Intertidal Reef Monitoring Program: Central Victoria Marine Protected Areas

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The Victorian Subtidal Reef Monitoring Program was initiated and funded by the then Department of Natural Resources and Environment until 2002, when Parks Victoria assumed responsibility.
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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 and the most recent survey took place in February and early March 2012.

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 Altona, there was a marked increase in sessile species diversity from 2010 to 2012;
- At Altona, there was a marked increase in *Bembicium* spp. density from 2011 to 2012;
- At Altona, total grazer density remained high following a marked increase in 2011; and
- An originally small patch of the seagrass *Zostera muelleri* at Point Cooke continued to increase in 2012 and is now the dominant biotic structure.

**Jawbone MS**
- In 2012, sessile species diversity at Jawbone was the highest recorded;
- *Hormosira banksii* cover at Williamstown has been increasing since the start of the monitoring period;
- There was a marked increase in *Austrocochlea porcata* density at Jawbone and similarly marked decrease at Williamstown this year;
- At Jawbone, erect coralline algal cover made stepwise increases in 2009 and 2012;
- In 2012, total grazer density at both sites were the highest recorded; and
- Green algal cover at both sites had a marked increase in 2011 and remained high in 2012.
Ricketts MS

- In 2011, the mobile invertebrate community structures of both sites departed substantially from the centroid established by community changes in previous years; this has persisted to a certain degree at Halfmoon Bay but appears to have returned to its previous state at Ricketts Point in 2012;

- *Hormosira banksii* cover increased steadily at Ricketts Point from 2005 to 2012;

- At Ricketts Point, *Austrocochlea porcata* and *Bembicium* spp. densities had marked increases in 2007 and 2011 respectively, and have remained high since;

- At Halfmoon Bay, *Cellana tramoserica* density declined in 2010 and remained low;

- At Ricketts Point, total algal cover had a marked increase in 2010 and remained high; and

- At Ricketts Point, total grazer density has steadily increased since 2009.

Port Phillip Heads MNP

- Algal and aggregating sessile invertebrate community structure at Point Lonsdale has been variable over time, but with no consistent trajectory in changes;

- In 2012, mobile species diversity was the lowest recorded at both sites since 2005; and

- *Bembicium nanum* mean densities at both sites had a marked downward trend over the monitoring period;

Mushroom Reef MS

- At West Flinders, mobile species diversity declined markedly in 2009 and has remained low since;

- Mobile species diversity at Mushroom Reef in 2012 was the lowest recorded throughout the monitoring period;

- Sessile species diversity at West Flinders in 2012 was the highest recorded throughout the monitoring period;

- There was a 20 % decrease in cover of *H. banksii* between 2005 and 2007, after which cover of *H. banksii* in subsequent surveys increased between 5 and 10 %;

- *Bembicium nanum* densities at both sites have declined since 2006;

- Mean sizes of *Bembicium nanum* at both sites in 2012 were the highest recorded during the monitoring period; and

- Erect coralline and turfing algal covers were very variable at West Flinders, both ranging from about 0 to 30 % across the monitoring period;
Bunurong MNP

- Algal and aggregating sessile invertebrate community structure at both sites has been variable over time, but with no consistent trajectory in changes;
- Mobile species richness at Eagles Nest appeared to have a downward trend, with species richness in 2012 being the lowest recorded in the monitoring period;
- Sessile species richness at both sites were at a high in 2012;
- At Caves, mobile species diversity had a marked increase in 2009 and remained high since; and
- There was a substantial upward trend in the mean size of *Cellana tramoserica* at both sites from 2006, with mean sizes increasing from approximately 20 mm to 35 mm by 2012.

Point Addis MNP

- In 2012, mobile species diversity at Winkipop was the lowest recorded in the monitoring period;
- In 2012, cover of *Hormosira banksii* at Winkipop was the lowest recorded in the monitoring period; and
- Erect coralline algal cover at Winkipop appeared to have a general upward trend since the start of the monitoring period;

Point Danger MS

- The community structure within the sanctuary was different in 2011 and 2012 because of decreases abundance of *Bembicium nanum* and increases in *Nodolittorina acutispira*;
- There was little change in species richness, although diversity indices fluctuated considerably;
- The abundance of *Hormosira banksii* was relatively constant at both sites over the monitoring period;
- *Clypidina rugosa* was the most abundant gastropod but was highly variable in abundance between times;
- There was a strong peak in *Bembicium nanum* abundance in 2007; and
- The mean size of *Cellana tramoserica* was relatively stable over the monitoring period. In contrast, *Bembicium nanum* was highly variable in mean size.
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 abundance of *Hormosira banksii* increased over the monitoring period and was at highest levels at both sites in 2011 and 2012;
- There were no notable changes in gastropod densities;
- The limpet *Cellana tramoserica* steadily increased in size inside the marine sanctuary. Sizes outside the sanctuary were more variable with no clear trends;
- Turfing algae had a general decreasing trend at both sites, with over 10 % cover at both sites in 2004 to virtually no cover in 2012; and
- Sediment cover appears to vary cyclically, with a peak of 10-20 % cover in 2006-2007 and a low in 2011.
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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*, the green algae sea lettuce *Ulva* spp. and *Enteromorpha* 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 conniwinks *Bembicium* spp. Molluscan predators include *Cominella lineolata* and *Lepsiella vinosa*. The small mussel *Xenostrobus 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 as 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).
2. INTERTIDAL REEF MONITORING PROGRAM

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 2.1). 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 2.1 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.
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; and autumn 2012.
Figure 2.2 Parks Victoria Ranger Mr Dale Appleton working with a marine biologist during intertidal reef monitoring surveys.

2.2.1. Monitoring Central Victorian Marine Protected Areas

This report describes the intertidal reef monitoring program and results from surveys, done in February to March 2012, in the following marine protected areas (and corresponding 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:

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 detected during monitoring.
3. **METHODS**

3.1. **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 3.1):
  - Point Cooke MS;
  - Jawbone MS; and
  - Ricketts Point MS;

- central coast of central Victoria (Figure 3.2):
  - Port Phillip Heads MNP; and
  - Mushroom Reef MS;

- eastern coast of central Victoria (Figure 3.3):
  - Bunurong MNP;

- western coast of central Victoria (Figure 3.4):
  - Point Addis MNP;
  - Point Danger MS; and
  - Barwon Heads MS.

Two sites were surveyed in each area, one inside and one outside the MPA.

Each site was assigned a number in accordance with the Parks Victoria (PV) and Department of Sustainability and Environment (DSE) database system for marine monitoring (Table 3.1). Survey dates are shown in Table 3.2. A description of each intertidal reef and sampling considerations at each site is given separately for each marine sanctuary in Appendix A – Site Details.
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Table 3.2 Survey periods of intertidal monitoring sites.

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</table>
3.1.1. 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 3.5). 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 dGPS and photographed (Figure 3.5). Five fixed transects, each running from high to low shore, were positioned across the intertidal area to be surveyed (Figure 3.5). Transect 1 was furthest to the right-hand side (looking seaward) and Transect 5 to the left-hand side of the reef when looking out to sea. Each transect ran between points on the high and low shore baselines. Adjacent transects are 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 3.6). The fixed sampling points were equidistant along each transect (Figure 3.6).
Figure 3.1 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.
3.2. Visual Census Techniques

3.2.1. 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 (Figure 3.7, Figure 3.8, Table 3.3). 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. Species were identified 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.

### 3.2.2. 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. 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 3.7). 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.

### 3.2.3. Video/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.

### 3.2.4. 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 are recorded. These were classified as:

(h) horizontal surface, flat, rock top;
(p) rock pool;
(r) rocky rubble or cobble;
(s) sand; and
(v) vertical surface, rock side, crevice.

Figure 3.3 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 3.4 Marine biologists counting invertebrates within quadrats during intertidal reef monitoring surveys at Halfmoon Bay (Site 4112), May 2009.
### Table 3.3 Intertidal species in south eastern Australia recorded by methods A and B

