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Victorian Intertidal Reef Monitoring Program: Central Victoria Marine Protected Areas

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**Victorian Intertidal Reef Monitoring
Program:
Victoria Marine Protected Areas**

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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 and again in autumn 2010.

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 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 non-sessile 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.

Point Cooke MS

Point Cooke MS is situated in Port Phillip Bay. Key observations made at Point Cooke MS and reference Altona site during the monitoring program are:

- Total algal cover has been low and relatively stable at both sites over the past three years.
- An originally small patch of the seagrass *Zostera muelleri* continued to increase in 2010.

Jawbone MS

Jawbone MS is situated in Port Phillip Bay. Key observations made at Jawbone MS and reference Williamstown site during the monitoring program are:

- Species richness and diversity levels were among the highest recorded in 2010.
- An increase in brown alga *Hormosira banksii* increased the total algal cover considerable during the 2010 survey.

Ricketts MS

Ricketts Point MS is situated in Port Phillip Bay. Key observations made at Ricketts Point MS and reference Half Moon Bay site during the monitoring program are:

- Species richness and diversity levels were among the highest recorded in 2010, excepting species richness of mobile invertebrate at Halfmoon Bay (which was the lowest recorded).
- Total algal cover has generally increased at both sites from 2005 to 2010.

Port Phillip Heads MNP

Key observations made at Port Phillip Heads MNP and reference Cheviot Bay site during the monitoring program are:

- Algal species richness was low at both sites over the survey period.
- Total algae cover increased at both sites in 2010 after slight but steady declines since December 2004.

Mushroom Reef MS

Key observations made at Mushroom Reef MS and reference West Flinders site during the monitoring program are:

- Species diversity levels had decreased during 2010 for both mobile invertebrate and algal and sessile invertebrates.

Bunurong MNP

Observations from 2010 were within the limits of previous surveys. There were no key changes at this site.

Point Addis MNP

Key observations made at Point Addis MNP and reference Winkipop site during the monitoring program are:

- Invertebrate species diversity was at the lowest level recorded at the Winkipop reference site.
- Algal and sessile invertebrate species diversity was at its highest recorded level at Point Addis.
- Total algal cover decreased at both sites from 2009 to 2010.

Point Danger MS

Key observations made at Point Danger MS and reference Point Danger West site during the monitoring program are:

- Mobile invertebrate species richness had increased in 2010 to the highest level recorded.
- At Point Danger MS the total algae cover continued to steadily increase from 2005 to 2010.

Barwon Bluff MS

Key observations made at Barwon Bluff MS and reference Barwon Beach site during the monitoring program are:

- Total algal cover increased at both site from 2009 to 2010 and is high compared to previous observations.

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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 headlands and points and are often isolated from each other by stretches of sandy beach. Victorian intertidal reefs vary in structure from steep sloping rock faces to relatively flat or gently sloping boulder fields and rock platforms. Weathering creates features on intertidal reefs including cobble fields, vertical steps, undulations in the reef, crevices, patches of sand and rock pools. The influence of the regular tidal cycle is the most important determinant of the types of biota inhabiting rocky reefs. Intertidal reefs tend to experience rapid changes and extremes in environmental conditions including temperature, salinity and exposure to air causing desiccation stress.

Typical algal species on protected intertidal reefs include the mat forming brown algae Neptune's necklace *Hormosira banksii* and 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 coniwinks *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 fishing bait, trampling and pollution from catchment discharges. To effectively manage and conserve these habitats, the Victorian Government, through Parks Victoria, has established the Intertidal Reef Monitoring Program (IRMP).

1.2 Intertidal Reef Monitoring Program

1.2.1 Objectives

An important aspect in the management and conservation of Victorian marine natural resources and assets is assessing the condition of the ecosystem and how this changes over time. 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 is allowing 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.

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

magnitude of environmental variation is different over different time scales, variation over long periods may not be adequately predicted from shorter-term data. Sources of environmental variation can operate at the scale of months (*e.g.* seasonal variation), years (*e.g.* El Niño), decades (*e.g.* extreme storm events) or even centuries (*e.g.* global warming). Other studies indicate this monitoring program will begin to adequately reflect average trends and patterns as the surveys continue over longer periods (multiple years to decades). Results always need to be interpreted within the context of the time scale over which they have been measured.

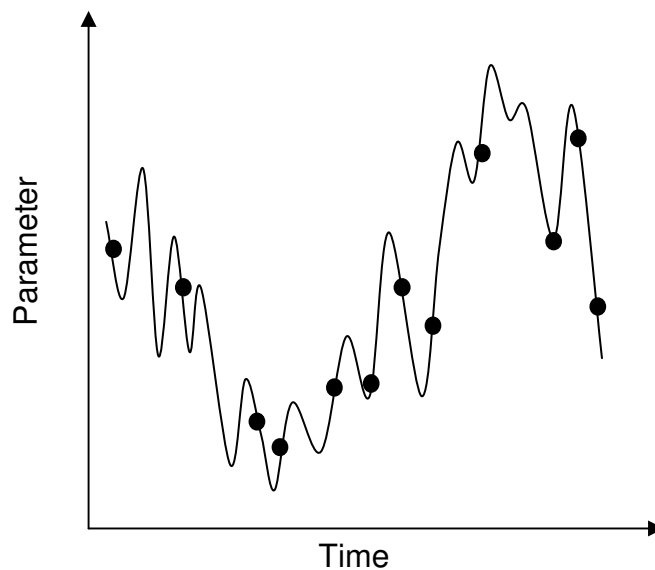


Figure 1.1. An example plot depicting change in an environmental, population or community variable over time (days, months or years). The black circles denote examples of monitoring times. Note how data from these times may not necessarily reflect patterns over shorter time periods, or true maxima or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

1.2.2 Monitoring Protocols and Locations

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

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

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

Existing monitoring sites in Port Phillip Bay and at the Mushroom Reef Marine Sanctuary were resurveyed in 2004 using the revised standard operating procedures (Hart and Edmunds 2005). At Barwon Heads Marine Sanctuary only Barwon Bluff (Site 4004) was surveyed during Survey 2, May 2004. Weather, tide and logistical limitations prevented the survey of Barwon Beach during this survey. 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; and autumn 2010.



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

1.2.3 Monitoring Central Victorian Marine Protected Areas

This report describes the intertidal reef monitoring program and results from surveys, done in April to June 2009, 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.

2 METHODS

2.1 Site Selection and Survey Times

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

- northern Port Phillip Bay (Figure 2.1):
 - Point Cooke Marine Sanctuary;
 - Jawbone Marine Sanctuary;
 - Ricketts Point Marine Sanctuary;
- central coast of central Victoria (Figure 2.2):
 - Port Phillip Heads Marine National Park;
 - Mushroom Reef Marine Sanctuary;
- eastern coast of central Victoria (Figure 2.3):
 - Bunurong Marine National Park;
- western coast of central Victoria (Figure 2.4):
 - Point Addis Marine National Park;
 - Point Danger Marine Sanctuary; and
 - Barwon Heads Marine Sanctuary.

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 2.1). Survey dates are shown in Table 2.2. A description of each intertidal reef and sampling considerations at each site is given separately for each marine sanctuary in Appendix A – *Site Details*.

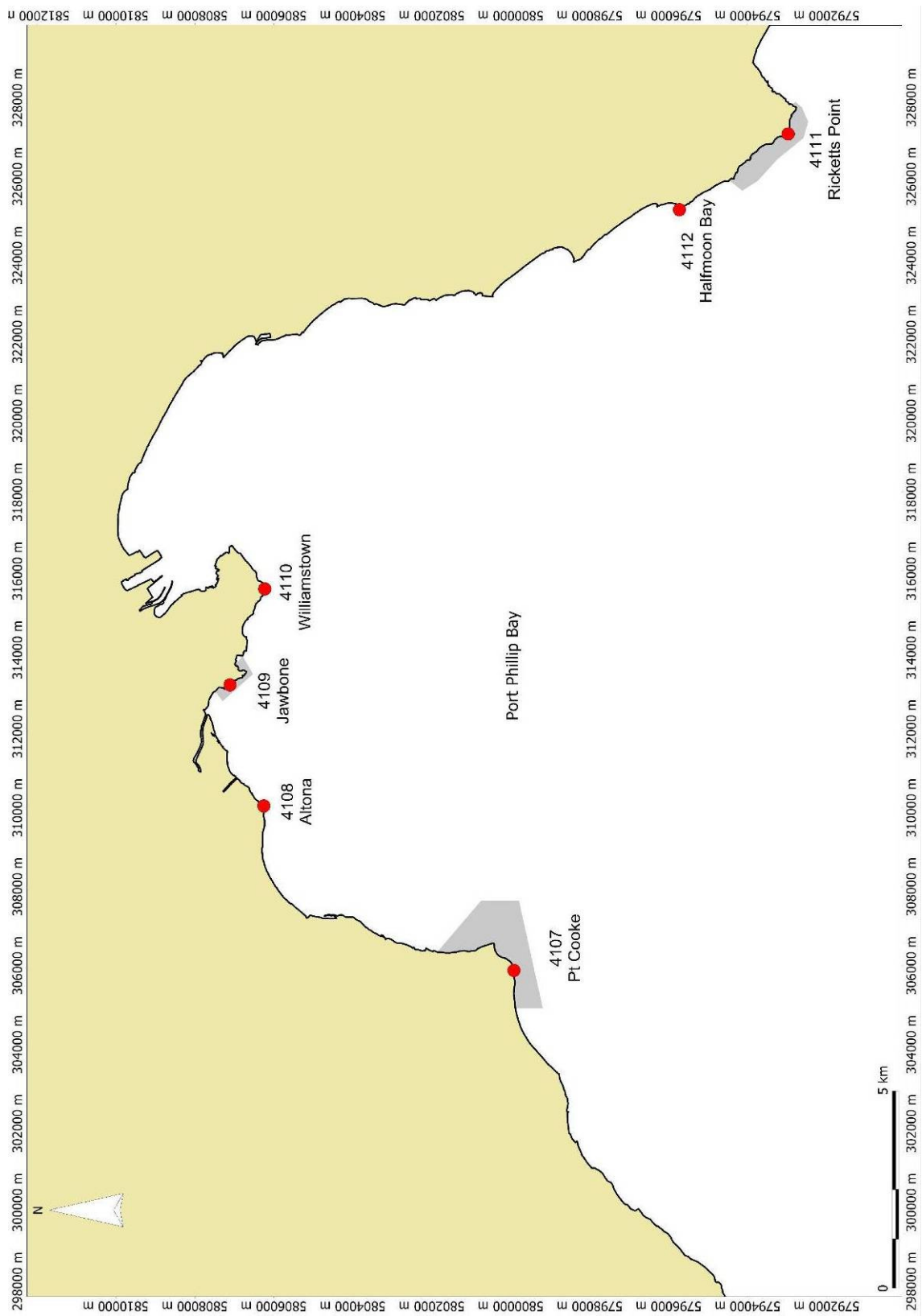


Figure 2.1. Location of intertidal monitoring sites in northern Port Phillip Bay. Marine Sanctuary areas are indicated by grey shading.

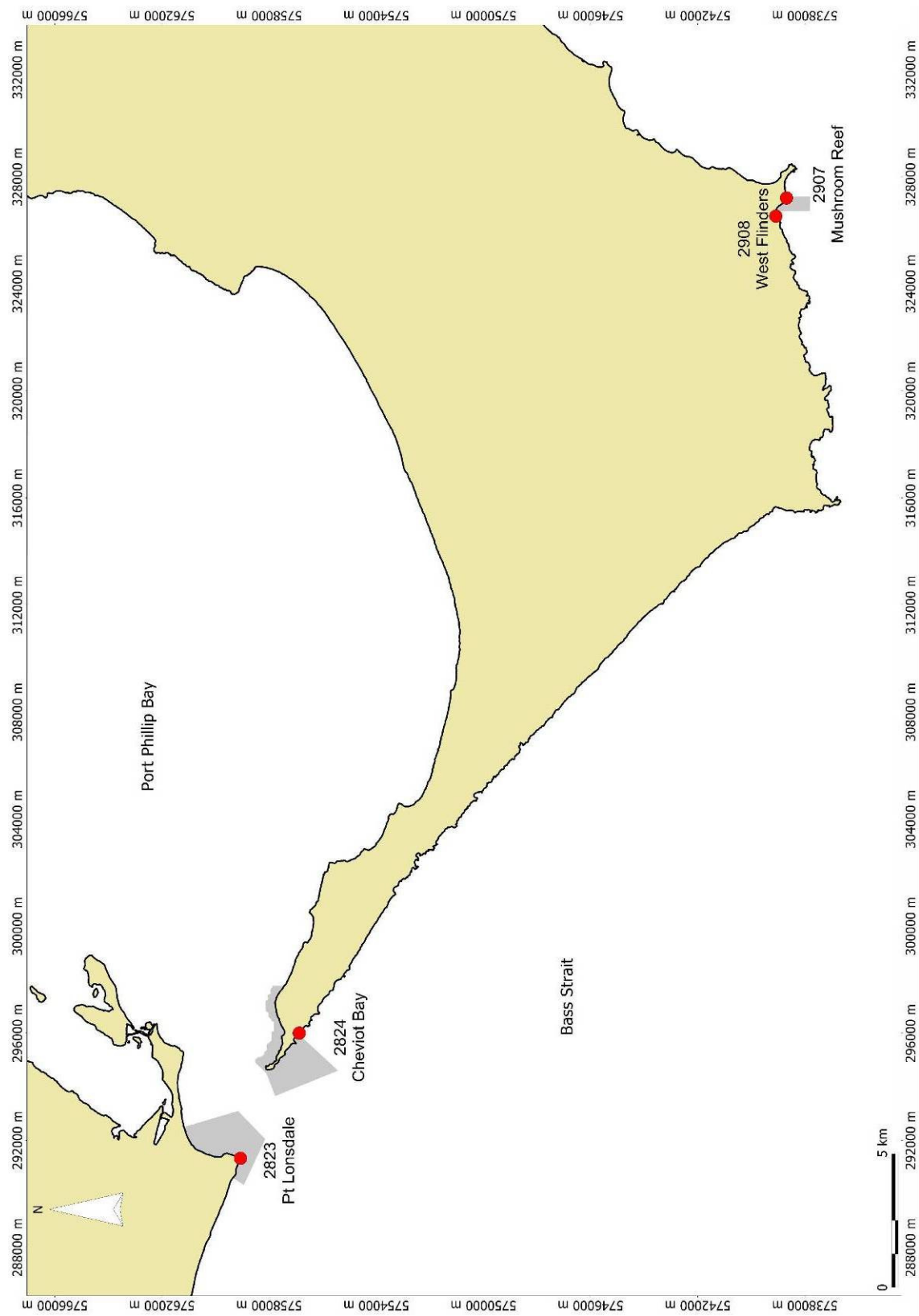


Figure 2.2. Location of intertidal monitoring sites along the coastline of central Victoria. Marine protected areas are indicated by grey shading.

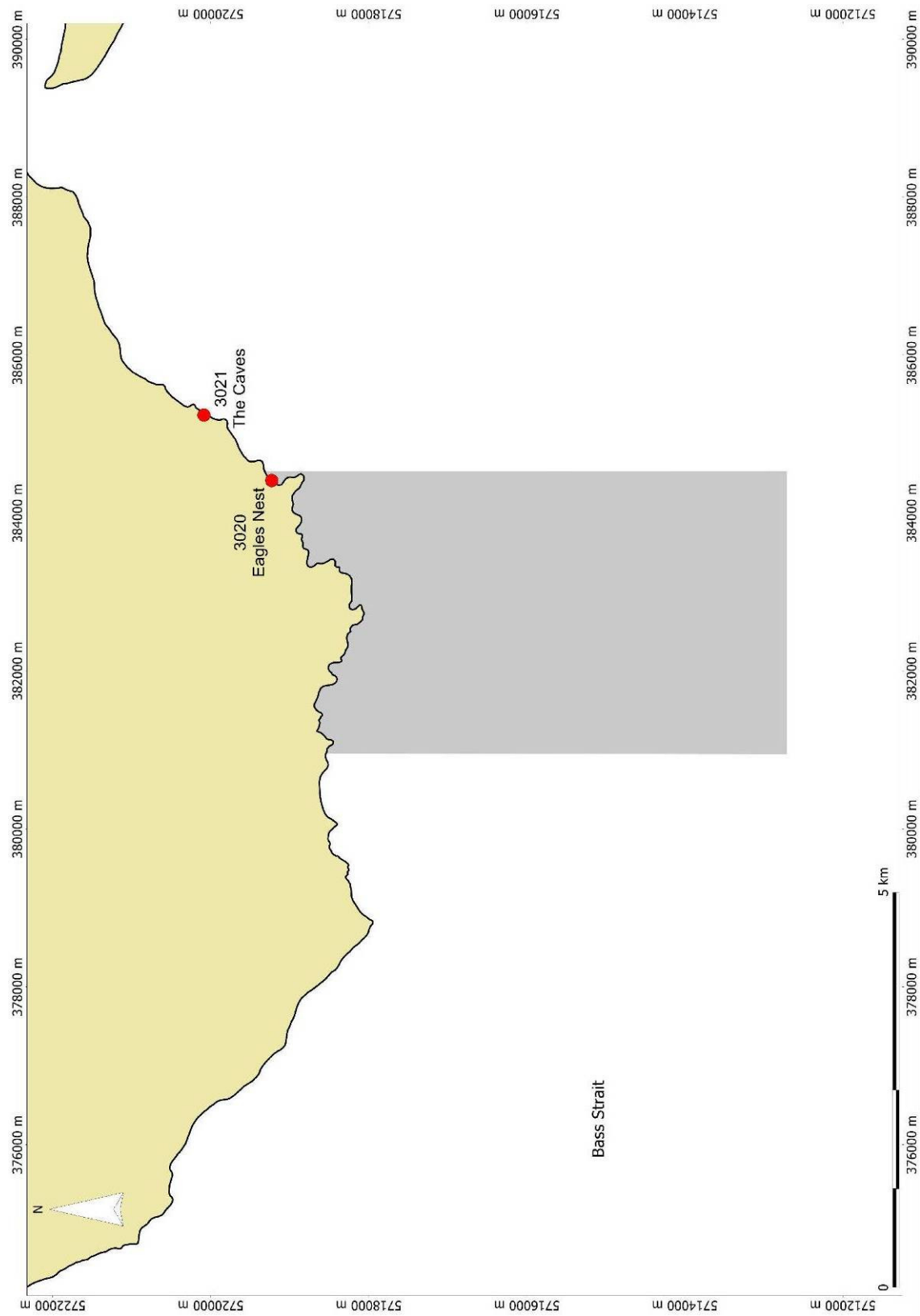


Figure 2.3. Location of intertidal monitoring sites at Bunurong Marine National Park. Marine National Park areas are indicated by grey shading.

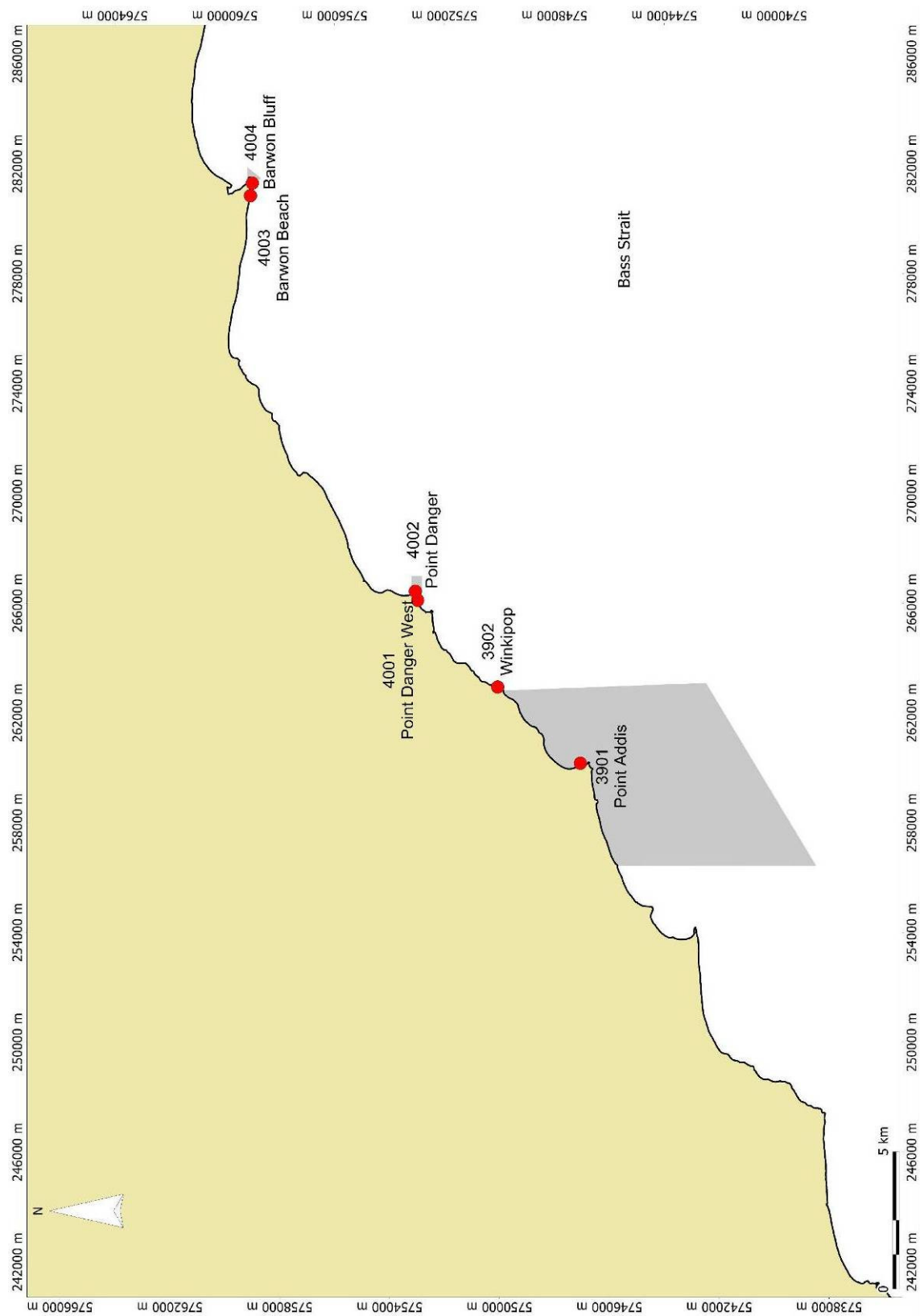


Figure 2.4. Location of intertidal monitoring sites along the western coastline of central Victoria. Marine protected areas' boundaries are indicated by grey shading.

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

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

Table 2.2. Survey periods of intertidal monitoring sites.

Survey	Period	Sites
1	April - July 2003	4107; 4108; 4109; 4110; 4111; 4112; 2907; 2908; 4001; 4002; 4003; 4004.
2	May - June 2004	4107; 4108; 4109; 4110; 4111; 4112; 2907; 2908; 4004.
3	December 2004 - April 2005	4107; 4108; 4109; 4110; 4111; 4112; 2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004.
4	September 2005- January 2006	2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004.
5	May - June 2007	4107; 4108; 4109; 4110; 4111; 4112; 2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004.
6	April - June 2009	4107; 4108; 4109; 4110; 4111; 4112; 2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004.
7	March - May 2010	4107; 4108; 4109; 4110; 4111; 4112; 2823; 2824; 2907; 2908; 3020; 3021; 3901; 3902; 4001; 4002; 4003; 4004.

2.1.1 General Survey Technique

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

Within the area to be surveyed, the high and low shore boundaries are identified. On vertically sloping shores, the high shore boundary generally approximates the mean high water level. On relatively flat shores with little variation in vertical height across the shore, the high shore is at the landward edge and the low shore is at the seaward edge of the flat area. A weighted tape measure or numbered transect line is placed along the high shore, beginning at the right hand side of the shore when looking towards the sea. This is the high-shore baseline (A-B, Figure 2.5). Similarly, a low shore baseline is established by placing a transect line along the low shore. The positions of each end of both baselines are recorded using dGPS and photographed (C-D, Figure 2.5).

Five fixed transects, each running from high to low shore, are positioned across the intertidal area to be surveyed (Figure 2.5). Transect 1 is 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 runs between points on the high and low shore baselines. Adjacent transects are roughly equidistant from each other.

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

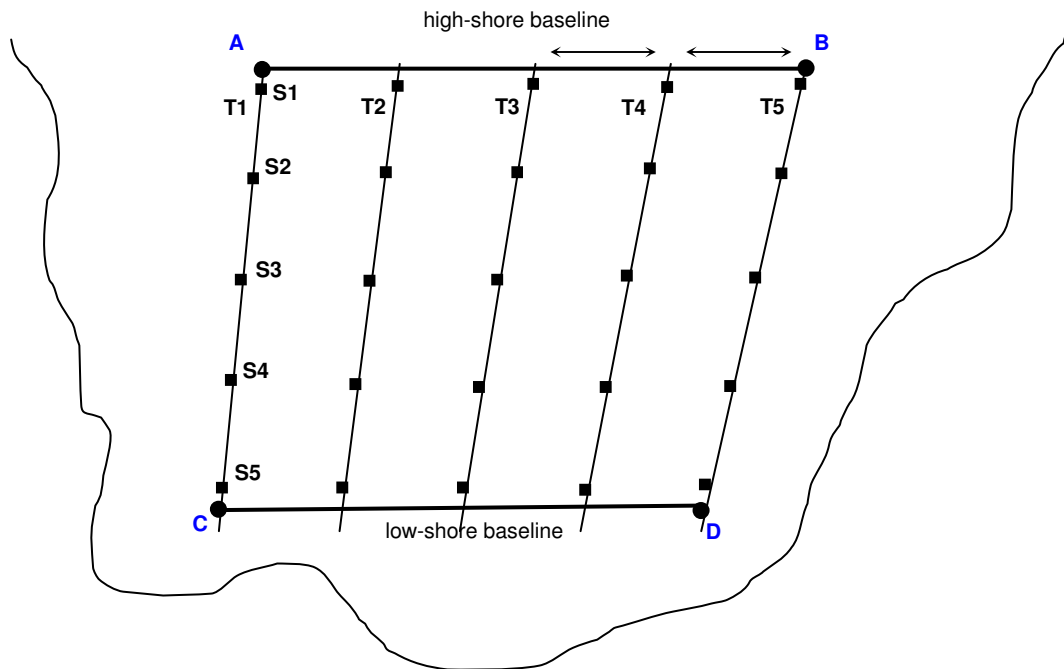


Figure 2.5. Example layout of high and low shore baselines and transects on an intertidal reef. Transects (T1-T5) run across the shore from right to left when looking towards the water. Endpoints of each transect are equidistant along each of the baselines. Sampling locations (S1-S5) are arranged down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

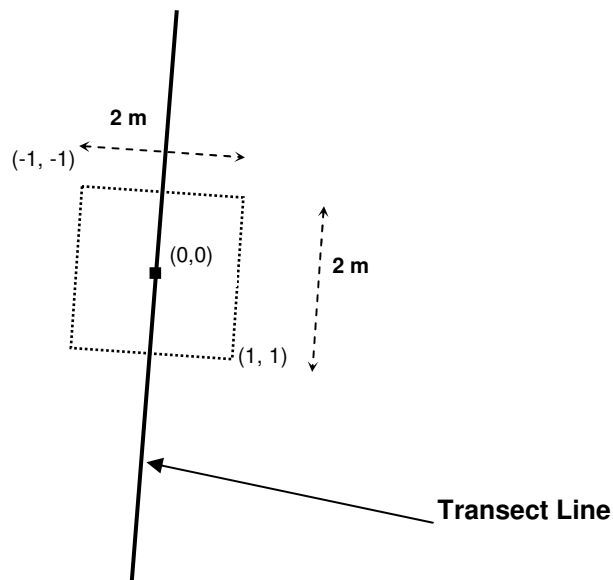


Figure 2.6. Configuration of a sampling location along a transect. Each 2 x 2 m sampling location is centred on a point along the transect line. A quadrat is placed randomly within the sampling location using random x- and y-coordinates between -1 and 1.

2.2 Visual Census Techniques

2.2.1 Method A – Mobile Invertebrates

The density of non-sessile invertebrates, such as gastropods and sea stars, is measured by counting individuals within the 0.5 x 0.5 m quadrats (Figures 2.7 and 2.8; Table 2.3). All observable individuals on the rock surface or within crevices and algal fronds are counted. To ensure the monitoring has minimal impact over time, rocks are not overturned or disturbed. Selected specimens are collected for identification and preservation in a reference collection.

The *Bembicium* populations are likely to comprise of three separate species: *Bembicium nanum*; *B. melanostomum*; and *B. auratum*. Anderson (1958) concluded these species could only be separated with difficulty in the field. This problem was compounded with the small sizes and heavy shell erosion of many individuals surveyed. As such, the species were grouped at genus level. Similarly, species from the genus *Siphonaria* were often too small to identify reliably in the field and were grouped as *Siphonaria* spp. Species were identified where possible.

The shell length of 50-100 individuals of abundant species of gastropod are measured at each site. This is 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 are 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 are taken from all individuals within aggregations nearest to the observer.

2.2.2 Method B – Macroalgae and Sessile Invertebrates

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

Some species 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 is recorded (if present and not detected under any points). Species recorded as present, but not recorded under any points, are only included in the analysis of species richness.

2.2.3 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.

2.2.4 Qualitative Observations

At each site, observers record 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 are also taken at each site.

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

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

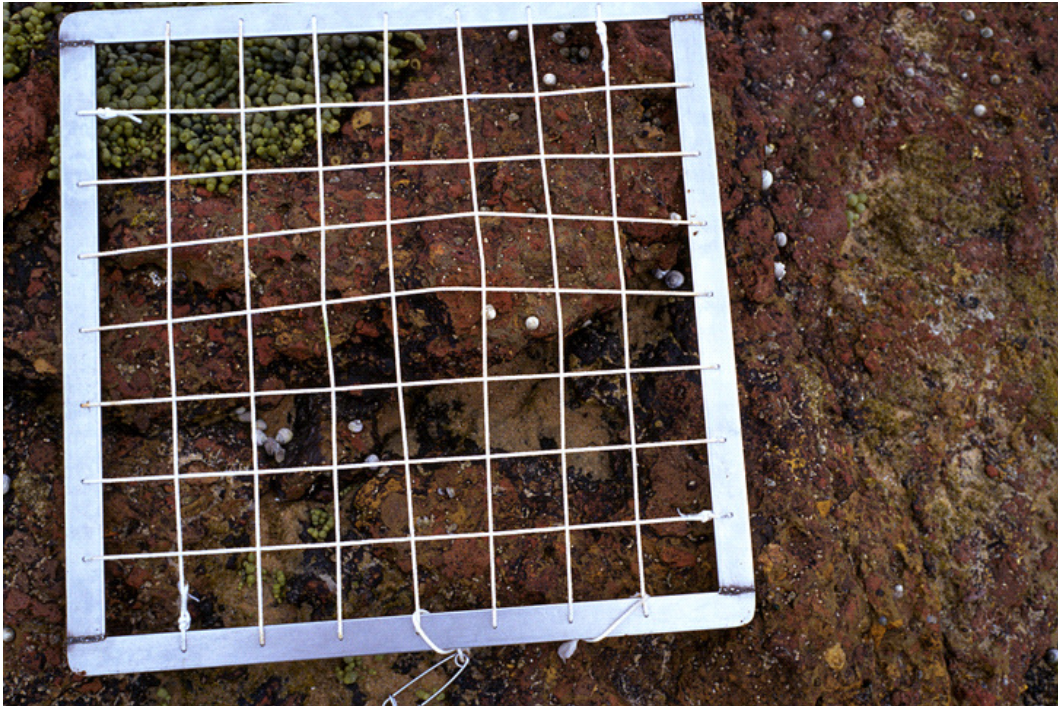


Figure 2.7. Quadrat with the alga *Hormosira banksii* and snail *Bembicium nanum*. The abundance of each gastropod is counted within the quadrat. The cover of macrophytes and highly aggregated animals is measured by the number of points intersecting each species on the quadrat grid.



Figure 2.8. Marine biologists counting invertebrates within quadrats during intertidal reef monitoring surveys at Halfmoon Bay (Site 4112), May 2009.

Table 2.3. Intertidal species in south eastern Australia surveyed using Methods A and B.

Algae	Sessile Invertebrates	Mobile Invertebrates
Algal Turf	Tube Worms	Limpets
	<i>Galeolaria caespitosa</i>	<i>Clypidina rugosa</i>
Blue-Green Algae		<i>Patella chapmani</i>
<i>Rivularia</i> sp.		<i>Cellana tramoserica</i>
<i>Symploca</i> sp.		<i>Patelloida alticostata</i>
	Barnacles	<i>Patelloida insignis</i>
Green Algae	<i>Catomerus polymerus</i>	<i>Patelloida latistrigata</i>
<i>Cladophora prolifera</i>	<i>Chthamalus antennatus</i>	<i>Notoacmea mayi</i>
<i>Cladophora subsimplex</i>	<i>Chaemosipho tasmanica</i>	<i>Notoacmea petterdi</i>
<i>Codium</i> spp	<i>Tesseropora rosea</i>	<i>Notoacmea</i> spp.
<i>Enteromorpha</i> spp	<i>Tetraclitella purpurascens</i>	<i>Siphonaria</i> spp.
<i>Dictyosphaeria serica</i>		
<i>Ulva</i> spp		Snails
<i>Caulerpa</i> spp.	Bivalves	<i>Austrocochlea constricta</i>
<i>Chaetomorpha coliformis</i>	<i>Xenostrobus pulex</i>	<i>Austrocochlea porcata</i>
	<i>Brachidontes rostratus</i>	<i>Austrocochlea odontis</i>
Brown Algae	<i>Mytilus galloprovincialis</i>	<i>Austrocochlea concamerata</i>
<i>Chordaria cladosiphon</i>		<i>Turbo undulatus</i>
<i>Colpomenia sinuosa</i>		<i>Nerita atramentosa</i>
<i>Hormosira banksii</i>	Anemones	<i>Bembicium nanum</i>
<i>Leathesia difformis</i>	<i>Actinia tenebrosa</i>	<i>Bembicium</i> spp.
<i>Notheia anomala</i>	<i>Aulactinia veratra</i>	<i>Bembicium melanostomum</i>
<i>Scytosiphon lomentaria</i>	<i>Anthothoe albocincta</i>	<i>Nodilittorina unifasciata</i>
<i>Lobophora variegata</i>	<i>Oulactis muscosa</i>	<i>Nodilittorina acutispira</i>
<i>Cladostephus spongiosus</i>		<i>Dicathais orbita</i>
<i>Notheia anomala</i>		<i>Lepsiella vinosa</i>
<i>Sargassum</i> spp.		<i>Cominella lineolata</i>
<i>Cystophora</i> spp		<i>Calliostoma armillata</i>
<i>Zonaria turneriana</i>		<i>Mitra glabra</i>
<i>Halopteris</i> spp		<i>Haustrum baileyanaum</i>
<i>Ectocarpus</i> spp		<i>Phasianotrochus eximius</i>
<i>Acrocarpia paniculata</i>		<i>Pterynotus triformis</i>
<i>Lobophora variegata</i>		<i>Cypraea angustata</i>
<i>Padina</i> sp.		<i>Batillaria australis</i>
Red Algae		Sea stars
<i>Corallina officinalis</i>		<i>Parvulastra exigua</i>
<i>Gracilaria</i> spp.		<i>Meridiastra calcar</i>
<i>Laurencia</i> spp.		<i>Tosia australis</i>
Encrusting coralline algae		<i>Coscinasterias muricata</i>
Erect coralline algae		
<i>Jania</i> spp.		Sea Slugs
<i>Haliptilon roseum</i>		<i>Onchidella patelloides</i>
<i>Echinothamnion</i> sp.		
<i>Heterosiphonia muelleri</i>		Sea Hares
<i>Caulocystis cephalornithos</i>		<i>Aplysia gigantea</i>
Seagrass		Crabs
<i>Heterozostera nigricaulis</i>		<i>Cyclograpsus granulosis</i>
<i>Zostera meulleri</i>		<i>Paragrapsus gaimardii</i>
<i>Amphibolis antarctica</i>		<i>Plagusia chabrus</i>
<i>Sarcocornia quinqueflora</i>		
		Nudibranchs
		<i>Pteraeolidia ianthina</i>

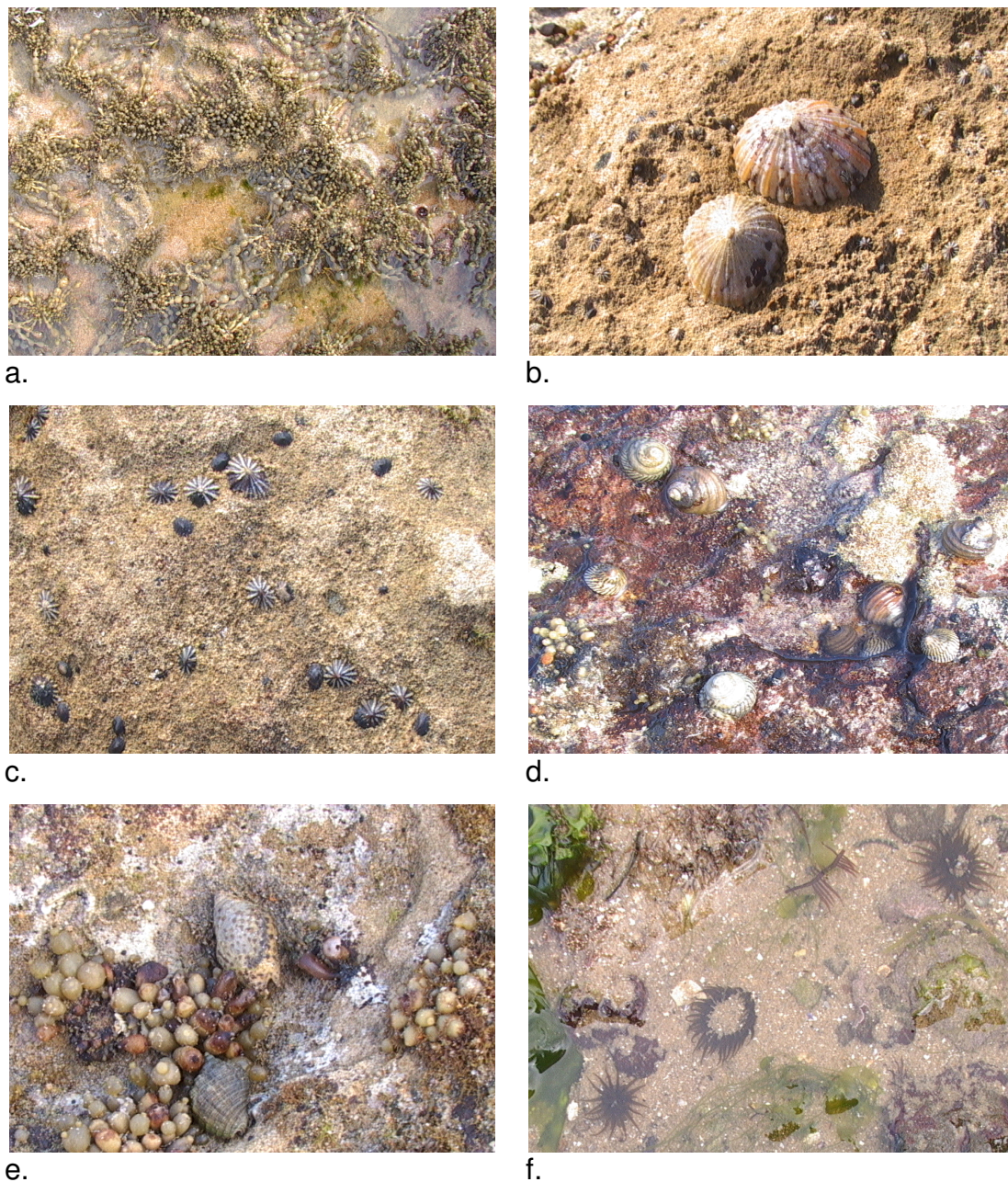


Figure 2.9. Examples of typical flora and fauna on intertidal reefs: (a) the brown alga *Hormosira banksii*; (b) the common limpet *Cellana tramoserica*; (c) the limpets *Siphonaria* spp (centre) and *Notoacmea mayi*; (d) the gastropods *Bembicium nanum* (bottom) and *Austrocochlea constricta*; (e) the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

2.3 Data Analysis

2.3.1 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 (2000), the counts 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 representation in fewer dimensions that best depicts the actual patterns in higher dimensions. The MDS results were then 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.

Kruskall stress is an indicator statistic calculated during the ordination process and 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 dangerous to interpret.

2.3.2 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 a community has most of the individuals belonging 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 just the abundance data was used for calculation of evenness and heterogeneity statistics. Species diversity (*i.e.* heterogeneity among species) was described using the reciprocal of Simpson's index ($1/D_{\text{Simpson}} = \text{Hill's } N_2$). This index provides more weighting for common species, as opposed to the weighting of rarer species such as by the Shannon-Weiner Index (Krebs 1999). The weighting of common species was considered more appropriate for this study, with the sampling being directed more towards the enumeration of common species rather than rarer ones.

