the east of the park at Winkipop reef. The intertidal area at Winkipop is a very low-relief, gently sloping reef. The area exposed at low tide is 30 to 50 m wide. This area is exposed to large southerly swell. There is a narrow band of sandy beach on the landward side of the reef. As at Point Addis, pools of standing water were common in undulations in the reef surface. This reef may be periodically subject to some sand inundation.

### Transect Layout

Baselines were run parallel to shore and were 100 m long. Transects were 35 m in length.

**Table 14.8** Site details for Winkipop (Site 3902), the reference site for Point Addis MNP.

|                   |               |             |              |            |            |
|-------------------|---------------|-------------|--------------|------------|------------|
| Site:             | 3902 Winkipop |             |              |            |            |
| MPA/Ref:          | Reference     |             |              |            |            |
| Site coordinates  |               |             |              |            |            |
| Baseline position | MGA Zone      | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55            | 262913      | 5750014      | 144.286277 | -38.366673 |
| B                 | 55            | 262948      | 5750105      | 144.286708 | -38.365863 |
| C                 | 55            | 262942      | 5749997      | 144.286603 | -38.366834 |
| D                 | 55            | 262986      | 5750086      | 144.287136 | -38.366045 |

## 14.5 Point Danger Marine Sanctuary

### 14.5.1 Point Danger – Site 4002

#### Site Description

The intertidal area at Point Danger is a large sandstone reef platform that is an extension of the Point Danger headland. The reef is exposed to the north, east and south, however most of the prevailing weather and waves are from the south and southwest. There are large areas of sandy beach to the west and north of the platform.

The reef is a relatively flat sandstone platform which quickly drains or floods with the tide. The reef surface has been eroded to make it rugose, with a relief of 10-15 cm. Most of the reef is affected by sand inundation, with a thin layer of sand being present in many quadrats.

The survey site is in the near shore region of the platform towards the south/west border of the sanctuary.

#### Transect Layout

The high and low-shore baselines are approximately transverse to the headland. High and low shore baseline lengths were 53 and 49 m respectively, with transects of 41-43 m.

**Table 14.9** Site details for Point Danger (Site 4002) in Point Danger MS.

|                   |                   |             |              |            |            |
|-------------------|-------------------|-------------|--------------|------------|------------|
| Site:             | 4002 Point Danger |             |              |            |            |
| MPA/Ref:          | MPA               |             |              |            |            |
| Site coordinates  |                   |             |              |            |            |
| Baseline position | MGA Zone          | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55                | 266413      | 5753027      | 144.327295 | -38.340469 |
| B                 | 55                | 266446      | 5753068      | 144.327686 | -38.340108 |
| C                 | 55                | 266447      | 5753006      | 144.327677 | -38.340667 |
| D                 | 55                | 266483      | 5753039      | 144.328100 | -38.340379 |

## 14.5.2 Point Danger West – Site 4001

### Site Description

The reference site, Point Danger West, is separated from the Point Danger intertidal platform by a short section of sandy beach. As with Point Danger, the sandstone platform has been eroded to create an uneven surface at the scale of 10s centimetres. This reef is subject to significant sand inundation.

### Transect Layout

The site baselines were 50 m, with transects of 30 m.

**Table 14.10** Site details for Point Danger West (Site 4001), the reference site for Point Danger MS.

|                   |                        |             |              |            |            |
|-------------------|------------------------|-------------|--------------|------------|------------|
| Site:             | 4001 Point Danger West |             |              |            |            |
| MPA/Ref:          | Reference              |             |              |            |            |
| Site coordinates  |                        |             |              |            |            |
| Baseline position | MGA Zone               | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55                     | 266093      | 5752959      | 144.323615 | -38.340998 |
| B                 | 55                     | 266143      | 5752979      | 144.324193 | -38.340831 |
| C                 | 55                     | 266099      | 5752928      | 144.323673 | -38.341278 |
| D                 | 55                     | 266144      | 5752946      | 144.324194 | -38.341128 |