<table>
<thead>
<tr>
<th>Algae</th>
<th>Sessile Invertebrates</th>
<th>Mobile Invertebrates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algal Turf</td>
<td>Tube Worms</td>
<td>Limpets</td>
</tr>
<tr>
<td>Blue-Green Algae</td>
<td><em>Galeolaria caespitosa</em></td>
<td><em>Clypidina rugosa</em></td>
</tr>
<tr>
<td>Rivularia sp.</td>
<td><em>Patella chapmani</em></td>
<td><em>Cellana tramoserica</em></td>
</tr>
<tr>
<td>Symplecta sp.</td>
<td><em>Patelloida alticostata</em></td>
<td></td>
</tr>
<tr>
<td>Green Algae</td>
<td><em>Catomerus polymerus</em></td>
<td><em>Patelloida latistriptaga</em></td>
</tr>
<tr>
<td>Cladophora prolifera</td>
<td><em>Chthamalus antennatus</em></td>
<td><em>Notoacmea mayi</em></td>
</tr>
<tr>
<td>Cladophora subsimplex</td>
<td><em>Chaemosiphos tasmanica</em></td>
<td><em>Notoacmea petterdi</em></td>
</tr>
<tr>
<td>Codium spp.</td>
<td><em>Tesseropora rosea</em></td>
<td><em>Notoacmea spp.</em></td>
</tr>
<tr>
<td>Enteromorpha spp.</td>
<td><em>Tetractillla purpurascens</em></td>
<td><em>Siphonaria spp.</em></td>
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<tr>
<td>Ditycosphaeria serica</td>
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<td></td>
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<tr>
<td>Ulva spp.</td>
<td>Bivalves</td>
<td><em>Austrocochlea constricta</em></td>
</tr>
<tr>
<td>Chaetomorpha coliformis</td>
<td><em>Xenostrobus pulex</em></td>
<td><em>Austrocochlea porcata</em></td>
</tr>
<tr>
<td>Scytosiphon lomentaria</td>
<td><em>Brachidontes rostratus</em></td>
<td><em>Austrocochlea odontis</em></td>
</tr>
<tr>
<td>Lobophora veriegata</td>
<td><em>Oulactis muscosa</em></td>
<td><em>Nodilittorina acutispira</em></td>
</tr>
<tr>
<td>Cladostephus spongiosus</td>
<td></td>
<td><em>Dichathis orbita</em></td>
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<tr>
<td>Notheia anomala</td>
<td><em>Actinia tenebrosa</em></td>
<td><em>Bembicium sp.</em></td>
</tr>
<tr>
<td>Scytosiphon lomentaria</td>
<td><em>Nella atramentosa</em></td>
<td></td>
</tr>
<tr>
<td>Hormosira banksii</td>
<td><em>Cominella lineolata</em></td>
<td><em>Bembicium melanostomum</em></td>
</tr>
<tr>
<td>Cystophora spp.</td>
<td><em>Calliostoma armillata</em></td>
<td>*Austrolittorina unifasciata</td>
</tr>
<tr>
<td>Zonaria turneriana</td>
<td><em>Mitra glabra</em></td>
<td><em>Nodilittorina acutispira</em></td>
</tr>
<tr>
<td>Halopteris spp.</td>
<td><em>Hastrum baileyanum</em></td>
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<tr>
<td>Ectocarpus spp.</td>
<td><em>Phasianotrochus eximius</em></td>
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<tr>
<td>Acrocarpa paniculata</td>
<td><em>Pteryxotus triforis</em></td>
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<tr>
<td>Lobophora variegata</td>
<td><em>Cyprea angustata</em></td>
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<tr>
<td>Padina sp.</td>
<td><em>Batillaria australis</em></td>
<td></td>
</tr>
<tr>
<td>Red Algae</td>
<td><em>Dicathais orbita</em></td>
<td>Sea stars</td>
</tr>
<tr>
<td>Corallina officinalis</td>
<td><em>Parvulastra exigua</em></td>
<td></td>
</tr>
<tr>
<td>Gracilaria spp.</td>
<td><em>Meridiastra calcar</em></td>
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<tr>
<td>Laurencia spp.</td>
<td><em>Tosia australis</em></td>
<td></td>
</tr>
<tr>
<td>Encrusting coralline algae</td>
<td><em>Coscinasterias muricata</em></td>
<td></td>
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<tr>
<td>Erect coralline algae</td>
<td></td>
<td></td>
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<tr>
<td>Jania spp.</td>
<td>Sea Slugs</td>
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<tr>
<td>Haliptilon roseum</td>
<td><em>Onchidella patelloides</em></td>
<td></td>
</tr>
<tr>
<td>Echinodermnion sp.</td>
<td><em>Pteryxotus triforis</em></td>
<td></td>
</tr>
<tr>
<td>Heterosiphonia muelleri</td>
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<td><em>Sea Hares</em></td>
</tr>
<tr>
<td>Caulocystis cephalomithos</td>
<td></td>
<td><em>Aplysia gigantea</em></td>
</tr>
<tr>
<td>Seagrass</td>
<td>Crabs</td>
<td></td>
</tr>
<tr>
<td>Zostera meulleri</td>
<td><em>Cyclograpsus granulosus</em></td>
<td></td>
</tr>
<tr>
<td>Amphibolus antarctica</td>
<td><em>Paragrapus gaimardii</em></td>
<td></td>
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<tr>
<td>Sarcocornia quinqueflora</td>
<td></td>
<td><em>Plagusia chabrus</em></td>
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<td></td>
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<tr>
<td></td>
<td>Nudibranchs</td>
<td><em>Pteraeolidia ianthina</em></td>
</tr>
</tbody>
</table>
Figure 3.5 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.
3.3. Data Analysis

3.3.1. 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.

3.3.2. 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
\(1/\text{DSimpson} = \text{Hill’s } N_2\). 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.

### 3.3.3. Species Populations

The abundances of each species were summarised by calculating the mean density per quadrat (0.25 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.

### 3.4. 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.

**Biodiversity**

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

**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.
**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.

**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.

**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*. 
Environment

Indicators of environment quality were:

- ratio of algae cover to grazer abundance;
- the total abundance of species indicative of nutrient loading (i.e. *Ulva*, *Enteromorpha* and *Cladophora* species);
- percentage cover of sediment; and
- the height zonation of habitats (this Indicator is being developed).
4. POINT COOKE MARINE SANCTUARY

4.1. Site Description and Transect Layout

4.1.1. 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 4.1). 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.

4.1.2. 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 4.1.2) 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 4.2). 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.
Figure 4.1 Intertidal reef habitat at Point Cooke Marine Sanctuary: (a) 1 June 2007; and (b) 29 April 2009.
Figure 4.2 Intertidal reef at the Altona reference site, 27 April 2009.
4.2. Point Cooke Community Structure
The mobile invertebrate community at Point Cooke MS (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 *A. porcata* and the limpet *Cellana tramoserica*.

The MDS analysis of mobile invertebrate communities showed similar degrees of variation within each site over time, aside from the outlying points at Point Cooke for the 2010 and 2011 surveys (Figure 4.3). The communities at these two sites were relatively dissimilar to each other compared to the other sites as a whole (Figure 4.3). 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*, with filamentous red algae also being common. At Altona, the community was composed of similar species: *Ulva* spp; *Symploca*; and calcareous tube-worm *Galeolaria caespitosa*. No seagrass was present within the study area at Altona.

The MDS analysis of percent cover showed relatively small temporal variation at both Point Cooke and the Altona reference site (Figure 4.4). The variation in algal/seagrass and aggregating sessile invertebrate communities between sites was higher than the temporal variation within sites, with the community at Point Cooke more closely resembling that of the other sites surveyed as a whole compared to the Altona reference site (Figure 4.4).

4.3. Point Cooke Diversity
The general trend of mobile invertebrate species richness at Point Cooke (Site 4107) was a slightly upward one apart from a spike in 2009 (Figure 4.5). At the Altona reference site (Site 4108), mobile invertebrate species richness held relatively stable, apart from a dip in 2007 (Figure 4.5).

Algal and aggregating sessile invertebrate species richness at Point Cooke appears relatively stable apart from an increase in the number of species detected in 2011 (Site 4107; Figure 4.6). Species richness at Altona (Site 4108) was far more variable over time, varying between 1 and 13 species over the monitoring period (Figure 4.6).

Mobile invertebrate species diversity at Point Cooke (Site 4107) and the reference site Altona (Site 4108) remained relatively stable throughout the monitoring period, although there appears to be an upward trend at Altona in the recent surveys (Figure 4.7).
Algal and aggregating sessile invertebrate species diversity was also generally stable at Point Cooke (Figure 4.8). The sessile species diversity in Altona, however, was more variable, with a decrease in 2009 followed by a marked increase in the subsequent three surveys (Figure 4.8).
**Figure 4.3** 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 4.4 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 4.5 Mobile invertebrate species richness at Point Cooke and Altona reference site.

Figure 4.6 Algal and aggregating sessile invertebrate species richness of intertidal sites at Point Cooke and the Altona reference site.
Figure 4.7 Mobile invertebrate diversity (Hills $N_2$) of intertidal sites at Point Cooke and the Altona reference site.

Figure 4.8 Algal and aggregating sessile invertebrate diversity (Hill’s $N_2$) of intertidal sites at Point Cooke and the Altona reference site.
4.4. Point Cooke Macroalgae and Aggregating Sessile Invertebrates

In April 2005, a large proportion (nearly 60 %) of the Point Cooke intertidal reef was covered with *Ulva* spp, spread evenly across the survey area (Figure 4.9). Coverage in other surveys between 2007 and 2009 has remained at 3-10 % (Figure 4.9) but appeared to increase steadily in subsequent surveys (Figure 4.9).

*Enteromorpha* spp. was recorded at Point Cooke in moderate quantities (15 %) in 2005, but has since been observed in very low quantities – 0.16 % in 2012. A previously small patch of sand and *Zostera muelleri* seagrass has gradually extended across a wide band of the reef and covered 12 % of the study area in April 2009, steadily increasing to over 36 % in 2012. The coverage of filamentous red algae, which 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. Compared to Point Cooke, the cover of *Ulva* spp. in Altona was generally low (Figure 4.9), and *Enteromorpha* spp. was detected in only two surveys (9 %, 2005 survey; 2 %, 2012 survey). Coralline algal species were intermittently detected at very low coverages throughout the monitoring period. *Zostera muelleri* was recorded at Altona only in the last two surveys (3 %, 2011 survey, 0.3 % 2012 survey).