2.3.3 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 of differences in survey methods. The sizes of common species were assessed using time series plots of mean lengths.

2.4 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 (in press). 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 were:

- 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 typically 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, in press):

- 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).

3 POINT COOKE MARINE SANCTUARY

3.1 Site Description and Transect Layout

3.1.1 Point Cooke Marine Sanctuary (Site 4107)

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

The survey site was established on the largest continuous area of reef to the west of Point Cooke (Figure 3.1). Both the high-shore and low-shore baselines were 100 m long and were approximately parallel. During the second survey (May 2004), a large amount of drift algae was present along the high shore covering a substantial area of intertidal reef. The five transects between the baselines and were between 30 m and 35 m long.

3.1.2 Altona Reference (Site 4108)

A nearby reference site, with intertidal habitat similar to that at Point Cooke could not be found. The intertidal area at Altona was established in 2003 as a reference site for Point Cooke Marine Sanctuary. 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 3.2). 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.



a.



b.

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



Figure 3.2. Intertidal reef at the Altona reference site, 27 April 2009.

3.2 Community Structure

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

The MDS analysis of mobile invertebrate communities showed similar variation through time at Point Cooke and Altona. The communities at these two sites were more similar to each other than they were to sites on the open coast, but relatively dissimilar to each other compared to other sites in northern Port Phillip Bay (Figure 3.3a). Their separation may reflect the relatively low abundance of *C. tramoserica* at Point Cooke.

The algal 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 slight variation through time at Point Cooke. The Altona reference site had higher temporal variation, which was related to an ephemeral coverage of sea lettuce *Ulva* spp and the green alga *Enteromorpha* spp . The algal communities at these sites were generally more similar to each other than to other sites in Central Victoria (Figure 3.3b).

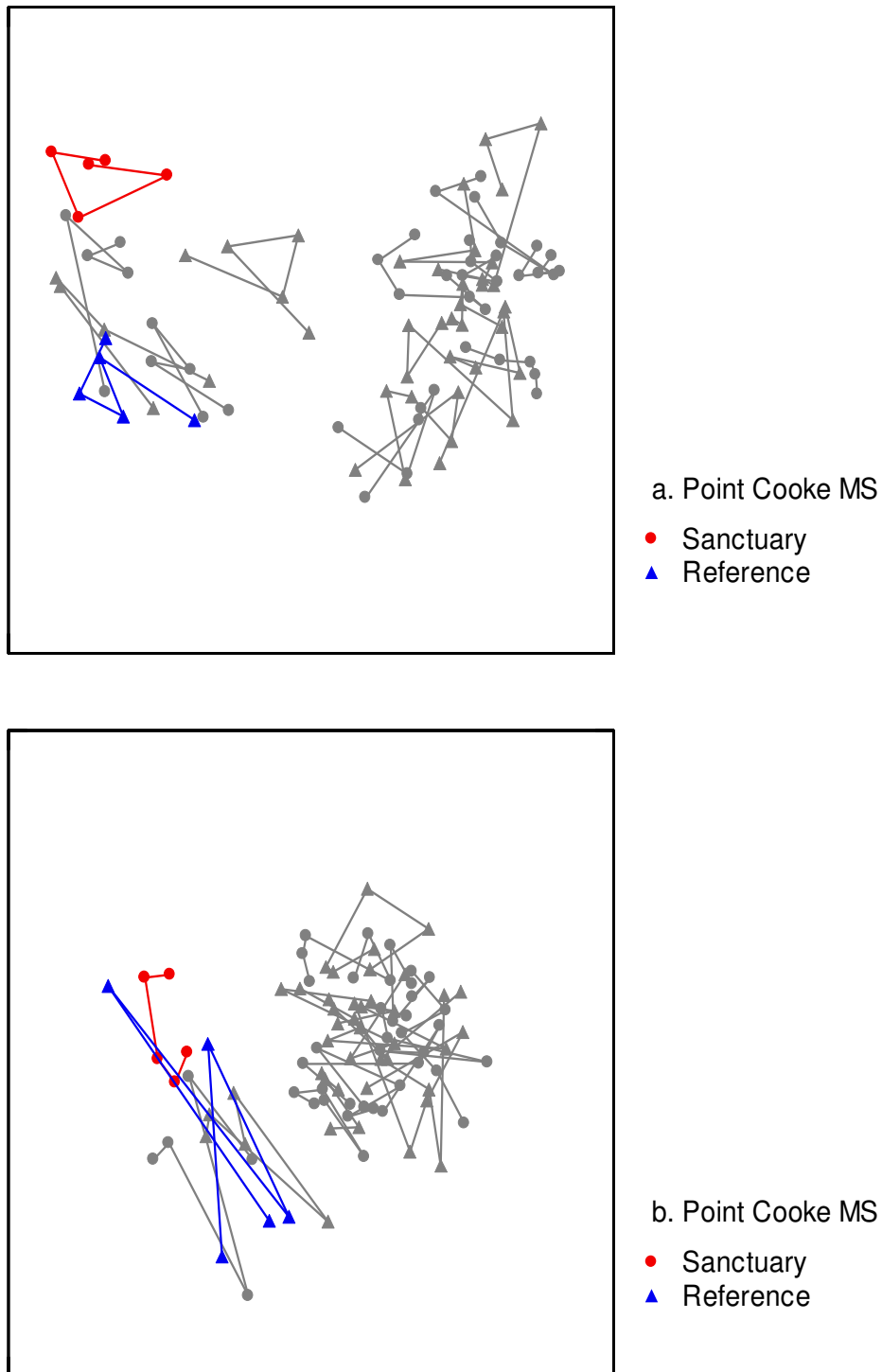


Figure 3.3. Two dimensional MDS plot of invertebrate assemblages on intertidal reefs at Point Cooke, within the Point Cooke MS, and the Altona reference site. (a) Mobile Invertebrates, Kruskal stress = 0.17 and (b) Macroalgae and Aggregating Sessile Invertebrates, Kruskal stress = 0.08. The grey lines represent data from all other intertidal sites used in the MDS analysis.

3.3 Diversity

Mobile invertebrate species richness at Point Cooke MS (Site 4107) was highest in 2009, increasing from 7 to 15 species, before returning to 8 in 2010 (Figure 3.4). Mobile invertebrate species richness was relatively stable at the reference site Altona (Site 4108; Figure 3.4).

Algal and aggregating sessile invertebrate species richness ranged between 7 and 11 species at Point Cooke (Site 4107; Figure 3.5). Species richness at Altona (Site 4108) was much more variable over time, varying between 1 and 13 species over the monitoring period (Figure 3.5).

Mobile Invertebrate species diversity at Point Cooke (Site 4107) and the reference site Altona (Site 4108) remained relatively stable throughout the monitoring period (Figure 3.6).

Algal and aggregating sessile invertebrate species diversity was also generally stable during the monitoring period with the exception of a decrease at Altona in 2009, when only one species was observed (Figure 3.7).

Species richness and diversity levels during 2009 were among the highest observed during the monitoring period.

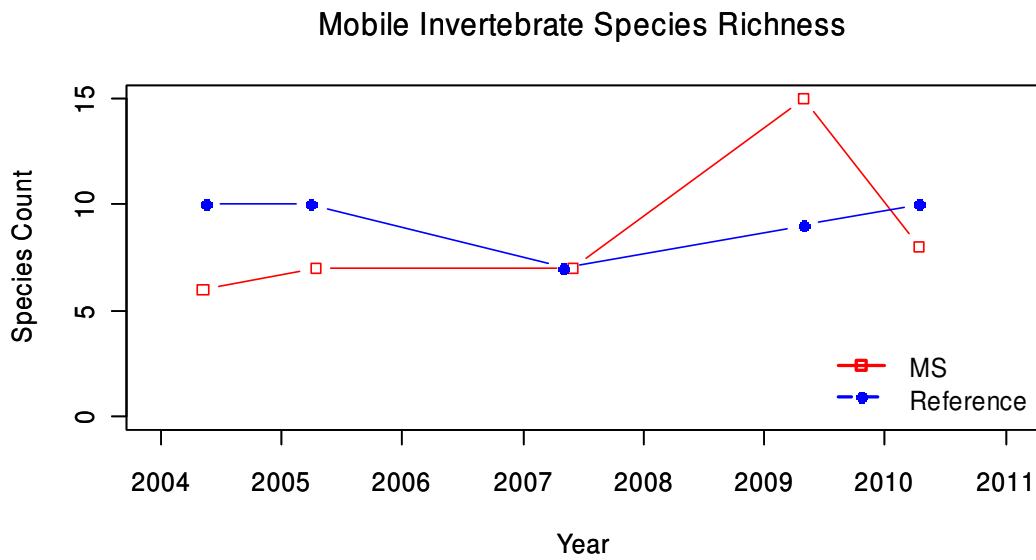


Figure 3.4. Mobile invertebrate species richness at Point Cooke, within the Point Cooke MS, and Altona reference site.

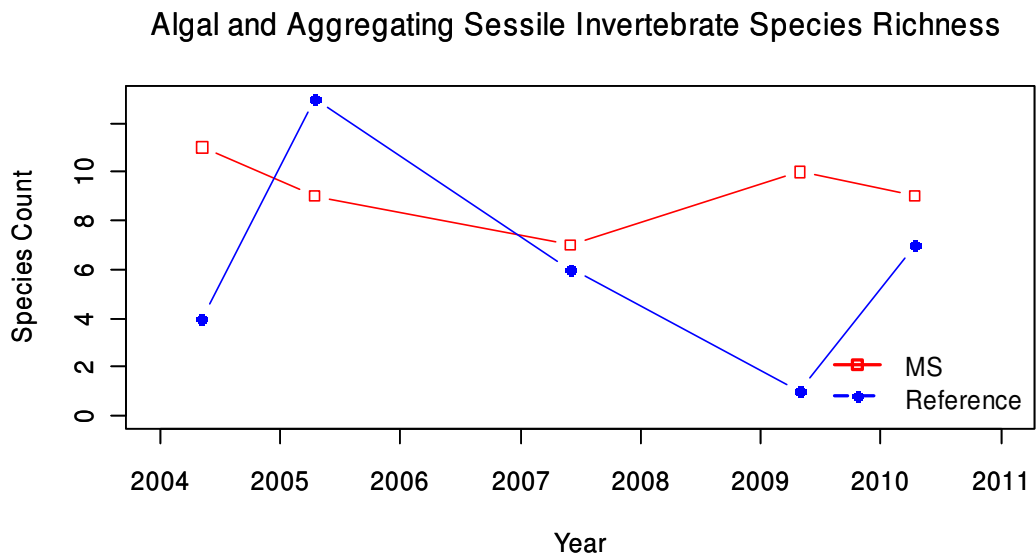


Figure 3.5. Algal and aggregating sessile invertebrate species richness of intertidal sites at Point Cooke, within the Point Cooke MS, and the Altona reference site.

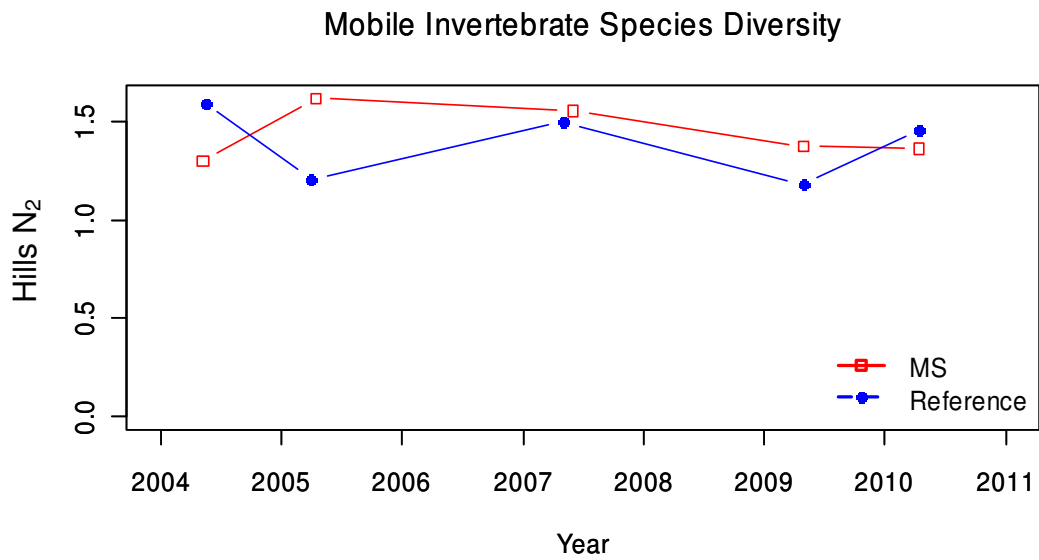


Figure 3.6. Mobile invertebrate diversity (Hills N₂) of intertidal sites at Point Cooke, within the Point Cooke MS, and the Altona reference site.

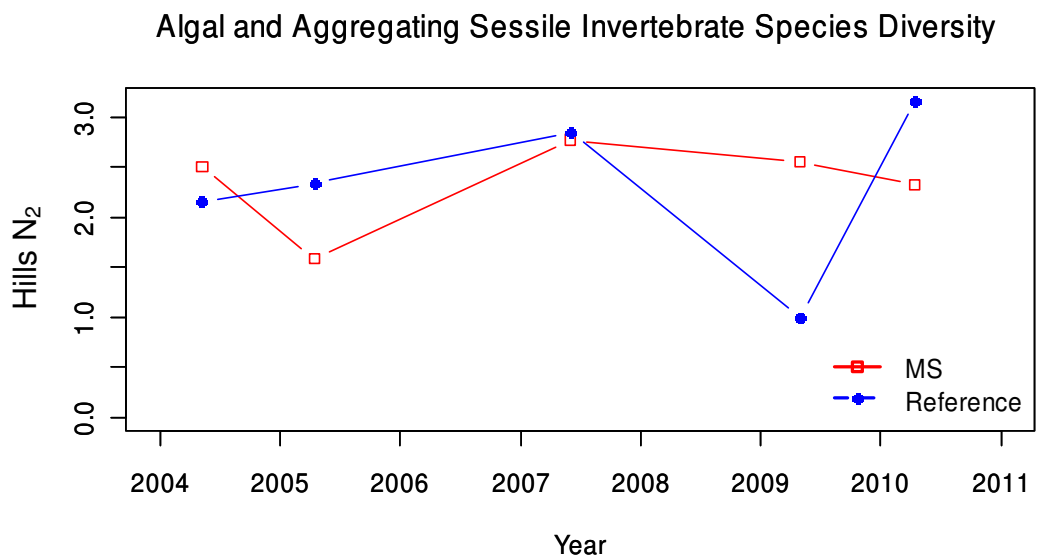


Figure 3.7. Algal and aggregating sessile invertebrate diversity (Hill's N₂) of intertidal sites at Point Cooke, within the Point Cooke MS, and the Altona reference site.

3.4 Macroalgae and Aggregating Sessile Invertebrates

In April 2005, a large proportion (nearly 60 %) of the Point Cooke intertidal reef was covered with *Ulva* spp, evenly spread across the survey area (Figure 3.8). Coverage in subsequent surveys was 3-12 % (Figure 3.8). *Enteromorpha* spp was recorded in moderate quantities (15 %) in 2005, but has not been observed since. A previously small patch of sand and *Zostera muelleri* seagrass has gradually extended across a wide band of the reef and *Z. muelleri* covered 12 % of the study area in April 2009, increasing to more than 16% in 2010. The coverage of filamentous red algae, which increased from none to almost 9 % in 2007, was 3 % in 2009. Filamentous red algae were not observed during the 2010 survey. High amounts of drift macroalgae were observed in 2004, but were not seen during subsequent surveys.

Altona had much less macroalgal cover than Point Cooke. No algae were recorded in the study area in May 2004. In April 2005 *Ulva* spp and *Enteromorpha* spp each covered nearly 10 %, although this had disappeared by May 2007. *Enteromorpha* spp was not observed during subsequent surveys. *Ulva* spp was recorded at almost 13 % during 2009, but was not present during the 2010 survey (Figure 3.8). A low coverage of coralline algal species was also observed in the 2005, 2007 and 2010 surveys.

Aggregating sessile invertebrates did not contribute greatly to the structure of either reef, although there were small patches of *Galeolaria caespitosa* on the low shoreline. The blue mussel *Mytilus galloprovincialis* was at Point Cooke 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 amount of sand inundation was similar at both sites to 2004, increasing at Point Cooke during subsequent surveys.

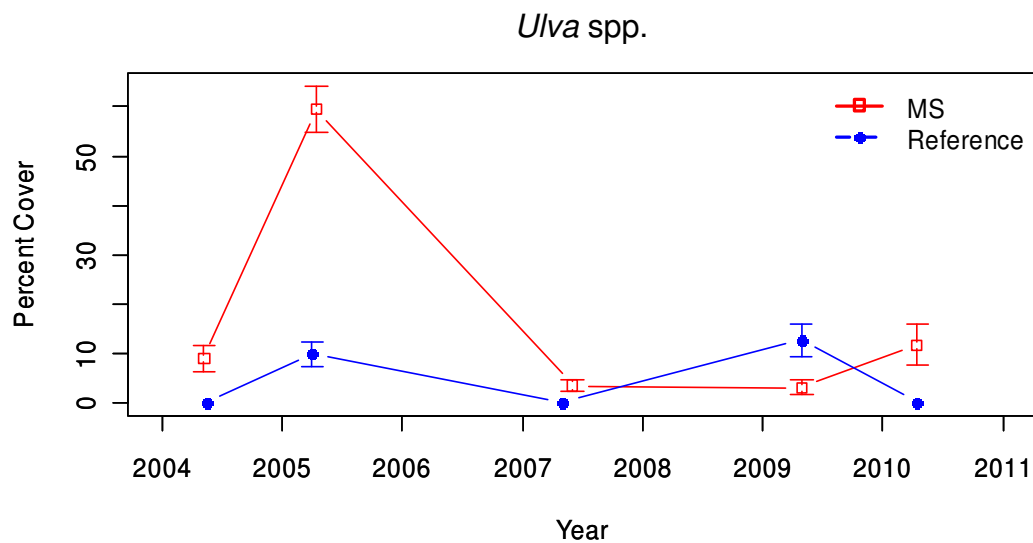


Figure 3.8 Mean density (\pm Standard Error) of *Ulva* spp. at Point Cooke, within the Point Cooke MS, and the Altona reference site.

3.5 Mobile Invertebrates

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

The herbivorous gastropod *Austrocochlea porcata* was the most abundant invertebrate at both sites. Initially, *A. porcata* occurred at much higher densities at Altona, however, there have been consistent and substantial increases in its abundance at Point Cooke over time and more recent increase at Altona (Figure 3.9a). Abundances of *A. porcata* were at their highest at both sites during 2009 and 2010.

The conniwink *Bembicium* spp were consistently present in low densities at Altona and only sporadically present at Point Cooke. There were marked increases in 2010, with a four-fold increase at Altona (Figure 3.9b).

The limpet *Cellana tramoserica* was only recorded at Point Cooke during the 2007 survey, but has been consistently present at Altona in low abundances. Higher densities were present at Altona in 2004 and 2010 (Figure 3.9c).

A slight declining trend in mean size of *Austrocochlea porcata* was apparent for Point Cooke and Altona (Figure 3.10a), however these have not been tested statistically. The mean size of *Cellana tramoserica* was relatively constant at both sites up to 2009. In 2009, size increased slightly at Point Cooke in 2010 but had declined markedly at Altona (Figure 3.10b).

The warrener *Turbo undulatus* was recorded in low densities on the low shore at Point Cooke. *Turbo undulatus* was only recorded at Altona, at low density, in 2005.

The carnivorous gastropods *Cominella lineolata* and *Lepsiella vinosa* occurred at Altona in similar densities to those found at Point Cooke. Densities of *C. lineolata* were higher at Point Cooke, although still recorded at low densities. *Lepsiella vinosa* was absent during 2009 at both sites, occurring again in low numbers during the 2010 survey.

The seastar *Parvulastra exigua* occurred on the seaward edge of the intertidal reef at Altona in low densities during surveys 2004 and 2005. The abundance of *Parvulastra exigua* increased substantially at Altona between 2005 and 2007, with a decreasing trend to 2009 and 2010. This species was not recorded at Point Cooke during any of the surveys.

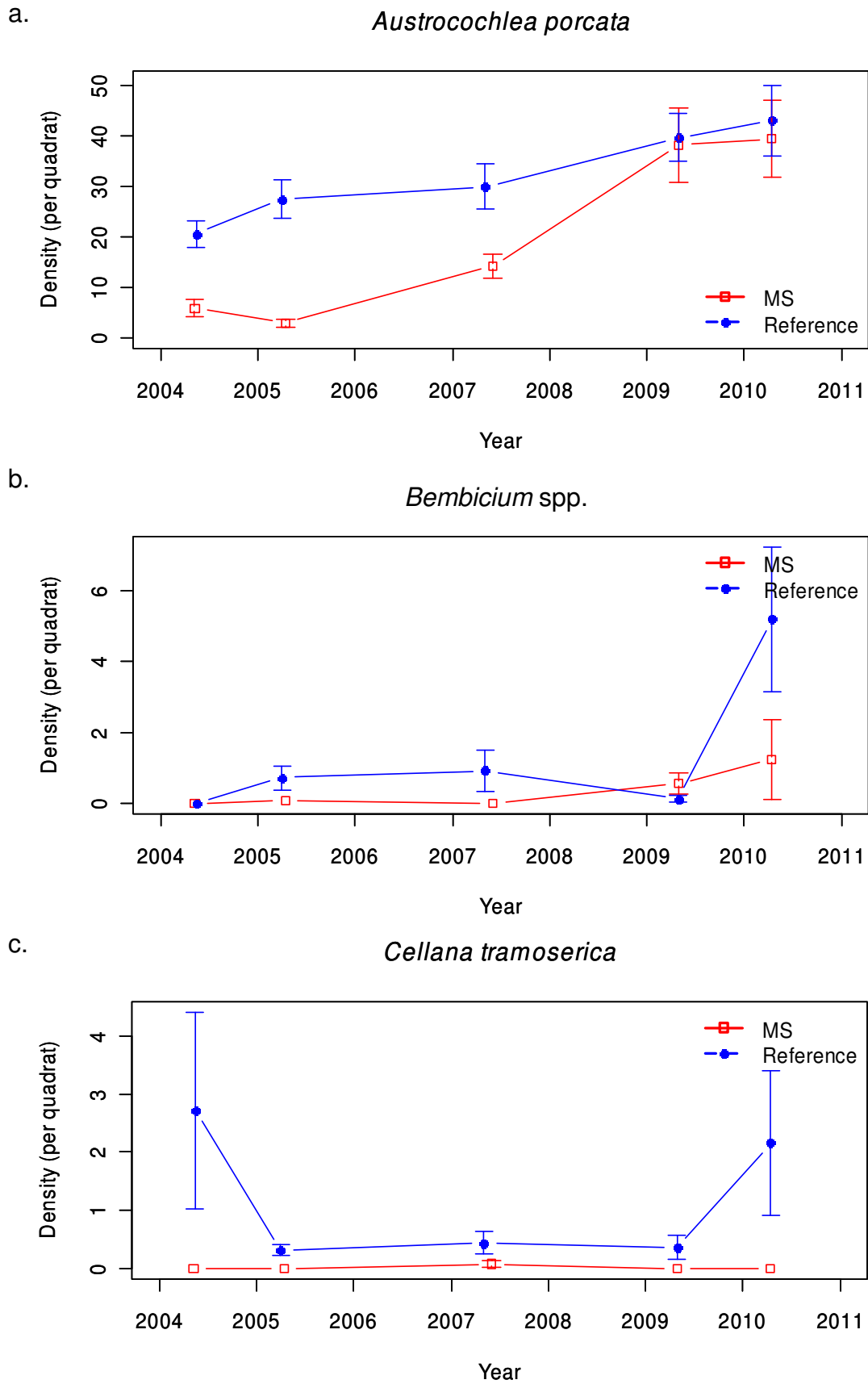


Figure 3.9. Mean density (\pm Standard Error) of: (a) the top shell *Austrocochlea porcata*; (b) the conniwink *Bembicium* spp.; and (c) the limpet *Cellana tramoserica* at Point Cooke, within the Point Cooke MS, and the Altona reference site.

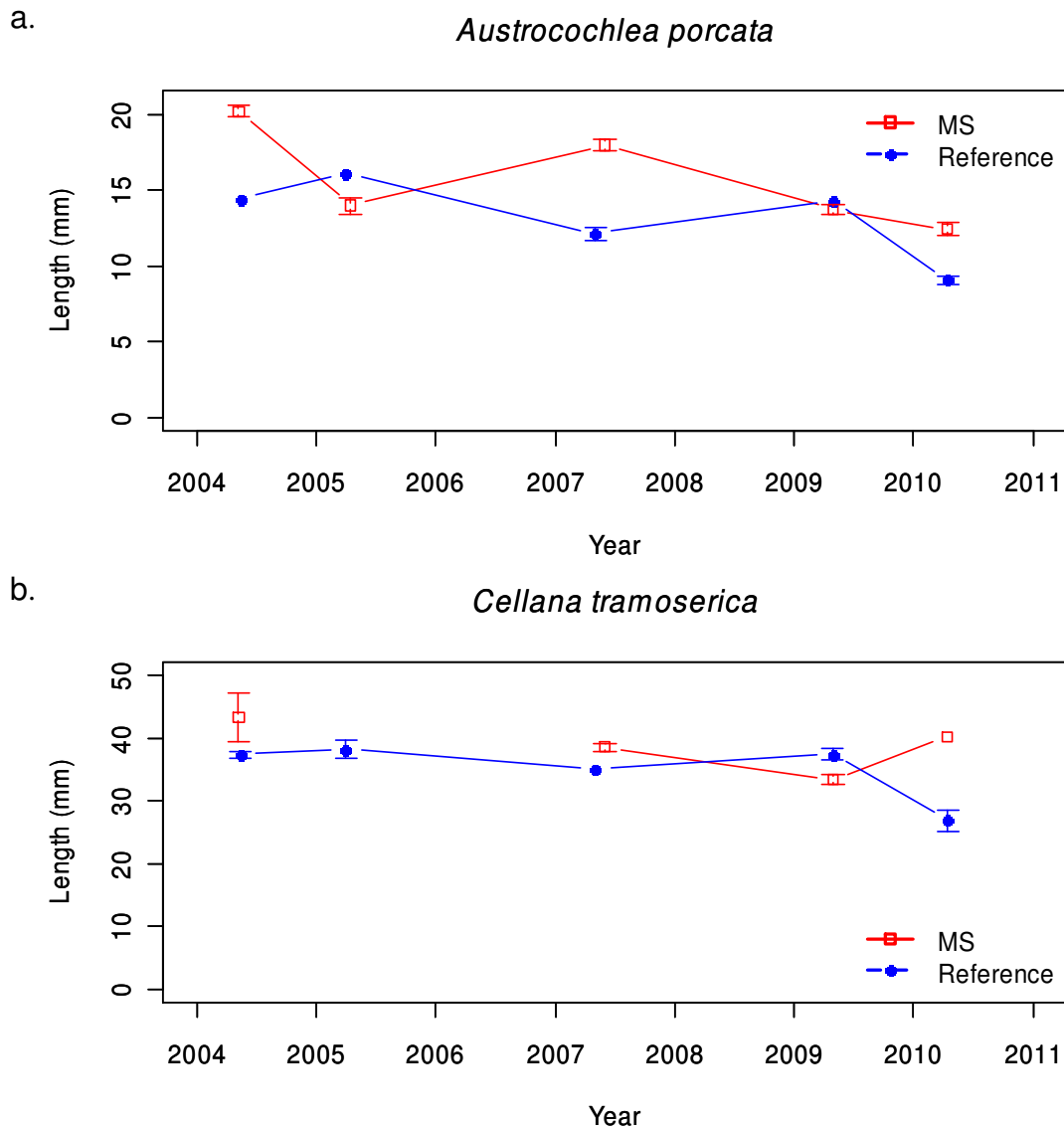


Figure 3.10. Mean sizes (\pm Standard Error) of: (a) the top shell *Austrocochlea constricta*; and (b) the limpet *Cellana tramoserica* at Point Cooke, and the Altona reference site.

3.6 Condition Indicators

Biodiversity

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

Introduced Species

There were no introduced species detected for these sites.

Ecosystem Function

Total algal cover has been low and relatively steady for the past three surveys at both sites (Figure 3.11a). Erect coralline algal cover and turfing algae were low and variable in cover over the monitoring period (Figure 3.11b and 3.11c). The total abundance of grazers and predators increased to 2009 and remained high to 2010 (Figure 3.12a and 3.12b). There was no apparent relationship between plant cover and grazer density.

Climate Change

There were no new species detected that were typically from adjacent bioregions.

Harvesting

Densities of *Austrocochlea porcata* have been increasing at both sites. A slight declining trend in mean size of *Austrocochlea porcata* was apparent for Point Cooke and Altona, however these have not been tested statistically. The mean size of *Cellana tramoserica* was relatively constant until a slight increase at Point Cooke and marked decline at Altona in 2010. These results did not provide clear indications of changes in harvesting pressure.

Trampling

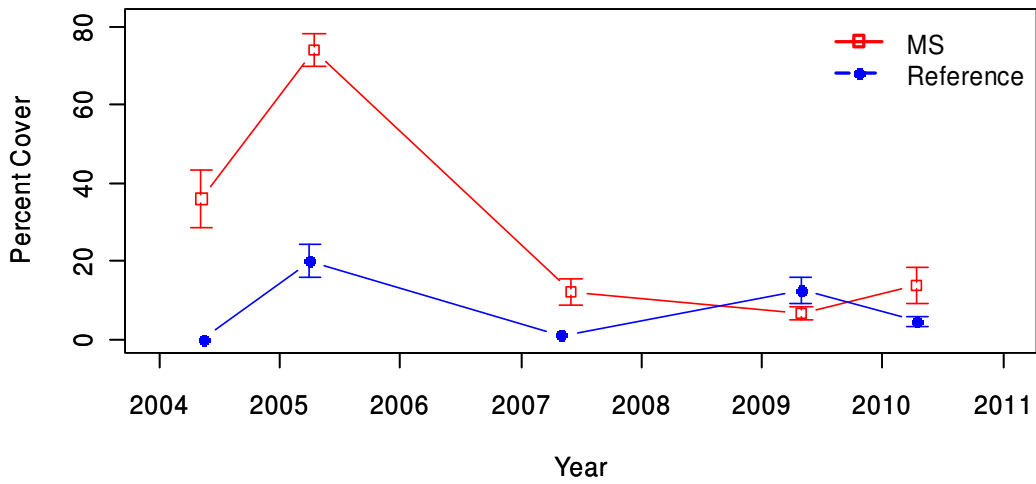
The *Hormosira banksii* is naturally low in cover at these sites.

Environment

The cover of green algal species indicative of nutrient loading was relatively low from 2007 to 2010 (Figure 3.13a). As noted above, there was a bloom of *Ulva* at Point Cooke during 2005. Sediment cover has been considerably higher at Point Cooke during the last three surveys and similar levels were observed at Altona during the last two surveys (Figure 3.13b).

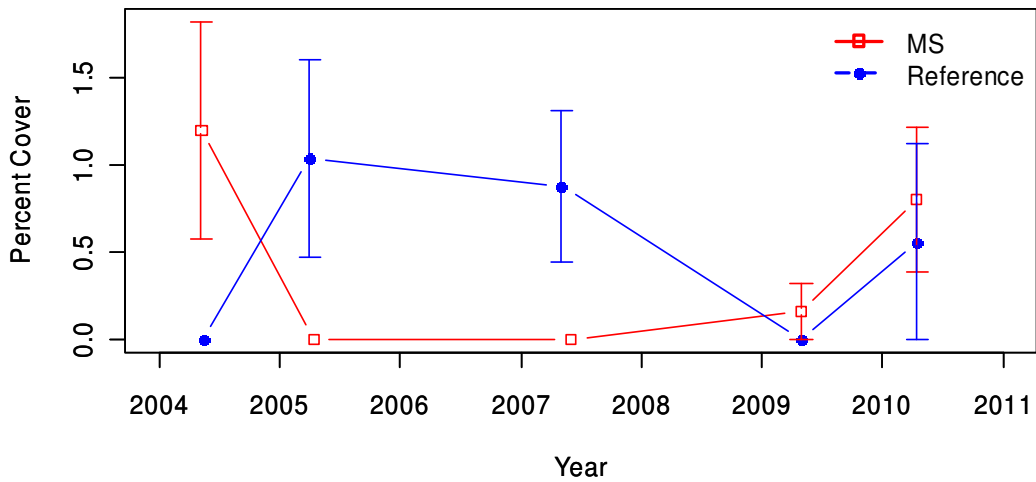
a.

Total Algae Cover



b.

Erect Coralline Algae Cover



c.

Turf Algae Cover

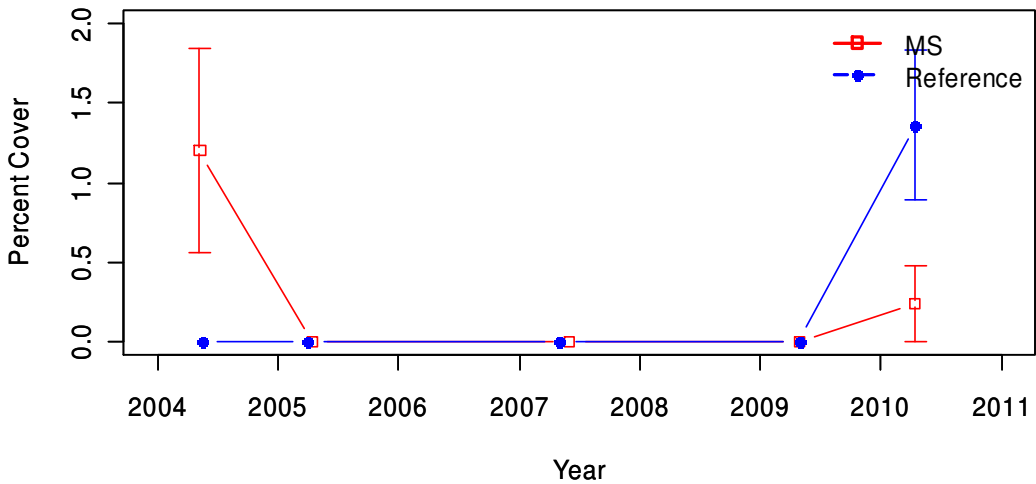
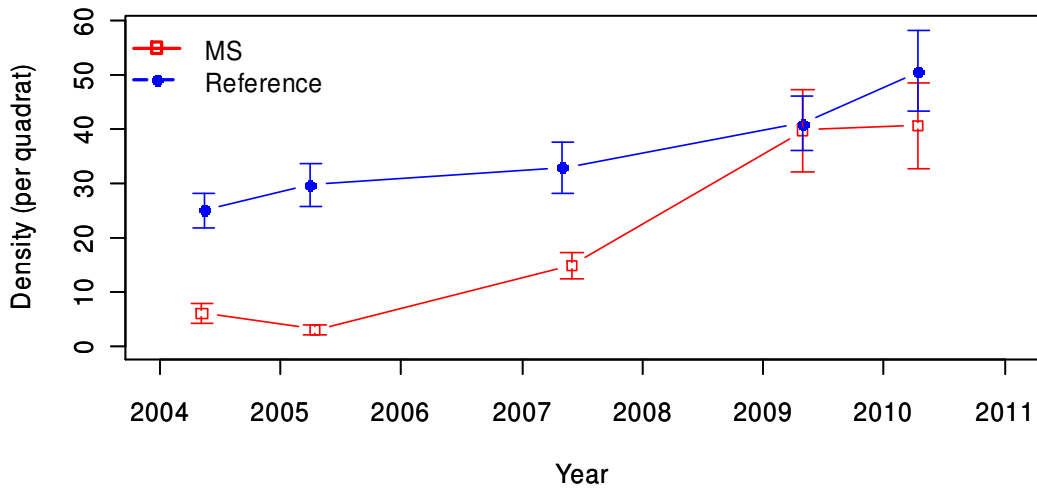


Figure 3.11. Mean cover (\pm Standard Error) of: (a) all algae; (b) erect coralline algae; and (c) turfing algae at Point Cooke, within the Point Cooke MS, and the Altona reference site.

a.

Total Grazers



b.

Total Predators

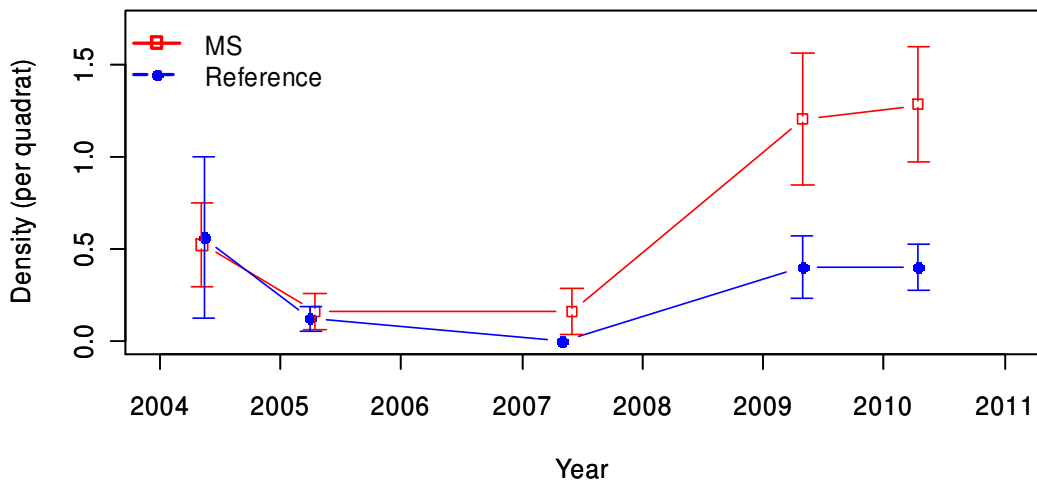
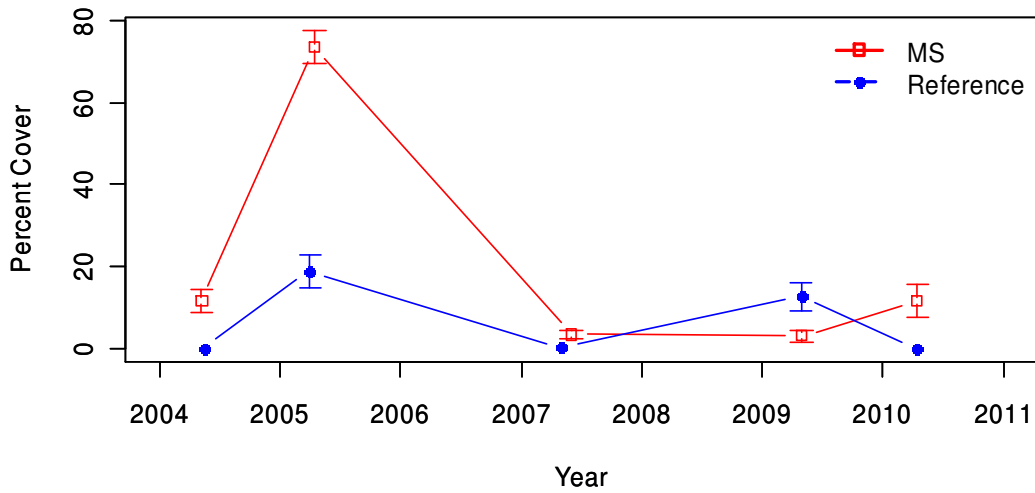


Figure 3.12. Mean abundance (\pm Standard Error) of: (a) all grazers; and (b) all predators at Point Cooke, within the Point Cooke MS, and the Altona reference site.

a.

Green Algae Cover



b.

Sediment Cover

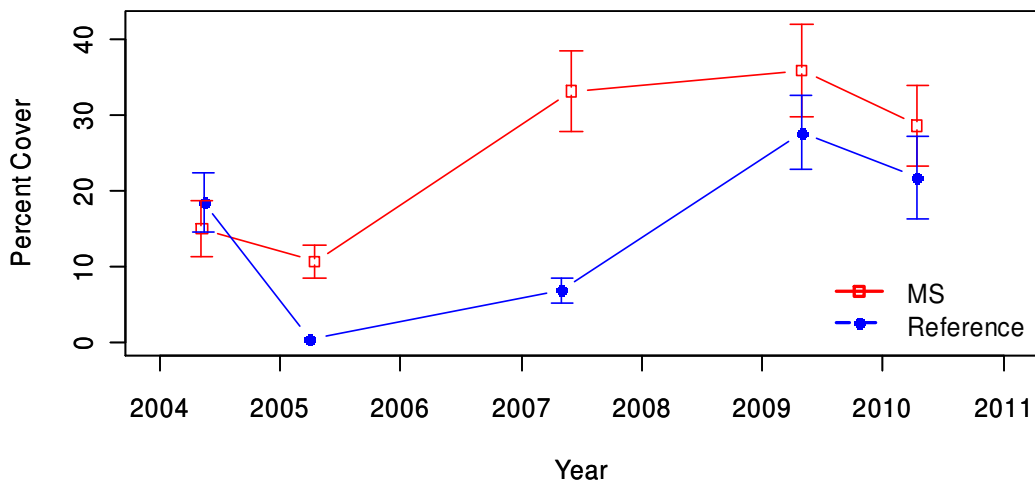


Figure 3.13. Mean cover (± Standard Error) of: (a) green algae *Ulva*, *Enteromorpha* and *Cladophora* species; and (b) sediment at Point Cooke, in Point Cooke MS, and the Altona reference site.