## 14.6 Barwon Bluff Marine Sanctuary

### 14.6.1 Barwon Bluff – Site 4004

#### Site Description

The intertidal reef at Barwon Bluff is composed of sections of sandstone and basalt reef. The intertidal rock platform extends from the end of Barwon Bluff as a pincer-shaped reef. The north-eastern section of the pincer is a basalt platform and boulder reef. This section of the reef is relatively protected from swell but has a large estuarine influence from the adjacent mouth of the Barwon River. The south-western section of the pincer is a relatively flat sandstone reef, which is more exposed to large swells and sand inundation due to its exposure towards the south and proximity to an adjacent surf beach and strong cross-shore currents. The survey site is on the sandstone section of the reef. The sandstone platform has three large rockpools in the centre of the survey area. The transects do not intercept any of these pools. Relief 5-10 cm high is present as ripples in the platform. These ripples act as traps for cross-shore sand movement. The edge of the platform drops sharply into subtidal habitat.

#### Transect Layout

At the high shore end of the platform there is a distinctive rise in shore height. This has been encompassed by the high shore baseline which follows this contour for 47 m. The low shore baseline borders rockpools on the south-western corner and is 64 m long. Transect lengths ranged from 47 m at Transect 1 to 49 m at Transect 5.

**Table 14.11** Site details for Barwon Bluff (Site 4004) in Barwon Bluff MS.

|                   |                   |             |              |            |            |
|-------------------|-------------------|-------------|--------------|------------|------------|
| Site:             | 4004 Barwon Bluff |             |              |            |            |
| MPA/Ref:          | MPA               |             |              |            |            |
| Site coordinates  |                   |             |              |            |            |
| Baseline position | MGA Zone          | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55                | 281293      | 5758960      | 144.499234 | -38.290805 |
| B                 | 55                | 281339      | 5758952      | 144.499757 | -38.290889 |
| C                 | 55                | 281289      | 5758913      | 144.499174 | -38.291228 |
| D                 | 55                | 281352      | 5758904      | 144.499891 | -38.291324 |

## 14.6.2 Barwon Beach – Site 4003

### Site Description

To the west of the intertidal platform at Barwon Bluff, there are several smaller isolated patches of intertidal sandstone reef. These reefs are directly exposed to large southerly swells and sand inundation due to their proximity to the adjacent surf beach and strong longshore currents. The reef surface has been weathered to create an uneven surface at the scale of 10s of centimetres. The reference site is on one of these reefs, approximately 400 m west of Barwon Bluff, directly below a set of access stairs. These stairs are the closest access point and are the first set west of Barwon Bluff.

The reef structure is rugose with many depressions or rock pools approximately 20 cm in depth and 20-100 cm in diameter. It is more rugose than the Barwon Bluff Marine Sanctuary (Site 4004).

### Transect Layout

The high shore baseline runs parallel to the shore for 47 m and follows the same shore height contour as at Barwon Bluff. The low shore baseline is 36 m long and is angled back towards shore such that Transect 1 is 33 m long and Transect 5 is 24 m long.

**Table 14.12** Site details for Barwon Beach (Site 4003), the reference site for Barwon Bluff MS.

|                   |                   |             |              |            |            |
|-------------------|-------------------|-------------|--------------|------------|------------|
| Site:             | 4003 Barwon Beach |             |              |            |            |
| MPA/Ref:          | Reference         |             |              |            |            |
| Site coordinates  |                   |             |              |            |            |
| Baseline position | MGA Zone          | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55                | 280828      | 5759028      | 144.493943 | -38.290080 |
| B                 | 55                | 280873      | 5759015      | 144.494453 | -38.290208 |
| C                 | 55                | 280828      | 5758994      | 144.493932 | -38.290386 |
| D                 | 55                | 280864      | 5758990      | 144.494342 | -38.290431 |

## 14.7 Port Phillip Heads Marine National Park

### 14.7.1 Point Lonsdale – Site 2823

#### Site Description

The intertidal reef surveyed for the Port Phillip Heads Marine National Park was located at Point Lonsdale. This is on the western side of Port Phillip Heads with an extensive, triangularly shaped intertidal platform projecting eastwards from the Point Lonsdale headland. The low relief calcarenite site is uneven in patches as a result of exposure to strong weather and wave action. The intertidal platform is subject to a high level of trampling by the public.

#### Transect Layout

The survey area is on the southern expanse of reef. The transect layout was simple with high and low shore baselines of 100 m, separated by 50-60 m long transects.