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

Waves and currents can deposit and erode 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, and has subsequently decreased to 10 % in 2012. At Altona, the sediment coverage has been more variable between surveys, ranging from 21 % in 2009 to none in 2012.
Figure 4.9 Mean density (± Standard Error) of *Ulva* spp. at Point Cooke and the Altona reference site.
4.5. 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; in 2012, the density at Altona was almost twice that of Point Cooke (41 compared to 22 per 0.25 m$^2$, Figure 4.10a).

Conniwinks, *Bembicum* spp., were consistently present in low densities at Altona and only sporadically present at Point Cooke. The last two surveys, however, have seen a marked increase in *Bembicum* densities at Altona (Figure 4.10b).

The limpet *Cellana tramoserica* was rarely found in quadrats throughout the survey period, but has been consistently present at Altona in low abundances. The overall trend remains consistent with the 2012 survey (Figure 4.10c).

A slight declining trend in mean size of *A. porcata* was apparent for Point Cooke and Altona (Figure 4.11a), while the mean size of *Cellana tramoserica* was relatively constant at both sites (Figure 4.11b). These trends remain consistent with the 2012 survey.

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.
Figure 4.10 Mean density (± Standard Error) of dominant mobile invertebrates at Point Cooke and the Altona reference site.
Figure 4.11 Mean sizes (± Standard Error) for dominant mobile invertebrates at Point Cooke and the Altona reference site.
4.6. Condition Indicators

Biodiversity
Community composition was 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.

Introduced Species
No introduced species were detected for these sites.

Ecosystem Function
Total algal cover has been low and relatively steady at both sites, apart from an *Ulva* spp. bloom at Point Cooke in 2005, though there has been a slight upward trend at Point Cooke MS in recent surveys (Figure 4.12a). Erect coralline algal cover and turining algae were low and variable in cover over the monitoring period (Figure 4.12b & c). Total grazer density appears consistently higher at Altona than Point Cooke, while the trend appears reversed for total predator density (Figure 4.13a & b). Within each site, the densities were variable throughout the monitoring period (Figure 4.13a & b).

Climate Change
No species from adjacent bioregions were detected.

Harvesting
The mean size and density of *Cellana tramoserica* at both sites have remained relatively consistent throughout the monitoring period. Although 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 and variations in natural population dynamics, such as recruitment.

Trampling
*Hormosira banksii* cover is naturally low at these sites. No evidence of trampling was visible.

Environment
Green algal species cover, sometimes indicative of nutrient loading, was relatively low from 2007 to 2012 (Figure 4.14a). As noted above, the peak at Point Cooke in 2005 was due to a bloom of *Ulva* spp., and the slight upward trend at Point Cooke in recent surveys was not strong enough to suggest an increase in nutrient loading.

Sediment cover at both sites has decreased in the last three surveys after an increase from 2005 to 2009. The level of sediment cover in 2012 is low compared to the rest of the monitoring period (Figure 4.14b).
Zostera muelleri 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 has increased to 36 % (Figure 4.14c). By contrast, Z. meulleri was only detected at the Altona reference site since 2011 at very low coverage (Figure 4.14c).
Figure 4.12 Mean cover (± Standard Error) of algae at Point Cooke and the Altona reference site.
Figure 4.13 Mean abundance (± Standard Error) of grazers and predators at Point Cooke and the Altona reference site.
Figure 4.14 Mean cover (± Standard Error) of: (a) green algae *Ulva, Enteromorpha* and *Cladophora* spp.; (b) sediment; and (c) *Zostera muelleri*, at Point Cooke and the Altona reference site.
5. JAWBONE MARINE SANCTUARY

5.1. Site Description and Transect Layout

5.1.1. Jawbone Marine Sanctuary (Site 4109)
There is an extensive area of fractured basalt reef and boulders in the intertidal area 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 west boundary of the Sanctuary. The large basalt boulders create medium to high relief intertidal reef with considerable habitat structure because of the large area of vertical substratum and associated crevices (Figure 5.1). The intertidal reef at Jawbone Marine Sanctuary is subject to the estuarine influence of nearby Kororoit Creek. An area of mangrove and salt marsh habitat exists at the eastern end of the sanctuary. This area is a Ramsar site, being an important habitat for migratory shorebirds. The survey site was established on a continuous area of reef.

5.1.2. Williamstown Reference (Site 4110)
The reference site for the Jawbone Marine Sanctuary was intertidal reef 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 5.2). The intertidal reef has a southerly aspect.
Figure 5.1 Intertidal reef at Jawbone Marine Sanctuary, 3 May 2007.

Figure 5.2 Intertidal reef at the Williamstown reference site, 30 April 2009.
5.2. Jawbone Community Structure
The mobile invertebrate community at Jawbone (4109) was largely composed of the top snail *Austrocochlea porcata* and limpet *Cellana tramoserica*. Commonly found species at Williamstown (Site 4110) were *A. porcata* and conniwinks *Bembicium* spp. The MDS analysis showed that the mobile invertebrate community structure at both sites were very similar to each other, and did not vary much during the monitoring period (Figure 5.3).

The algal and aggregating sessile invertebrate community structure differed 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, however, showed that the two sites had similar community structures in perspective of the total observed variation (Figure 5.4).

5.3. Jawbone Diversity
The species richness of mobile invertebrate species was moderately variable with no trends at both sites (Figure 5.5).

Sessile species richness at Jawbone (Site 4009) was also variable (Figure 5.6b). Species richness at Williamstown increased gradually up to a maximum recorded in 2010, and has decreased slightly in the last two surveys (Figure 5.6).

Mobile invertebrate diversity (Hills $N_2$) was relatively constant at both sites, with levels consistently higher at Jawbone than Williamstown (Figure 5.7).

Sessile species diversity appears relatively stable for Williamstown (Figure 5.8). Within the Jawbone sanctuary, there was an increase in diversity after 2008 (Figure 5.8).
Figure 5.3 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 5.4 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 5.5 Mobile invertebrate species richness at Jawbone and the Williamstown reference site.

Figure 5.6 Algal and aggregating sessile invertebrate species richness of intertidal sites at Jawbone and the Williamstown reference site.
Figure 5.7 Mobile invertebrate diversity (Hills $N_2$) of intertidal sites at Jawbone and the Williamstown reference site.

Figure 5.8 Algal and aggregating sessile invertebrate diversity (Hill’s $N_2$) of intertidal sites at Jawbone and the Williamstown reference site.
5.4. Jawbone Macroalgae and Aggregating Sessile Invertebrates

The abundance of sessile species was very low at Jawbone (Site 4109). The calcareous tube-worm *Galeolaria caespitosa* was present at low densities, low on the intertidal zone. Turfing and coralline algae, the green algae *Ulva* spp. and *Codium fragile* and the seagrass *Zostera muelleri* were present close to the subtidal zone, 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 through the monitoring period (Figure 5.9).

![Hormosira banksii Cover](image)

**Figure 5.9** Mean density (± Standard Error) of Neptune’s necklace *Hormosira banksii* at Jawbone and the Williamstown reference site.
5.5. Jawbone Mobile Invertebrates

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

The density of *A. porcata* saw a marked increase at Jawbone and similarly marked but opposite decrease at Williamstown in 2012 (Figure 5.10a). The density of *A. porcata* at Jawbone this year was the highest recorded throughout the monitoring period, while the density at Williamstown was one of the lowest recorded (Figure 5.10a).

*Cellana tramoserica* had persistently low densities at Williamstown (Figure 5.10b). At Jawbone, *C. tramoserica* densities declined to 2009 with a spike in abundance in 2010 (Figure 5.10b).

The mean size of *A. porcata* was slightly lower and more variable at Jawbone than Williamstown, but the mean sizes at both sites remain stable in 2012 (Figure 5.11a). Mean size of *C. tramoserica* was very similar between Jawbone and Williamstown and changed little during the monitoring period (Figure 5.11b).
Figure 5.10 Mean density (± Standard Error) of: (a) the top shell *Austrocochlea porcata*; and (b) the limpet *Cellana tramoserica* at Jawbone and the Williamstown reference site.
**Figure 5.11** Mean sizes (± Standard Error) of: (a) the top shell *Austrocochlea porcata*; and (b) the limpet *Cellana tramoserica* at Jawbone MS and the Williamstown reference site.
5.6. Jawbone Condition Indicators

**Biodiversity**
Community composition and species richness were within the range of states and changes observed previously. Species diversity was among the highest recorded for the monitoring program.

**Introduced Species**
No introduced species were detected for these sites.

**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 despite an absence of *H. banksii*, but decreased slightly in 2012 (Figure 5.12a). Erect coralline algal cover and turfing algae were low and variable in cover over the monitoring period at both sites, although there was a slight increase in erect coralline algal cover in 2012 (Figure 5.12b & c). 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 for both sites (Figure 5.13a). Total predator densities were low with no clear trends (Figure 5.13b).

**Climate Change**
No novel species typical of adjacent bioregions were detected.

**Harvesting**
High densities of *C. tramoserica* at Jawbone in 2010 were followed by a decrease in 2011. There were no indications of increasing harvesting pressure based on mean sizes.