4 JAWBONE MARINE SANCTUARY

4.1 Site Description and Transect Layout

4.1.1 Jawbone Marine Sanctuary (Site 4109)

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 4.1). 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.

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.

4.1.2 Williamstown Reference (Site 4110)

The reference site for the Jawbone Marine Sanctuary was intertidal reef at Point Gellibrand, Williamstown (site 4110). As at 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 4.2). The intertidal reef has a south-westerly aspect.

The high-shore baseline was 62 m. The low-shore baseline was 100 m in length. The five transects established were 30-44 m in length.



Figure 4.1. Intertidal reef at Jawbone Marine Sanctuary, 3 May 2007.



Figure 4.2. Intertidal reef at the Williamstown reference site, 30 April 2009.

4.2 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 the reference Williamstown (Site 4110) were *Austrocochlea porcata* and coniwink *Bembicium* spp. The MDS analysis showed similar variation throughout time at both Jawbone and the reference Williamstown site (Figure 4.3a).

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 caespitose*. In contrast, the cover at Williamstown was mostly the plant *Hormosira banksii*. The MDS analysis reflected the differences in these sites, placing the two sites in different clusters (Figure 4.3b). The Jawbone site had greater variation throughout the monitoring period.

4.3 Diversity

The species richness of mobile invertebrate species was relatively stable at Jawbone and more variable over time at Williamstown (Figure 4.4). Species richness at Jawbone was higher in 2010 than previously recorded.

Algal and aggregating sessile invertebrate species richness at Jawbone (Site 4009) has steadily increased from 6 species per site from the first survey in 2004 to 14 species in 2010 (Figure 4.5b). Species richness at Williamstown was highly variable (Figure 4.5).

Mobile invertebrate species diversity, in terms of Hills N_2 , was relatively constant at both sites, with levels consistently higher at Jawbone than Williamstown (Figure 4.6).

Algal and aggregating sessile invertebrate species diversity was relatively stable and similar between sites up to 2007. In 2009 and 2010 there was a distinct upward trend at Jawbone and a decrease at Williamstown (Figure 4.7).

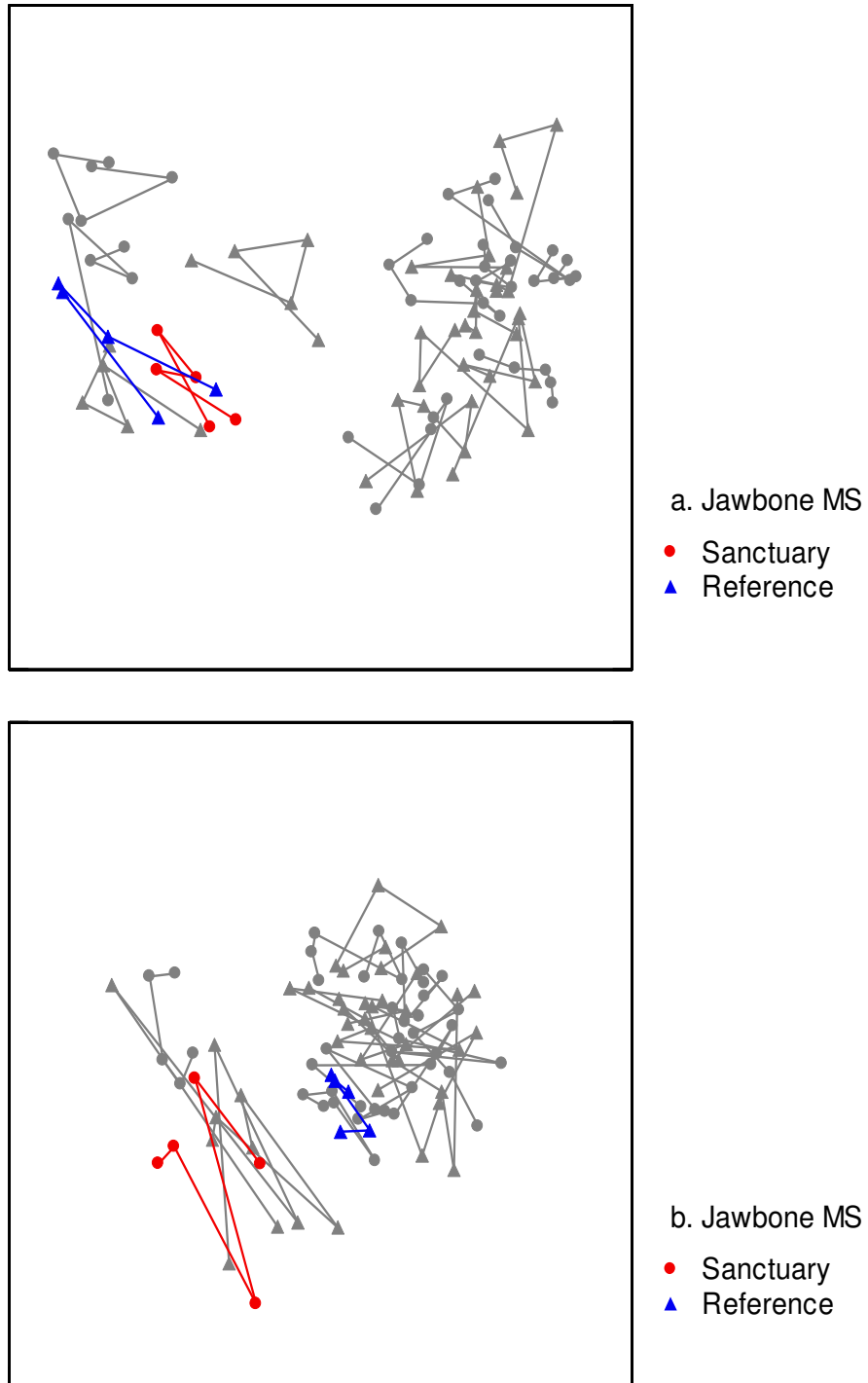


Figure 4.3. Two dimensional MDS plot of invertebrate assemblages on intertidal reefs at Jawbone, within the Jawbone MS, and the Williamstown reference site. (a) Mobile Invertebrate, Kruskal stress = 0.17 and (b) Macroalgae and Aggregating Sessile Invertebrates, Kruskal stress = 0.08. The grey lines represent data from all other intertidal sites used in the MDS analysis.

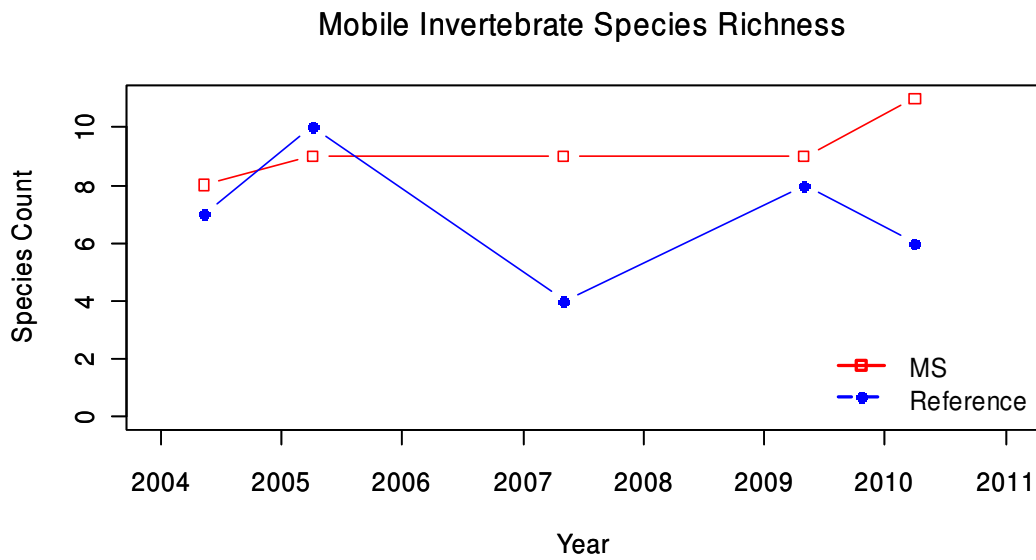


Figure 4.4. Mobile invertebrate species richness at Jawbone, within the Jawbone MS, and the Williamstown reference site.

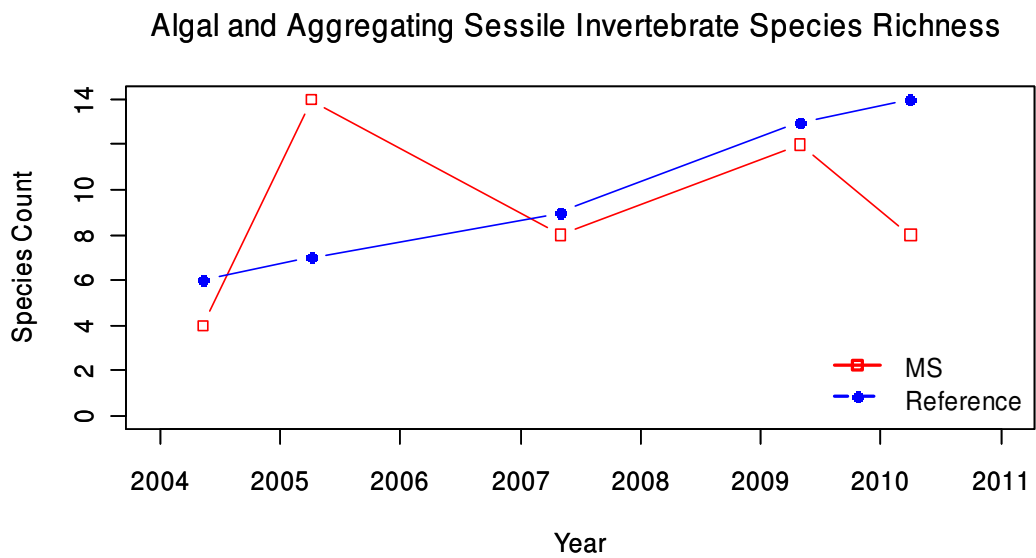


Figure 4.5. Algal and aggregating sessile invertebrate species richness of intertidal sites at Jawbone, within the Jawbone MS, and the Williamstown reference site.

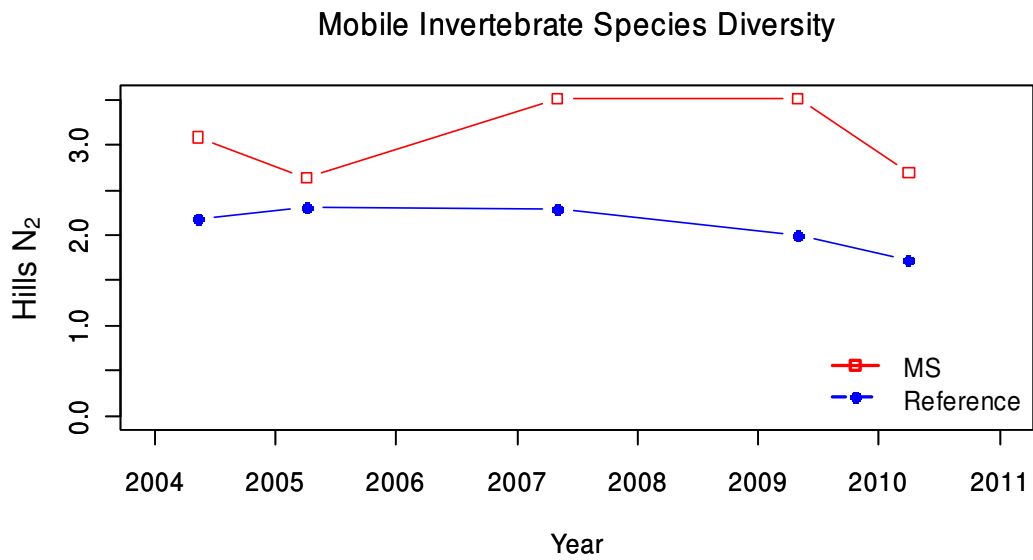


Figure 4.6. Mobile invertebrate diversity (Hills N₂) of intertidal sites at Jawbone, within the Jawbone MS, and the Williamstown reference site.

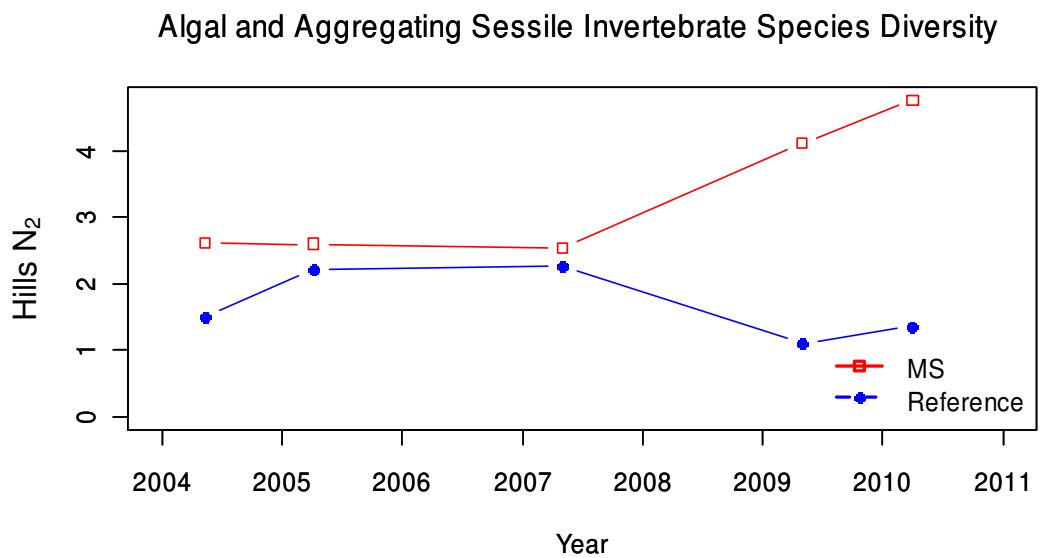


Figure 4.7. Algal and aggregating sessile invertebrate diversity (Hill's N₂) of intertidal sites at Jawbone, within the Jawbone MS, and the Williamstown reference site.

4.4 Macroalgae and Aggregating Sessile Invertebrates

The abundance of macroalgae and sessile invertebrates was very low at the Jawbone (Site 4109). The calcareous tube-worm *Galeolaria caespitosa* was present at low densities, low in the intertidal zone. Turfing and coralline algae, the green algae sea lettuce *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* steadily increased at Williamstown between 2004 and 2009, from 7 % to 27 % cover (Figure 4.8). Abundance remained high, but slightly lower, in 2010. Turfing algae had low coverage during 2004 to 2007, with 4 % coverage in 2010.

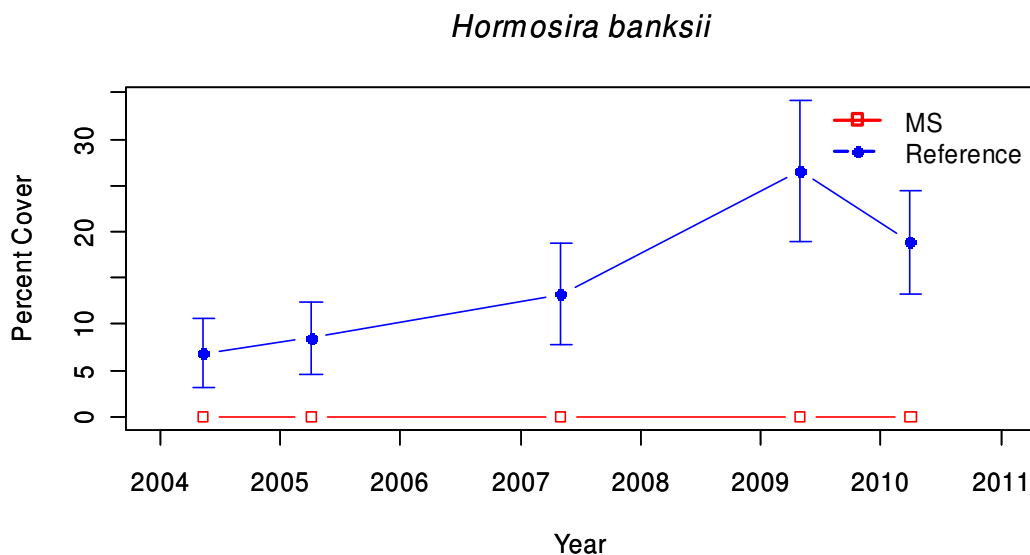


Figure 4.8. Mean density (\pm Standard Error) of Neptune's necklace *Hormosira banksii* at Jawbone, within the Jawbone MS, and the Williamstown reference site.

4.5 Mobile Invertebrates

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

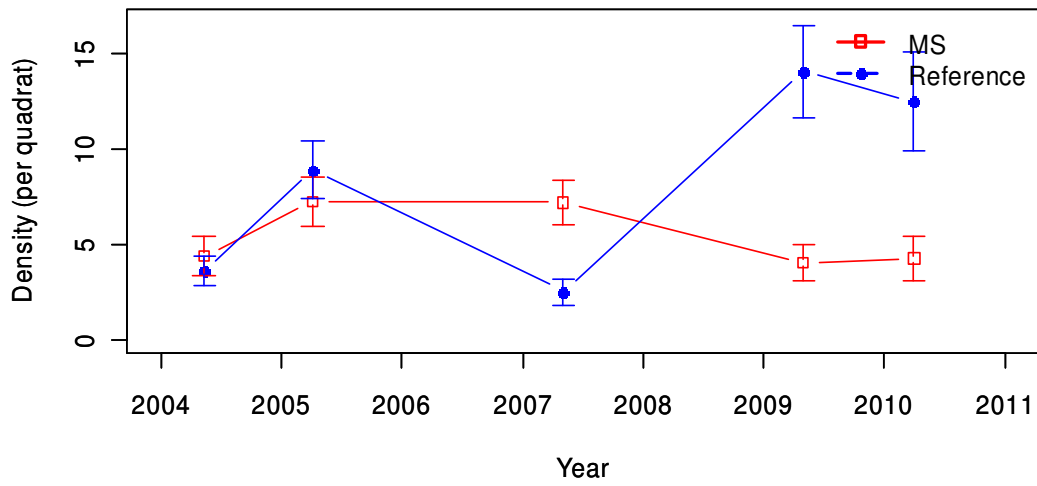
Densities of *Austrocochlea porcata* varied slightly at Jawbone with slightly lower densities in 2009 and 2010 (Figure 4.9). Densities were more variable between years at Williamstown and were at the highest recorded densities during the last two surveys (Figure 4.9a).

Cellana tramoserica was consistently higher in abundance at Jawbone than Williamstown, with both sites having a near-linear decline in density from 2004 to 2009 (Figure 4.9). In 2010, There was a marked increase in density at Jawbone, to highest recorded levels, but there was not an equivalent increase at Williamstown.

The mean size of *Austrocochlea porcata* was slightly lower and more variable at Jawbone than Williamstown, however there were no major trends through time (Figure 4.10a). Mean size of *Cellana tramoserica* was similar between sites and constant through time (Figure 3.10b).

a.

Austrocochlea porcata



b.

Cellana tramoserica

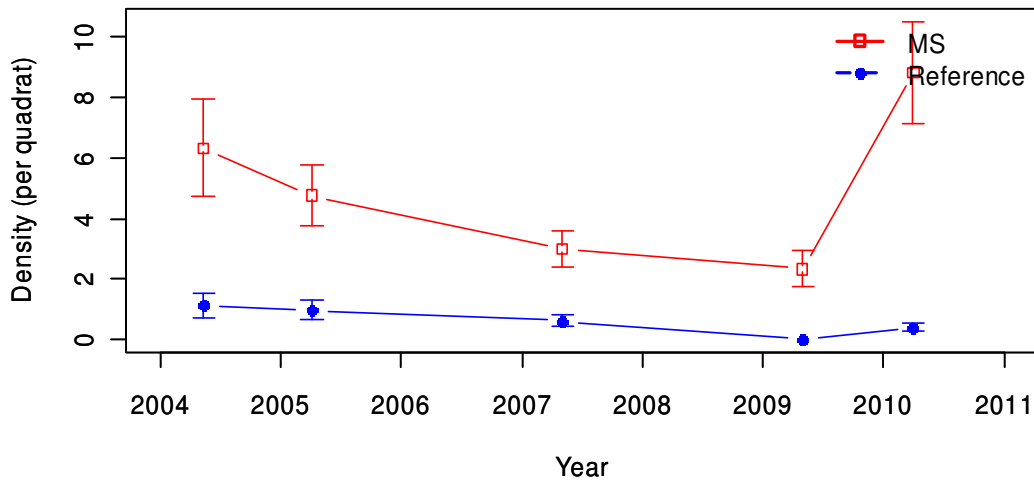
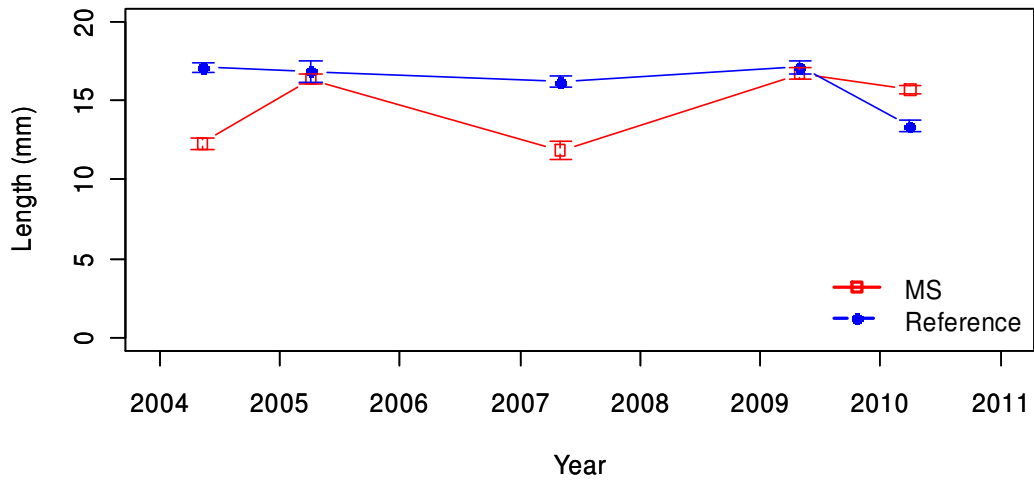


Figure 4.9. Mean density (\pm Standard Error) of: (a) the top shell *Austrocochlea porcata*; and (b) the limpet *Cellana tramoserica* at Jawbone, within the Jawbone MS, and the Williamstown reference site.

a.

Austrocochlea porcata



b.

Cellana tramoserica

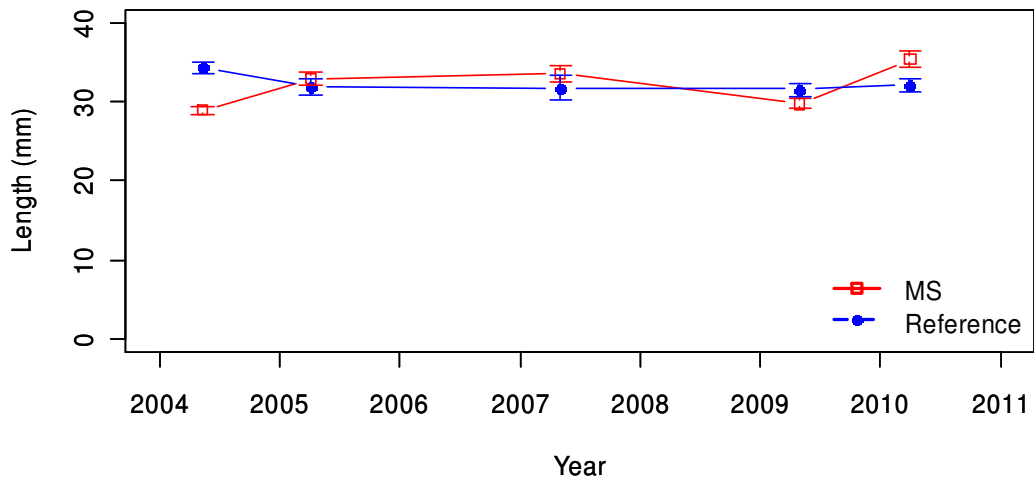


Figure 4.10. Mean sizes (\pm Standard Error) of: (a) the top shell *Austrocochlea porcata*; and (b) the limpet *Cellana tramoserica* at Jawbone MS, and the Williamstown reference site.

4.6 Condition Indicators

Biodiversity

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

Introduced Species

There were no introduced species detected for these sites.

Ecosystem Function

Total algal cover has increased considerably at Williamstown with the increase in *Hormosira banksii* cover. There was an increase in total algal cover at Jawbone in recent years (Figure 4.11a). Erect coralline algal cover and turfing algae were low and variable in cover over the monitoring period at both sites (Figure 4.11b and 4.11c). An exception was a spike in turfing cover (13 %) at Williamstown during 2007.

The total abundance of grazers and predators had overlapping ranges of variation at both sites with no clear patterns or trends (Figure 4.12a and 4.12b). There was no apparent relationship between plant cover and grazer density.

Climate Change

There were no new species detected that were typically from adjacent bioregions.

Harvesting

The declining densities of *C. tramoserica* indicated there may have been harvesting at Jawbone and Williamstown until 2009, however this evidence is inconclusive and the declines may have been for other reasons. The subsequent increase to high densities at Jawbone indicated either improved conditions or a recruitment spike. There were no indications of increasing harvesting pressure based on mean sizes.

Trampling

The increase in cover of *Hormosira banksii* at Williamstown indicates trampling is not a constraining factor to the population.

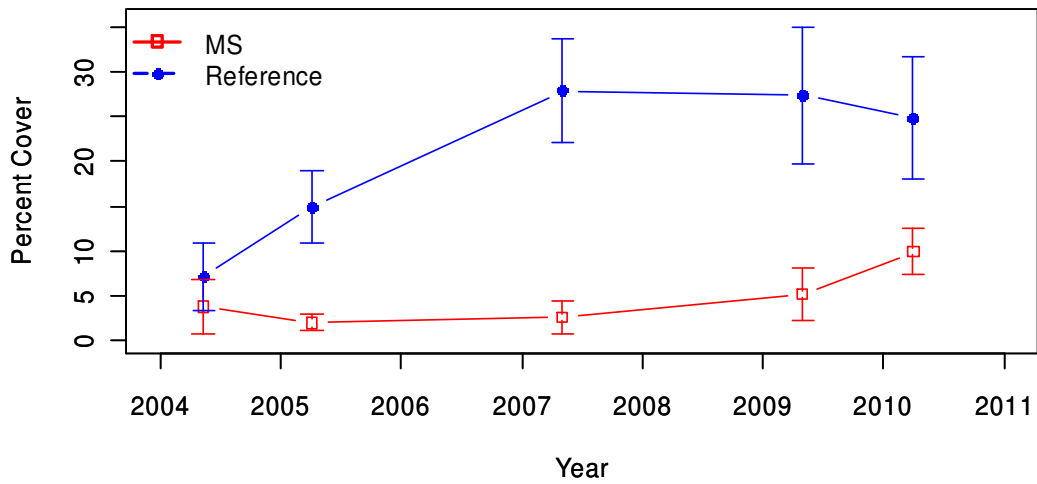
Environment

The cover of green algal species indicative of nutrient loading was relatively low, < 2 % cover, at both sites during all surveys (Figure 3.13a). There was a spike in sediment cover at

both sites during 2007 and coverage in 2009 and 2010 was higher than in years prior to the 2007 spike (Figure 3.13b).

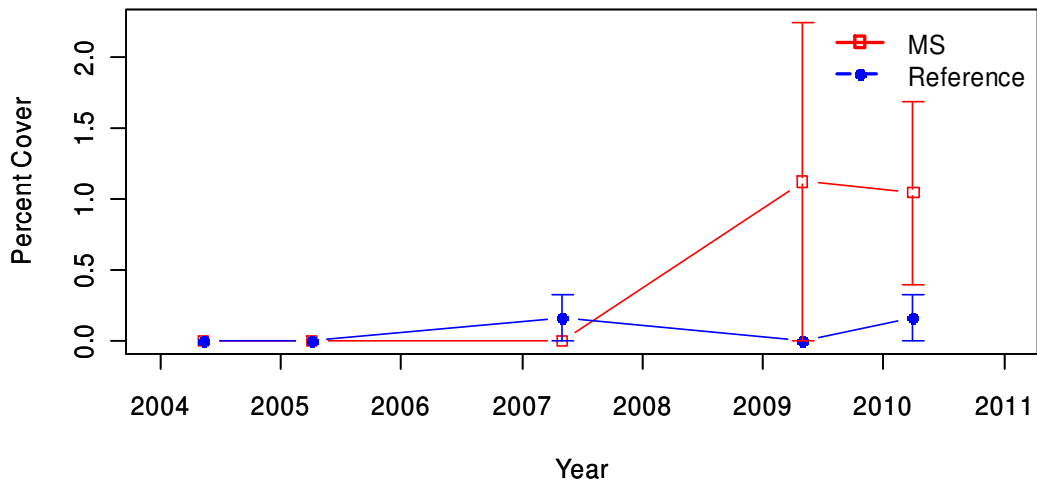
a.

Total Algae Cover



b.

Erect Coralline Algae Cover



c.

Turf Algae Cover

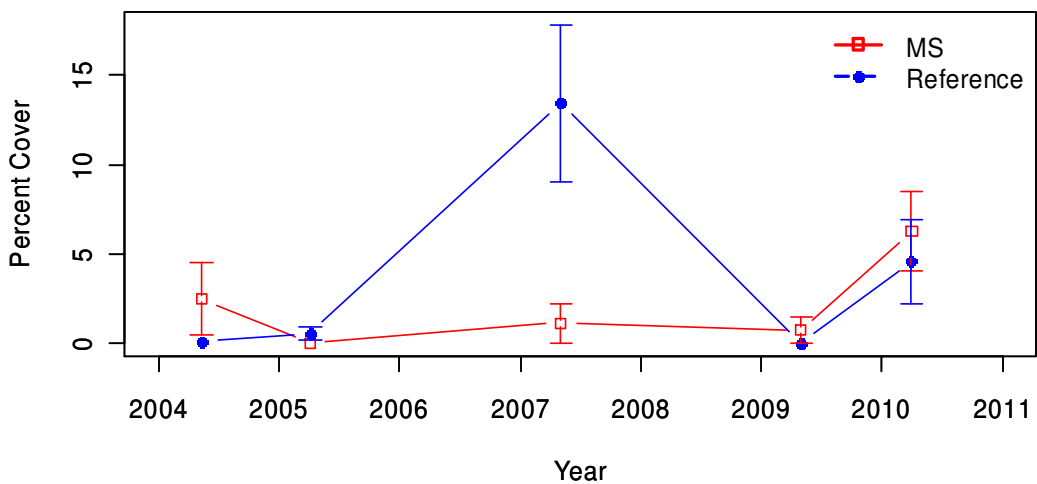
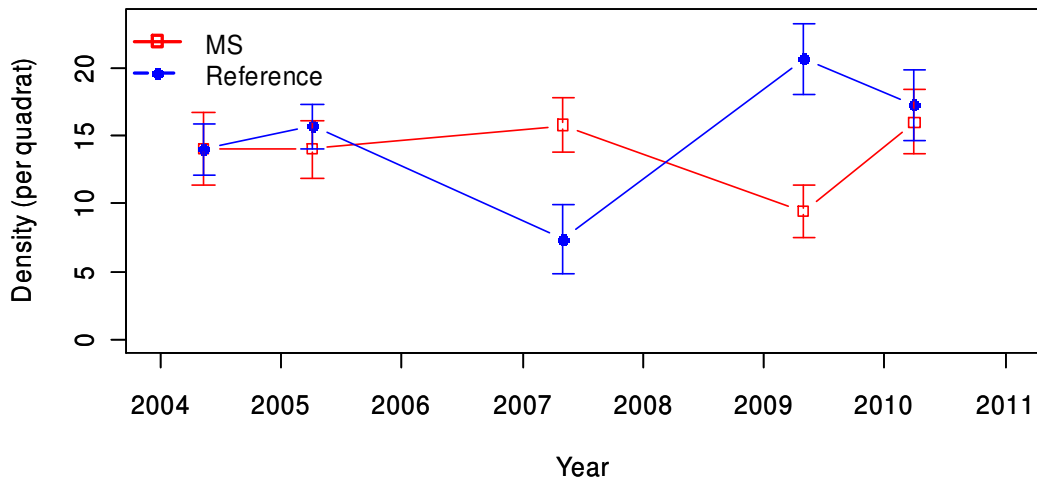


Figure 4.11. Mean cover (\pm Standard Error) of: (a) all algae; (b) erect coralline algae and (c) turfing algae at Jawbone MS, and the Williamstown reference site.

a.

Total Grazers



b.

Total Predators

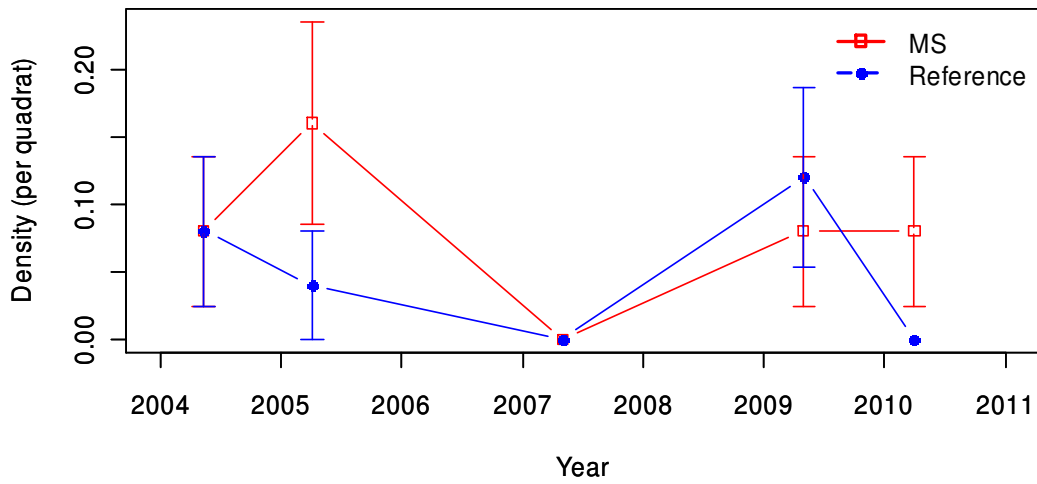
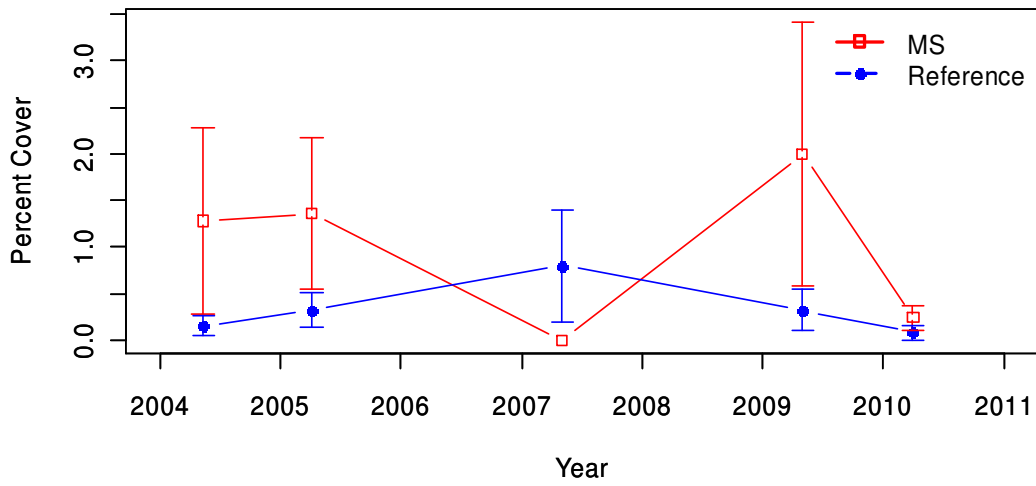


Figure 4.12. Mean abundance (\pm Standard Error) of: (a) all grazers; and (b) all predators at Jawbone, and the Williamstown reference site.

a.

Green Algae Cover



b.

Sediment Cover

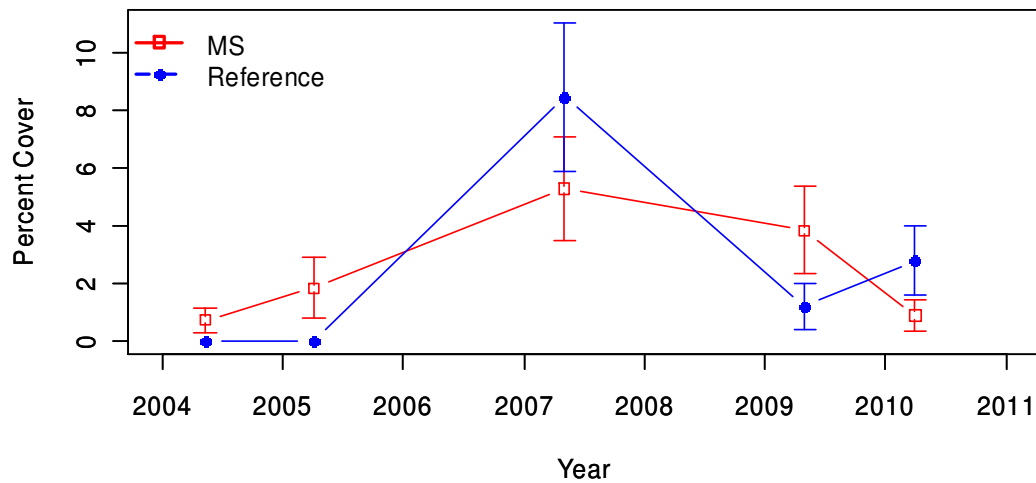


Figure 4.13. Mean cover (\pm Standard Error) of: (a) green algae *Ulva*, *Enteromorpha* and *Cladophora* species; and (b) sediment at Jawbone MS, and the Williamstown reference site.

5 RICKETTS POINT MARINE SANCTUARY

5.1 Site description and Transect layout

5.1.1 Ricketts Point Marine Sanctuary (Site 4111)

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 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 that is above the high tide mark and supports patches of the beaded glasswort *Sarcocornia quinqueflora*. There are also small rock pools in this central area. To the north and south of the central region are cobble field and sediment habitats. The seaward edge of the platform is fractured basalt with small boulders. Across the intertidal area there are low basalt protrusions which provide some vertical structure.

The main difficulties in establishing a monitoring site at Ricketts Point were: (1) determining which of cobble field or solid basalt reef was the predominant habitat type; and (2) the 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. The high shore baseline was 40 m long and ran north-south above a rock step. Below the rock step the shore sloped away gradually. The low shore baseline was 40 m long, traversing 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 and 7 m apart.

5.1.2 Halfmoon Bay Reference (Site 4112)

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. 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 10 m long and 5 m apart (Figure 6.2).



Figure 5.1. Intertidal reef at Ricketts Point Marine Sanctuary, 28 April 2009.



Figure 5.2. The intertidal reef monitoring reference site at Halfmoon Bay, 1 May 2009. The high-shore baseline is at the right of the reef.

5.2 Community Structure

The mobile invertebrate community at Ricketts Point (Site 4111) largely composed of the herbivorous gastropod *Austrocochlea porcata* and coniwink *Bembicium* spp. Commonly found species at the reference Half Moon Bay (Site 4112) were the limpet *Cellana tramoserica*, *Patelloida alticostata* and the carnivorous gastropods *Lepsiella vinosa*. These two sites differed in mobile invertebrate assemblage structure. Ricketts Point was closely related to other sites within Port Phillip Bay, while Half Moon Bay had affinities with both the Port Phillip Bay and the open coast sites (Figure 5.3a). The MDS analysis showed a similar amount of variation through time at both Ricketts Point and the reference Half Moon Bay site.

The algal and aggregating sessile invertebrate community structure also differed between Ricketts Point and Half Moon Bay (Figure 5.3b). The Ricketts point assemblage largely consisted of the brown algae Neptune's necklace *Hormosira banksii*, calcareous tube-worm *Galeolaria caespitosa*, *Symploca* and algal turf. The cover at Half Moon Bay was mainly composed of *Galeolaria caespitosa*, *Ulva* spp. and algal turf. Half Moon Bay had a greater variation throughout time than Ricketts Point (Figure 5.3b).

5.3 Diversity

Mobile invertebrate species richness was consistently lower at Ricketts Point than Halfmoon Bay and the temporal variations were very similar until 2009 (Figure 5.4). This pattern was different in 2010, with species richness at Ricketts Point increasing between 2009 and 2010 and decreasing at Halfmoon Bay, to that of Ricketts Point (Figure 5.4).

Algal and aggregating sessile invertebrate species richness was very similar at both sites for most times. The exception was in 2009, when there was a spike at Halfmoon Bay (Figure 5.5).