**Table 14.13** Site details for Point Lonsdale (Site 2823) in Port Phillip Heads MNP.

|                   |                     |             |              |            |            |
|-------------------|---------------------|-------------|--------------|------------|------------|
| Site:             | 2823 Point Lonsdale |             |              |            |            |
| MPA/Ref:          | MPA                 |             |              |            |            |
| Site coordinates  |                     |             |              |            |            |
| Baseline position | MGA Zone            | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55                  | 291321      | 5759033      | 144.613824 | -38.292536 |
| B                 | 55                  | 291418      | 5759009      | 144.614926 | -38.292774 |
| C                 | 55                  | 291301      | 5758977      | 144.613580 | -38.293035 |
| D                 | 55                  | 291397      | 5758951      | 144.614669 | -38.293291 |

## 14.7.2 Cheviot Bay – Site 2824

### Site Description

The intertidal reef is less extensive than at Point Lonsdale and is interrupted by large rock pools and tidal channels. The reef at this site is exposed to the prevailing south-westerly weather and sub-maximal wave conditions. The low relief survey area is located immediately to the east of the Point Nepean section of the Port Phillip Heads Marine National Park, with the western end of Cheviot Beach being included within the Marine Park Boundary. It is in an area of restricted access because of unexploded ordinance in the vicinity and thus is protected from the high levels of human trampling that occur at Point Lonsdale. Special permission for the management authority (Parks Victoria) is required.

### Transect Layout

The high shore baseline of the survey area followed the contour of the shore for 85 m. The low shore baseline was 100 m long and was run at a slight angle giving Transect 1 a length of 35 m compared to 52 m for Transect 5.

**Table 14.14** Site details for Cheviot Bay (Site 2824), the reference site for Port Phillip Heads MNP.

|                   |                  |             |              |            |            |
|-------------------|------------------|-------------|--------------|------------|------------|
| Site:             | 2824 Cheviot Bay |             |              |            |            |
| MPA/Ref:          | Reference        |             |              |            |            |
| Site coordinates  |                  |             |              |            |            |
| Baseline position | MGA Zone         | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55               | 295939      | 5756879      | 144.665967 | -38.312994 |
| B                 | 55               | 296006      | 5756827      | 144.666718 | -38.313478 |
| C                 | 55               | 295916      | 5756854      | 144.665697 | -38.313214 |
| D                 | 55               | 295983      | 5756778      | 144.666441 | -38.313913 |

## 14.8 Mushroom Reef Marine Sanctuary

### 14.8.1 Mushroom Reef – Site 2907

#### Site Description

Mushroom Reef is a basalt intertidal reef in the shape of a mushroom when observed from the air. There is a large intertidal isthmus (the stem of the mushroom) that is composed of basalt pebbles and boulders. Sections of the isthmus tend to inundate with water soon after the tide begins to rise. The head of the mushroom is low-relief but uneven basalt reef with some pebbles and boulders. The highest section of the reef is the centre of the head of the mushroom. This area slopes away gently to the subtidal at its outer edge. Mushroom Reef is exposed on all sides, but is protected from large swell a shallow reef further offshore.

#### Transect Layout

The survey site at Mushroom Reef was positioned at the south eastern side of the head of the mushroom as this is representative of the predominant intertidal habitat. The baselines were 100 m long and parallel to shore. Transects were 40-45 m long.

**Table 14.15** Site details for Mushroom Reef (Site 2907) in Mushroom Reef MS.

|                   |                    |             |              |            |            |
|-------------------|--------------------|-------------|--------------|------------|------------|
| Site:             | 2907 Mushroom Reef |             |              |            |            |
| MPA/Ref:          | MPA                |             |              |            |            |
| Site coordinates  |                    |             |              |            |            |
| Baseline position | MGA Zone           | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55                 | 327050      | 5738412      | 145.017058 | -38.485864 |
| B                 | 55                 | 327150      | 5738408      | 145.018214 | -38.485920 |
| C                 | 55                 | 327053      | 5738374      | 145.017094 | -38.486208 |
| D                 | 55                 | 327153      | 5738363      | 145.018226 | -38.486326 |

## 14.8.2 Flinders West – Site 2908

### Site Description

The reference site for Mushroom Reef was on the nearest intertidal platform to the west of the marine sanctuary. The intertidal area at Flinders West is a low-relief gently sloping basalt reef with occasional small steps and boulder outcrops. Patches of sand covered areas at the lowest reef extent. As with Mushroom Reef, Flinders West has a south-easterly aspect and is moderately sheltered from wind and waves from the southwest. It is also protected from large swell by a shallow reef further offshore.