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

**Environment**
The cover of green algal species, sometimes indicative of high nutrient loads, was relatively low at both sites, < 2 % until 2010. This has increased markedly to 5-10 % in the last two surveys (Figure 5.14a). Apart from a spike in sediment cover in 2007 at both sites, sediment cover remained low at both sites (Figure 5.14b).
**Figure 5.12** Mean cover (± Standard Error) of algae at Jawbone MS and the Williamstown reference site.
Figure 5.13 Mean abundance (± Standard Error) of: (a) all grazers; and (b) all predators at Jawbone MS and the Williamstown reference site.
Figure 5.14 Mean cover (± Standard Error) of: (a) green algae *Ulva*, *Enteromorpha* and *Cladophora* species; and (b) sediment at Jawbone MS and the Williamstown reference site.
6. RICKETTS POINT MARINE SANCTUARY

6.1. Site description and Transect layout

6.1.1. 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 mud and seagrass (Figure 6.1).

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.

6.1.2. 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 6.1 Intertidal reef at Ricketts Point Marine Sanctuary, 28 April 2009.

Figure 6.2 The intertidal reef monitoring reference site at Halfmoon Bay, 1 May 2009. The high-shore baseline is at the right of the reef.
6.2. Ricketts Point Community Structure

The two sites differed in mobile invertebrate assemblage structure. The mobile invertebrate community at Ricketts Point (Site 4111) was largely composed of the herbivorous gastropod *Austrocochlea porcata* and conniwink *Bembicium* spp. Commonly found species at the Halfmoon Bay reference site (Site 4112) were the limpet *Cellana tramoserica*, *Patelloida alticostata* and the carnivorous gastropods *Lepsiella vinosa*. The MDS analysis showed that both sites were similar in community structure (Figure 6.3). There also appears to have been a marked shift in community structure at both sites in 2011; this has persisted to a certain degree at Halfmoon Bay but appears to have returned to its previous state at Ricketts Point in 2012 (Figure 6.3).

The sessile species community structure differed between Ricketts Point and Half Moon Bay (Figure 6.4). The Ricketts point assemblage largely consisted of the brown algae Neptune’s necklace *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. Halfmoon Bay had a greater variation through time than Ricketts Point (Figure 6.4).

6.3. Ricketts Point Diversity

Mobile invertebrate species richness was consistently lower at Ricketts Point than Halfmoon Bay and the temporal variations were, in general, very similar (Figure 6.5).

Sessile species richness was very similar between sites, apart from a disparity in 2009 (Figure 6.6).

Mobile invertebrate species diversity, Hill’s $N_2$, was relatively constant over time at Ricketts Point. At Halfmoon Bay, mobile species diversity appeared to have periodic spikes in 2004 and 2010 (Figure 6.7).

Sessile species diversity was similar in range and variability between Ricketts Point and Halfmoon Bay throughout the monitoring period (Figure 6.8).
**Figure 6.3** 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 6.4 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 6.5 Mobile invertebrate species richness at Ricketts Point and the Half Moon Bay reference site.

Figure 6.6 Algal and aggregating sessile invertebrate species richness of intertidal sites at Ricketts Point and the Half Moon Bay reference site.
Figure 6.7 Mobile invertebrate diversity (Hills N2) of intertidal sites at Ricketts Point and the Half Moon Bay reference site.

Figure 6.8 Algal and aggregating sessile invertebrate diversity (Hill’s N2) of intertidal sites at Ricketts Point and the Half Moon Bay reference site.
6.4. 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*. *H. banksii* coverage at Ricketts Point generally followed an upward trend from 2005 (Figure 6.9). At Halfmoon Bay, however, coverage was consistently close to zero (Figure 6.9).

Patches of the calcareous tube-worm *Galeolaria caespitosa* were present at Ricketts Point at very low coverage throughout the surveys, but had much higher and more variable coverage at Halfmoon Bay (Figure 6.10).
Figure 6.9 Mean cover (± Standard Error) of Neptune’s necklace *Hormosira banksii* at Ricketts Point and the Half Moon Bay reference site.

Figure 6.10. Mean cover (± Standard Error) of the reef forming tube worm *Galeolaria caespitosa* at Ricketts Point and the Half Moon Bay reference site.
6.5. Ricketts Point Mobile Invertebrates

At Ricketts Point (Site 4111), the limpet *Cellana tramoserica* was consistently at very low abundance (Figure 6.11a). Densities were consistently higher at Halfmoon Bay, and following a marked decline in 2010, the population appears to have stabilised since (Figure 6.11a).

The gastropod *Austrocochlea porcata* was the most abundant mobile invertebrate at Halfmoon Bay, where there was a gradual downward trend over the monitoring period (Figure 6.11b). Abundances at Ricketts Point were similar in 2004 and 2005, but increased markedly in 2007 and stayed relatively high thereafter (Figure 6.11b).

The densities of *Bembicium* spp. were very similar at Ricketts Point and Halfmoon Bay, with the same pattern of temporal variation. In 2011, where there was a marked increase in the density at Ricketts Point (Figure 6.11c).

The mean size of *A. porcata* at both sites was relatively constant with periodic dips through the monitoring period (Figure 6.12a).

The mean size of *Bembicium* spp. followed similar patterns of temporal variation at both sites (Figure 6.12b). Mean sizes of *Bembicium* spp. at both sites varied between 5 and 15 mm (Figure 6.12b).

Anemones, such as *Aulactinia veratra* and *Actinia tenebrosa*, and 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 6.11 Mean density (± Standard Error) of dominant mobile invertebrates at Ricketts Point MS and the Half Moon Bay reference site.
Figure 6.12 Mean sizes (± Standard Error) of: (a) the top shell *Austrocochlea porcata*; and (b) the conniwink *Bembicium* spp. at Ricketts Point and the Half Moon Bay reference site.
6.6. Ricketts Point Condition Indicators

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

Introduced Species
No introduced species were detected for these sites.

Ecosystem Function
Total algal cover has varied considerably over the monitoring period at both sites (Figure 6.13a). Since 2010, total algal cover at Ricketts Point appeared consistently higher than Halfmoon Bay (Figure 6.13a).

Erect coralline algal cover was consistently higher at Halfmoon Bay compared to Ricketts Point, although coverage at both sites was very low (Figure 6.13b). Turfing algal cover was consistently higher at Halfmoon Bay than at Ricketts Point, and both sites appear to have similar temporal variations (Figure 6.13c).

The temporal variations of total grazers and predators were relatively similar at both sites until 2010 (Figure 6.14). The density of grazers at Halfmoon Bay declined markedly in recent surveys (Figure 6.14a). Predator abundance remained consistently higher and more variable through time at Halfmoon Bay than at Ricketts Point through all surveys (Figure 6.14b).

Climate Change
No novel species typical of adjacent bioregions were detected.

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.

Trampling
The increase in cover of Hormosira banksii at Ricketts Point over time means this indicator does not provide evidence for trampling impacts.

Environment
The cover of green algal species has been relatively variable with some peaks up to 8% cover (Figure 6.15a). Sediment cover was low over the monitoring period for both sites (Figure 6.15b).
Figure 6.13 Mean cover (± Standard Error) of algae within the Ricketts Point MS and the Half Moon Bay reference site.
Figure 6.14 Mean abundance (± Standard Error) of: (a) all grazers; and (b) all predators within the Ricketts Point MS and the Half Moon Bay reference site.
Figure 6.15 Mean cover (± Standard Error) of: (a) green algae (*Ulva, Enteromorpha* and *Cladophora* species); and (b) sediment, at Ricketts Point and the Half Moon Bay reference site.
7.  PORT PHILLIP HEADS MARINE NATIONAL PARK

7.1. Site Description and Transect Layout

7.1.1. Point Lonsdale (Site 2823)
The intertidal reef surveyed for the Port Phillip Heads Marine National Park was located at Point Lonsdale (Figure 7.1), on the western side of Port Phillip Heads. The extensive, triangular intertidal platform projects south and east from the Point Lonsdale headland. The calcarenite reef is predominantly very low relief, 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.

7.1.2. Cheviot Bay Reference (Site 2824)
The intertidal reef is less extensive than at Cheviot Bay (Figure 7.2) 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 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 human trampling that occur at Point Lonsdale.
Figure 7.1 Intertidal reef at Point Lonsdale, Port Phillip Heads Marine National Park, 12 June 2009.

Figure 7.2 Intertidal reef at the Cheviot Bay reference site, 22 December 2004.
7.2. Port Phillip Heads Community Structure

The mobile invertebrate communities at Point Lonsdale (2823) and the Cheviot Bay reference site (Site 2824) were similar (Figure 7.3). The slit limpet *Clipydina 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 *Bembicum nanum* was abundant at Point Lonsdale. The MDS analysis showed that the community structure at both sites shared certain similarities. The community structure at Point Lonsdale was more variable over time than Cheviot Bay (Figure 7.3).

The sessile species community structure was similar at Point Lonsdale and Cheviot Bay. The brown algae Neptune’s necklace *Hormosira banksii* was the dominant cover, with some *Corallina officinalis*, *Ulva* spp. and algal turf also present. The mat-forming mussel *Xenostrobus 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. The shifts in community structure at Point Lonsdale over time appear to be on a trajectory away from the Cheviot Bay community structure (Figure 7.4).

7.3. Port Phillip Heads Diversity

Species richness of mobile invertebrates was relatively stable at both Point Lonsdale and the reference Cheviot Bay (Figure 7.5).

Sessile species richness at both sites was likewise stable, apart from a spike at both sites in 2006 (Figure 7.6).