Mobile invertebrate species diversity, Hill's N_2 , was relatively constant over time at Ricketts Point. Diversity was consistently higher at Halfmoon Bay with a decreasing and then increasing trend (Figure 5.6).

Half Moon Bay (Site 4112) had dropped in 2005 after the first survey in 2004, then continued to then increase during surveys till 2010 (Figure 5.6). Species diversity at Ricketts Point (Site 4111) was lower than at the reference Half Moon Bay. Diversity at Ricketts Point remained stable over time.

Algal and aggregating sessile invertebrate diversity was similar in range and variability between Ricketts Point and Halfmoon Bay. (Figure 5.7).

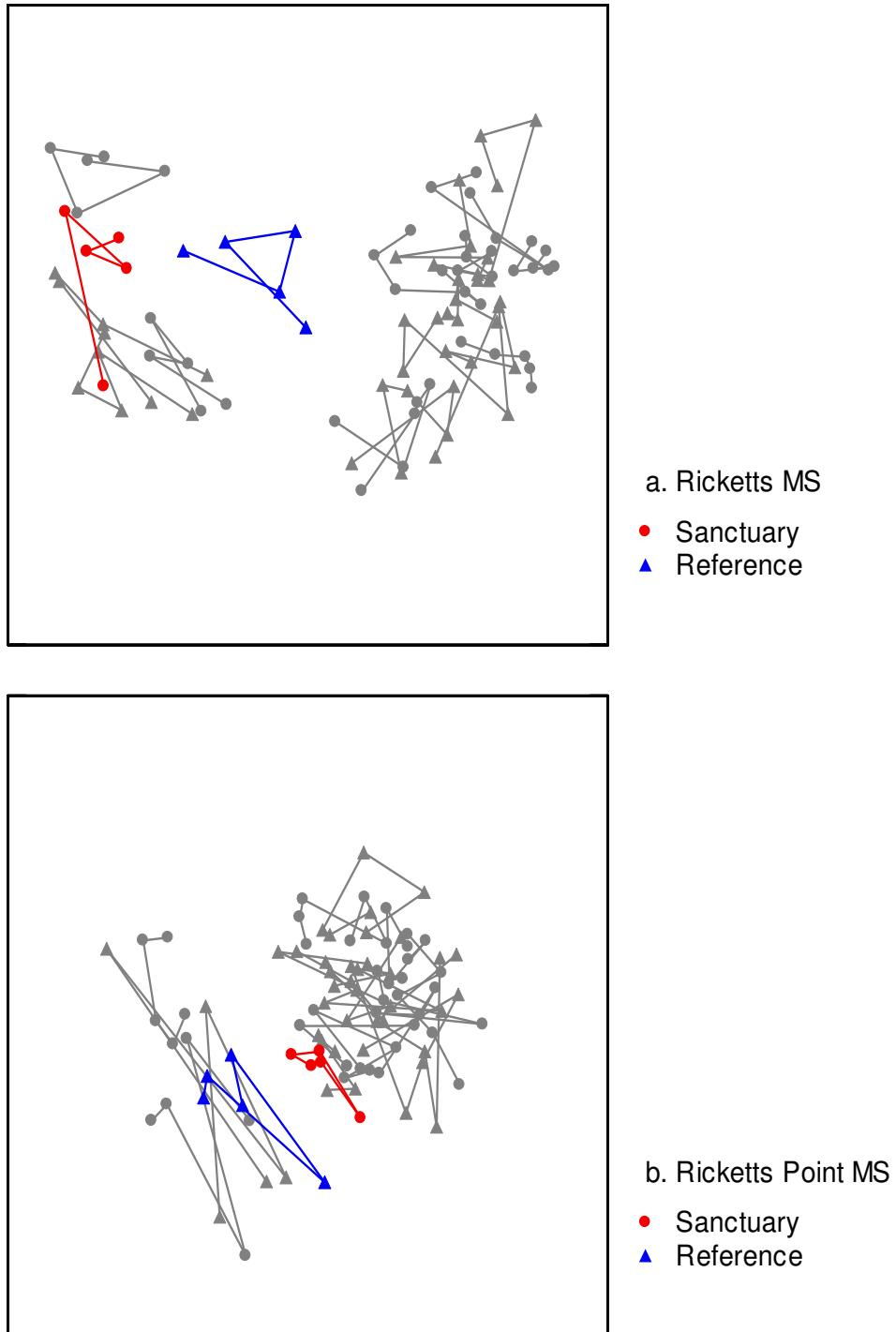


Figure 5.3. Two dimensional MDS plot of invertebrate assemblages on intertidal reefs at Ricketts Point, within the Ricketts Point MS, and the Half Moon Bay reference site. (a) Mobile Invertebrate, Kruskal stress = 0.17 and (b) Macroalgae and Aggregating Sessile Invertebrates, Kruskal stress = 0.08. The grey lines represent data from all other intertidal sites used in the MDS analysis.

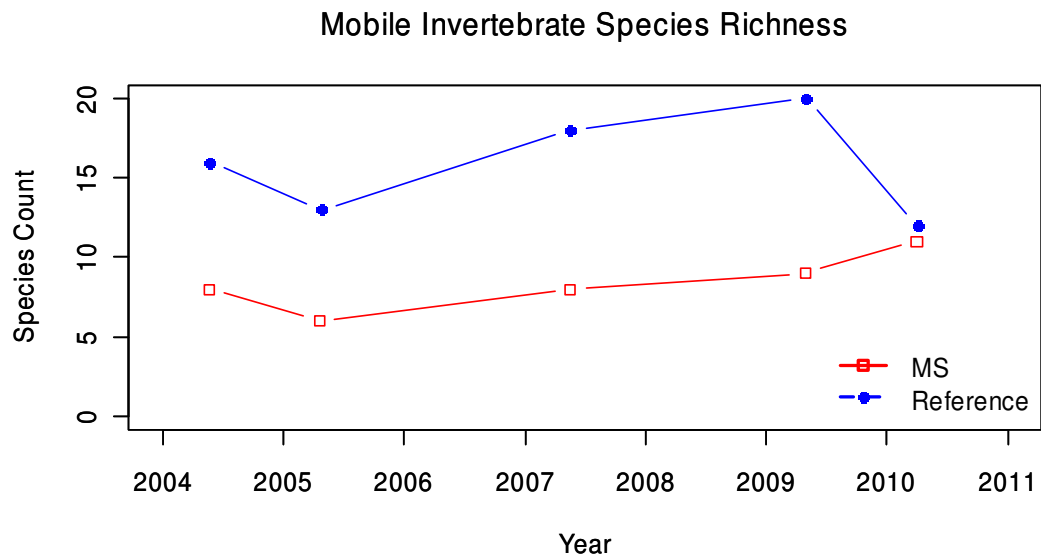


Figure 5.4. Mobile invertebrate species richness at Ricketts Point, within the Ricketts Point MS, and the Half Moon Bay reference site.

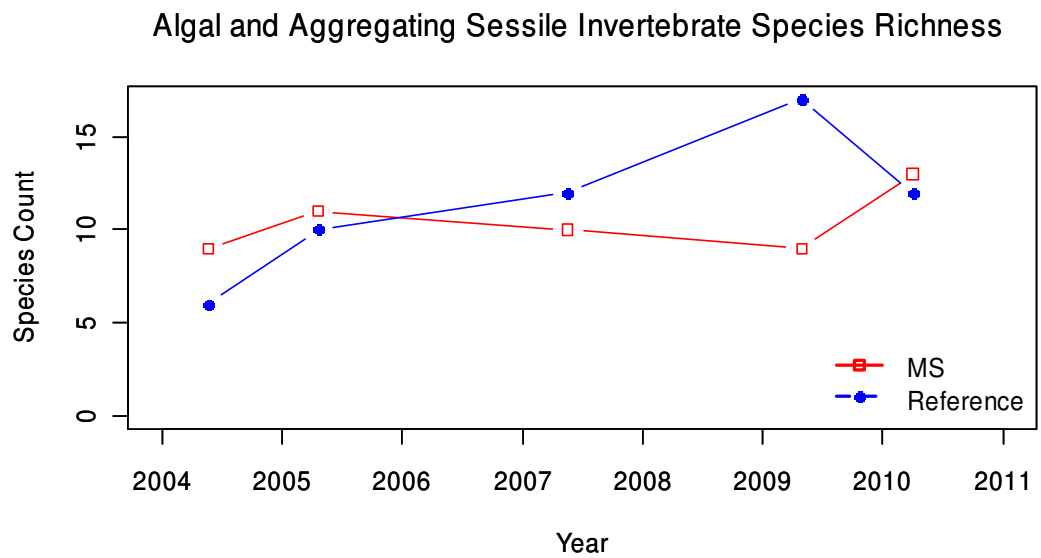


Figure 5.5. Algal and aggregating sessile invertebrate species richness of intertidal sites at Ricketts Point, within the Ricketts Point MS, and the Half Moon Bay reference site.

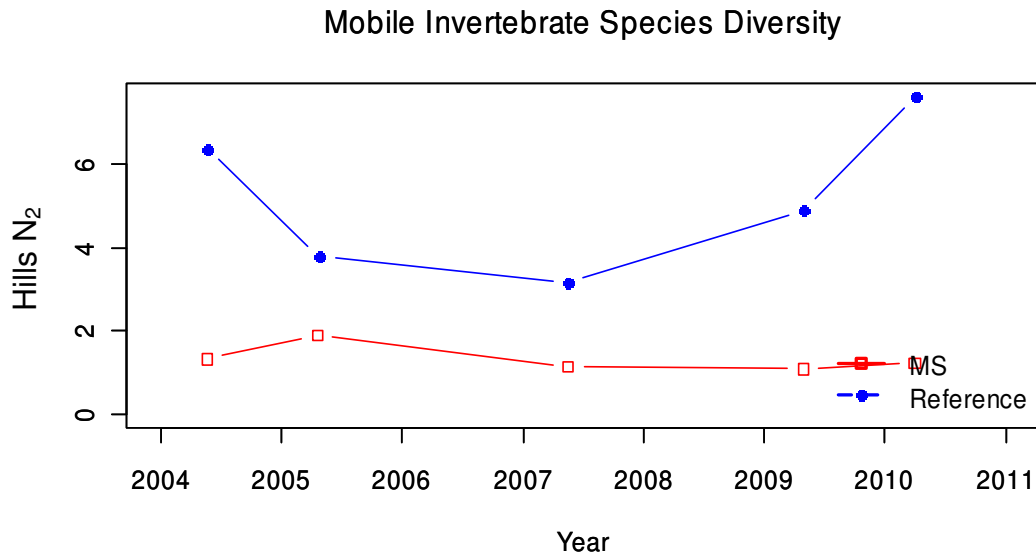


Figure 5.6. Mobile invertebrate diversity (Hills N₂) of intertidal sites at Ricketts Point, within the Ricketts Point MS, and the Half Moon Bay reference site.

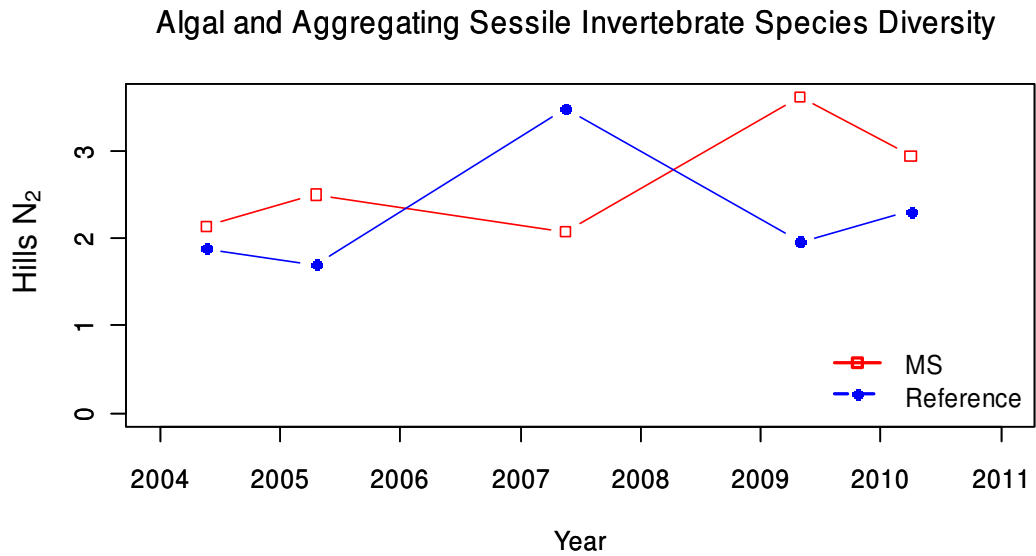


Figure 5.7. Algal and aggregating sessile invertebrate diversity (Hill's N₂) of intertidal sites at Ricketts Point, within the Ricketts Point MS, and the Half Moon Bay reference site.

5.4 Macroalgae and Aggregating Sessile Invertebrates

The high shore area of the Ricketts Point site is exposed for long times between high tide periods resulting in a low algal coverage of the area. Macroalgal cover along the seaward edge of the Ricketts Point platform was predominantly the brown alga Neptune's necklace *Hormosira banksii*. *Hormosira banksii* had relatively high coverage at the start of the monitoring in 2004 and during the last survey in 2010, with lower coverage in the intervening period (Figure 5.8). Small patches of the calcareous tube-worm *Galeolaria caespitosa* were present, occurring in higher abundance near the subtidal zone.

Halfmoon Bay had less than 1 % coverage of *H. banksii* recorded during 2009 and no presence at other times (Figure 5.8). A patch of the blue-green algae *Symploca* sp. was present in 2007, although has not been recorded in subsequent surveys. The filter-feeding polychaete *Galeolaria caespitosa* was abundant at Halfmoon Bay from 2004 to 2007, forming patches the low shore region.

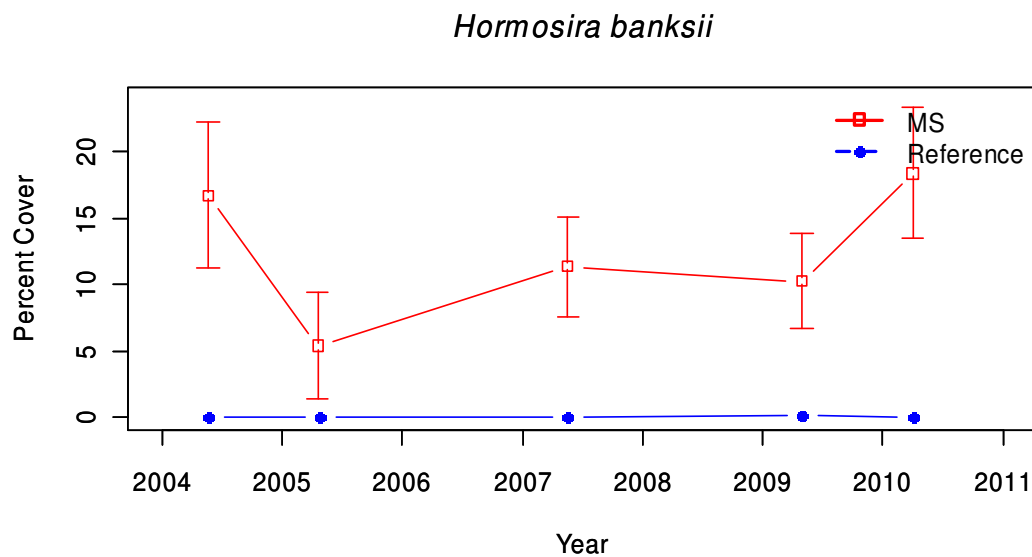


Figure 5.8. Mean density (\pm Standard Error) of Neptune's necklace *Hormosira banksii* at Ricketts Point, within the Ricketts Point MS, and the Half Moon Bay reference site.

5.5 Mobile Invertebrates

At Ricketts Point (Site 4111), the limpet *Cellana tramoserica* was very low in abundance at all times (< 1 per quadrat; Figure 5.9a). Densities were comparatively higher at Halfmoon Bay during most surveys, however there was a rapid decline between 2009 and 2010, when densities dropped to those similar to Ricketts Point (Figure 5.8a).

The gastropod *Austrocochlea porcata* was the most abundant mobile invertebrate at Ricketts Point, where there was a gradual decreasing trend over the monitoring period (Figure 5.8b). Abundances at Halfmoon Bay were similar in 2004 and 2005, but increased markedly to 2007 and stayed relatively high thereafter (Figure 5.9b).

The densities of *Bembicium* spp were very similar at Ricketts Point and Halfmoon Bay, with the same pattern of temporal variation (Figure 5.9c). Densities in 2010 at both sites were among the highest observed during the monitoring program.

The mean size of *Austrocochlea porcata* was relatively constant between 2005 and 2009, with a distinct decline from 2009 to 2010 (Figure 5.12a). There was a decreasing trend in size of *A. porcata* at Halfmoon Bay to 2009 with a subsequent increase to 2010 (Figure 5.12a).

The mean size of *Bembicium* spp had similar patterns of temporal variation at both sites; mean sizes in 2010 were at the lower end of the range for each site in 2010 (Figure 5.12).

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.

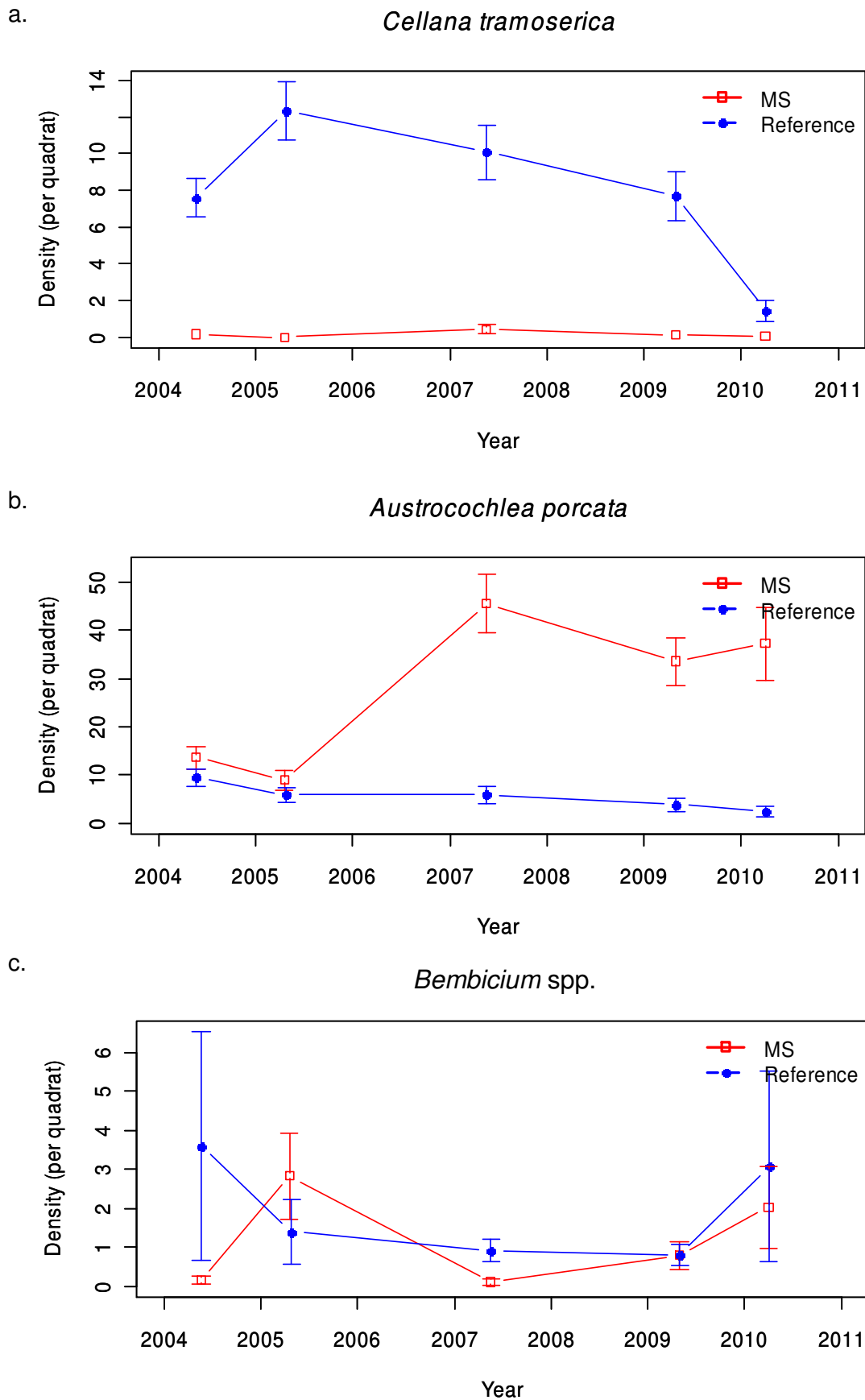
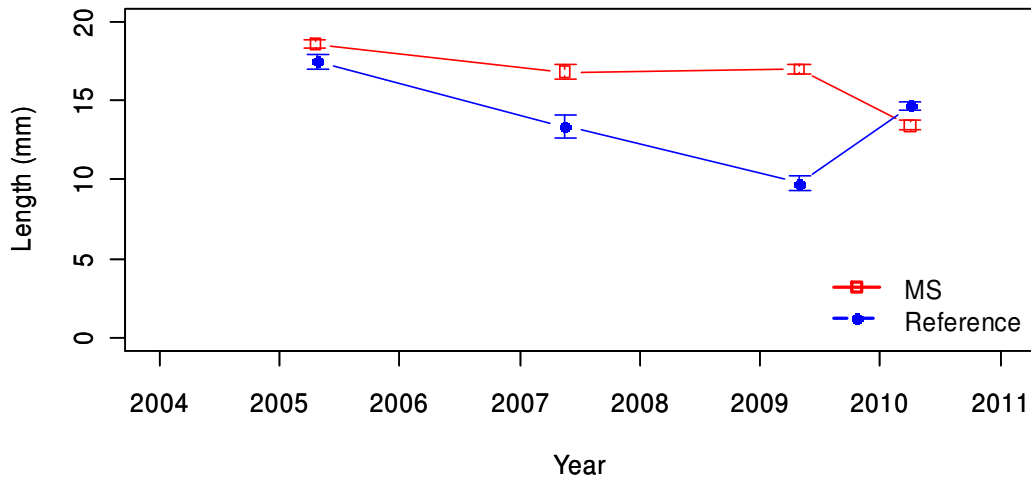


Figure 5.9. Mean density (\pm Standard Error) of: (a) the limpet *Cellana tramoserica*; (b) the top shell *Austrocochlea porcata*; and (c) the conniwink *Bembicium* spp. at Ricketts Point, within the Ricketts Point MS, and the Half Moon Bay reference site.

a.

Austrocochlea porcata

b.

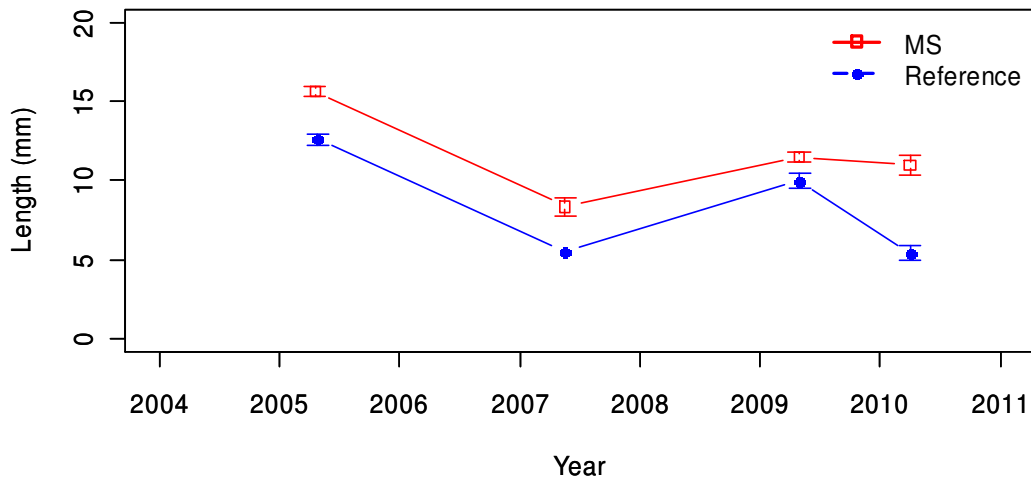
Bembicium spp.

Figure 5.10. Mean sizes (\pm Standard Error) of: (a) the top shell *Austrocochlea porcata*; and (b) the conniwink *Bembicium* spp. at Ricketts Point, in Ricketts Point MS, and the Half Moon Bay reference site.

5.6 Condition Indicators

Biodiversity

Community composition was within the range of states and changes previously observed. Species richness and diversity levels were among the highest recorded for the monitoring program, excepting species richness of mobile invertebrates at Halfmoon Bay (which was at its lowest).

Introduced Species

There were no introduced species detected for these sites.

Ecosystem Function

Total algal cover has generally increased at both sites from 2005 to 2010 (Figure 5.11a). Erect coralline algal cover also increased at both sites during recent years, although the coverage at both sites was very low (Figure 5.11b). Turfing algae had contrary trends between the two sites: Ricketts Point increased from low coverage between 2009 and 2010 while coverage at Halfmoon Bay decreased (Figure 5.11c).

The temporal variations of total grazers was similar at both sites during the first few years of monitoring. The density of grazers was relatively low at Halfmoon Bay in 2010 and relatively high at Ricketts Point (Figure 5.12a). The pattern of temporal variations was also similar between sites for predators, although predator abundance was consistently higher at Halfmoon Bay than Ricketts Point (Figure 5.12b). Predator abundances in 2010 were at levels frequently observed in previous years for each site (excepting the 2007 spike).

Climate Change

There were no new species detected that were typically from adjacent bioregions.

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

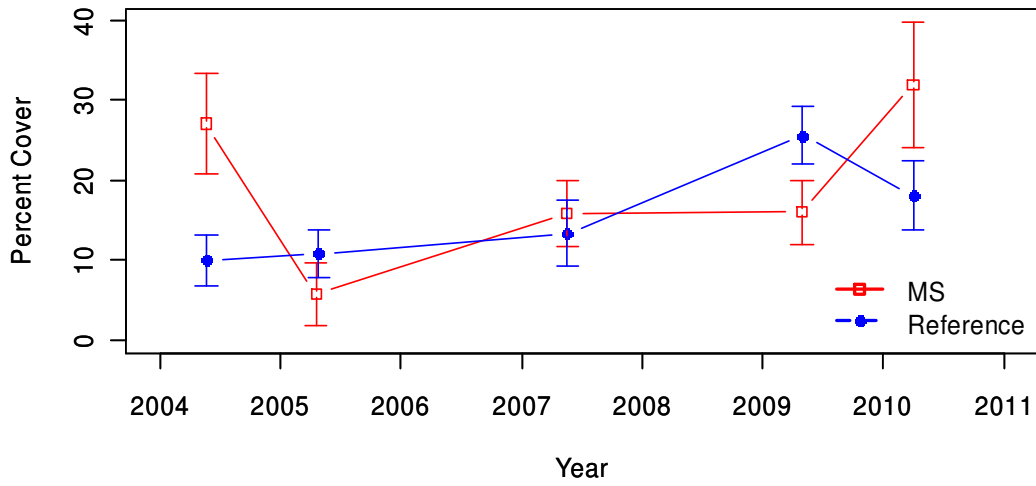
The increase in cover of *Hormosira banksii* at Ricketts Point to 2010 indicates trampling is not presently a constraining factor to the population.

Environment

The cover of green algal species, potentially indicative of nutrient loading, was relatively low, < 2 % cover, at both sites during 2010 (Figure 5.13a). This index has been considerably variable in previous years but coverage has always been below 5 %. Sediment cover was relatively low during the monitoring period for both sites (< 2 %) throughout the monitoring period (Figure 5.13b).

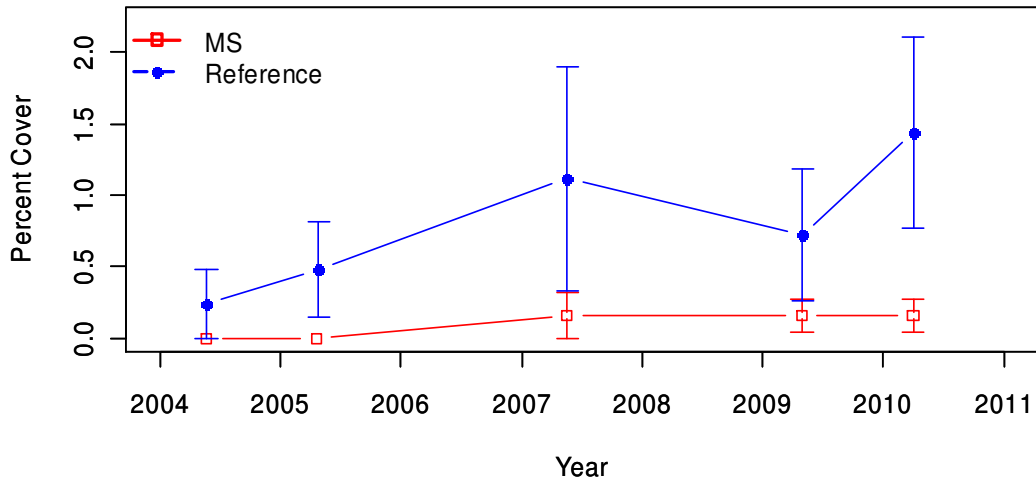
a.

Total Algae Cover



b.

Erect Coralline Algae Cover



c.

Turf Algae Cover

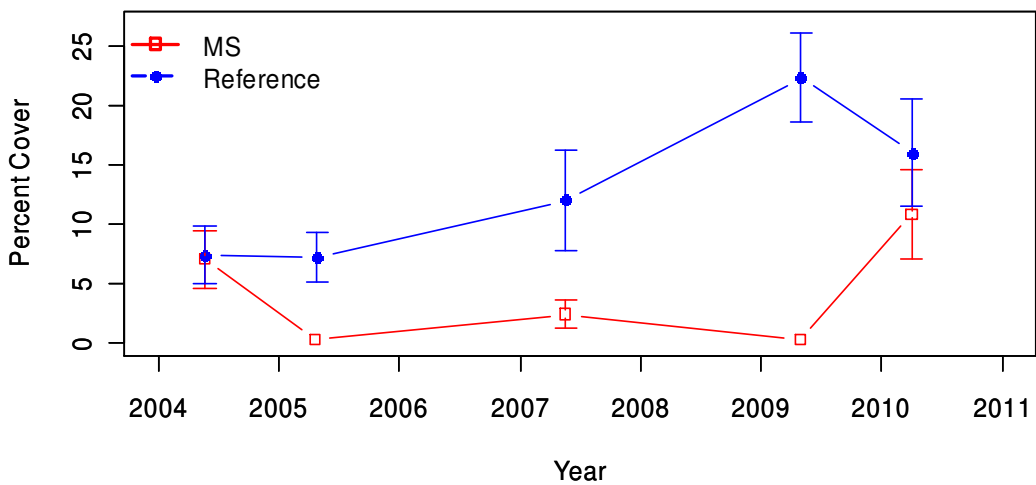


Figure 5.11. Mean cover (\pm Standard Error) of: (a) all algae; (b) erect coralline algae; and (c) turfing algae at Ricketts Point, within the Ricketts Point MS, and the Half Moon Bay reference site.

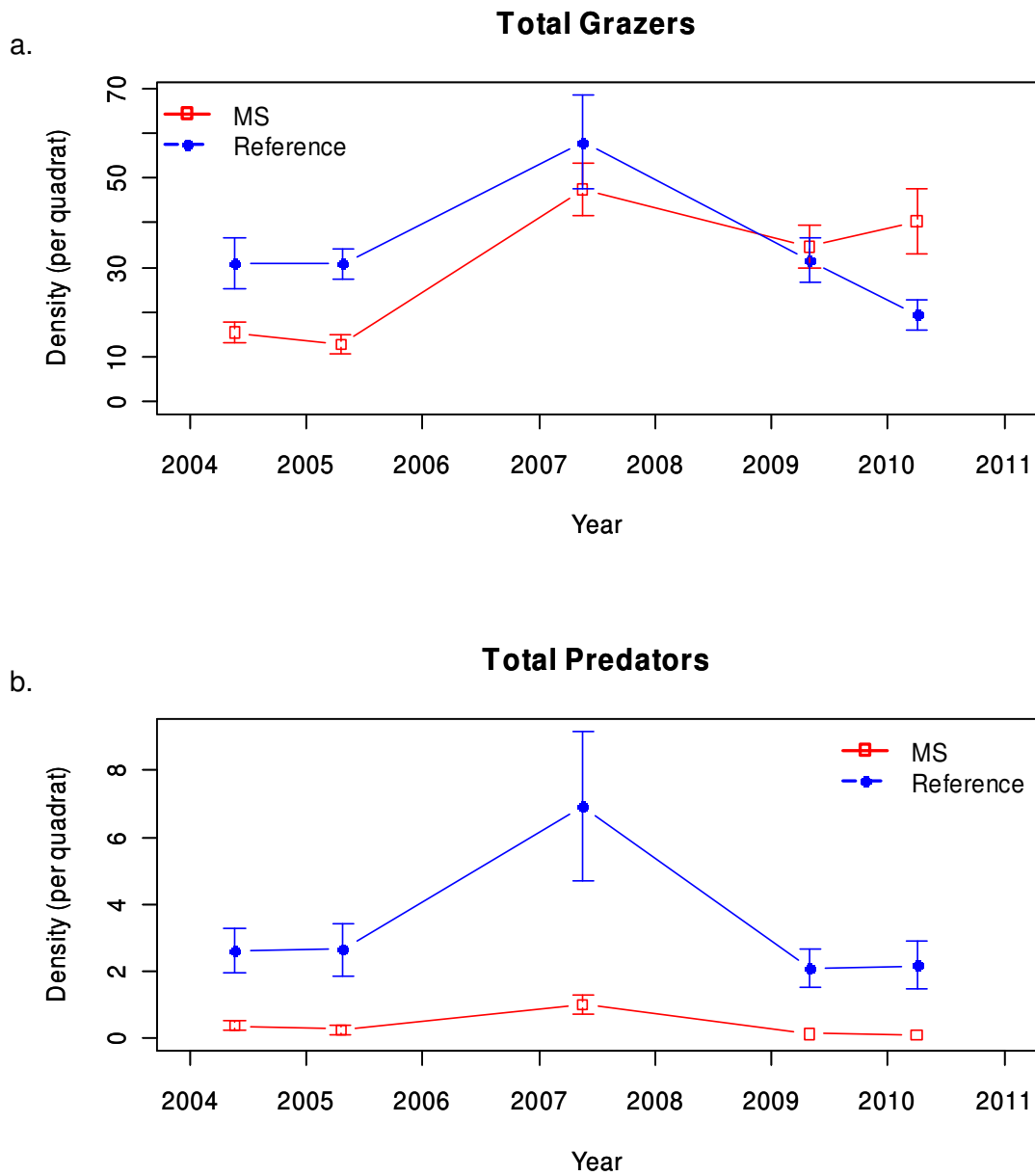
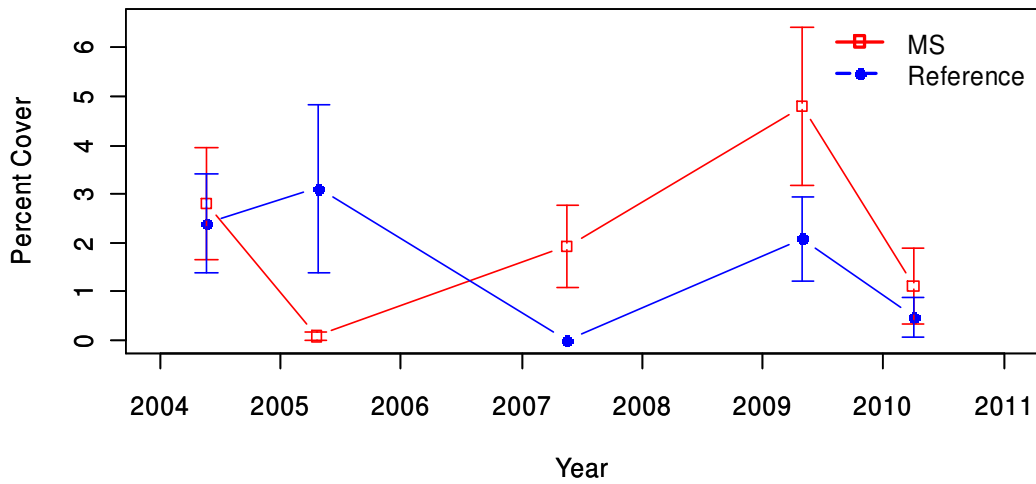


Figure 5.12. Mean abundance (\pm Standard Error) of: (a) all grazers; and (b) all predators at Ricketts Point, within the Ricketts Point MS, and the Half Moon Bay reference site.

a.

Green Algae Cover



b.

Sediment Cover

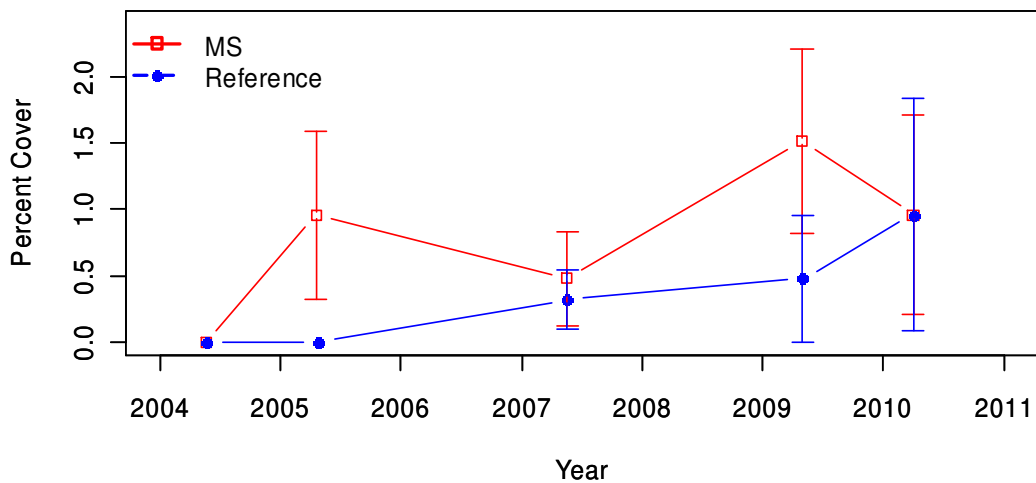


Figure 5.13. Mean cover (\pm Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment, at Ricketts Point, in Ricketts Point MS, and the Half Moon Bay reference site.

6 PORT PHILLIP HEADS MARINE NATIONAL PARK

6.1 Site Description and Transect Layout

6.1.1 Point Lonsdale (Site 2823)

The intertidal reef surveyed for the Port Phillip Heads Marine National Park was located at Point Lonsdale, is on the western side of Port Phillip Heads. The extensive, triangularly shaped intertidal platform projecting south and eastwards 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. Both high and low shore baselines were 100 m long, The five transects between the baselines were 50-60 m long and approximately 17 m apart.

6.1.2 Cheviot Bay Reference (Site 2824)

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. Special permission from the management authority (Parks Victoria) is required to access the area because of unexploded ordinance in the vicinity. The intertidal platform is consequently protected from the high levels of human trampling that occur at Point Lonsdale.

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.



Figure 6.1. Intertidal reef at Point Lonsdale, Port Phillip Heads Marine National Park, 12 June 2009.



Figure 6.2. Intertidal reef at the Cheviot Bay reference site, 22 December 2004.

6.2 Community Structure

The mobile invertebrate communities at Point Lonsdale (2823) and the Cheviot Bay reference site (Site 2824) were similar (Figure 6.3a). The slit limpet *Clypidina rugosa* and false limpet *Siphonaria* spp. were prevalent at both sites. Other limpets *Cellana tramoserica*, *Patelloida alticostata* and *Notoacmea* spp. were also common. The coniwink *Bembicium* spp. was abundant at Point Lonsdale. The MDS analysis showed a similar amount of variation through time at Point Lonsdale and Cheviot Bay (Figure 6.3a).

The algal and aggregating sessile invertebrate 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 reflected the similarity in these sites, situating them close together within the same cluster. Both sites showed a similar amount of variation throughout the monitoring period (Figure 6.3b).

6.3 Diversity

Species richness of mobile invertebrates was relatively stable at both Pt Lonsdale (Site 2823) and the reference Cheviot Bay (Site 2824; Figure 6.4).

Algal and sessile invertebrate species richness at both sites increased sharply during 2005 to 25 and 22 species per site respectively, before subsequently declining. Species richness at Cheviot Bay was lower in 2010 than previously recorded.

Mobile invertebrate species diversity, in terms of Hills N_2 , has co-varied at Pt Lonsdale (Site 2823) and Cheviot Bay (Site 2824) since the 2005 survey (Figure 6.6). The species diversity of the algal and aggregating sessile invertebrate community was low, between 1 and 2, reflecting the dominance of *Hormosira banksii* at these sites (Figure 6.7).