### Transect Layout

Baselines were run on the eastern side of the reef and were fanned out across the triangularly shaped intertidal platform. The high shore baseline was 54 m long while the low shore baseline was 48 m long. Transect lengths varied from 35 to 23 m.

**Table 14.16** Site details for Flinders West (Site 2908), the reference site for Mushroom Reef MS.

|                   |                    |             |              |           |           |
|-------------------|--------------------|-------------|--------------|-----------|-----------|
| Site:             | 2908 Flinders West |             |              |           |           |
| MPA/Ref:          | Reference          |             |              |           |           |
| Site coordinates  |                    |             |              |           |           |
| Baseline position | MGA Zone           | MGA Easting | MGA Northing | Longitude | Latitude  |
| A                 | 55                 | 326497      | 5739009      | 145.01087 | -38.48038 |
| B                 | 55                 | 326549      | 5738995      | 145.01146 | -38.48052 |
| C                 | 55                 | 326499      | 5738974      | 145.01088 | -38.48070 |
| D                 | 55                 | 326540      | 5738971      | 145.01135 | -38.48073 |

## 14.9 Bunurong Marine National Park

### 14.9.1 Eagles Nest – Site 3020

#### Site Description

Located on the eastern side of the Eagles Nest headland, Site 3020 was selected as being representative of the predominant habitat type of the area. The site is on the eastern side of the Marine National Park. It has an east facing aspect with the Eagles Nest headland sheltering it from the north and west. It is exposed to swells from the southeast, but not directly exposed to the prevailing south and southwest swell. The reef platform is relatively flat with little relief.

#### Transect Layout

High and low shore baselines were 59 m and 46 m, respectively. The transects range in length from 25 m at Transect 1 to 50 m at Transect 5.

**Table 14.17** Site details for Eagles Nest (Site 3020) in Bunurong MNP.

|                   |                  |             |              |            |            |
|-------------------|------------------|-------------|--------------|------------|------------|
| Site:             | 3020 Eagles Nest |             |              |            |            |
| MPA/Ref:          | MPA              |             |              |            |            |
| Site coordinates  |                  |             |              |            |            |
| Baseline position | MGA Zone         | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55               | 384362      | 5719082      | 145.670753 | -38.669302 |
| B                 | 55               | 384327      | 5719129      | 145.670347 | -38.668873 |
| C                 | 55               | 384382      | 5719098      | 145.670985 | -38.669160 |
| D                 | 55               | 384372      | 5719143      | 145.670878 | -38.668753 |

## 14.9.2 The Caves – Site 3021

### Site Description

The reference site is at the Caves (Site 3021), located to the east of Bunurong Marine National Park. The site is situated directly below the access stairs from the Caves carpark. As with Eagles Nest, the reef substratum is mudstone, has a southeast facing aspect and is sheltered from the north and west by the Caves headland. The reef is exposed to southeast and southerly swell but is more sheltered from direct exposure to the prevailing southwest swell. There is a large area platform at this site, with little rugose structure or relief. On the eastern end of the survey area (Transect 5), there is more structure with large rocky outcrops towards the high shore level.

### Transect Layout

Baselines were 43 and 46 m long and transects ranged from 80 m in length at Transect 1 to 100 m in length at Transect 5.

**Table 14.18** Site details for the Caves (Site 3021), the reference site for Bunurong MNP.

|                   |            |             |              |            |            |
|-------------------|------------|-------------|--------------|------------|------------|
| Site:             | 3021 Caves |             |              |            |            |
| MPA/Ref:          | Reference  |             |              |            |            |
| Site coordinates  |            |             |              |            |            |
| Baseline position | MGA Zone   | MGA Easting | MGA Northing | Longitude  | Latitude   |
| A                 | 55         | 385203      | 5719868      | 145.680548 | -38.662330 |
| B                 | 55         | 385209      | 5719911      | 145.680624 | -38.661943 |
| C                 | 55         | 385281      | 5719858      | 145.681442 | -38.662430 |
| D                 | 55         | 385303      | 5719898      | 145.681713 | -38.662072 |

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