Diversity (Hills $N_e$) of mobile invertebrates has co-varied at Point Lonsdale (Site 2823) and Cheviot Bay (Site 2824) since the 2005 survey. It is at the lowest recorded for the monitoring period in 2012 (Figure 7.7).

Sessile species diversity at both sites remained low and stable throughout the monitoring period, reflecting the dominance of *H. banksii* at these sites (Figure 7.8).
Figure 7.3 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 7.4** 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 7.5 Mobile invertebrate species richness at Point Lonsdale and the Cheviot Bay reference site.

Figure 7.6 Algal and aggregating sessile invertebrate species richness of intertidal sites at Point Lonsdale and the Cheviot Bay reference site.
Figure 7.7 Mobile invertebrate diversity (Hills N₂) of intertidal sites at Point Lonsdale and the Cheviot Bay reference site.

Figure 7.8 Algal and aggregating sessile invertebrate diversity (Hill’s Nₐ) of intertidal sites at Point Lonsdale and the Cheviot Bay reference site.
7.4. 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 were high and relatively stable (Figure 7.9).

In the 2012 survey, experiments set up by other institutions were observed within the sampling area at Cheviot Bay.

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

Sand inundation was generally low and variable at both sites, generally covering between 5% and 10% of the reef throughout all surveys.

**Figure 7.9** Mean density (± Standard Error) of Neptune’s necklace *Hormosira banksii* at Point Lonsdale and the Cheviot Bay reference site.
7.5. Port Phillip Heads Mobile Invertebrates

The invertebrate community at Point Lonsdale (Site 2823) and the reference Cheviot Bay (Site 2824) was largely composed of the false limpet *Siphonaria* spp., variegated limpet *Cellana tramoserica* and conniwink *Bembicium nanum*.

The mean density of *C. tramoserica* at Point Lonsdale decreased from 15 individuals 0.25 m$^{-2}$ in 2004 to 5 individuals 0.25 m$^{-2}$ in 2005 and has remained relatively stable since. Cheviot Bay generally had lower abundances of *C. tramoserica* (Figure 7.10a). The conniwink *Bembicium nanum* mean density was consistently higher in Point Lonsdale than Cheviot Bay, both with a marked downward trend since 2009 (Figure 7.10b). *Clypidina rugosa* was the most abundant mobile invertebrate species at both sites, and densities were stable, though with some fluctuations, over the years (Figure 7.10c). *Siphonaria* spp. was at reasonably high densities at both sites (Figure 7.10d).

The mean length of *C. tramoserica* has been relatively stable at both Point Lonsdale and Cheviot Bay with similar mean lengths at both sites (Figure 7.11).
Figure 7.10 Mean density (± Standard Error) of: (a) the limpet *Cellana tramoserica*; (b) the striped conniwink *Bembicium nanum*; (c) the slit limpet *Clypidina rugosa*, at Point Lonsdale and the Cheviot Bay reference site.
Figure 7.11 (continued) Mean density (± Standard Error) of: (d) the false limpets *Siphonaria* spp. at Point Lonsdale and the Cheviot Bay reference site.

![Siphonaria spp. Density Graph](image)

**Cellana tramoserica** Size

Figure 7.12 Mean sizes (± Standard Error) of the limpet *Cellana tramoserica* at Point Lonsdale and the Cheviot Bay reference site.

![Cellana tramoserica Size Graph](image)
7.6. Port Phillip Heads Condition Indicators

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

Introduced Species
No introduced species were detected for these sites.

Ecosystem Function
Total algae cover was stable and remained high at both sites (Figure 7.12a). Erect coralline algae and turfing algae cover was generally higher and more variable at Point Lonsdale compared to Cheviot Bay (Figure 7.12b-c). The total grazer density appears stable at both sites apart from a spike at Cheviot Bay in 2007 (Figure 7.13a). Total predator density appears low and stable at both sites (Figure 7.13b).

Climate Change
No novel species from adjacent bioregions were detected.

Harvesting
Mean size of Cellana tramoserica has been relatively stable at both sites since 2005 and provides no indications of change to harvesting pressure.

Trampling
There is restricted access to the Cheviot Bay reference site and trampling pressure is negligible. Point Lonsdale is a popular location amongst the general public and there is likely to be some trampling pressure, particularly over holiday periods. However, 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.

Environment
The cover of green algal species was relatively low at these sites (Figure 7.14a). Sediment cover was generally low and variable at both sites. There was a peak of 10 % cover in 2009 (Figure 7.14b).
Figure 7.13 Mean cover (± Standard Error) of algae at Point Lonsdale and the Cheviot Bay reference site.
Figure 7.14 Mean abundance (± Standard Error) of: (a) all grazers; and (b) all predators at Point Lonsdale and the Cheviot Bay reference site.
Figure 7.15 Mean cover (± Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Point Lonsdale and the Cheviot Bay reference site.
8. MUSHROOM REEF MARINE SANCTUARY

8.1. Site Description and Transect Layout

8.1.1. 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 8.1a). 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 8.1b and c). 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.

8.1.2. 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 8.2). 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 8.1 Intertidal reef at Mushroom Reef Marine Sanctuary: (a) the cobble causeway, 8 June 2004; and b-c) the reef platform, 29 May 2009.
Figure 8.2 Intertidal reef at the Flinders West reference site, 8 June 2007.
8.2. Mushroom Reef Community Structure

The mobile invertebrate community at Mushroom Reef (Site 2907) was dominated by the top shell *Austrocochlea constricta*, conniwink *Bembicum* spp., and carnivorous gastropod *Lepsiella vinosa*. Commonly found species at the reference West Flinders site (Site 2908) were the top shell *A. constricta*, *L. 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 other pairs of sites (Figure 8.3). The sites were relatively dissimilar to each other (Figure 8.3).

The sessile species were consistent between Mushroom Reef and the reference West Flinders site. The assemblage consisted of predominantly the brown algae Neptune’s necklace *Hormosira banksii*, *Corallina officinalis*, encrusting corallines 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 at all times (Figure 8.4).

8.3. 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 8.5).

Algal and aggregating sessile invertebrate species richness at both sites showed fluctuations through time with no apparent trends (Figure 8.6).

Mobile invertebrate Hills diversity ($N_2$) 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 8.7).

Sessile species diversity was more variable at West Flinders than Mushroom Reef (Figure 8.7). Sessile species diversity at West Flinders in 2012 was highest in 2012 (Figure 8.7).
Figure 8.3 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 8.4 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 8.5** Mobile invertebrate species richness at Mushroom Reef and the West Flinders reference site.

**Figure 8.6** Algal and aggregating sessile invertebrate species richness of intertidal sites at Mushroom Reef and the West Flinders reference site.
Figure 8.7 Mobile invertebrate diversity (Hills $N_2$) of intertidal sites at Mushroom Reef, and the West Flinders reference site.

Figure 8.8 Algal and aggregating sessile invertebrate diversity (Hill's $N_2$) of intertidal sites at Mushroom Reef and the West Flinders reference site.
8.4. 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 *Enteromorpha* spp, and the mat forming mussel *Xenostrobus pulex* occurring in low densities. The cover of *H. banksii* was variable, ranging between 1 and 16 % cover over time (Figure 8.9).

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 12 % (Figure 8.9). The seagrass *Zostera muelleri* has been intermittently detected at Flinders West since 2004, in low densities.

![Hormosira banksii Cover](image)

*Figure 8.9* Mean density (± Standard Error) of Neptune’s necklace *Hormosira banksii* at Mushroom Reef and the West Flinders reference site.
8.5. 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 8.10a). Abundances peaked in 2007 to 27 individuals 0.25 m$^{-2}$, decreasing during subsequent surveys to 6 individuals 0.25 m$^{-2}$ in 2012. Densities at West Flinders were lower and relatively stable over time (Figure 8.10a).

*Bembicium nanum* densities were likewise consistently higher at Mushroom Reef, although both sites have declined in densities since 2006 (Figure 8.10b).

The mean size of *B. nanum* followed similar patterns through time at both sites (Figure 8.11a). There was an upward trend since 2007 and mean sizes at both sites in 2012 were the highest recorded (Figure 8.11a).

The mean size of *A. constricta* was stable through time, showing no clear patterns (Figure 8.11b).
Figure 8.10 Mean density (± Standard Error) of: (a) the top shell *Austrocochlea constricta*; and (b) the striped conniwink *Bembicium nanum* at Mushroom Reef and the West Flinders reference site.
Figure 8.11 Mean sizes (± Standard Error) of: (a) the coniwink *Bembicium* spp. And (b) the top shell *Austrocochlea constricta* at Mushroom Reef and the West Flinders reference site.
8.6. Mushroom Reef Condition Indicators

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 was the lowest recorded at Mushroom Reef, while sessile species diversity was the highest recorded at West Flinders.

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

Ecosystem Function
Total algae cover was relatively stable at both sites, with cover being consistently higher at West Flinders (Figure 8.12a). Erect coralline and turfing algal covers were likewise higher, but also far more variable, at West Flinders, both ranging from about 0 to 30 % during the monitoring period (Figure 8.12b-c). Erect coralline and turfing algal cover was consistently low at Mushroom Reef (Figure 8.12b-c).