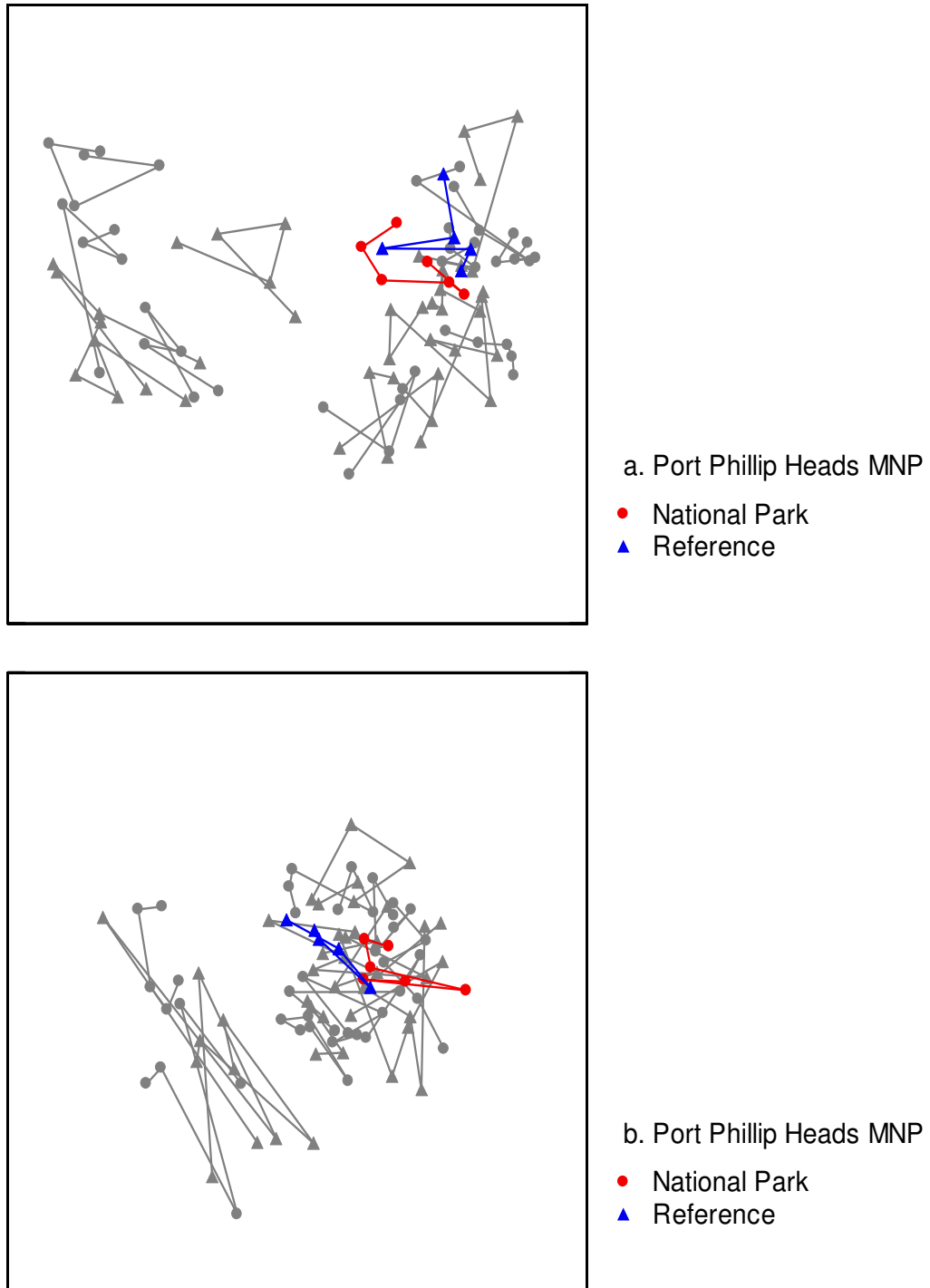


Figure 6.3. Two dimensional MDS plot of invertebrate assemblages on intertidal reefs at Point Lonsdale, within the Port Phillip Heads MNP, and the Cheviot Bay reference site. (a) Mobile Invertebrate, Kruskal stress = 0.17 and (b) Macroalgae and Aggregating Sessile Invertebrates, Kruskal stress = 0.08. The grey lines represent data from all other intertidal sites used in the MDS analysis.

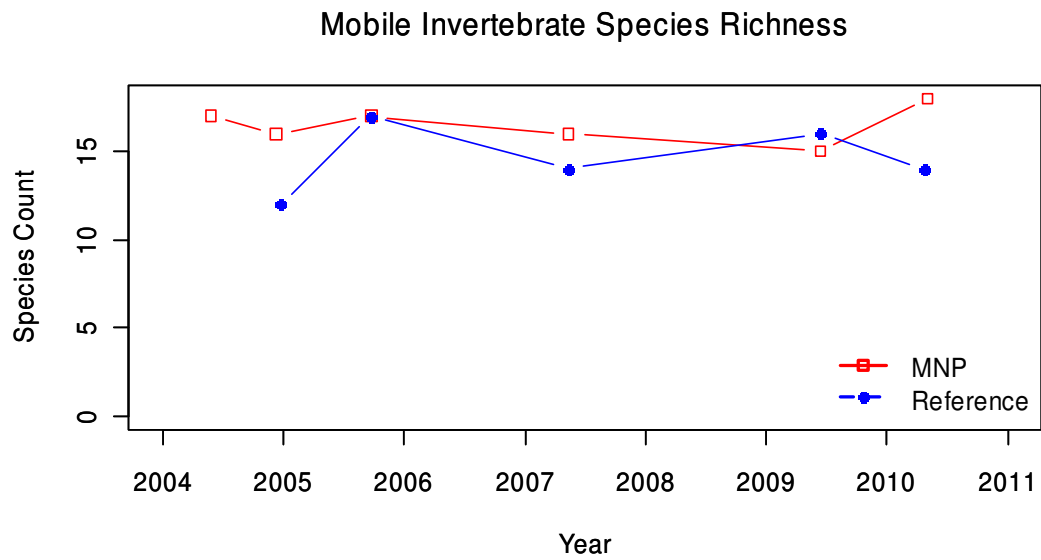


Figure 6.4. Mobile invertebrate species richness at Point Lonsdale within the Port Phillip Heads MNP, and the Cheviot Bay reference site.

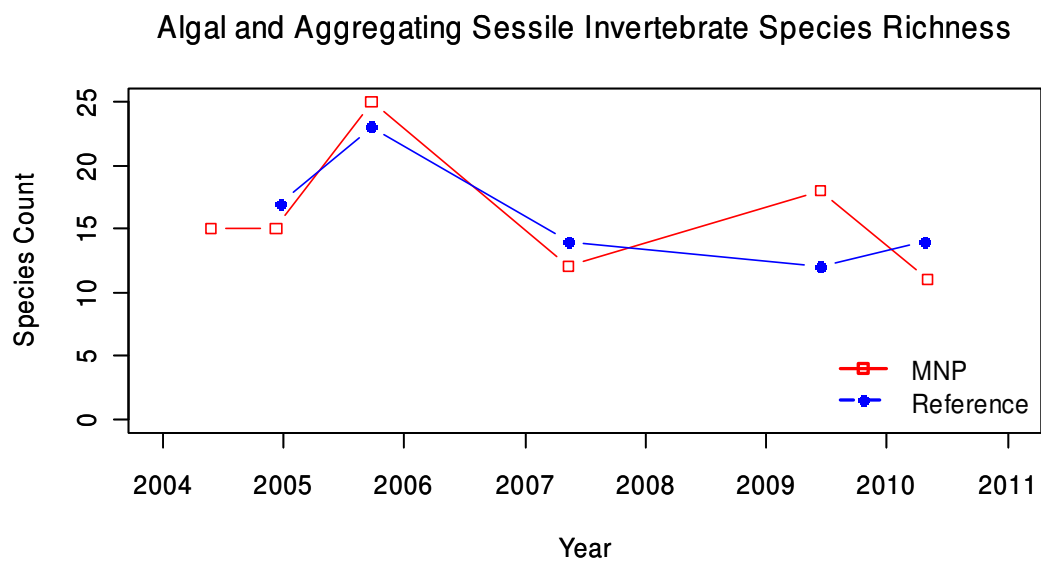


Figure 6.5. Algal and aggregating sessile invertebrate species richness of intertidal sites at Point Lonsdale within the Port Phillip Heads MNP, and the Cheviot Bay reference site.

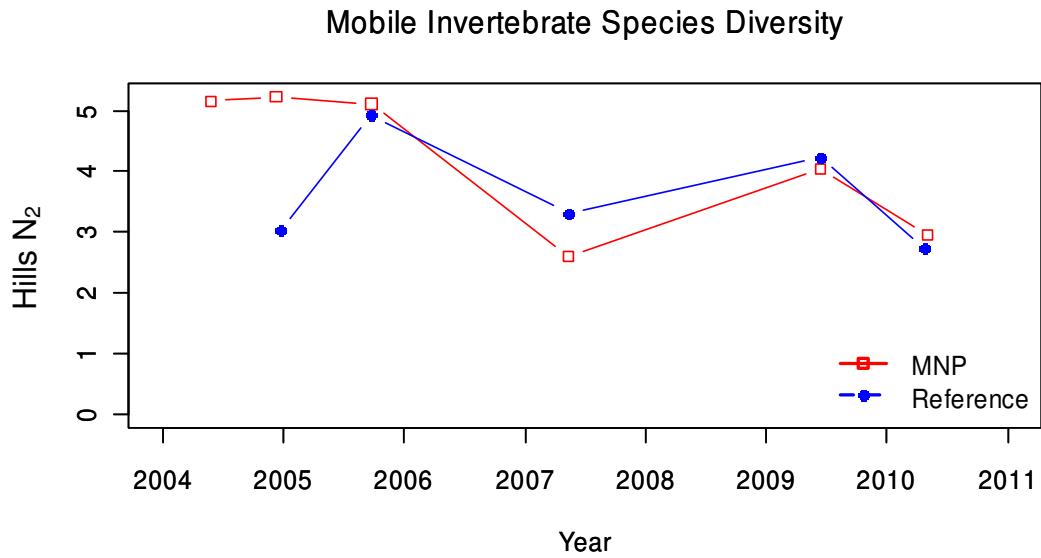


Figure 6.6. Mobile invertebrate diversity (Hills N₂) of intertidal sites at Point Lonsdale within the Port Phillip Heads MNP, and the Cheviot Bay reference site.

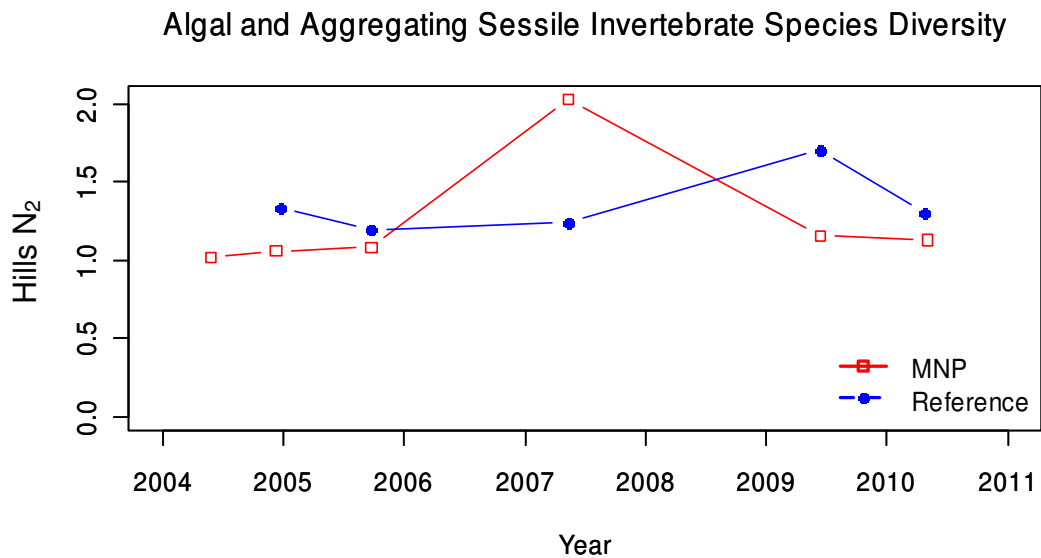


Figure 6.7. Algal and aggregating sessile invertebrate diversity (Hill's N₂) of intertidal sites at Point Lonsdale within the Port Phillip Heads MNP, and the Cheviot Bay reference site.

6.4 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*. Since 2005, the cover of *H. banksii* was usually around 10 % higher at Point Lonsdale than Cheviot Bay; however, in 2010 cover at both sites was approximately the same, at 70 % (Figure 6.8). Coralline and turfing algae were consistently more abundant at Cheviot Bay, although they were present at only low densities, generally less than 5 %.

Sand inundation was similar at these sites, generally covering between 5 % and 10 % of the reef.

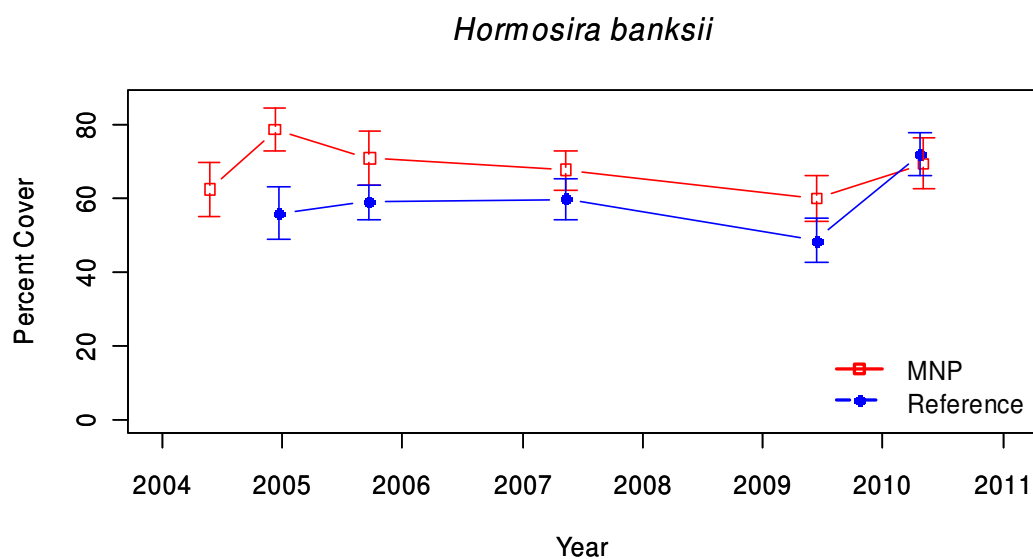


Figure 6.8. Mean density (\pm Standard Error) of Neptune's necklace *Hormosira banksii* at Point Lonsdale within the Port Phillip Heads MNP, and the Cheviot Bay reference site.

6.5 Mobile Invertebrates

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

Clypidina rugosa was the most abundant mobile invertebrate species at both Point Lonsdale and Cheviot Bay. Abundance of *C. rugosa* peaked at 51 per 0.25m² at Cheviot Bay in 2007. In 2010 there were 22 *C. rugosa* per 0.25m² at Cheviot Bay and 31 per 0.25m² at Point Lonsdale, the highest abundance recorded at this site. *Siphonaria* spp abundance was higher at Cheviot Bay than Point Lonsdale.

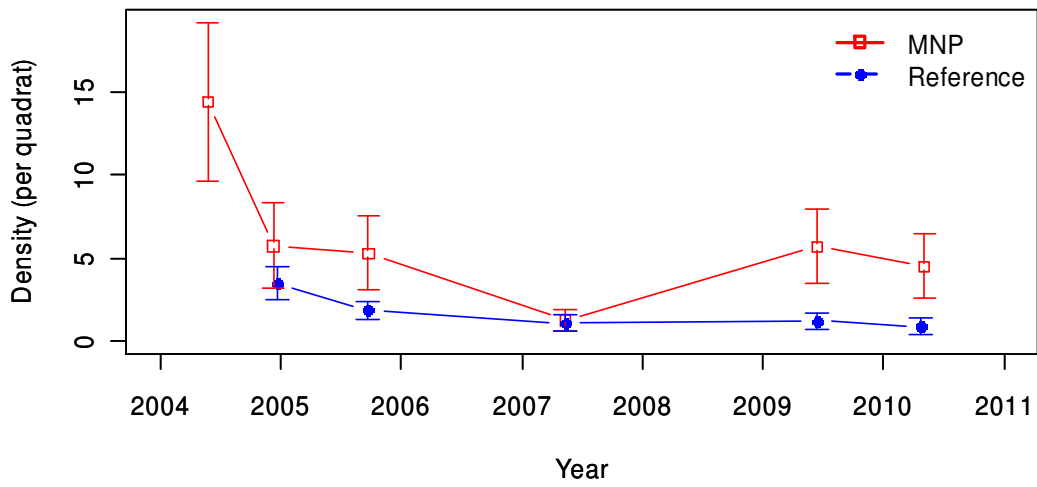
The mean density of *Cellana tramoserica* at Point Lonsdale decreased from 15 per 0.25 m² in 2004 to 5 per 0.25 m² in 2005 and has remained relatively stable since. Cheviot Bay generally had lower abundances of *C. tramoserica* (Figure 6.9).

The conniwink *Bembicium* spp was more common at Point Lonsdale than Cheviot Bay. Abundance has consistently declined at Cheviot Bay since monitoring began in 2004 (Figure 6.10).

The mean length of *Cellana tramoserica* has steadily increased at Point Lonsdale over the monitoring period to a similar size at Cheviot Bay during the 2010 survey (Figure 6.10).

a.

Cellana tramoserica



b.

Bembicium spp.

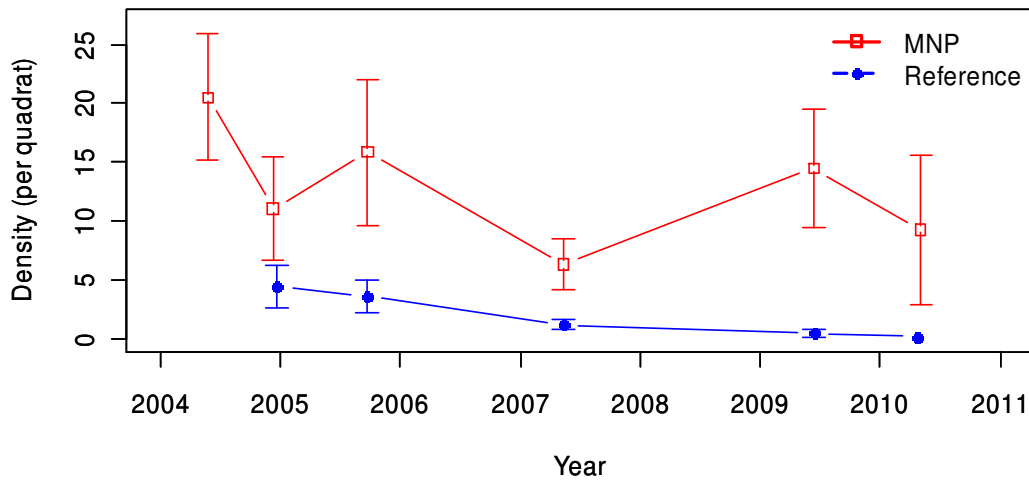


Figure 6.9. Mean density (\pm Standard Error) of: (a) the limpet *Cellana tramoserica*; and (b) the striped conniwink *Bembicium* spp, at Point Lonsdale within the Port Phillip Heads MNP, and the Cheviot Bay reference site.

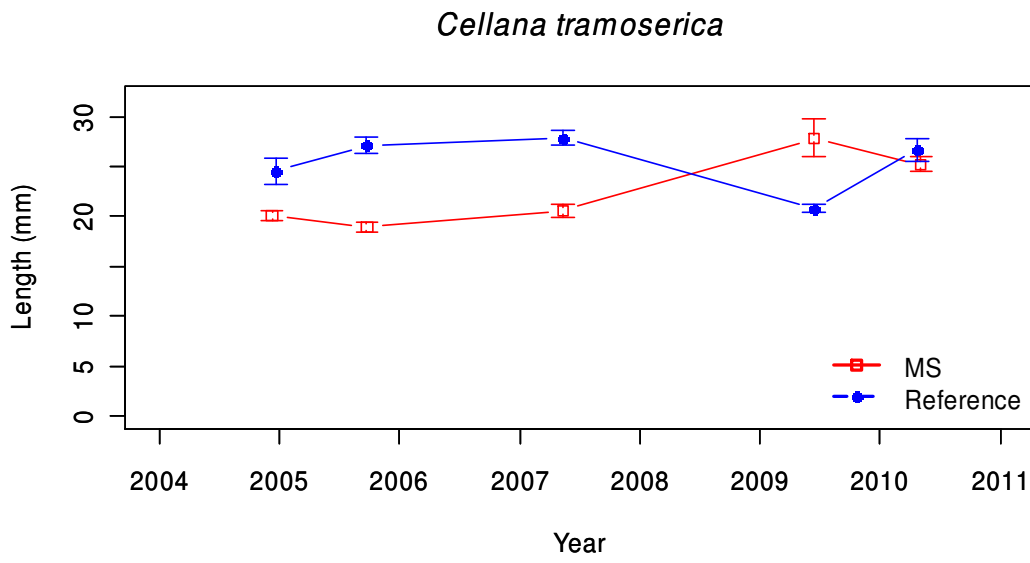


Figure 6.10. Mean sizes (\pm Standard Error) of the limpet *Cellana tramoserica* at Point Lonsdale within the Port Phillip Heads MNP, and the Cheviot Bay reference site.

6.6 Condition Indicators

Biodiversity

Community composition was within the range of states and changes previously observed.

Mobile invertebrate species richness was within the range previously observed. Algal and sessile invertebrate species richness was low at both the marine national park and reference sites. Mobile invertebrate diversity was also low, while algal and sessile invertebrate diversity was within the previously observed range.

Introduced Species

There were no introduced species detected for these sites.

Ecosystem Function

Total algae cover increased at both sites to 2010 after slight but steady declines since December 2004 (Figure 6.11a). Erect coralline algae and turfing algae cover were low and variable at Cheviot Bay and almost non-existent at Point Lonsdale (Figure 6.11b and 6.11c).

The total abundance of grazers at Point Lonsdale was within the range previously observed. The abundance of predators was higher than previously observed.

There was no apparent relationship between plant cover and grazer density.

Climate Change

There were no new species detected that were typically from adjacent bioregions.

Harvesting

Densities of *Cellana tramoserica* have been relatively stable at both sites since 2005. Fewer large *C. tramoserica* (30 mm to 50 mm) were measured in 2010 compared to 2009. This may indicate harvesting pressure on larger individuals; however it may also have arisen due to other factors, including observer error

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 variation through time.

Environment

The cover of green algal species indicative of nutrient loading was relatively low at these sites (Figure 6.13a).

Sediment cover at Point Lonsdale steadily increased from 2 % to 11 % between 2005 and 2009, before dropping to 5 % to 2010 (Figure 6.13b). Sediment cover has been highly variable at the reference site (Figure 6.13b).

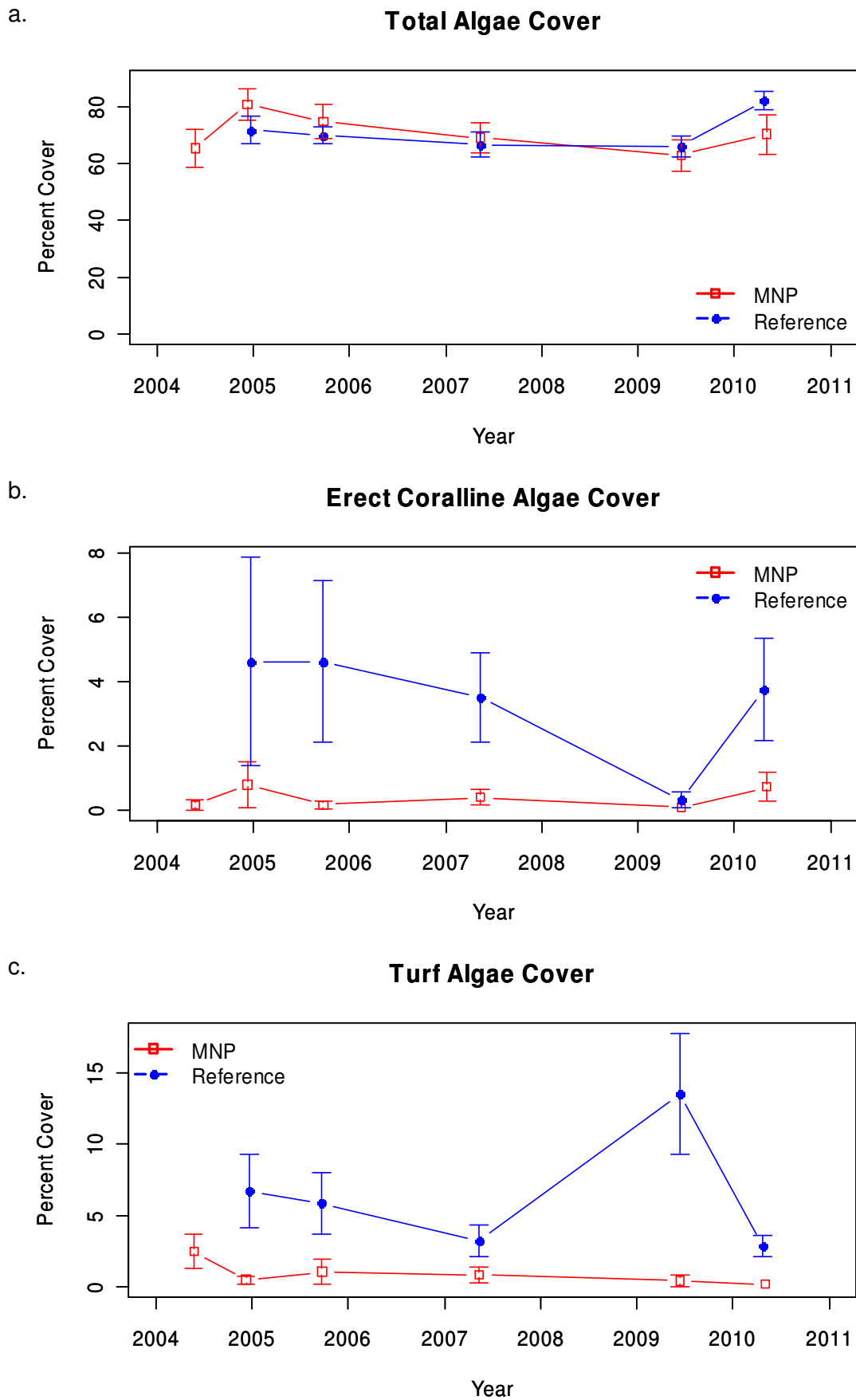
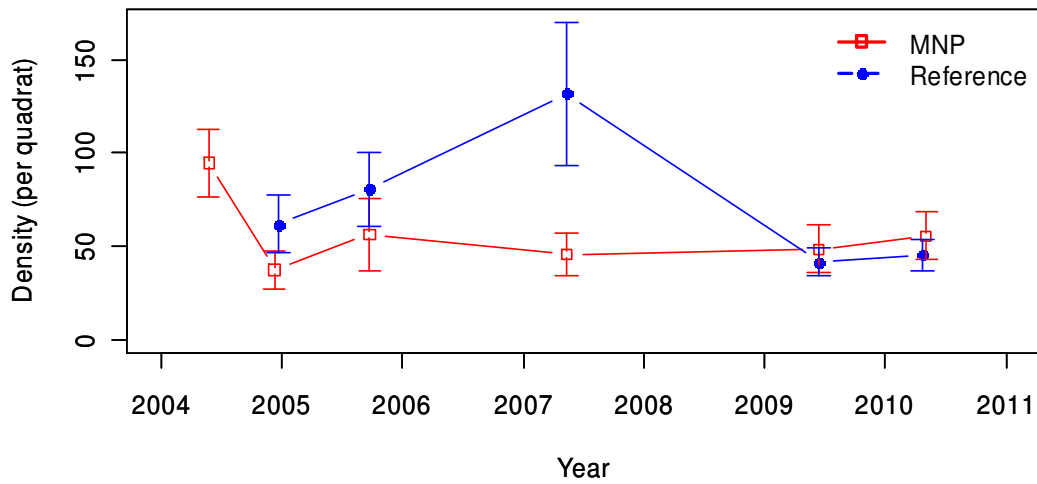


Figure 6.11. Mean cover (\pm Standard Error) of: (a) all algae; (b) erect coralline algae; and (c) turfing algae at Point Lonsdale within the Port Phillip Heads MNP, and the Cheviot Bay reference site.

a.

Total Grazers



b.

Total Predators

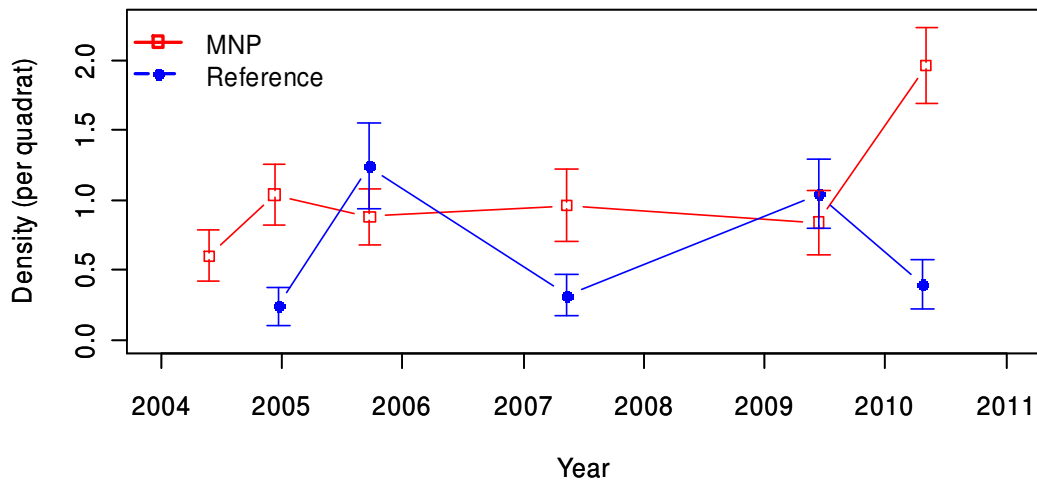
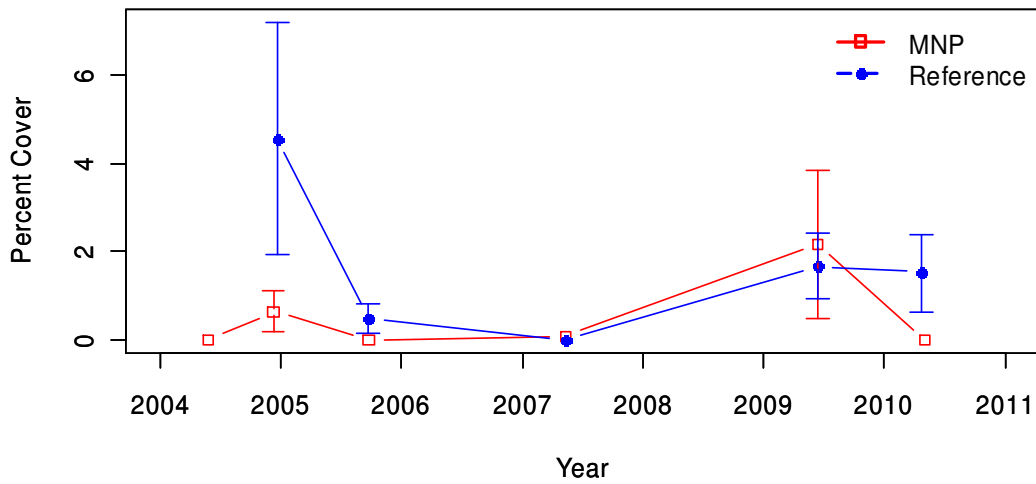


Figure 6.12. Mean abundance (\pm Standard Error) of: (a) all grazers; and (b) all predators at Point Lonsdale within the Port Phillip Heads MNP, and the Cheviot Bay reference site.

a.

Green Algae Cover



b.

Sediment Cover

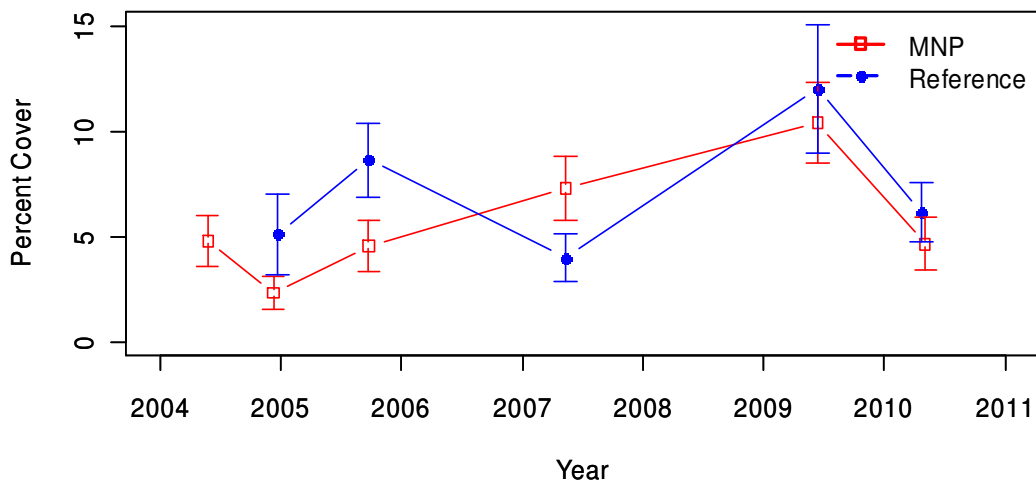


Figure 6.13. Mean cover (\pm Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Point Lonsdale within the Port Phillip Heads MNP, and the Cheviot Bay reference site.

7 MUSHROOM REEF MARINE SANCTUARY

7.1 Site Description and Transect Layout

7.1.1 Mushroom Reef Marine Sanctuary (Site 2907)

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 (Figure 7.1a). Sections of the isthmus tend to inundate with water soon after the tide begins to rise. The head of the mushroom is low-relief but uneven basalt reef with some pebbles and boulders (Figure 7.1b). 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 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 and separated by 25 m.

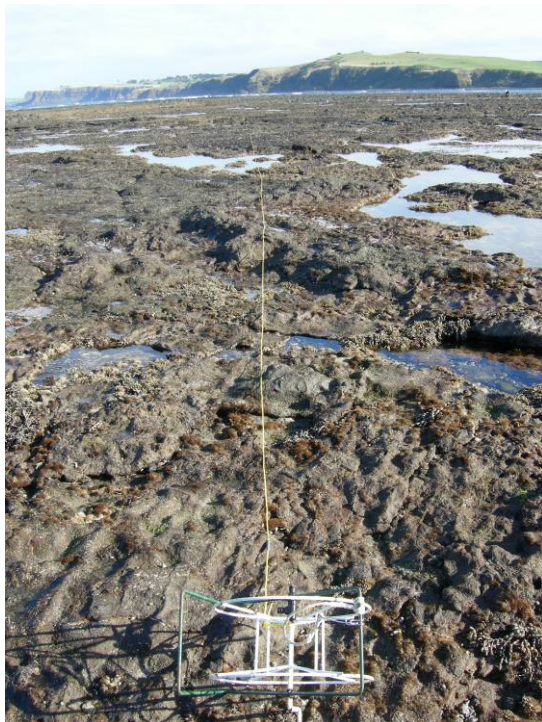
7.1.2 Flinders West Reference (Site 2908)

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

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 approximately 55 m long while the low shore baseline was approximately 70 m long. Transects increase in length along these baselines with Transect 1 measuring 27 m and Transect 5 measuring 62 m.



a.



b.



c.

Figure 7.1. Intertidal reef at Mushroom Reef Marine Sanctuary: (a) the cobble causeway, 8 June 2004; and b-c) the reef platform, 29 May 2009.



Figure 7.2. Intertidal reef at the Flinders West reference site, 8 June 2007.

7.2 Community Structure

The mobile invertebrate community at Mushroom Reef (Site 2907) was dominated by the top shell *Austrocochlea constricta*, conniwink *Bembicium* 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 similar variation through time at both Mushroom Reef and West Flinders. There is no distinction between these two sites (Figure 7.3a).

The algal and aggregating sessile invertebrate community structure was 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 West Flinders had greater variation in community structure through time. There is no distinction between these two sites (Figure 7.3b).

7.3 Diversity

The species richness of mobile invertebrate species was relatively stable at Mushroom Reef (Site 2907) and the reference West Flinders site (Site 2908) through time (Figure 7.4).

Algal and aggregating sessile invertebrate species richness at both sites showed fluctuations through time with no apparent trends (Figure 7.5).

Mobile invertebrate species diversity, in terms of Hills N_2 was relatively stable at Mushroom and more variable at West Flinders (Figure 7.6). Since the 2007 survey species diversity at both sites has decreased, a more substantial decrease at West Flinders.

Algal and aggregating sessile invertebrate species diversity followed similar patterns at both sites. There was a peak during the 2009 surveys that was more pronounced at the West Flinders site.

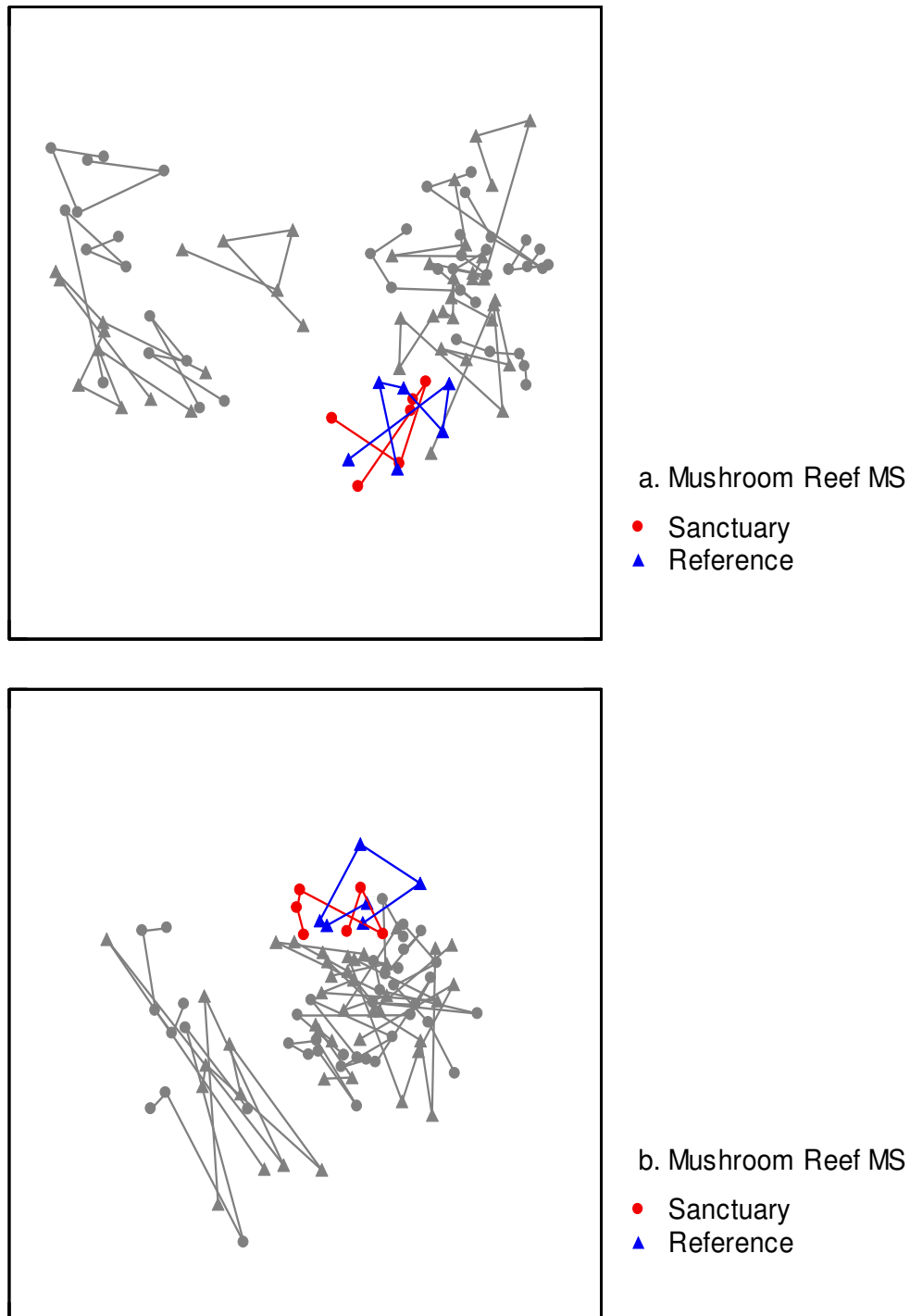


Figure 7.3. Two dimensional MDS plot of invertebrate assemblages on intertidal reefs at Mushroom Reef, within the Mushroom Reef MS, and the West Flinders reference site. (a) Mobile Invertebrate, Kruskal stress = 0.2 and (b) Macroalgae and Aggregating Sessile Invertebrates, Kruskal stress = 0.08. The grey lines represent data from all other intertidal sites used in the MDS analysis.