Total grazer abundance was more variable at Mushroom Reef compared to West Flinders over the monitoring period (Figure 8.13). Total predator density at Mushroom Reef appeared to be declining since 2009, and was at its lowest recorded level in 2012 (Figure 8.13b). Total predator density at West Flinders was moderately variable (Figure 8.13b).

Climate Change
No novel species typical of adjacent bioregions were detected.

Harvesting
The mean size of *Bembicium nanum* and *Austrocochlea porcata* were relatively constant at Mushroom Reef and West Flinders sites (Figure 8.11b). These results did not provide evidence that could distinguish harvesting pressure from natural population dynamics.

Trampling
There were no major changes in *Hormosira banksii* cover at both sites in recent surveys. This indicates trampling is not presently a constraining factor to the population.

Environment
The cover of green algal species was consistently low at West Flinders. The cover at Mushroom Reef fluctuated between 2 and 8 % until 2007, after which the cover dropped to similar levels as West Flinders (Figure 8.14a).

Sediment cover was consistently low (< 3 %) over the monitoring period (Figure 8.14b).
Figure 8.12 Mean cover (± Standard Error) of algae at Mushroom Reef and the West Flinders reference site.
Figure 8.13 Mean abundance (± Standard Error) of: (a) all grazers; and (b) all predators at Mushroom Reef and the West Flinders reference site.
Figure 8.14 Mean cover (± Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Mushroom Reef and the West Flinders reference site.
9. BUNURONG MARINE NATIONAL PARK

9.1. Site Description and Transect Layout

9.1.1. Eagles Nest (Site 3020)

Many intertidal reefs exist within the Bunurong Marine National Park that could act 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 9.1).

9.1.2. 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 substrate 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 9.2). At the eastern end of the survey area (Transect 5) has more structure with large rocky outcrops towards the high shore level.
Figure 9.1 Intertidal reef at Eagles Nest, Bunurong Marine National Park, 7 June 2007.

Figure 9.1 Intertidal reef at the Caves reference site, 7 June 2007, showing (a) the study area and (b) the limpet *Cellana tramoserica*. 
9.2. 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 *Bembicum nanum*, periwinkles *Nodilittorina acutispira* and *Austrolittorina unifasciata*, and *Siphonaria* spp. The MDS analysis of mobile invertebrate communities showed that both sites were similar with moderate variations in community structure over time, although there is no overlap in community structure (Figure 9.3).

The sessile species were also consistent between Eagles Nest and the Caves. The community was dominated by the mat forming mussel *Xenostrobus pulex*, the brown algae Neptune’s necklace *Hormosira banksii* and algal turf. The MDS plot illustrates greater, 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 9.3).

9.3. Bunurong Diversity
Mobile species richness at Eagles Nest appeared to have a downward trend, with species richness in 2012 being the lowest recorded in the monitoring period (Figure 9.5). Mobile species richness at Caves exhibited no clear trends (Figure 9.5).

Shifts in sessile species richness at Eagles Nest and the Caves varied very similarly through time (Figure 9.6). Sessile species richness at both sites was at a high in 2012 (Figure 9.6).

Mobile invertebrate diversity (*Hills N*₂) exhibited low variability at Eagles Nest (Figure 9.7). At the Caves, there was a marked increase in mobile species diversity in 2009, which remained high since 2009 (Figure 9.7).

There were no clear trends in sessile species diversity for either site. Sessile species diversity was at the low end of the range at Caves and the high end of the range at Eagles Nest in 2012 (Figure 9.8).
Figure 9.2 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 9.3 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 9.4 Mobile invertebrate species richness at Eagles Nest and the Caves reference site.

Figure 9.5 Algal and aggregating sessile invertebrate species richness of intertidal sites at Eagles Nest and the Caves reference site.
Figure 9.6 Mobile invertebrate diversity (Hills $N_2$) of intertidal sites at Eagles Nest and the Caves reference site.

Figure 9.7 Algal and aggregating sessile invertebrate diversity (Hill’s $N_2$) of intertidal sites at Eagles Nest and the Caves reference site.
9.4. Bunurong Macroalgae and Aggregating Sessile Invertebrates

The cover of the brown algae Neptune’s necklace *Hormosira banksii* was relatively stable through time with consistently low cover (Figure 9.9). The mat-forming mussel *Xenostrobus pulex* cover was variable and low. Sand cover at both sites was variable through time with no consistent patterns.

**Figure 9.8** Mean density (± Standard Error) of Neptune’s necklace *Hormosira banksii* at Eagles Nest and the Caves reference site.
9.5. Bunurong Mobile Invertebrates

The species composition of the mobile invertebrates at Eagles Nest (Site 3020) and the reference Caves (Site 3021) were similar. The community was dominated by *Nodilittorina acutispira*, *Austrolittorina unifasciata* and limpet *Cellana tramoserica*. The snail *Austrocochlea constricta*, and limpets *Notoacmea mayi* and *Patelloida alticostata* were also common.

The mean densities of *A. unifasciata* at both sites were quite variable over time, but both sites generally exhibited similar temporal variability apart from a spike at Eagles Nest in 2010 (Figure 9.10a).

*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 9.10b).

*Cellana tramoserica* occurs in consistently low densities at these two sites (Figure 9.10a).

The mean size of *C. tramoserica* was similar at both sites. There was a substantial upward trend from 2006, with mean sizes increasing from approximately 20 mm to 35 mm by 2012 (Figure 9.11).
Figure 9.9 Mean density (± Standard Error) of (a) *Austrolittorina unifasciata*; (b) the striped conniwink *Bembicium nanum*; and (c) the limpet *Cellana tramoserica* at Eagles Nest and the Caves reference site.
Figure 9.10 Mean sizes (± Standard Error) of the limpet *Cellana tramoserica* at Eagles Nest and the Caves reference site.
9.6. Bunurong Condition Indicators

Biodiversity
There were changes in community composition at both sites. In 2012, mobile species richness at Eagles Nest was at a low, while sessile species richness at both sites was high. Sessile species diversity was high for Eagles Nest and low for the Caves.

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

Ecosystem Function
Total algal cover and erect coralline algae cover had overlapping ranges of variation at both sites having no clear patterns or trends (Figure 9.12a-b). Turfing algal cover was very similar at both sites, with a peak in 2009 (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 0.25 m$^{-2}$ (Figure 9.13a). Total predator abundance was very low at both sites and appeared to have slight downward trends (Figure 9.13b).

Climate Change
No novel species typical of adjacent bioregions were observed during the intertidal reef surveys in this area.

Harvesting
The increasing trend of mean sizes of *C. tramoserica* possibly indicates a reduction in harvesting pressure, but may also be a response to other environmental parameters (Figure 9.11).

Trampling
The fluctuation of *Hormosira banksii* densities (Figure 9.9) provides little information with respect to trampling pressure.

Environment
The mean cover of green algal species at both sites was in general very low throughout the monitoring period (Figure 9.14a). Sediment cover at both sites was variable over time, ranging from 0 to 13 % cover (Figure 9.14b).
Figure 9.11 Mean cover (± Standard Error) of algae at Eagles Nest and the Caves reference site.
Figure 9.12 Mean abundance (± Standard Error) of: (a) all grazers; and (b) all predators at Eagles Nest and the Caves reference site.
Figure 9.13 Mean cover (± Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Eagles Nest and the Caves reference site.
10. POINT ADDIS MARINE NATIONAL PARK

10.1. Site Description and Transect Layout

10.1.1. 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 10.1). 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.

10.1.2. 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 10.2). 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.
Figure 10.1 Intertidal reef at Point Addis Marine National Park, 17 December 2004.

Figure 10.2 Intertidal reef at the Winkipop reference site, 28 May 2009.
10.2. Point Addis Community Structure

The mobile invertebrate community was generally more species rich at Winkipop than Point Addis. The false limpet *Siphonaria* spp. was abundant at both sites. True limpets, such as *Cellana tramoserica* and *Notoacmea* spp. were also common. The limpet *Clypidina rugosa* and conniwink *Bembicium nanum* were more prevalent at Winkipop than Point Addis.

These patterns were reflected in the MDS analysis which placed Point Addis and Winkipop as distinct from one another but within the same cluster of open coast sites (Figure 10.3).

The sessile species communities at Point Addis and the Winkipop reference site were dominated by the brown algae *Hormosira banksii*. Brown algal turf was common at Point Addis, while *Corallina officinalis* was more common at Winkipop.

The MDS analysis showed that both sites were similarly grouped, but Point Addis was more variable over time than Winkipop (Figure 10.4).

10.3. 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 10.5).

Sessile species richness was similar at Point Addis and Winkipop and trends at the two sites have tracked each other closely since 2006 (Figure 10.6).

Mobile invertebrate diversity (Hills $N_H$) 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 10.7). Mobile species diversity at Point Addis was generally lower and less variable (Figure 10.7).

Algal and aggregating sessile invertebrate species diversity remained low (less than 2) with little variability at both sites (Figure 10.8).
Figure 10.3 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 10.4** 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 10.5 Mobile invertebrate species richness at Point Addis and the Winkipop reference site.

Figure 10.6 Algal and aggregating sessile invertebrate species richness of intertidal sites at Point Addis and the Winkipop reference site.
Figure 10.7 Mobile invertebrate diversity (Hills N₂) of intertidal sites at Point Addis and the Winkipop reference site.

Figure 10.8 Algal and aggregating sessile invertebrate diversity (Hill’s N₂) of intertidal sites at Point Addis and the Winkipop reference site.
10.4. Point Addis Macroalgae and Aggregating Sessile Invertebrates

The brown alga *Hormosira banksii* was the dominant cover at both sites, with cover consistently 20% to 30% higher at the Winkipop reference site. The cover of *H. banksii* at both sites had similar temporal variations and appeared stable over time (Figure 10.9). Algal turf cover was consistently higher at Point Addis (5% to 15%) than Winkipop (0% to 3%).

In the 2012 survey, large patches of sunburnt *H. banksii* were observed at both sites. Experiments set up by other institutions were observed within the sampling area at Winkipop. There were no marked trends in the abundances of the sessile organisms over time. The tube worm *Galeolaria caespitosa*, barnacle *Chthamalus antennatus* and mussel *Xenostrobus pulex* have been observed intermittently at both sites.

*Figure 10.9* Mean density (± Standard Error) of Neptune’s necklace *Hormosira banksii* at Point Addis and the Winkipop reference site.
10.5. Point Addis Mobile Invertebrates

The types of mobile invertebrate species present at Point Addis and Winkipop were generally similar. Abundances of the false limpet *Siphonaria* spp., and limpets *Notoacmea* spp. and *Patelloida alticostata* were similar between sites. 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.

*Clypidina rugosa* density was generally low at both sites, apart from a couple of spikes at Winkipop in 2010 and 2012 (Figure 10.10a).

The densities of *B. nanum* and *C. tramoserica* were generally low and variable through all surveys (Figure 10.10b-c). *Bembicium nanum* was generally more abundant at Winkipop than at Point Addis (Figure 10.10b) and *C. tramoserica* was more abundant at Point Addis than at Winkipop (Figure 10.10c).

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 10.11).
Figure 10.10 Mean density (± Standard Error) of dominant mobile invertebrates at Point Addis and the Winkipop reference site.
Figure 10.11 Mean sizes (± Standard Error) of harvested invertebrates at Point Addis and the Winkipop reference site.
10.6. Point Addis Condition Indicators

Biodiversity
The community structure at Point Addis was more variable than that at Winkipop. In 2012, community structure at Point Addis diverged from, but followed the same trajectory as previous years. Species richness at these sites was within the range of states and changes previously observed. Mobile species diversity was the lowest recorded at Winkipop.

Introduced Species
No introduced species were detected at these sites.

Ecosystem Function
Total algal cover was very high and generally stable at both sites (Figure 10.12a). 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 10.12b). Turfing algal cover was consistently higher and more variable at Point Addis than Winkipop throughout the monitoring period (Figure 10.12c).

Total grazer density remained stable throughout the monitoring period, apart from a spike at Point Addis in 2007 (Figure 10.13a). Total predator density at both sites was variable with no clear trends (Figure 10.13b).

Climate Change
No novel species typical of adjacent bioregions were detected.

Harvesting
Cellana tramoserica occur at very low densities at these sites, <1 individuals 0.25 m² quadrat. There were no indications of increased harvesting pressure based on densities, however mean sizes increased.

Trampling
The cover of Hormosira banksii at both sites was consistently high and appeared stable. The cover in 2012 was the lowest recorded at Winkipop, but cover was still high (about 60 %, Figure 10.9).

Environment
The cover of green algal species, sometimes indicative of nutrient loading, was low and highly variable at these sites (Figure 10.14a). Sediment cover at both sites was relatively low (Figure 10.14b).
Figure 10.12 Mean cover (± Standard Error) of algae at Point Addis and the Winkipop reference site.
Figure 10.13 Mean abundance (± Standard Error) of: (a) all grazers; and (b) all predators at Point Addis and the Winkipop reference site.
Figure 10.14 Mean cover (± Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Point Addis and the Winkipop reference site.
11. POINT DANGER MARINE SANCTUARY

11.1. Site Description and Transect Layout

11.1.1. 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 11.1). 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.

11.1.2. 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 11.2).
Figure 11.1 Intertidal reef at Point Danger Marine Sanctuary: (a-b) 14 January 2005; (c-d) 30 April 2009.
Figure 11.2 Intertidal reef at the Point Danger West reference site: (a) 17 January 2005; (b) 30 April 2009. Note: sand inundation along the high shore was lower in 2009, but remained higher than when the site was established.
11.2. 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 coniwink *Bembicium* spp., periwinkle *Nodilittorina acutispira* and slit limpet *Clipydina rugosa*. Both sites showed a similar degree of variation during much of the monitoring period (Figure 11.3). The community structure within the sanctuary during 2011 and 2012 was distinct from previous surveys. This change was largely because of decreases in abundance of *Bembicium nanum* and corresponding increases in *Nodolittorina acutispira*. A similar change was observed in 2011 for the reference site, however there was a return to the more usual community structure in 2012 (Figure 11.3).

The sessile species community structure was also similar between Point Danger the Point Danger West sites. The most common species were the brown algae Neptune’s necklace *Hormosira banksii*, mat-forming mussel *Xenostrobus 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 (Figure 11.4).

11.3. 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 11.5).

Sessile species richness fluctuated at both Point Danger and Point Danger West, however no obvious trends were apparent (Figure 11.6).

Mobile invertebrate diversity (Hills $N_2$) fluctuated considerably at both sites (Figure 11.7) while sessile species diversity was comparatively stable (Figure 11.8).
Figure 11.3 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 11.4 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 11.5 Mobile invertebrate species richness at Point Danger sites.

Figure 11.6 Sessile species richness of intertidal sites at Point Danger sites.
Figure 11.7 Mobile invertebrate diversity (Hills $N_2$) of intertidal sites at Point Danger sites.

Figure 11.8 Sessile species diversity (Hill’s $N_2$) of intertidal sites at Point Danger sites.
11.4. Point Danger Sessile Species

The sessile species were similar at both Point Danger (Site 4002) and the Point Danger West site (Site 4001). The community was predominantly comprised of the brown alga Neptune’s necklace *Hormosira banksii*, green algae *Enteromorpha* spp, algal turfs and the mat-forming mussel *Xenostrobus pulex*. Other sessile species were observed in low densities of < 3 % cover. The cover of *H. banksii* was similar at both sites and remained relatively stable over the monitoring period (Figure 11.9).

*Figure 11.9* Mean density (± Standard Error) of Neptune’s necklace *Hormosira banksii* at Point Danger.
11.5. Point Danger Mobile Invertebrates

Point Danger and Point Danger West had a similar suite of mobile invertebrate species which were generally similar in abundances between the two sites. The conniwink *Bembicium* spp. and the limpets *Clypidina rugosa* and *Siphonaria* spp. were the numerically dominant species. Snails *Dicathais orbita*, *Lepsiella vinosa*, *Turbo undulatus* and limpet *Patelloidea alticostata* contributed to the community structure although occurring at lower densities.

The abundance of *C. rugosa* fluctuated considerably between survey times (Figure 11.10a).

For *Bembicium nanum*, there was a strong peak in abundance in 2007 in the sanctuary. This peak was not reflected at the reference site, and abundances in the sanctuary subsequently fell to reference site levels by 2009 (Figure 11.10b).

The limpet *C. tramoserica* was initially present in low densities at both sites, with a general decline over the monitoring program to being virtually absent from both sites in 2011 and 2012.

Mean sizes of *B. nanum* were fluctuated considerably through time (Figure 11.11a). Mean sizes of *C. tramoserica* were relatively stable through time (figure 11.11b).
Figure 11.10 Mean Density (± Standard Error) of dominant mobile invertebrates at Point Danger.
Figure 11.11 Mean sizes (± Standard Error) of invertebrates at Point Danger.
11.6. Point Danger Condition Indicators

Biodiversity
Community composition was within the range of sites and changes previously observed for the reference site. The sanctuary site state for 2011 and 2012 was different with decreased *Bembicium nanum* and increased *Nodolittorina acutispira* abundances. Species diversity remained stable over surveys with few clear patterns or trends in the data.

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

Ecosystem Function
Total algal cover varied gradually up and down over time – the 2012 state was with lower algal cover (Figure 11.11a). The cover of erect coralline algae was very low during all surveys (Figure 11.11b). The cover of algal turf at both sites was variable over time with no clear patterns (Figure 11.11c).

Point Danger had consistently higher abundances of grazers and predators. The abundance of grazers was variable between survey times, with similar variations at both sites (Figure 11.12a). Predator abundances were relatively stable until 2009, survey before dropping at Point Danger in 2010 and at Point Danger West in 2011 (Figure 11.12b).

Climate Change
No novel species typical of adjacent bioregions were detected.

Harvesting
There were no changes in abundances and sizes of gastropods. This indicator did not provide evidence that could distinguish harvesting pressure from natural population dynamics.

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

Environment
The cover of green algal species potentially indicates nutrient loading. The coverage fluctuated considerably at both Point Danger sites, with the highest coverage being at Point Danger in 2010. This peak subsequently reduced to near absence, with a corresponding increase in coverage at Point Danger West (Figure 11.14a).