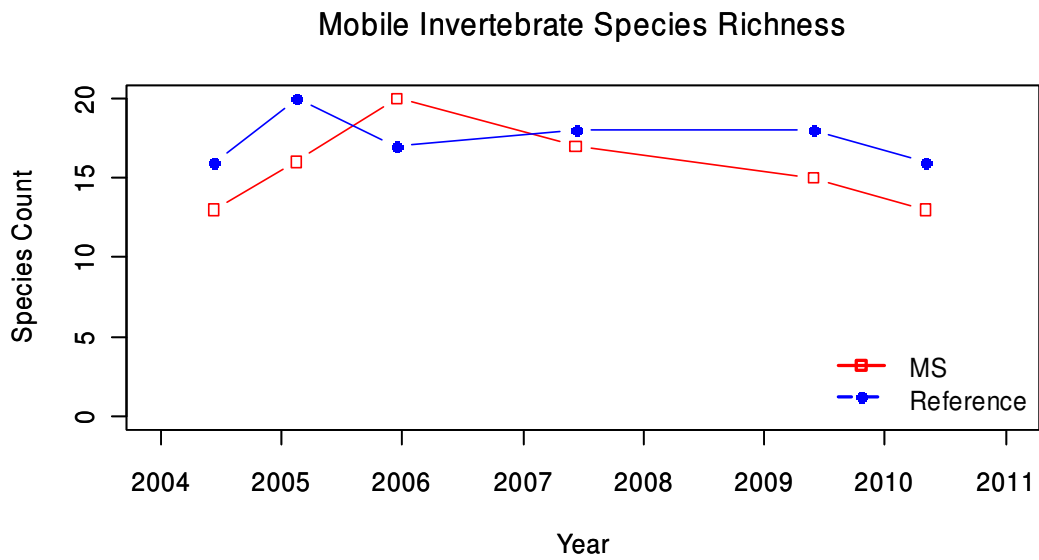


Figure 7.4. Mobile invertebrate species richness at Mushroom Reef, within the Mushroom Reef MS, and the West Flinders reference site.

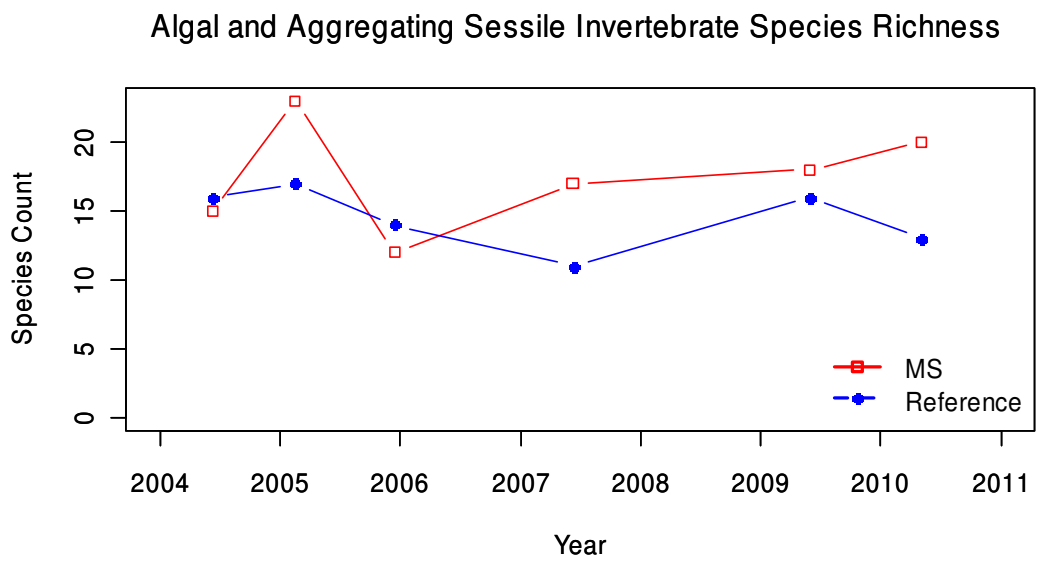


Figure 7.5. Algal and aggregating sessile invertebrate species richness of intertidal sites at Mushroom Reef, within the Mushroom Reef MS, and the West Flinders reference site.

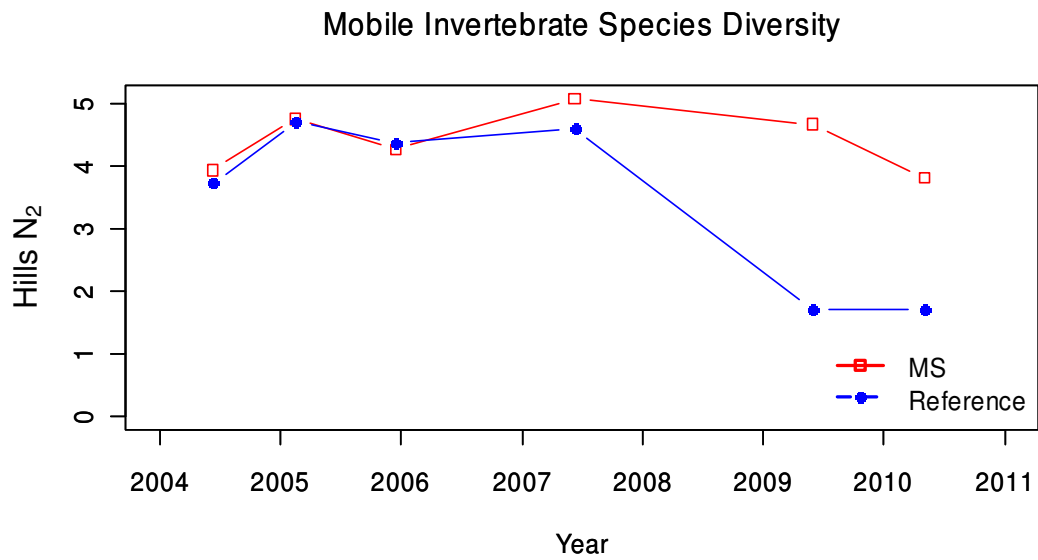


Figure 7.6. Mobile invertebrate diversity (Hills N₂) of intertidal sites at Mushroom Reef, within the Mushroom Reef MS, and the West Flinders reference site.

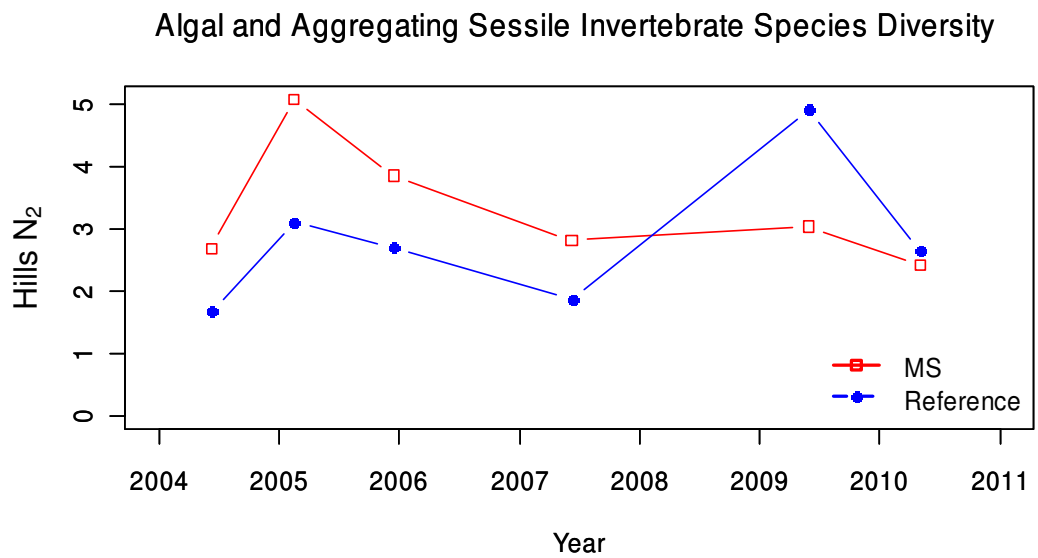


Figure 7.7. Algal and aggregating sessile invertebrate diversity (Hill's N₂) of intertidal sites at Mushroom Reef, within the Mushroom Reef MS, and the West Flinders reference site.

7.4 Macroalgae and Aggregating Sessile Invertebrates

The abundance of 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 13 and less than 1 % cover over time (Figure 7.8). The sea lettuce *Ulva* spp was present in low densities, less than 7 % up to 2005, it was not recorded during subsequent surveys.

Macroalgal cover at West Flinders (Site 2908) was variable through surveys. Cover of *H. banksii* appears to be increasing from the 2007 survey after a substantial decrease between 2005 and 2007 (Figure 7.8). The cover of the seagrass *Zostera muelleri*, has been recorded on and off at Flinders West since 2004, in low densities.

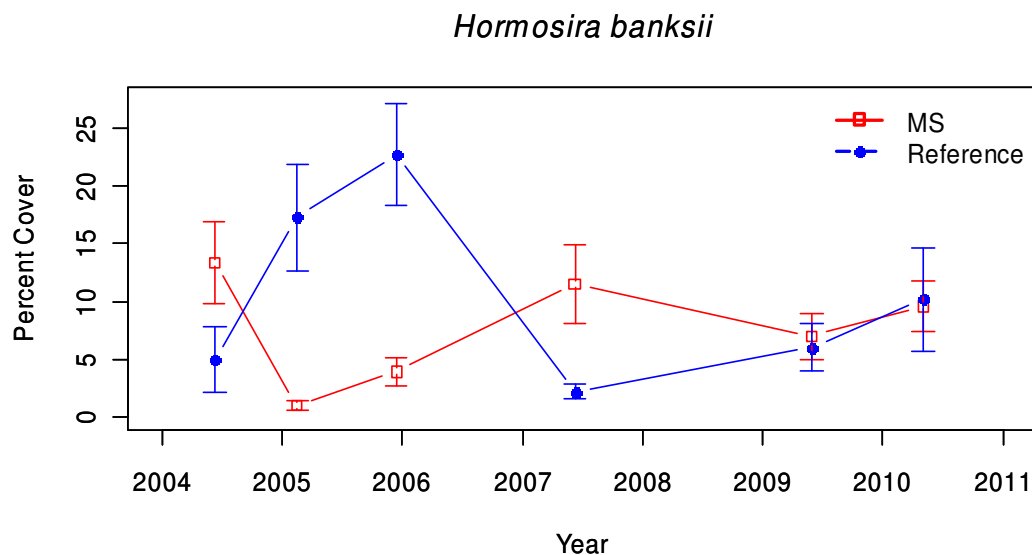


Figure 7.8. Mean density (\pm Standard Error) of Neptune's necklace *Hormosira banksii* at Mushroom Reef, within the Mushroom Reef MS, and the West Flinders reference site.

7.5 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 coniwink *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* was consistently higher at Mushroom Reef (Figure 7.9a). Abundances had peaked in 2007 to 27 individuals 0.25 m⁻² decreasing during subsequent surveys to 12 individuals 0.25 m⁻² in 2010. Densities at West Flinders were relatively stable over time (Figure 7.9a).

Bembicium nanum trends were relatively consistent over sites. Densities at Mushroom Reef were higher than at the reference site (Figure 7.9b).

The mean size of *Bembicium nanum* followed similar patterns through time at both sites, the mean size recorded at either site during 2010 is almost the same. The mean size remained relatively stable ranging from 6 mm to 10 mm (Figure 7.10a).

The mean size of *A. constricta* was variable through time showing no clear patterns (Figure 7.10b).

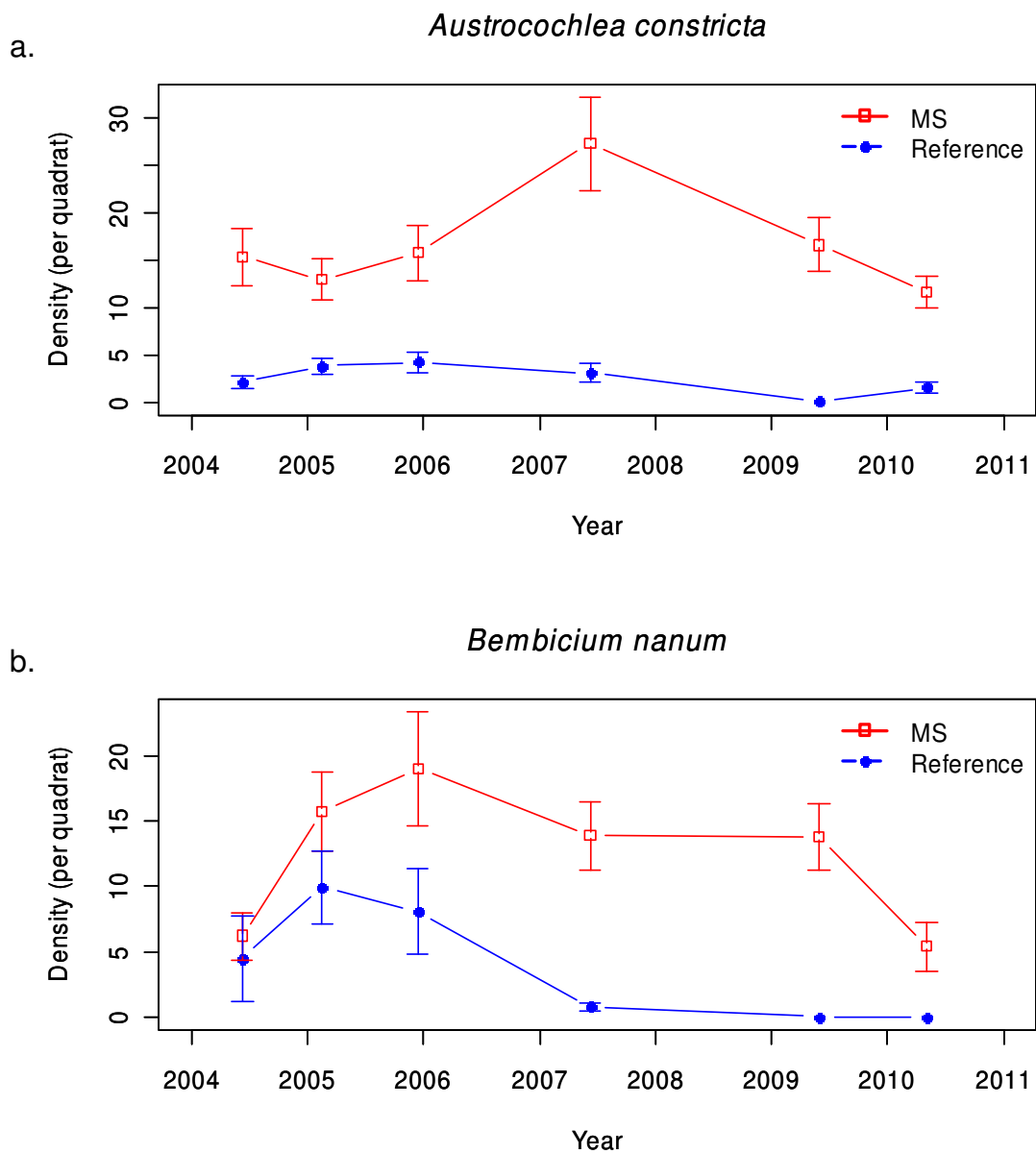


Figure 7.9. Mean density (\pm Standard Error) of: (a) the top shell *Austrocochlea constricta*; and (b) the striped coniwink *Bembicium nanum* at Mushroom Reef, within the Mushroom Reef MS, and the West Flinders reference site.

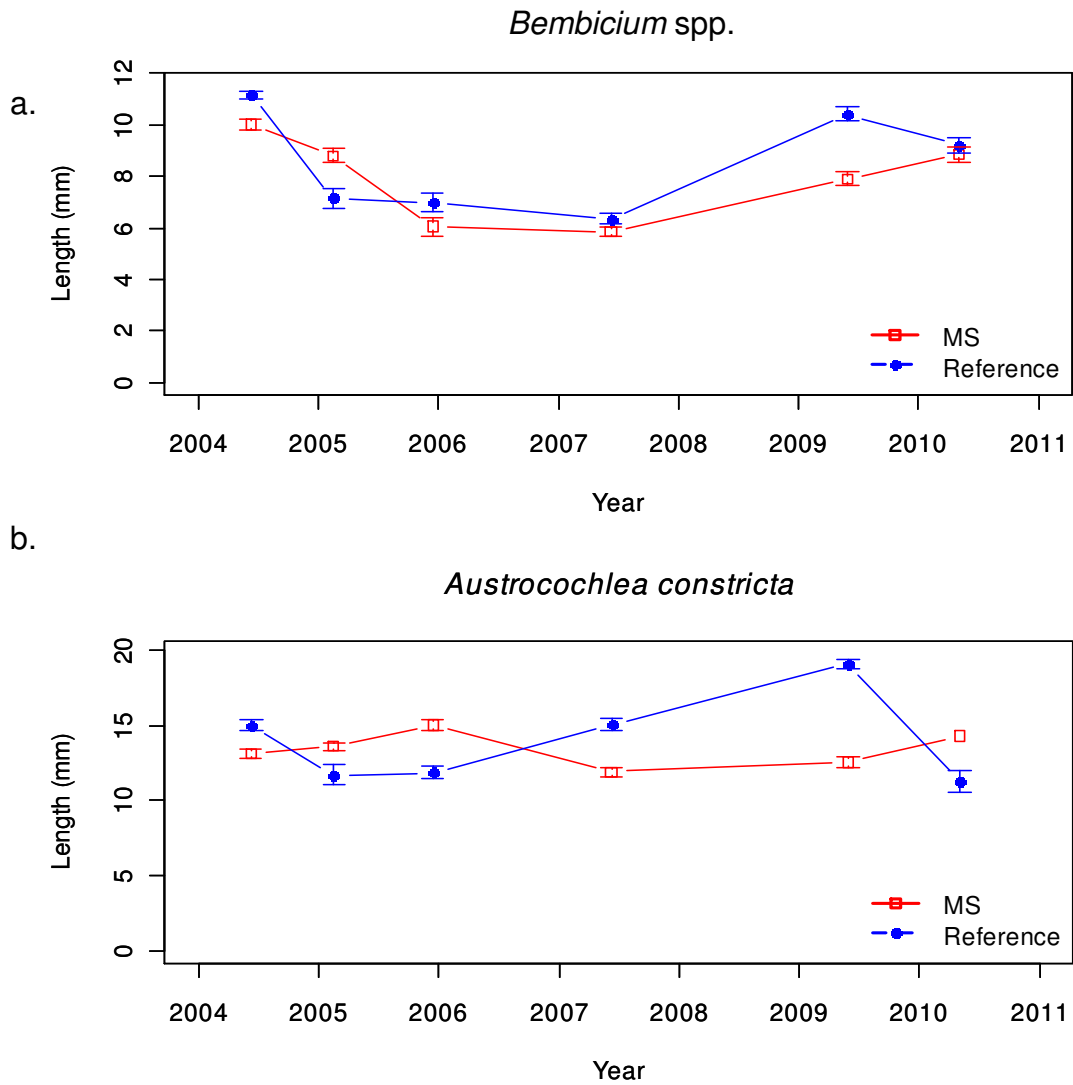


Figure 7.10. Mean sizes (\pm Standard Error) of: (a) the conniwink *Bembicium* spp. And (b) the top shell *Austrocochlea constricta* at Mushroom Reef, within the Mushroom Reef MS, and the West Flinders reference site.

7.6 Condition Indicators

Biodiversity

Community composition was within the range of states and changes previously observed. Species diversity levels had decreased in 2010 for both mobile invertebrate and algal and other sessile invertebrates.

Introduced Species

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

Ecosystem Function

The cover of Total Algae, encrusting corallines and algal turf followed similar patterns. The Mushroom Reef site was more stable compared to the variability at West Flinders (Figure 7.11a-c). Cover was consistently higher at West Flinders over surveys (Figure 7.11a- c).

The total abundance of grazers was predominantly greater at Mushroom Reef, with the exception of 2010. Densities of grazers at this site have been decreasing since the 2005 survey (Figure 7.12a). Total abundance of predators was variable at both sites. Densities were greater at Mushroom Reef following the 2005 survey (Figure 7.12b).

Climate Change

There were no new species detected that were typically from adjacent bioregions.

Harvesting

Densities of *Bembicium* spp. have followed similar patterns at both Mushroom Reef and West Flinders (Figure 7.10a). The mean size decreased between 2004 and 2005 then increasing over subsequent surveys. The mean size of *Austrocochlea porcata* was relatively constant at Mushroom Reef compared to the variable West Flinders site (Figure 7.10b). These results did not provide clear indications of changes in harvesting pressure.

Trampling

The fluctuation of *Hormosira banksii* densities indicating trampling is not presently a constraining factor to the population.

Environment

The cover of green algal species indicative of nutrient loading was relatively low, <2 % cover at West Flinders. Cover at Mushroom Reef fluctuated between 2004 and 2005 up to 8 % before decreasing to <2 % in subsequent surveys (Figure 7.13a). Sediment cover remained low <2 % over survey times (Figure 7.13b).

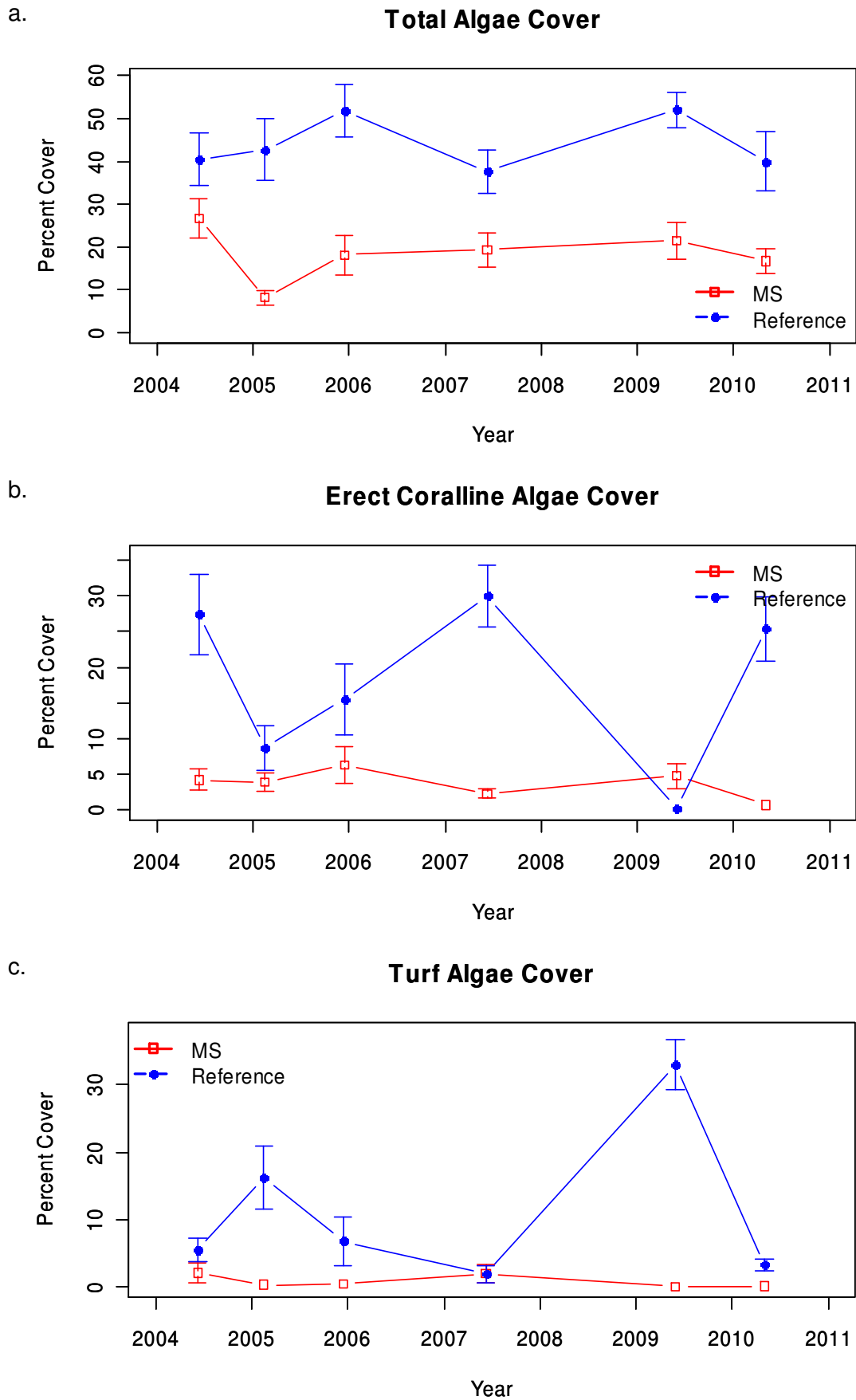
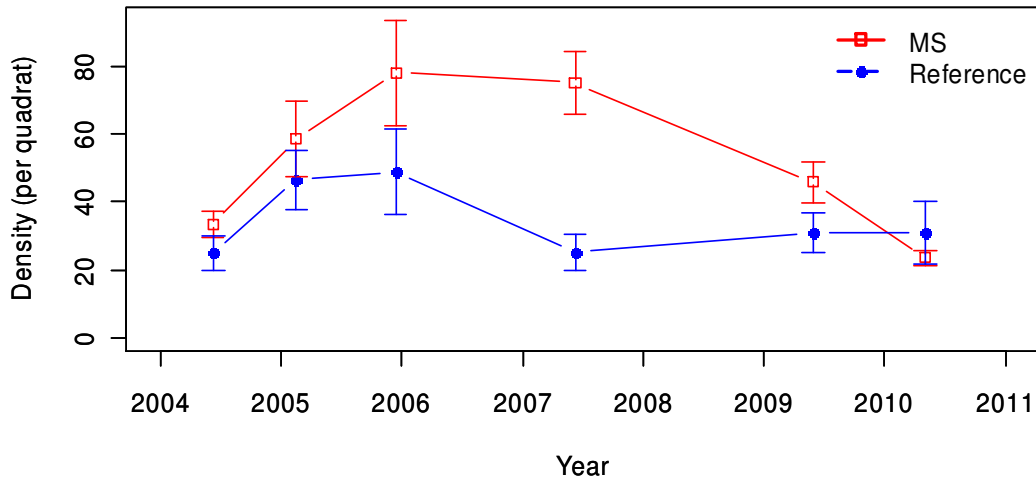


Figure 7.11. Mean cover (\pm Standard Error) of: (a) all algae; (b) erect coralline algae; and (c) turfing algae at Mushroom Reef, within the Mushroom Reef MS, and the West Flinders reference site.

a.

Total Grazers



b.

Total Predators

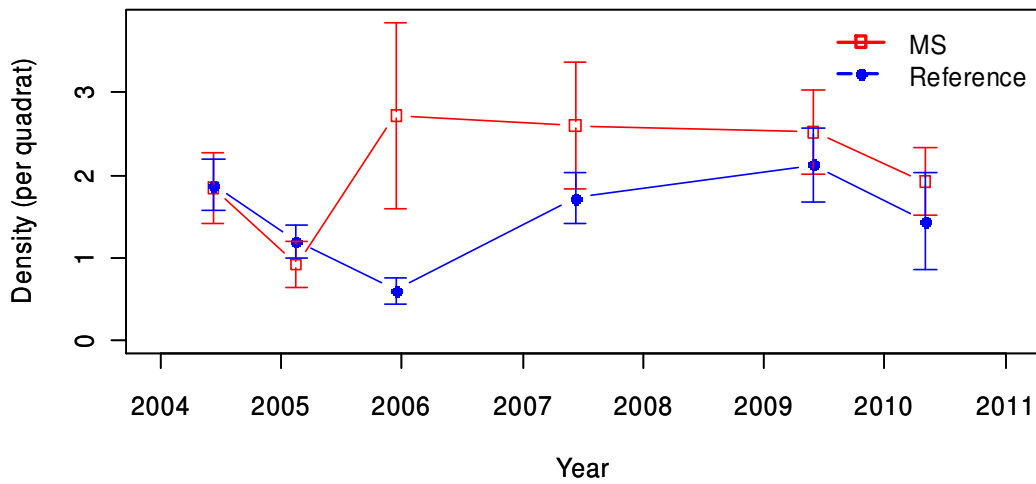
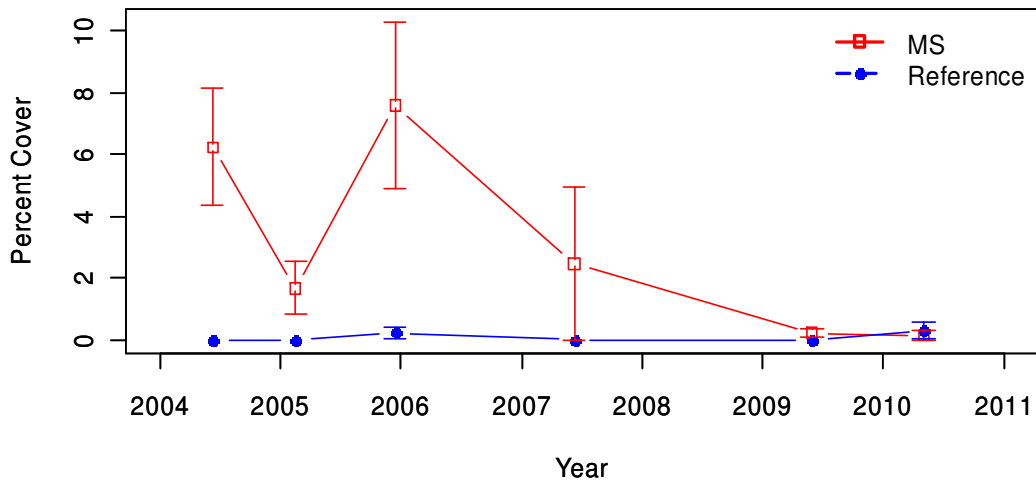


Figure 7.12. Mean abundance (\pm Standard Error) of: (a) all grazers; and (b) all predators at Mushroom Reef, within the Mushroom Reef MS, and the West Flinders reference site.

a.

Green Algae Cover



b.

Sediment Cover

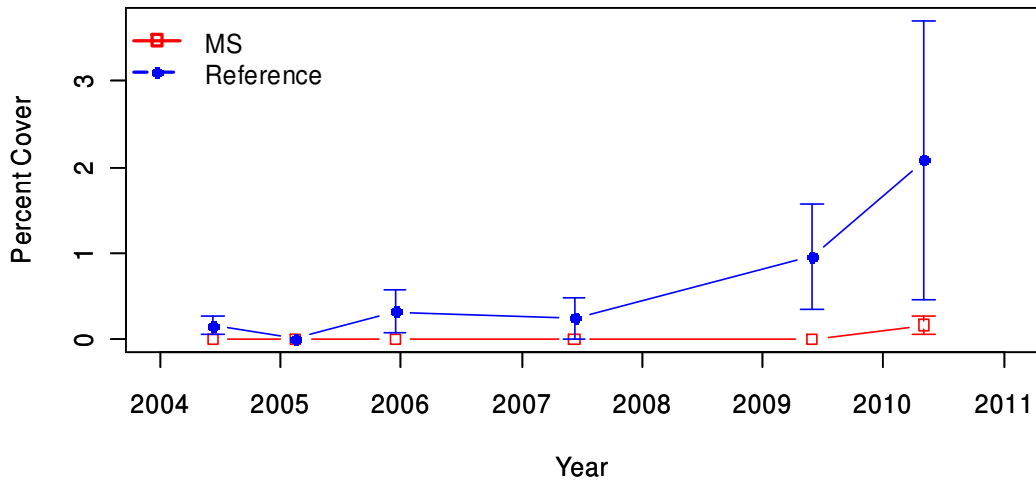


Figure 7.13. Mean cover (± Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Mushroom Reef, within the Mushroom Reef MS, and the West Flinders reference site.

8 BUNURONG MARINE NATIONAL PARK

8.1 Site Description and Transect Layout

8.1.1 Eagles Nest (Site 3020)

There were many potential intertidal reefs within the Bunurong Marine National Park that could have been monitored. 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 predominant 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 not directly exposed to the prevailing south and southwest swell. The reef platform is relatively flat with little relief (Figure 8.1).

High and low shore baselines were 56 m and 48 m, respectively. The transects range in length from 25 m at Transect 1 to 50 m at Transect 5.

8.1.2 Caves Reference (Site 3021)

The reference site is at the Caves (Site 3021), located to the east of Bunurong Marine National Park. The site is 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 (Figure 8.2). On the eastern end of the survey area (Transect 5), there is more structure with large rocky outcrops towards the high shore level. Baselines were 48 m long and transects ranged from 80 m in length at Transect 1 to 100 m in length at Transect 5.



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



a.



b.

Figure 8.2. Intertidal reef at the Caves reference site, 7 June 2007, showing (a) the study area and (b) the limpet *Cellana tramoserica*.

8.2 Community Structure

The mobile invertebrate community structure at Eagles Nest (3020) and the reference Caves (Site 3021) is similar. The communities were largely composed of the coniwink *Bembicium* spp., periwinkles *Nodilittorina acutispira* and *Nodilittorina unifasciata*, and *Siphonaria* spp. The MDS analysis of mobile invertebrate communities showed Eagles Nest to have greater assemblage stability over time compared with the Caves site (Figure 8.3a).

The algal and aggregating sessile invertebrate community structure was 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 analysis showed similar variation between survey times for both Eagles Nest and the reference Caves site. There is no distinction between the two sites (Figure 8.3b).

8.3 Diversity

Mobile invertebrate species richness at Eagles Nest has steadily decreased from 20 species per site from the first survey in 2004 to 13 species in 2010. Species richness at the Caves was more variable through time (Figure 8.4).

Algal and sessile invertebrate species richness was consistently similar between sites, with the exception of the first survey in 2004. Trends were variable at over time ranging between 13 and 19 species per site (Figure 8.5).

Mobile invertebrate species diversity, in terms of Hills N_2 was relatively stable at Eagles Nest and more variable at the Caves over time. Species diversity was higher at the Caves site in 2010 than previously recorded (Figure 8.6).

Algal and sessile invertebrate species diversity showed consistent patterns at both sites, with the exception of the 2009 survey. In 2009 Eagles Nest dropped whilst the reference Caves site increased to the highest level recorded (Figure 8.7).

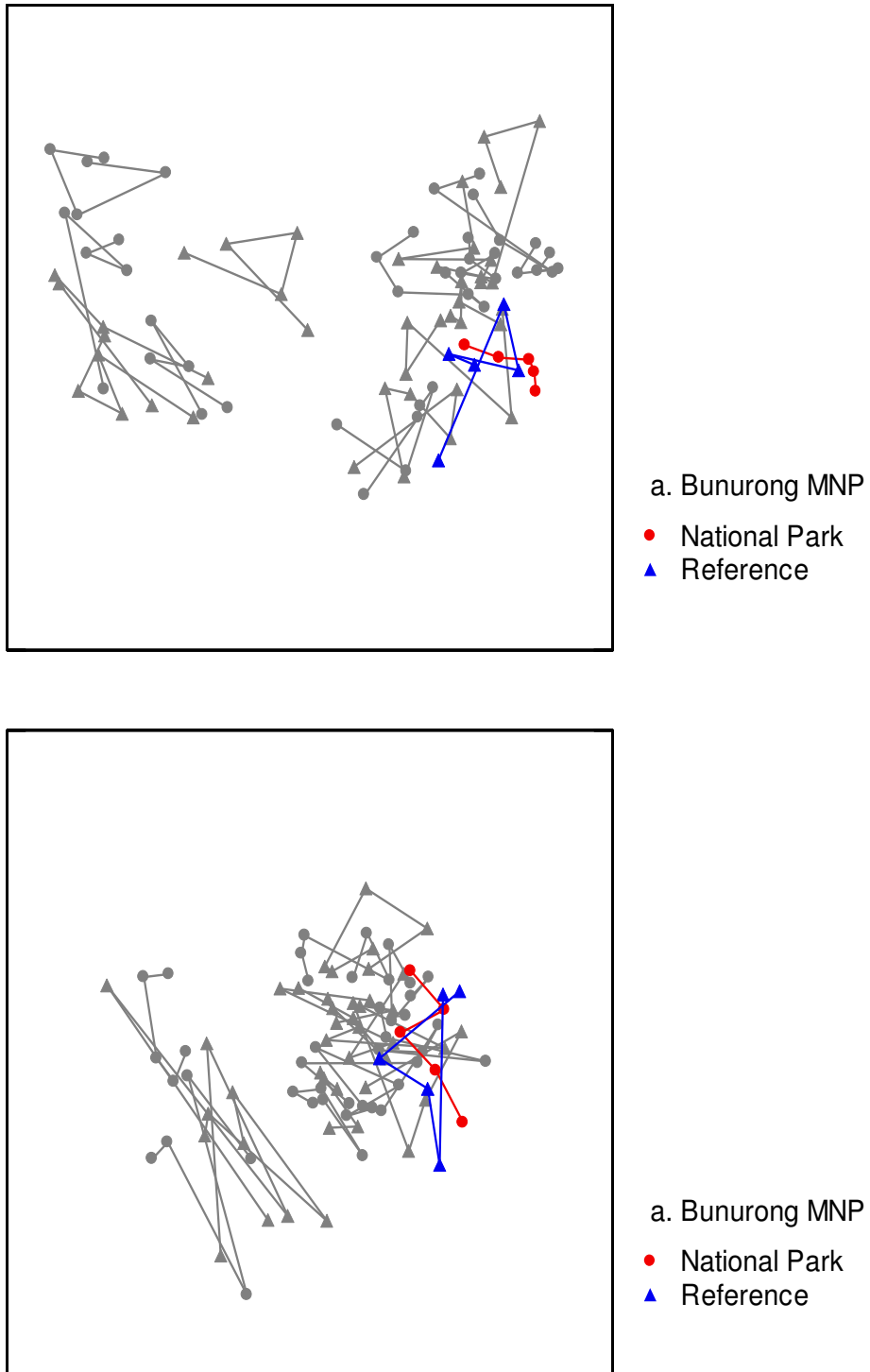


Figure 8.3. Two dimensional MDS plot of invertebrate assemblages on intertidal reefs at Eagles Nest, within the Bunurong MNP, and the Caves reference site. (a) Mobile Invertebrate, Kruskal stress = 0.2 and (b) Macroalgae and Aggregating Sessile Invertebrates, Kruskal stress = 0.8. The grey lines represent data from all other intertidal sites used in the MDS analysis.

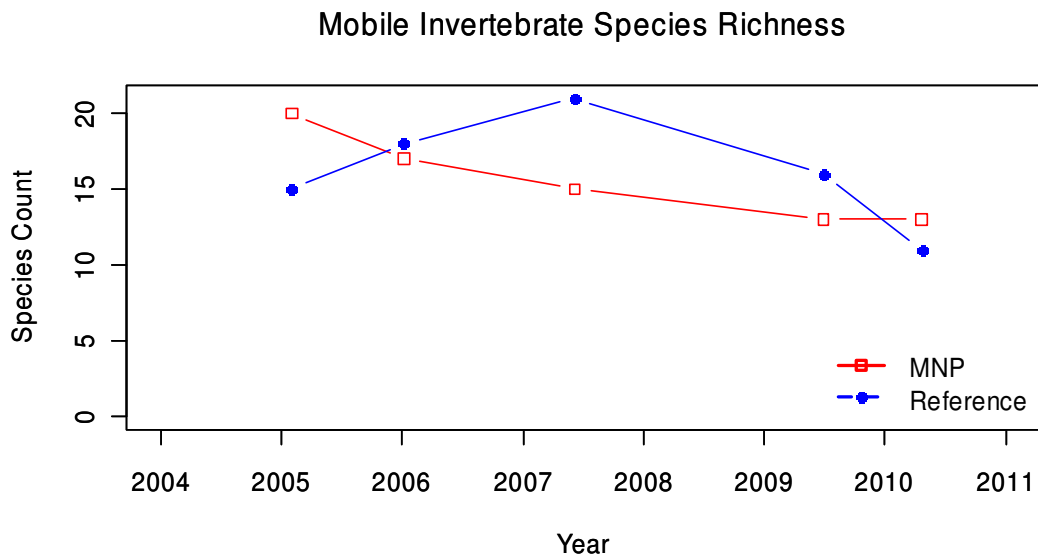


Figure 8.4. Mobile invertebrate species richness at Eagles Nest, within the Bunurong MNP, and the Caves reference site.