Sediment cover had a large range of up to 30% at both sites during the monitoring program. High coverages were observed in 2011 and intermediate coverage was present in 2012 (Figure 11.14b).
Figure 11.12 Mean cover (± Standard Error) of functional algal groups at Point Danger.
Figure 11.13 Mean abundance (± Standard Error) of: (a) all grazers; and (b) all predators at Point Danger.
Figure 11.14 Mean cover (± Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Point Danger.
12. BARWON BLUFF MARINE SANCTUARY

12.1. Site Description and Transect Layout

12.1.1. 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.

12.1.2. 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.
Figure 12.1 Intertidal reef at Barwon Bluff Marine Sanctuary: (a) 30 November 2005; and (b) 1 May 2009.
12.2. 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 *Notoacmea* spp., periwinkles *Nodilittorina acutispira*, and slit limpets *Clypidina rugosa*.

The MDS analysis of mobile invertebrate community structure indicated both sites were similar to each other during most times, placing them close together within the same cluster on the MDS plot (Figure 12.2). The community structure at Barwon Bluff remained relatively stable throughout the monitoring period. The community structure at Barwon Beach was slightly more variable, particularly between surveys 4 and 5, when species richness at this site decreased (Figure 12.2).

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 *Xenostrobus 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, indicating their similarity with each other throughout the monitoring program (Figure 12.3). The MDS also illustrated a similar degree of variation between times for both sites.

12.3. 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 12.2). 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 (Figure 12.5).

Mobile invertebrate diversity (Hills $N_2$) was reasonably variable at both Barwon Heads sites, with intermediate levels observed in 2012 (Figure 12.5). Algal and aggregate sessile invertebrate diversity remained low and relatively stable, between 1 and 1.5, throughout the monitoring program (Figure 12.5).
Figure 12.2 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 12.3 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 12.4** Mobile invertebrate species richness at Barwon Bluff sites.

**Figure 12.5** Sessile species richness of intertidal sites at Barwon Bluff sites.
**Figure 12.6** Mobile invertebrate diversity (Hills N$_2$) of intertidal sites at Barwon Bluff sites.

**Figure 12.7** Sessile species diversity (Hill's N$_2$) of intertidal sites at Barwon Bluff sites.
12.4. Barwon Bluff Sessile Species

As with many exposed rock platforms of the central Victorian coast, the brown algae Neptune’s necklace *Hormosira banksii* was the dominant algae cover at both Barwon Bluff and the reference site at Barwon Beach. The cover of *H. banksii* was typically 15% to 20% higher at Barwon Bluff, except for 2009 when cover decreased significantly at the Barwon Bluff site (Figure 12.8). 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. 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.

![Hormosira banksii Cover](image)

**Figure 12.8** Mean percent cover (± Standard Error) of Neptune’s necklace *Hormosira banksii* at Barwon Bluff sites.
12.5. Barwon Bluff Mobile Invertebrates

The mobile invertebrate assemblages Barwon Bluff and Barwon Beach sites were both dominated by gastropod snails, particularly the limpets Clypidina rugosa, Notoacmea mayi, and Cellana tramoserica, conniwinks Bembicum nanum and periwinkle Nodilittorina acutispira.

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. The abundance of N. acutispira decreases substantially to 2009. While it was not recorded at either site during the 2010 survey it was again recorded at Barwon Beach in 2011 (Figure 12.9a).

The limpet C. rugosa was the most abundant species at both sites, although abundances were highly variable in the Barwon Bluff marine sanctuary. At this site, there was a peak in 2009 and consistent decline to 2012 (Figure 12.9b).

Cellana tramoserica has been absent from the Barwon Bluff marine sanctuary site since 2007 but relatively persistent at Barwon Beach (Figure 12.9c).

The mean length of C. tramoserica in the Barwon Bluff marine sanctuary site steadily increased over the monitoring period, although there was a dip in size during 2011 (Figure 12.10). Mean size was more variable with no clear trend outside the marine sanctuary.

The predatory gastropods Cominella lineolata and Dicathais orbita occurred at low abundances at both sites during all surveys.
Figure 12.9 Mean Density (± Standard Error) of dominant mobile invertebrates at Barwon Bluff sites.
Figure 12.10 Mean sizes (± Standard Error) of the limpet *Cellana tramoserica* at Barwon Bluff, within the Barwon Bluff MS, and the Barwon Beach reference site.
12.6. Barwon Bluff Condition Indicators

Biodiversity
Community composition, species richness and diversity levels were all within the range previously observed at these sites.

Introduced Species
No introduced species were detected for these sites.

Ecosystem Function
Total algal cover was at its highest from 2010 to 2012 (Figure 12.11a). Erect coralline algae cover was low and variable at both sites, approaching zero coverage in 2011 and 2012 (Figure 12.11b). Turfing algae had a generally decreasing trend over the monitoring period, with very little cover observed in 2012 (Figure 12.11c).

The total abundance of grazers at Barwon Bluff ranged between 50 and 80 individual per quadrat over the monitoring period (Figure 12.12a). The total abundance of grazers at Barwon Beach has been more variable, with a spike of over 1400 individuals per quadrat in 2007 (Figure 12.12a). This is primarily due to changes in the abundance of the periwinkle Nodilittorina acutispira.

Total predator abundances have been low and variable at both sites, however a general decreasing trend was apparent over the monitoring period (Figure 12.12b).

Climate Change
There were no species changes indicative of processes expected with climate change.

Harvesting
The density of Cellana tramoserica was low at Barwon Bluff MS throughout the monitoring. The decrease in density between 2006 and 2007 may indicate harvesting at this site in this period, however this is not reflected in the sizes, with a general increasing trend over the monitoring period.

Trampling
There was no evidence of trampling impacts, with Hormosira banksii cover generally increasing at both sites over the monitoring period.

Environment
The cover of green algal species can sometimes be indicative of nutrient loading. This was relatively low (< 2 %) at both sites during all surveys (Figure 12.13a).

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 12.13b).
Figure 12.11 Mean cover (± Standard Error) of algae within the Barwon Bluff MS, and the Barwon Beach reference site.
Figure 12.12 Mean abundance (± Standard Error) of: (a) all grazers; and (b) all predators at Barwon Bluff sites.
Figure 12.13 Mean cover (± Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Barwon Bluff sites.
13. REFERENCES


14. ACKNOWLEDGEMENTS

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15. APPENDICES – SITE DETAILS

15.1. Point Cooke Marine Sanctuary

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 5.1). 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 15.1 Site details for Point Cooke (Site 4107) in Point Cooke MS.
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 15.2 Site details for Altona (Site 4108), the reference site for Point Cooke MS.

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15.2. Jawbone Marine Sanctuary

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 6.1). 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 15.3 Site details for Jawbone (Site 4109) in Jawbone MS.

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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 6.2). 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 15.4 Site details for Williamstown (Site 4110), the reference site for Jawbone MS.

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15.3. Ricketts Point Marine Sanctuary

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 15.5 Site details for Ricketts Point (Site 4111) in Ricketts Point MS.

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

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15.4. Point Addis Marine National Park

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.

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**Table 15.7** Site details for Point Addis (Site 3901) in Point Addis MNP.

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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 15.8 Site details for Winkipop (Site 3902), the reference site for Point Addis MNP.

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15.5. Point Danger Marine Sanctuary

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 15.9 Site details for Point Danger (Site 4002) in Point Danger MS.

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<tr>
<th>Site:</th>
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<td>144.328100</td>
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</table>
**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 15.10** Site details for Point Danger West (Site 4001), the reference site for Point Danger MS.

<table>
<thead>
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<th>Baseline position</th>
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<th>MGA Easting</th>
<th>MGA Northing</th>
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15.6. Barwon Bluff Marine Sanctuary

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 (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 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 15.11 Site details for Barwon Bluff (Site 4004) in Barwon Bluff MS.

<table>
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<td>B</td>
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<tr>
<td>C</td>
</tr>
<tr>
<td>D</td>
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</table>
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 15.12 Site details for Barwon Beach (Site 4003), the reference site for Barwon Bluff MS.

<table>
<thead>
<tr>
<th>Site: 4003 Barwon Beach</th>
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<td>D</td>
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</tbody>
</table>
15.7. Port Phillip Heads Marine National Park

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 15.13 Site details for Point Lonsdale (Site 2823) in Port Phillip Heads MNP.

<table>
<thead>
<tr>
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<td>D</td>
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</table>
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 Phillips 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 ordnance 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 15.14 Site details for Cheviot Bay (Site 2824), the reference site for Port Phillip Heads MNP.

<table>
<thead>
<tr>
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15.8. Mushroom Reef Marine Sanctuary

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 15.15 Site details for Mushroom Reef (Site 2907) in Mushroom Reef MS.

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

<table>
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<th>Site:</th>
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</table>
15.9. Bunurong Marine National Park

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 15.17 Site details for Eagles Nest (Site 3020) in Bunurong MNP.

<table>
<thead>
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</table>
Cave – 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 15.18 Site details for the Caves (Site 3021), the reference site for Bunurong MNP.

<table>
<thead>
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Parks Victoria is responsible for managing the Victorian protected area network, which ranges from wilderness areas to metropolitan parks and includes both marine and terrestrial components.

Our role is to protect the natural and cultural values of the parks and other assets we manage, while providing a great range of outdoor opportunities for all Victorians and visitors.

A broad range of environmental research and monitoring activities supported by Parks Victoria provides information to enhance park management decisions. This Technical Series highlights some of the environmental research and monitoring activities done within Victoria’s protected area network.

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