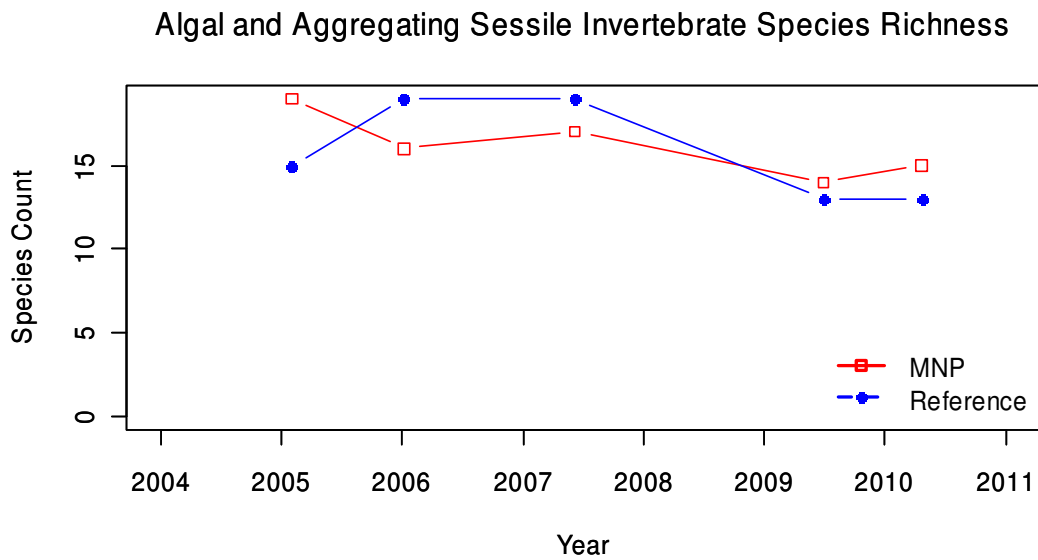


Figure 8.5. Algal and aggregating sessile invertebrate species richness of intertidal sites at Eagles Nest, within the Bunurong MNP, and the Caves reference site.

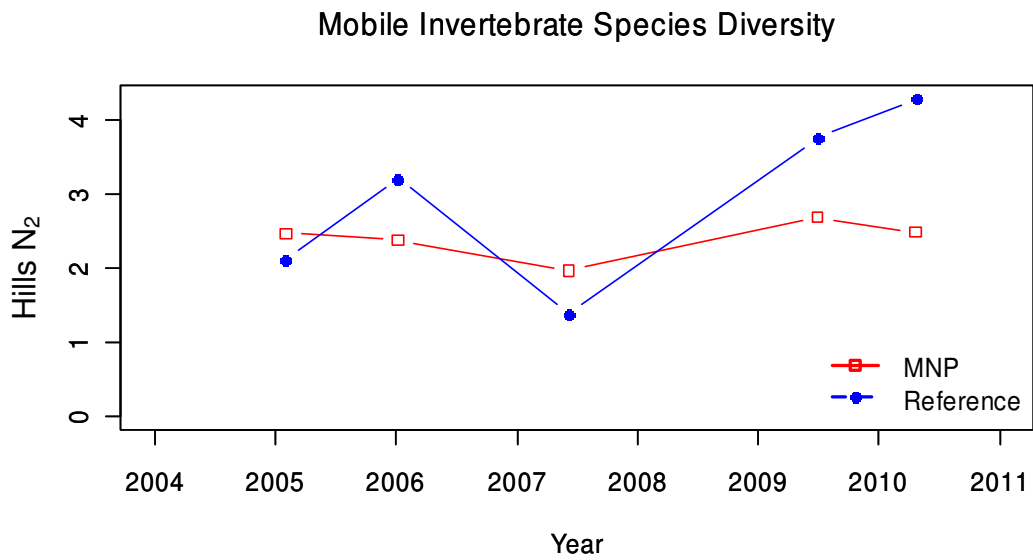


Figure 8.6. Mobile invertebrate diversity (Hills N₂) of intertidal sites at Eagles Nest, within the Bunurong MNP, and the Caves reference site.

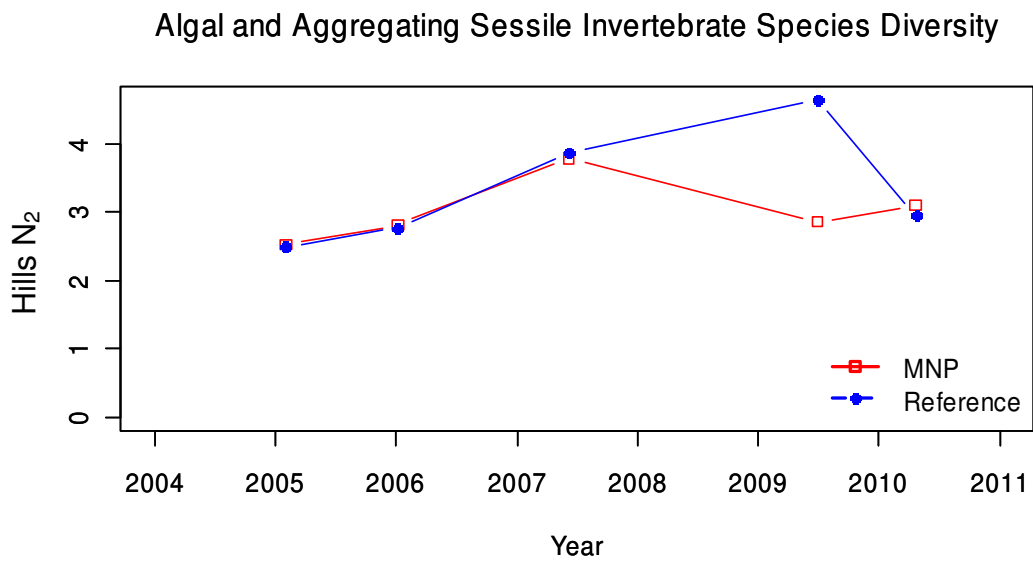


Figure 8.7. Algal and aggregating sessile invertebrate diversity (Hill's N₂) of intertidal sites at Eagles Nest, within the Bunurong MNP, and the Caves reference site.

8.4 Macroalgae and Aggregating Sessile Invertebrates

The species abundances of macroalgae and sessile organisms was generally similar between the two sites.

The cover of the brown algae Neptune's necklace *Hormosira banksii* was relatively stable through time with consistently low cover (Figure 8.8). The mat forming mussel *Xenostrobus pulex* steadily increased at both sites between 2007 and 2010, again in low densities. Sand cover at both sites had been variable through time with no consistent patterns.

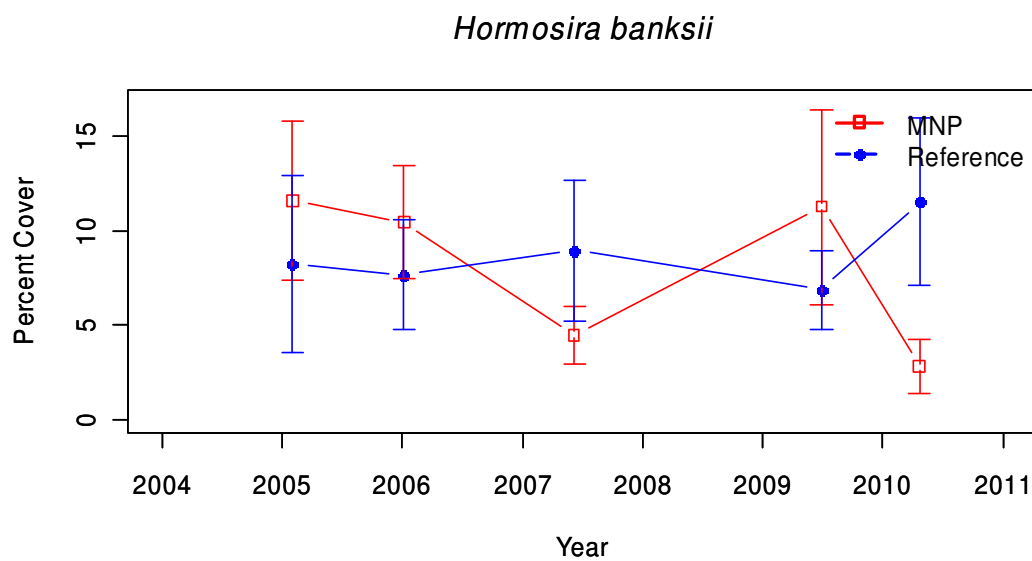


Figure 8.8. Mean density (\pm Standard Error) of Neptune's necklace *Hormosira banksii* at Eagles Nest, within the Bunurong MNP, and the Caves reference site.

8.5 Mobile Invertebrates

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

The mean density of *Nodilittorina unifasciata* at Eagles Nest followed a similar pattern to the Caves site. The abundance increased at both sites during 2010, to the highest recorded for Eagles Nest (Figure 8.9a). This coincided with a significant decrease in species *Nodilittorina acutispira* at both sites. It is worth noting there were no *N. acutispira* individuals recorded at the Caves during the 2010 survey.

Densities of *B. nanum* at Eagles Nest remained stable except for the last year. At Eagles Nest abundances increased 4 fold from 55 to 241 individuals per 0.25 m² (Figure 8.9b). *C. tramoserica* consistently present at these two sites in low densities (Figure 8.9c).

There were no apparent trends in the mean size of *C. tramoserica*, although it did increase at both sites during 2010 (Figure 8.10).

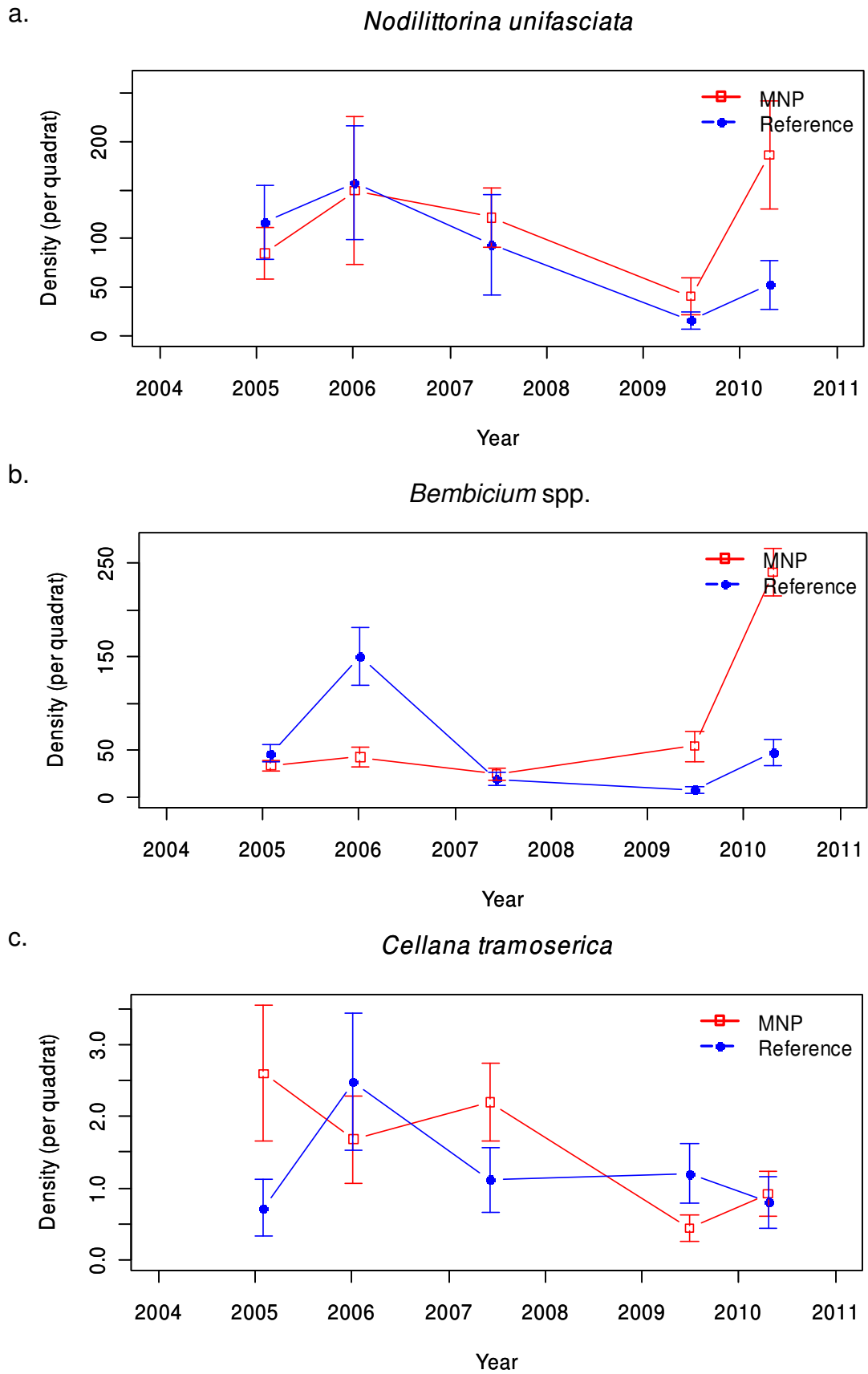


Figure 8.9. Mean density (\pm Standard Error) of (a) *Nodilittorina unifasciata*; (b) the striped conniwink *Bembicium nanum*; and (c) the limpet *Cellana tramoserica* at Eagles Nest, within the Bunurong MNP, and the Caves reference site.

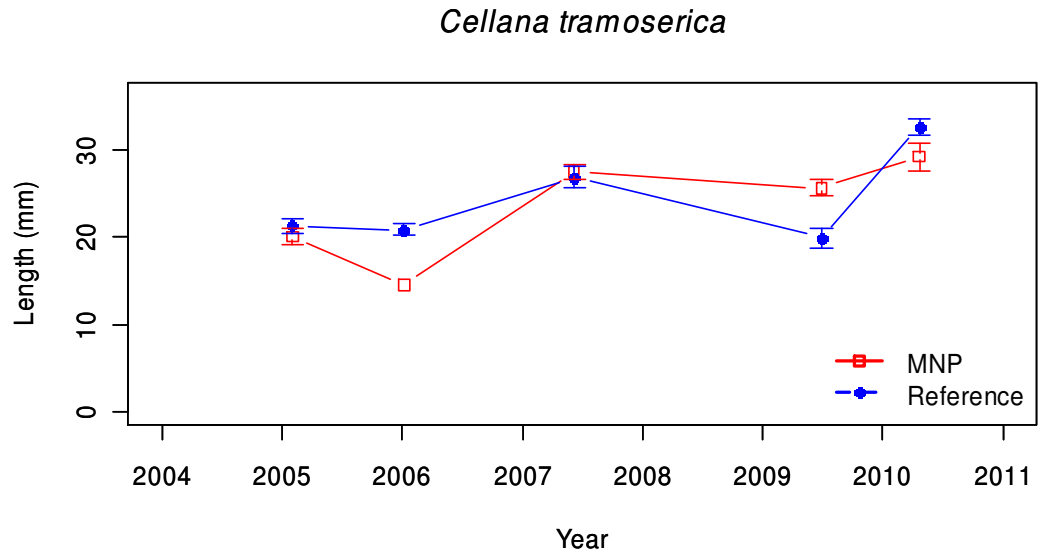


Figure 8.10. Mean sizes (\pm Standard Error) of the limpet *Cellana tramoserica* at Eagles Nest, within the Bunurong MNP, and the Caves reference site.

8.6 Condition Indicators

Biodiversity

Community composition was within the range of sites and changes previously observed.

Introduced Species

There were no introduced species 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 with no clear patterns or trends (Figure 8.11a and 8.11b). A drop in the cover of turfing algal at both sites during 2010 interrupted an increasing trend (Figure 8.11c).

The total abundance of grazers and predators has been variable over time. Abundances remained stable after a peak during the 2007 survey (Figure 8.12a and 8.12b).

Climate Change

There were no species typically of adjacent bioregions observed during the intertidal reef surveys in this area.

Harvesting

There were three main size cohorts of *Cellana tramoserica* during 2009 and 2010 at Eagles Nest, the Caves having two main size groups. The mean size had increased from 2009 to 2010 by 10 cm at both sites (Figure 8.10). The temporal patterns of mean sizes provide no clear indications of changes in harvesting pressure.

Trampling

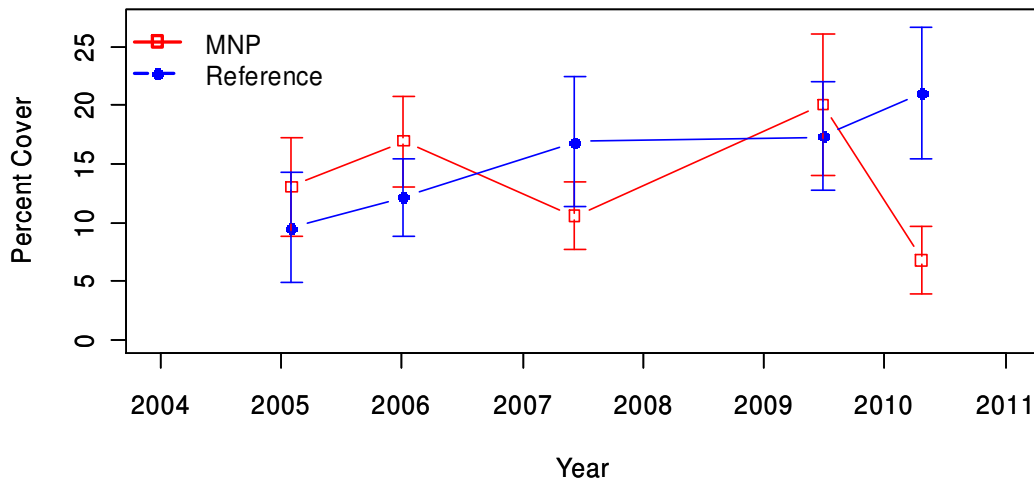
The fluctuation of *Hormosira banksii* densities (Figure 8.8) indicating trampling is not presently a constraining factor to the population.

Environment

The mean cover of green algal species indicative of nutrient loading was relatively low, <1 % cover at both sites during all surveys (Figure 8.13a). Sediment cover was variable at both sites over survey times ranging from 3 to 13 % cover (Figure 8.13b).

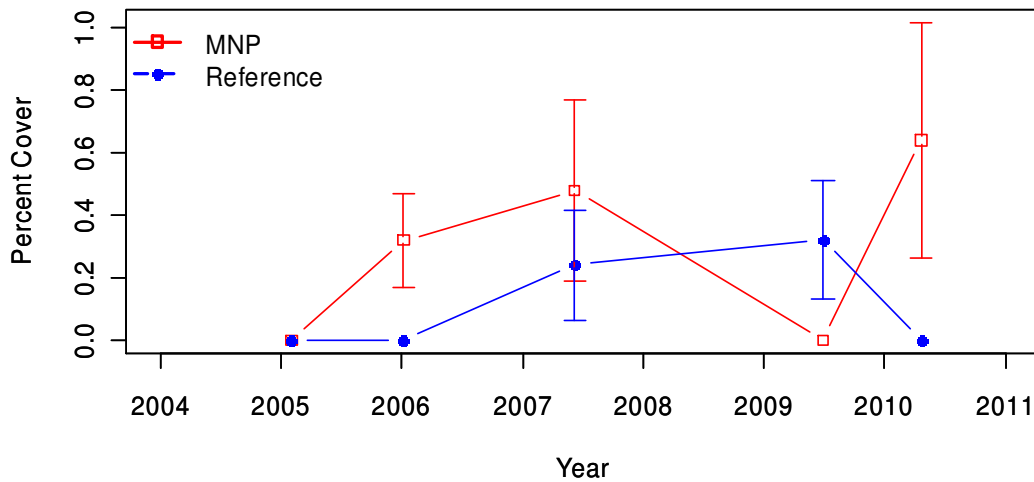
a.

Total Algae Cover



b.

Erect Coralline Algae Cover



c.

Turf Algae Cover

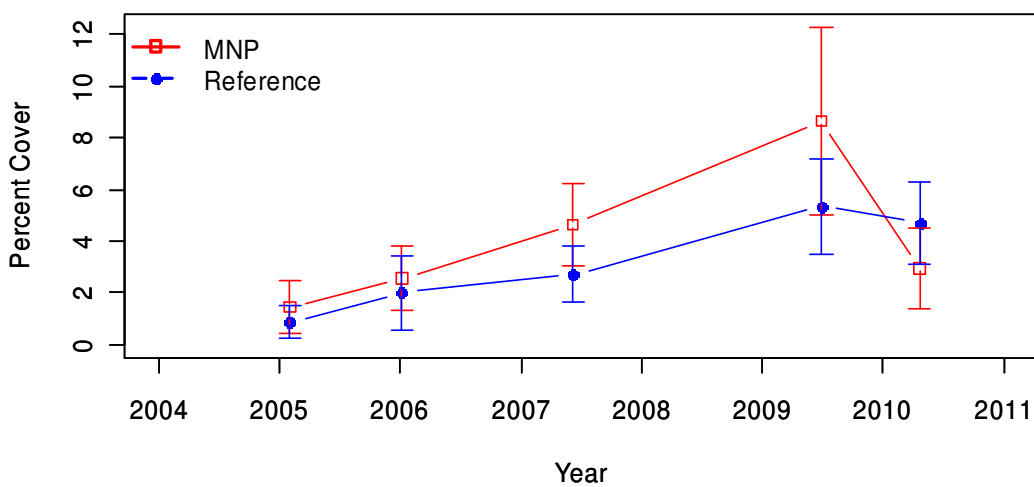
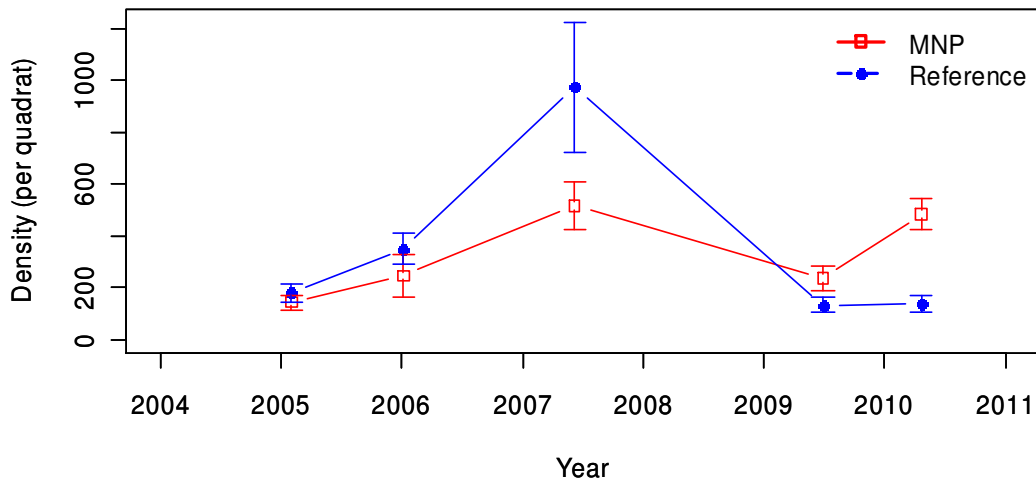


Figure 8.11. Mean cover (\pm Standard Error) of: (a) all algae; (b) erect coralline algae; and (c) turfing algae at Eagles Nest, within the Bunurong MNP, and the Caves reference site.

a.

Total Grazers



b.

Total Predators

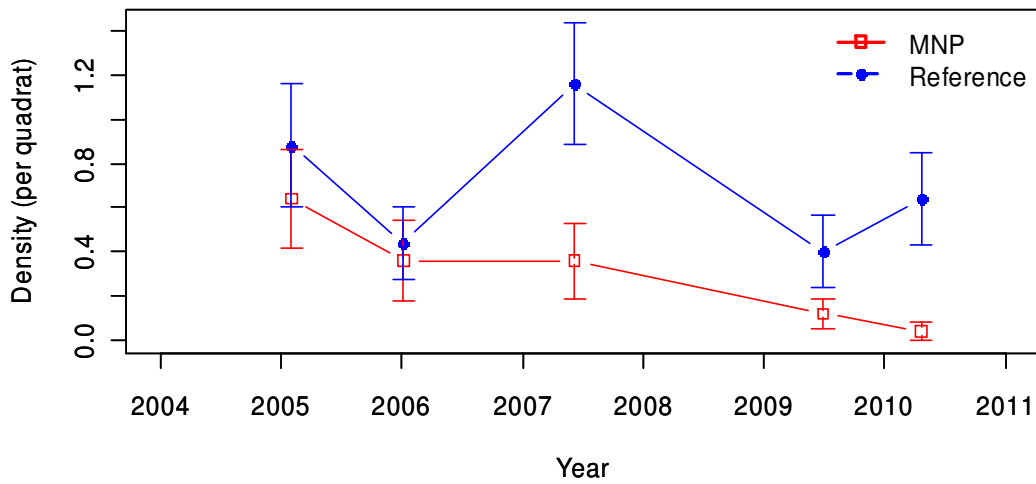
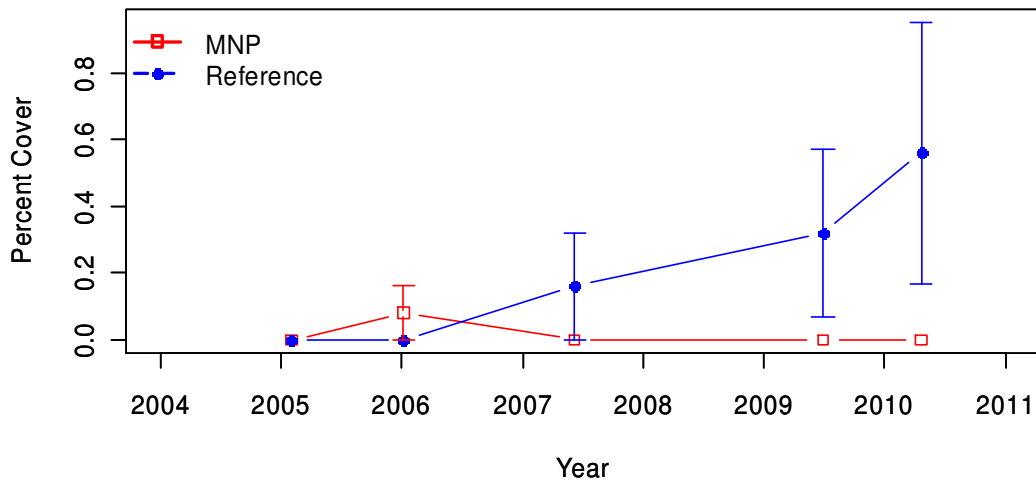


Figure 8.12. Mean abundance (\pm Standard Error) of: (a) all grazers; and (b) all predators at Eagles Nest, within the Bunurong MNP, and the Caves reference site.

a.

Green Algae Cover



b.

Sediment Cover

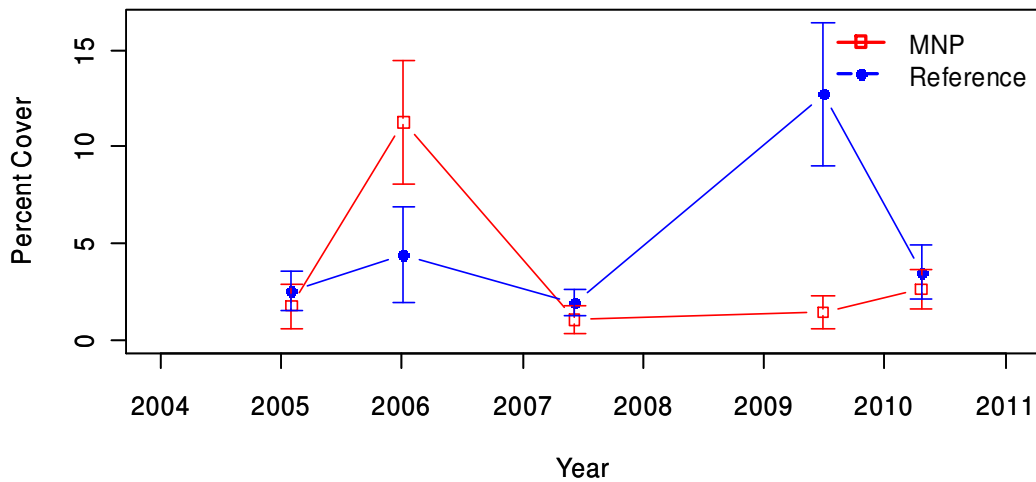


Figure 8.13. Mean cover (\pm Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Eagles Nest, within the Bunurong MNP, and the Caves reference site.

9 POINT ADDIS MARINE NATIONAL PARK

9.1 Site Description and Transect Layout

9.1.1 Point Addis Marine National Park (Site 3901)

The main intertidal reef at Point Addis is a large and prominent tongue of intertidal platform that extends east from the base of cliffs northeast of Point Addis. This reef is long and 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 (Figure 10.1). 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. 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.

9.1.2 Winkipop Reference (Site 3902)

The reference site for Point Addis Marine National Park was located to the east of the park at Winkipop reef. The intertidal area at Winkipop is a very low-relief, gently sloping reef (Figure 10.2). 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. Baselines were run parallel to shore and were 100 m long. Transects were evenly spaced every 25 m and each was approximately 35 m in length.



Figure 9.1. Intertidal reef at Point Addis Marine National Park, 17 December 2004.



Figure 9.2. Intertidal reef at the Winkipop reference site, 28 May 2009.

9.2 Community Structure

The mobile invertebrate community was 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* spp were much more prevalent at Winkipop than Point Addis.

These general similarities and slight differences in mobile invertebrate community structure are reflected in the MDS analysis which placed Point Addis and Winkipop within the same cluster of open coast sites, but distinct from one another (Figure 9.3a).

The algal and aggregating sessile invertebrate communities at Point Addis and the Winkipop reference site are 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 reflected the similarities in the two assemblages, with the two sites overlying (Figure 9.3b). There was a similar amount of variation in community structure through time at Point Addis and the reference Winkipop site.

9.3 Diversity

Mobile invertebrate species richness was relatively stable and generally higher at the Winkipop than at Pt Addis, except in 2009 when there was a dip in species richness at Winkipop (Figure 9.4).

Algal and aggregating sessile invertebrate species richness was very similar at Pt Addis and Winkipop. It was also relatively stable over time, with between 16 and 23 species observed per survey (Figure 9.5).

Mobile invertebrate species diversity, in terms of Hills N_2 , was initially higher at Winkipop than Pt Addis. It has increased at Pt Addis since 2007, while decreasing at Winkipop. In 2010 these sites had similar species diversity, of 2.8 and 2.5 respectively (Figure 9.6).

Algal and aggregating sessile invertebrate species diversity was low (less than 2) at both sites (Figure 9.7). In 2010, algal species diversity at Pt Addis was the highest recorded at either site.

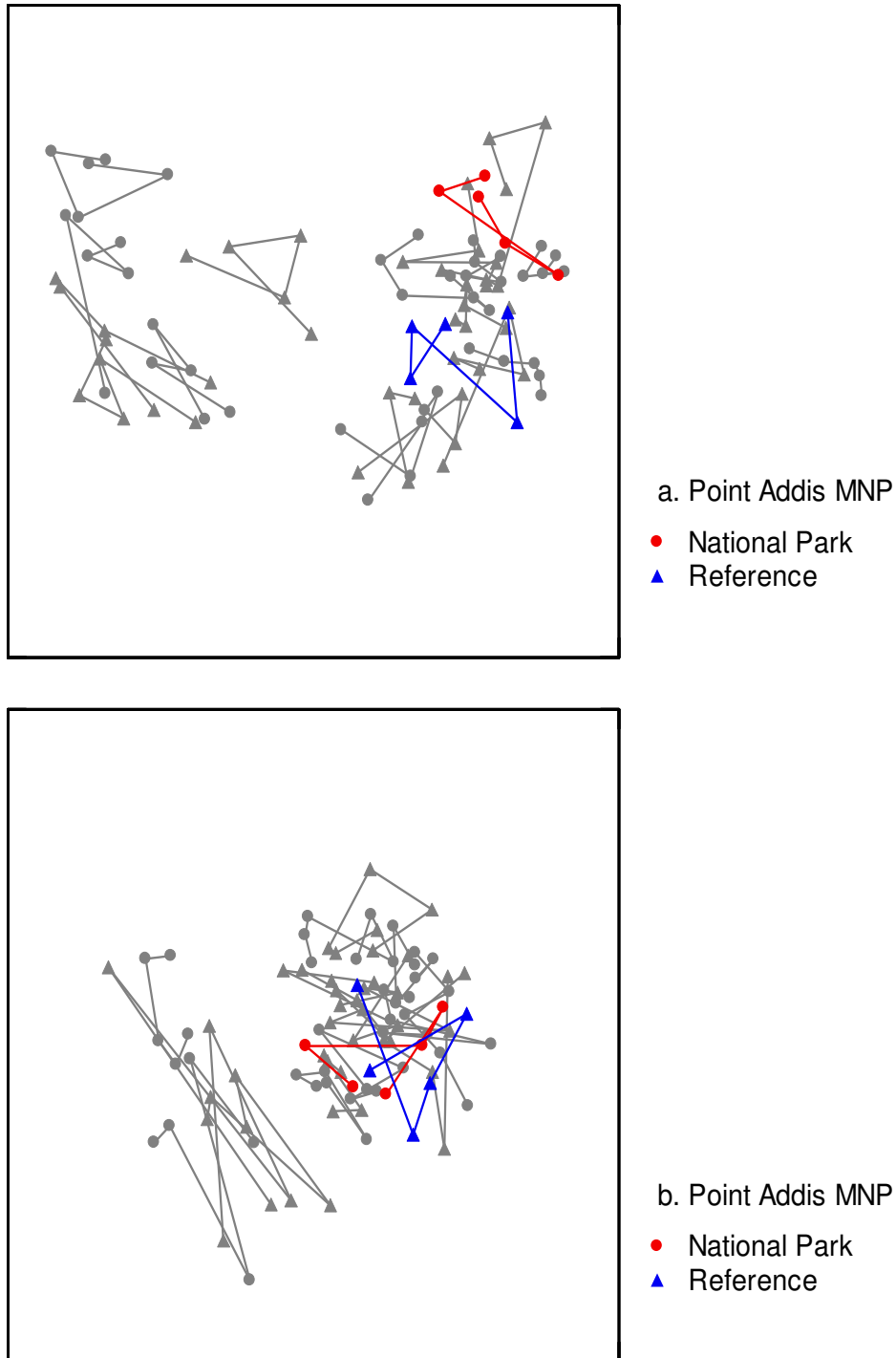


Figure 9.3. Two dimensional MDS plot of invertebrate assemblages on intertidal reefs at Point Addis, within the Point Addis MNP, and the Winkipop reference site. (a) Mobile Invertebrate, Kruskal stress = 0.17427 and (b) Macroalgae and Aggregating Sessile Invertebrates, Kruskal stress = 0.08. The grey lines represent data from all other intertidal sites used in the MDS analysis.

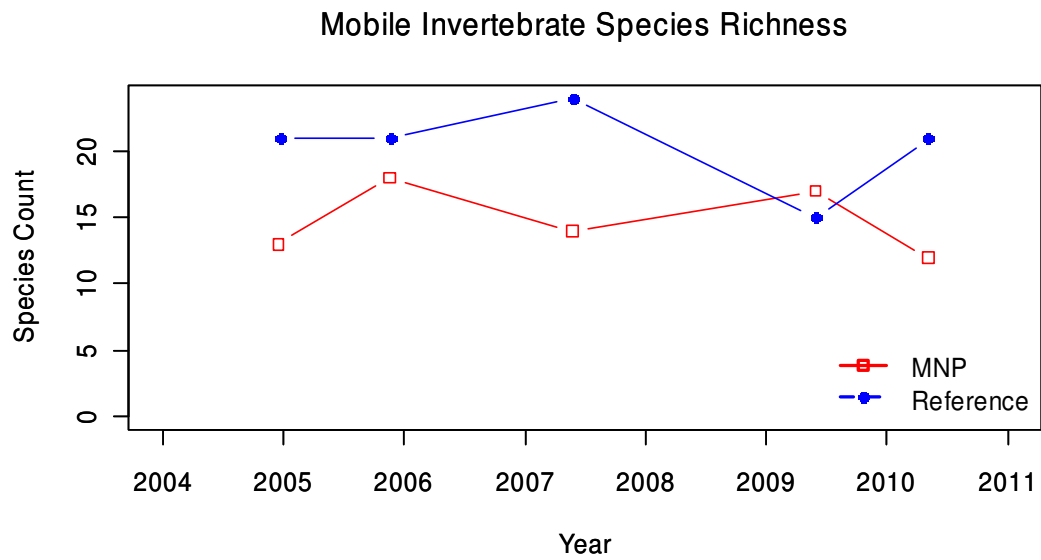


Figure 9.4. Mobile invertebrate species richness at Point Addis within the Point Addis MNP, and the Winkipop reference site.

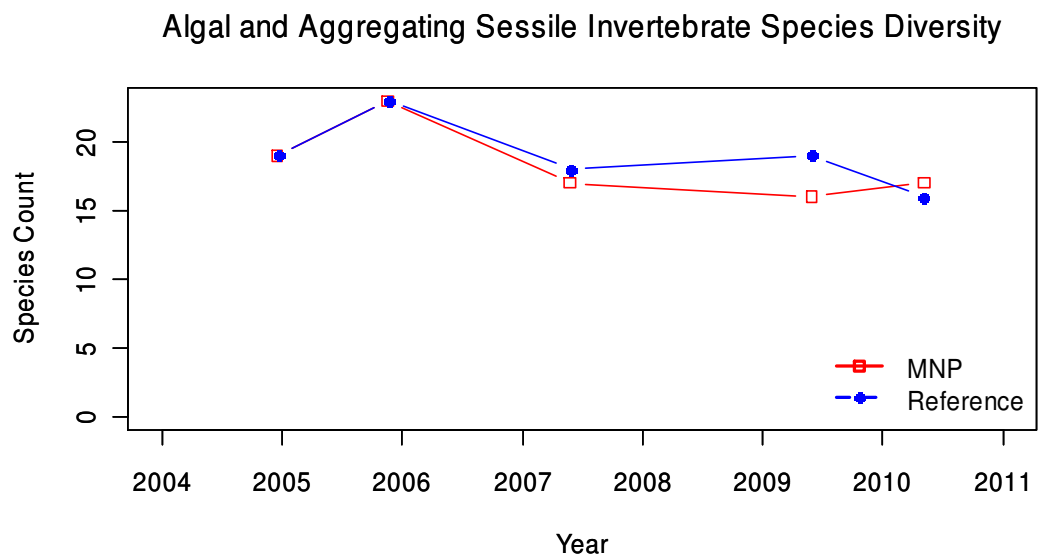


Figure 9.5. Algal and aggregating sessile invertebrate species richness of intertidal sites at Point Addis within the Point Addis MNP, and the Winkipop reference site.

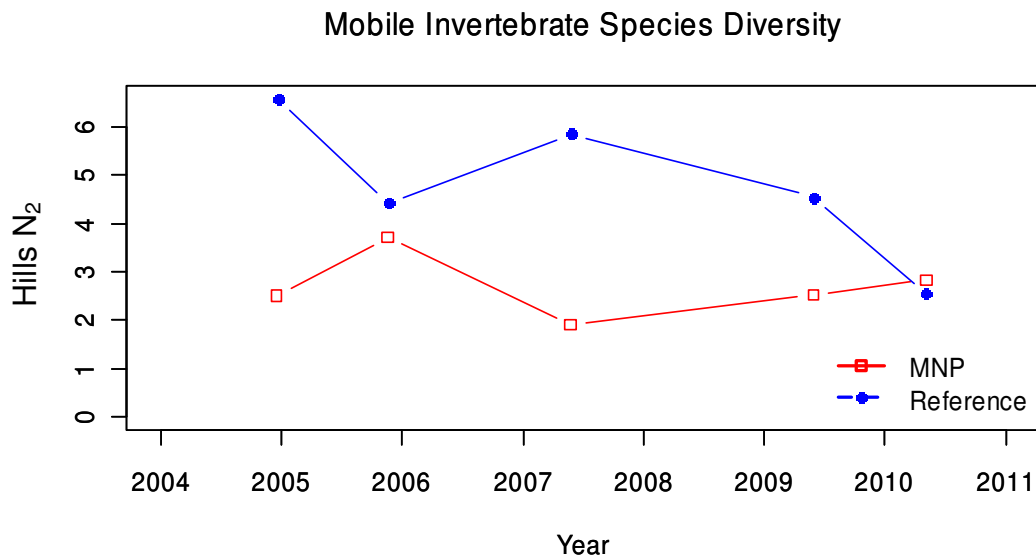


Figure 9.6. Mobile invertebrate diversity (Hills N₂) of intertidal sites at Point Addis within the Point Addis MNP, and the Winkipop reference site.

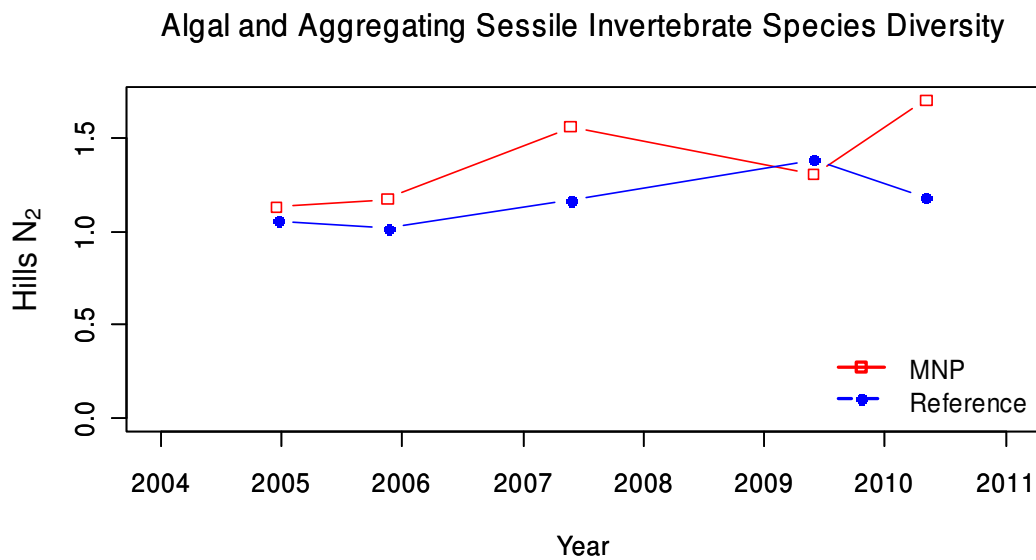


Figure 9.7. Algal and aggregating sessile invertebrate diversity (Hill's N₂) of intertidal sites at Point Addis within the Point Addis MNP, and the Winkipop reference site.

9.4 Macroalgae and Aggregating Sessile Invertebrates

The brown alga *Hormosira banksii* was the dominant cover at both sites, although it was consistently 20 % to 30 % higher at the Winkipop reference site. The cover of *H. banksii* has remained relatively stable throughout the monitoring period, but was at its lowest level at both sites in 2010 (Figure 9.8). Algal turf covered 12 % of the reef at Point Addis in 2010, but was not observed at Winkipop.

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

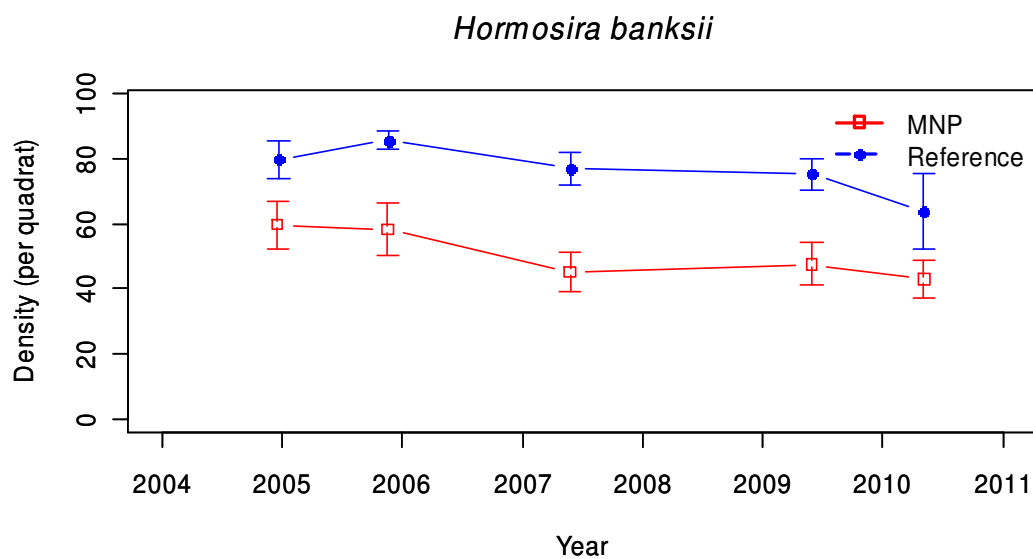


Figure 9.8. Mean density (\pm Standard Error) of Neptune's necklace *Hormosira banksii* at Point Addis within the Point Addis MNP, and the Winkipop reference site.

9.5 Mobile Invertebrates

The types of mobile invertebrate species present at Point Addis and Winkipop were generally similar, but there were considerable differences in abundances. Abundances of the false limpet *Siphonaria* spp., and limpets *Notoacmea* spp. and *Patelloida alticostata* were consistently higher (at least double) at Point Addis than Winkipop. 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 *Hormosira*. Anemones have only been observed intermittently at Point Addis.

At the reference Winkipop site, the abundance of the *Clypidina rugosa* increased dramatically during 2010, from nothing in 2009 to 47 individuals 0.25 m⁻². The abundance of this species had previously been low and stable with consistent patterns over the two sites (Figure 9.9a).

The abundance of *Bembicium nanum* was greater at the reference Winkipop site although trends were variable over time. Trends were more consistent for this species at the Point Addis site (Figure 9.9b).

The limpet *Cellana tramoserica* was found in low abundances at both sites. Point Addis and the reference Winkipop site had opposite pattern in abundance over survey times. The abundances were lower at Winkipop, with no individuals recorded during the 2007 and 2009 surveys (Figure 9.9c).

The mean size of *C. tramoserica* at Point Addis and the reference Winkipop site remained relatively constant through time (Figure 9.10).

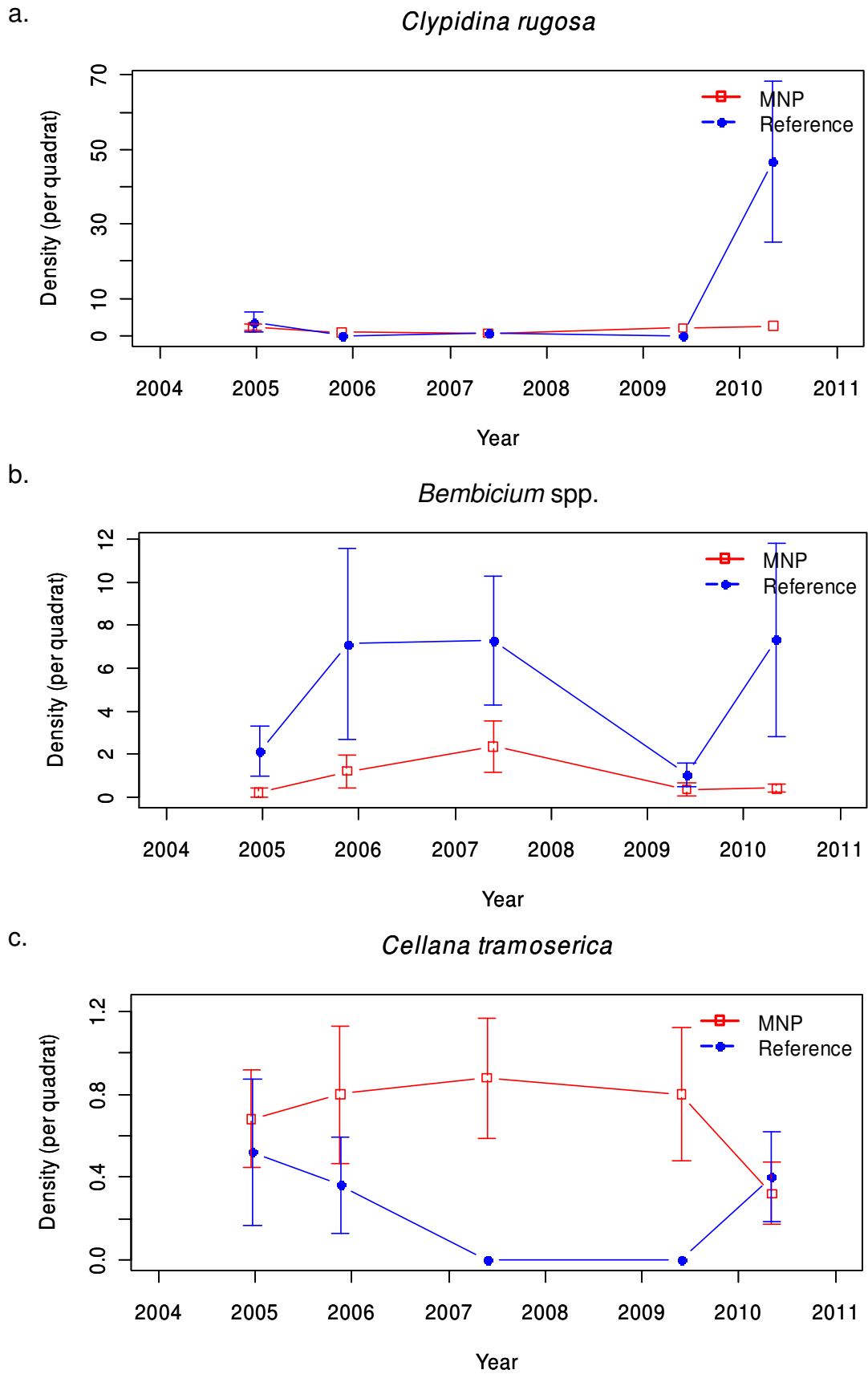


Figure 9.9. Mean density (\pm Standard Error) of: (a) the limpet *Clypidina rugosa*; (b) the striped conniwink *Bembicium nanum*; and (c) the limpet *Cellana tramoserica* at Point Addis within the Point Addis MNP, and the Winkipop reference site.

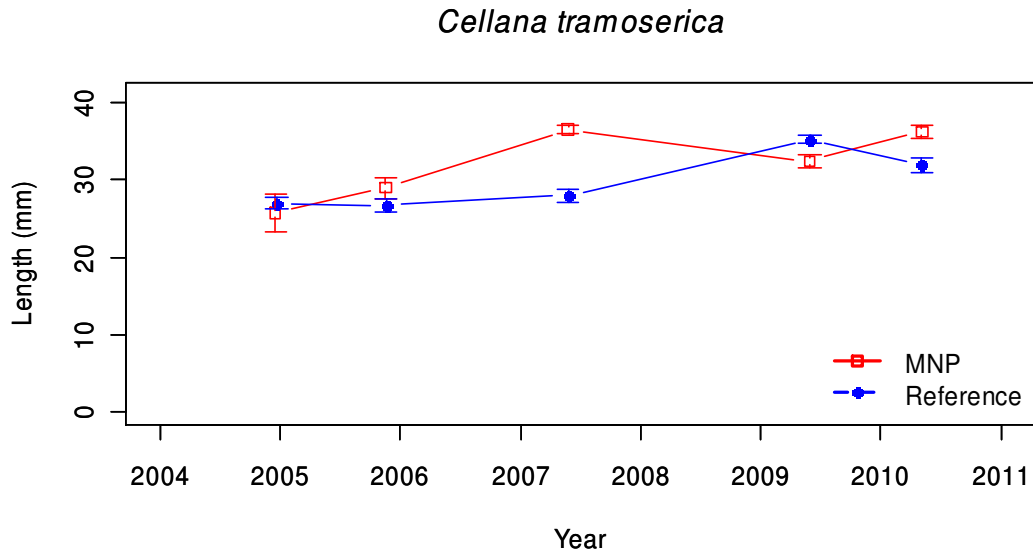


Figure 9.10. Mean sizes (\pm Standard Error) of the limpet *Cellana tramoserica* at Point Addis, within the Point Addis MNP, and the Winkipop reference site.

9.6 Condition Indicators

Biodiversity

Community composition at these sites was within the range of states and changes previously observed.

Species richness was also within the range previously observed.

Invertebrate species diversity was at the lowest level recorded at the Winkipop reference site. Conversely, algal and sessile invertebrate species diversity was at its highest recorded level at Point Addis.

Introduced Species

There were no introduced species detected for these sites.

Ecosystem Function

Total algal cover decreased at both sites from 2009 to 2010 (Figure 9.11a). There has been an increasing trend in the abundance of erect coralline algae at Winkipop, but it remains absent at Point Addis (Figure 9.11b). Turfing algae cover remained relatively high at Point Addis, covering approximately 12 % of the study area (Figure 9.11c).

The total abundance of grazers and total abundance of predators both decreased at Point Addis from 2009 to 2010, but increased at Winkipop (Figure 9.12). The decrease in grazers at Point Addis was mainly due to decreases in the abundance of *Siphonaria* spp. and *Notoacmea* spp.

Climate Change

There were no new species detected that were typically from adjacent bioregions.

Harvesting

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

Trampling

The cover of *Hormosira banksii* has declined slightly at both sites over the monitoring period and was at its lowest level at both sites in 2010 (Figure 9.8). This decrease may or may not be due to trampling pressure.

Environment

The cover of green algal species indicative of nutrient loading was relatively low at these sites (Figure 9.13a).

The cover of sand at Point Addis has varied between 1 and 9 %, while remaining relatively constant at Winkipop, with 6-8 % cover. In 2010 sand cover at Point Addis decreased to 1 %.

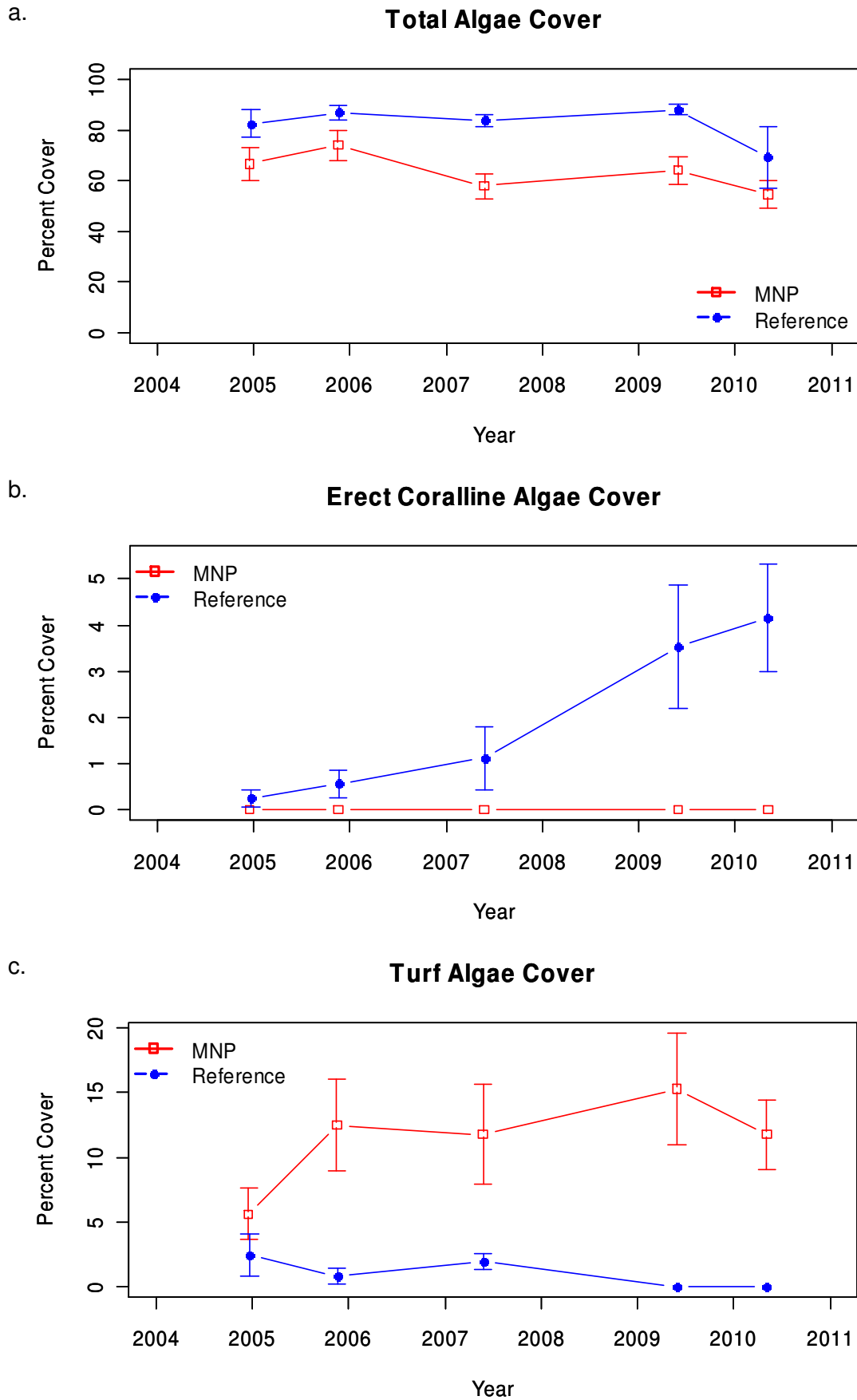
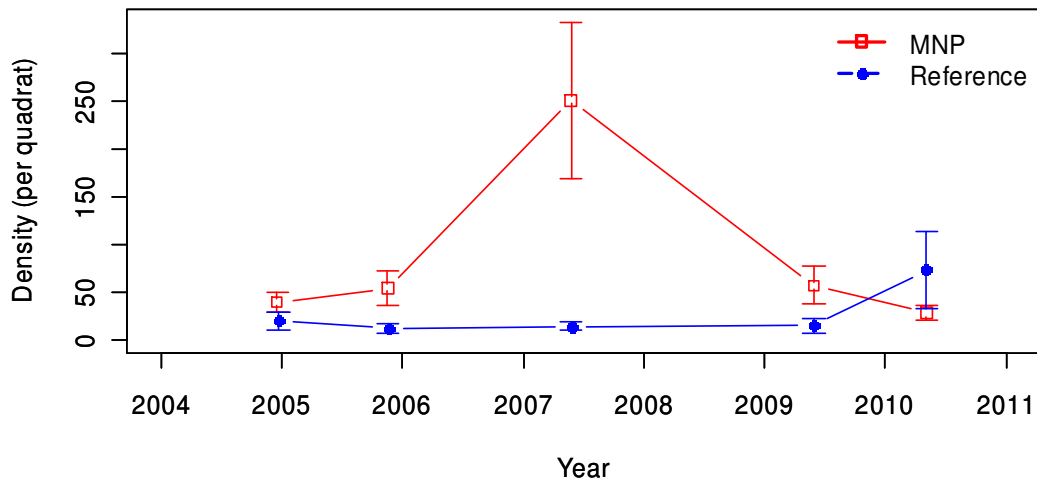


Figure 9.11. Mean cover (\pm Standard Error) of: (a) all algae; (b) erect coralline algae; and (c) turfing algae at Point Addis within the Point Addis MNP, and the Winkipop reference site.

a.

Total Grazers



b.

Total Predators

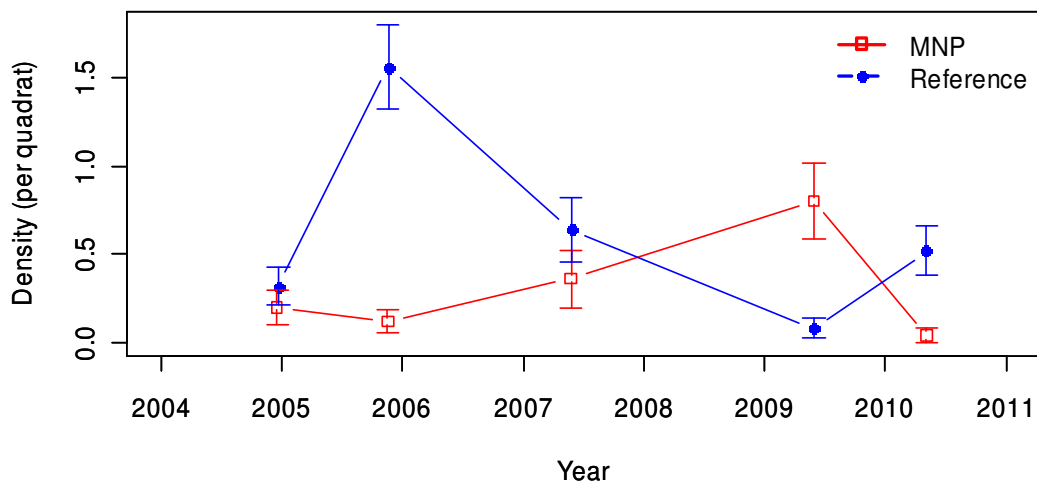
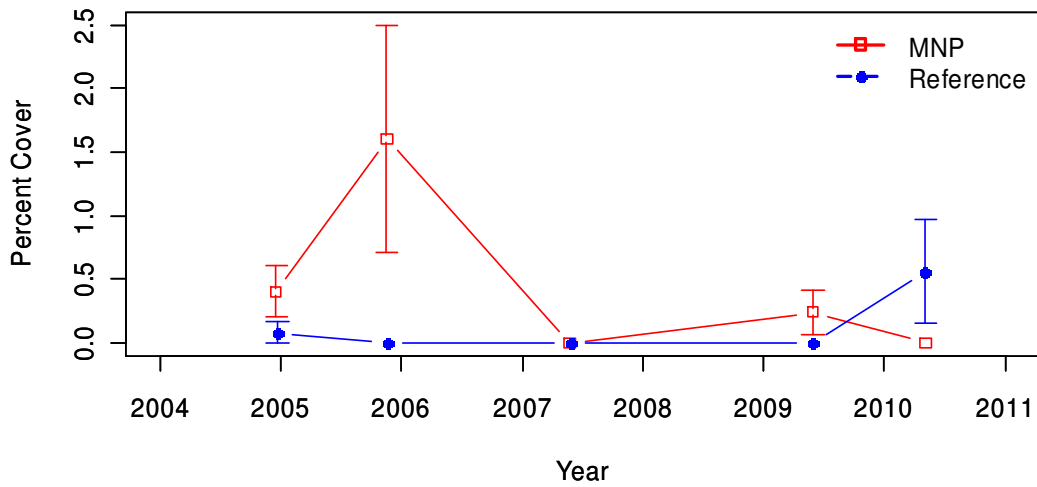


Figure 9.12. Mean abundance (\pm Standard Error) of: (a) all grazers; and (b) all predators at Point Addis within the Point Addis MNP, and the Winkipop reference site.

a.

Green Algae Cover



b.

Sediment Cover

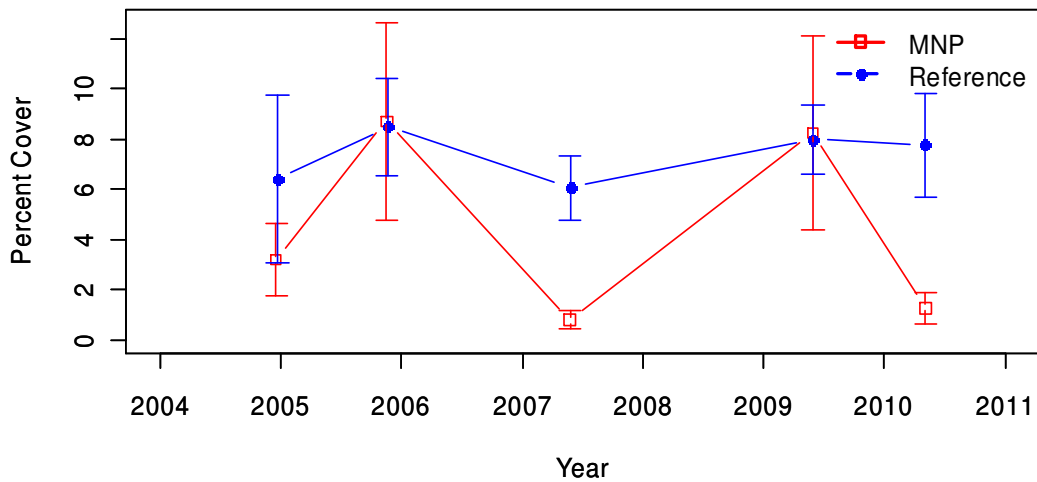


Figure 9.13. Mean cover (\pm Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Point Addis within the Point Addis MNP, and the Winkipop reference site.

10 POINT DANGER MARINE SANCTUARY

10.1 Site Description and Transect Layout

10.1.1 Point Danger Marine Sanctuary (Site 4002)

The intertidal area at Point Danger is a large sandstone reef platform that is an extension of the Point Danger headland (Figure 10.1). The reef is exposed to the north, east and south, however most of the prevailing weather and waves are from the 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. The high and low-shore baselines are approximately transverse to the headland. Baseline lengths were 46 m each, with transects of 41-43 m, forming a square survey area.

10.1.2 Point Danger West Reference (Site 4001)

The reference site, Point Danger West, is separated from the Point Danger intertidal platform by a short section of sandy beach. As with Point Danger, the sandstone platform has been eroded to create an uneven surface at the scale of 10s centimetres. This reef is subject to significant sand inundation (Figure 10.2). The site baselines were 50 m, with transects of 30 m.



a.



b.



c.



d.

Figure 10.1. Intertidal reef at Point Danger Marine Sanctuary: (a-b) 14 January 2005; (c-d) 30 April 2009.



a.



b.

Figure 10.2. 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.

10.2 Community Structure

The mobile invertebrate community structure at Point Danger (4002) and the reference site Point Danger West (Site 4001) are similar. The community is dominated by the coniwink *Bembicium* spp., periwinkle *Nodilittorina acutispira*, and slit limpet *Clypidina rugosa*. The MDS analysis reflected the similarities in these sites, situating them close together within the same cluster. Both sites showed a similar amount of variation throughout the monitoring period (Figure 10.3a).

The algal and aggregating sessile invertebrate community structure was again similar between Point Danger the Point Danger West site. The most commonly found species are the brown algae Neptune's necklace *Hormosira banksii*, mat forming mussel *Xenostrobus pulex* and algal turf. The calcareous tube-worm *Galeolaria caespitosa* was recorded at Point Danger West, but not at the Point Danger site. The MDS analysis showed the Point Danger marine sanctuary and reference sites had relatively small changes over time compared to the overall assemblage variability (Figure 10.3b).

10.3 Diversity

Species Richness of mobile invertebrates was relatively stable over survey times at both Pt Danger (Site 4002) and the reference Point Danger West site (Site 4001). Richness at Point Danger West was consistently higher compared to Point Danger. Both sites had highest recorded species richness levels in 2010 (Figure 10.4).

Algal and sessile invertebrate species richness was variable between 2005 and 2007. Since 2007 it remained relatively stable at both Pt Danger and the Pt Danger West site for subsequent surveys (Figure 10.5).

Mobile invertebrate species diversity in terms of Hills N_2 at Point Danger (Site 4002) has been increasing since 2007, reaching its highest in 2010 (Figure 10.6). This coincided with a decrease in diversity at the reference Pt Danger West site.

Algal and aggregating sessile invertebrate species diversity at Pt Danger and Pt Danger West remained relatively stable through surveys times. Diversity was consistently low at both sites (Figure 10.7).

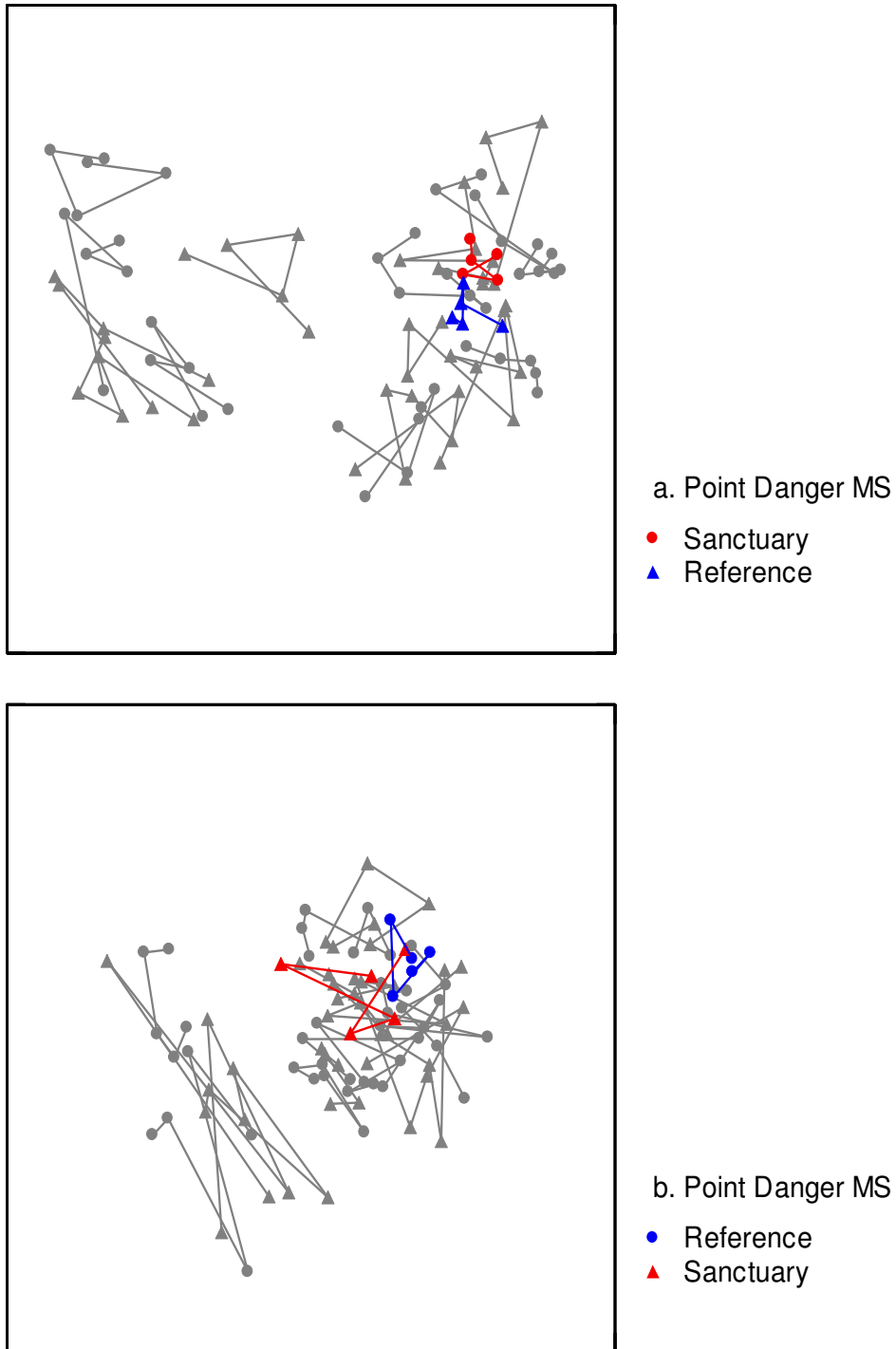


Figure 10.3. Two dimensional MDS plot of invertebrate assemblages on intertidal reefs at Point Danger, within the Point Danger MS, and the Point Danger West reference site. (a) Mobile Invertebrate, Kruskal stress = 0.2 and (b) Macroalgae and Aggregating Sessile Invertebrates, Kruskal stress = 0.8. The grey lines represent data from all other intertidal sites used in the MDS analysis.

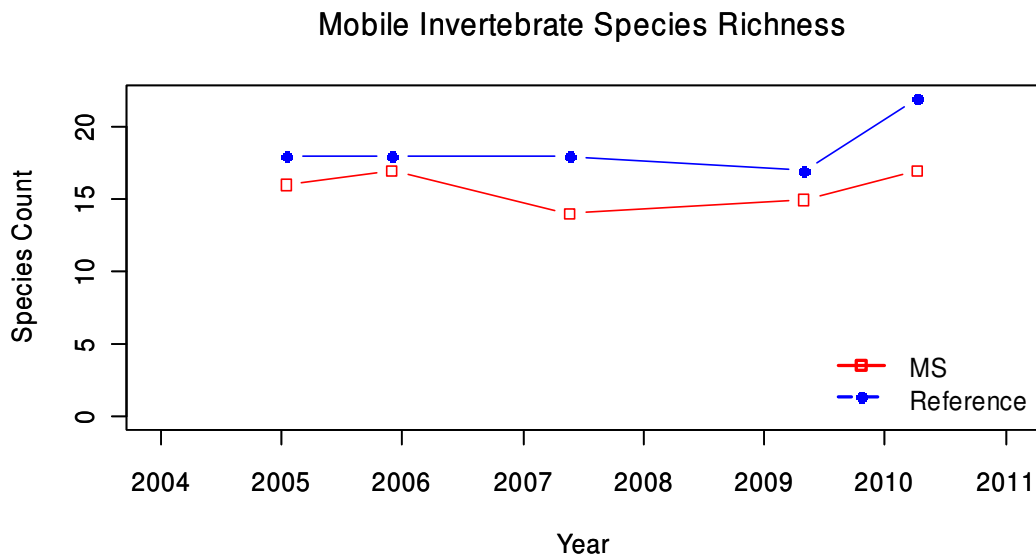


Figure 10.4. Mobile invertebrate species richness at Point Danger, within the Point Danger MS, and the Point Danger West reference site.

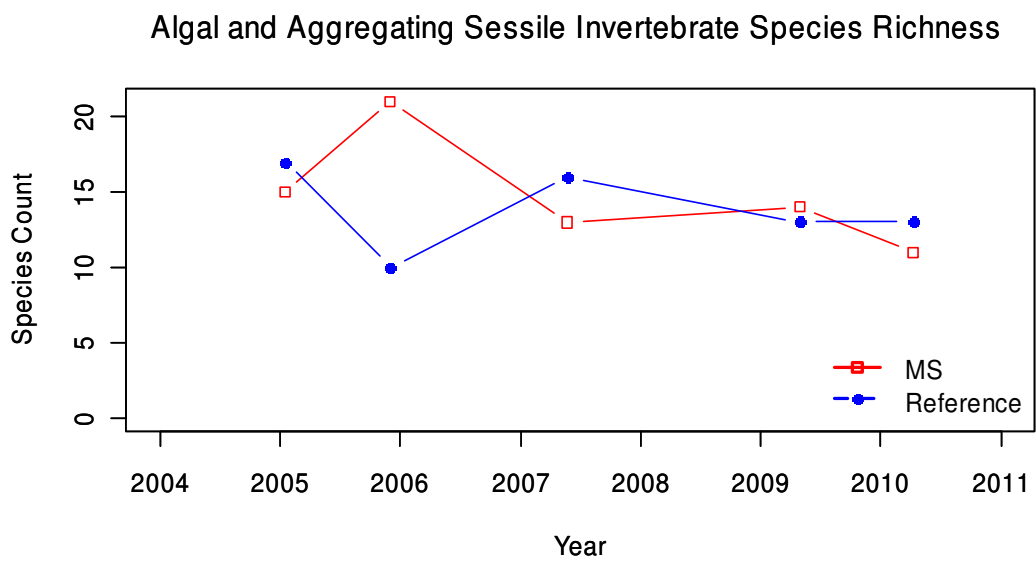


Figure 10.5. Algal and aggregating sessile invertebrate species richness of intertidal sites at Point Danger, within the Point Danger MS, and the Point Danger West reference site.

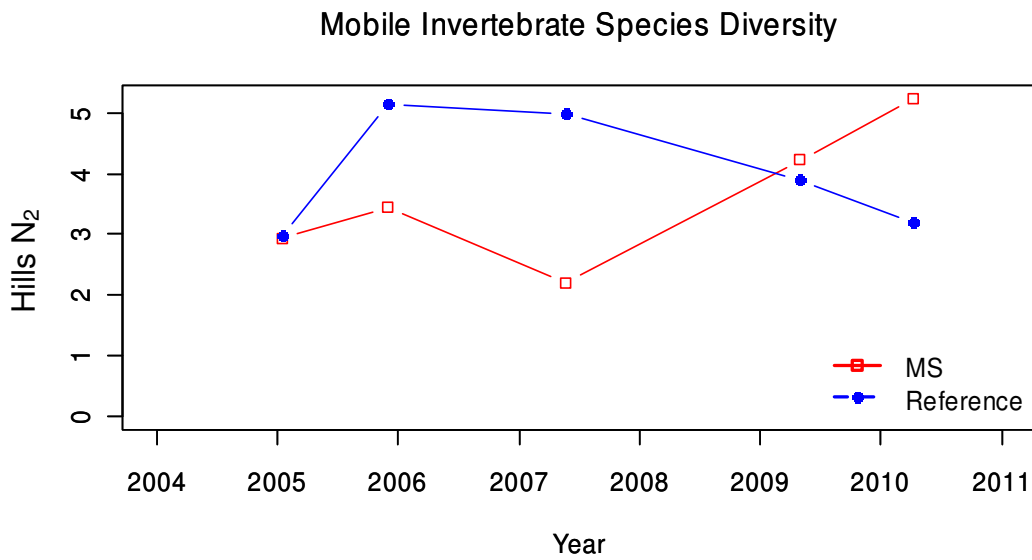


Figure 10.6. Mobile invertebrate diversity (Hills N₂) of intertidal sites at Point Danger, within the Point Danger MS, and the Point Danger West reference site.

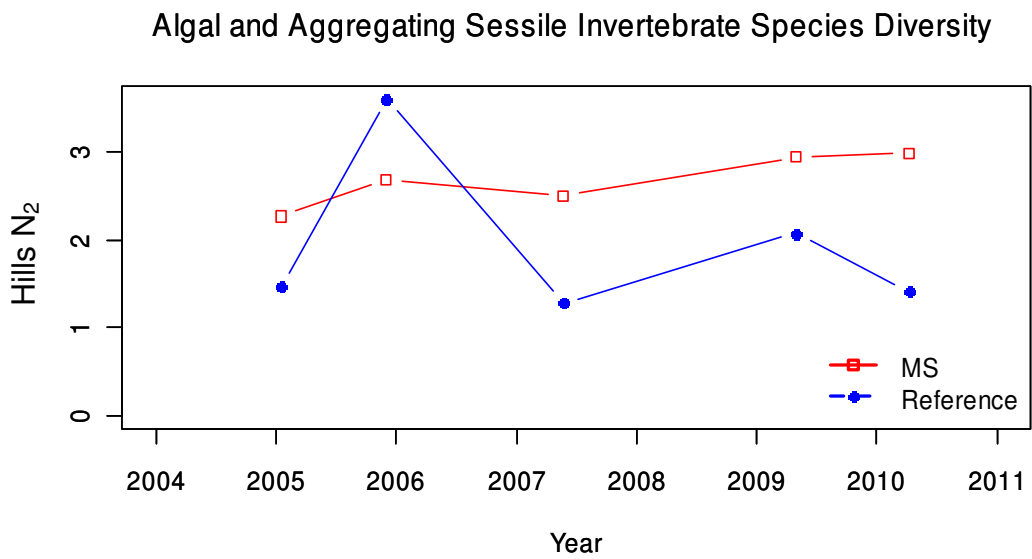


Figure 10.7. Algal and aggregating sessile invertebrate diversity (Hill's N₂) of intertidal sites at Point Danger, within the Point Danger MS, and the Point Danger West reference site.

10.4 Macroalgae and Aggregating Sessile Invertebrates

Macroalgal and aggregating sessile invertebrates were similar at both Point Danger (Site 4002) and the Point Danger West site (Site 4001). The community was comprised of predominantly 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. With the exception of the first survey in 2004 the cover of *H. banksii* remained relatively stable. Observations showed both sites having similar coverage (Figure 10.8).

It is worth noting there was an increase in cover of *Enteromorpha* spp. from 4 to 12 % in 2010 at Point Danger West. Sand inundation at both reefs was variable between surveys, ranging from 2-33 % cover. Highest recordings were during the May 2007 survey.

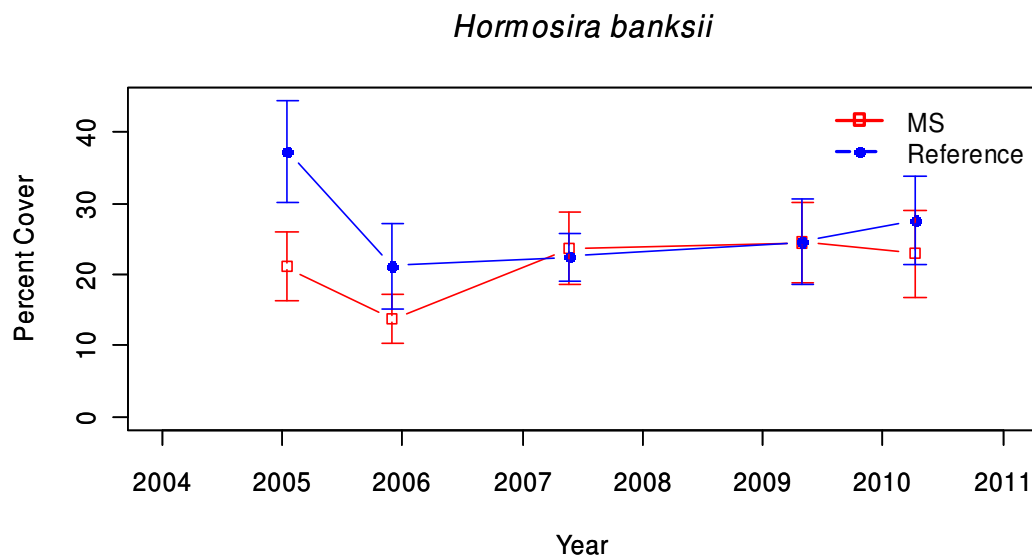


Figure 10.8. Mean Density (\pm Standard Error) of Neptune's necklace *Hormosira banksii* at Point Danger, within the Point Danger MS, and the Point Danger West reference site.

10.5 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 coniwink *Bembicium* spp and the limpets *Clypidina rugosa* and *Siphonaria* spp were the numerically dominant species. Snails *Dicathais orbita*, *Lepsiella vinosa*, *Turbo undulatus* and limpet *Patelloida alticostata* contributed to the community structure although occurring at lower densities.

The abundance of *Clypidina rugosa* was relatively variable and stable through survey times. In 2010 abundances at Point Danger West increased from 10 to 24 individuals per 0.25 m², the highest recorded (Figure 10.9a).

The two sites differed in the densities of *B. nanum* (Figure 10.9b). Point Danger consistently had higher densities, with the exception of the 2010 survey. The mean density of limpet *Cellana tramoserica* were relatively stable over time at both sites. Abundances were variable over survey times, with few consistent patterns (Figure 10.11).

Mean sizes were recorded for *B. nanum* and *C. tramoserica*. For both species the mean size remained relatively stable through time (Figure 10.12). Sizes at the reference site Point Danger West were consistently larger, with the exception of the drop for *B. nanum* during 2010 (Figure 10.12a).

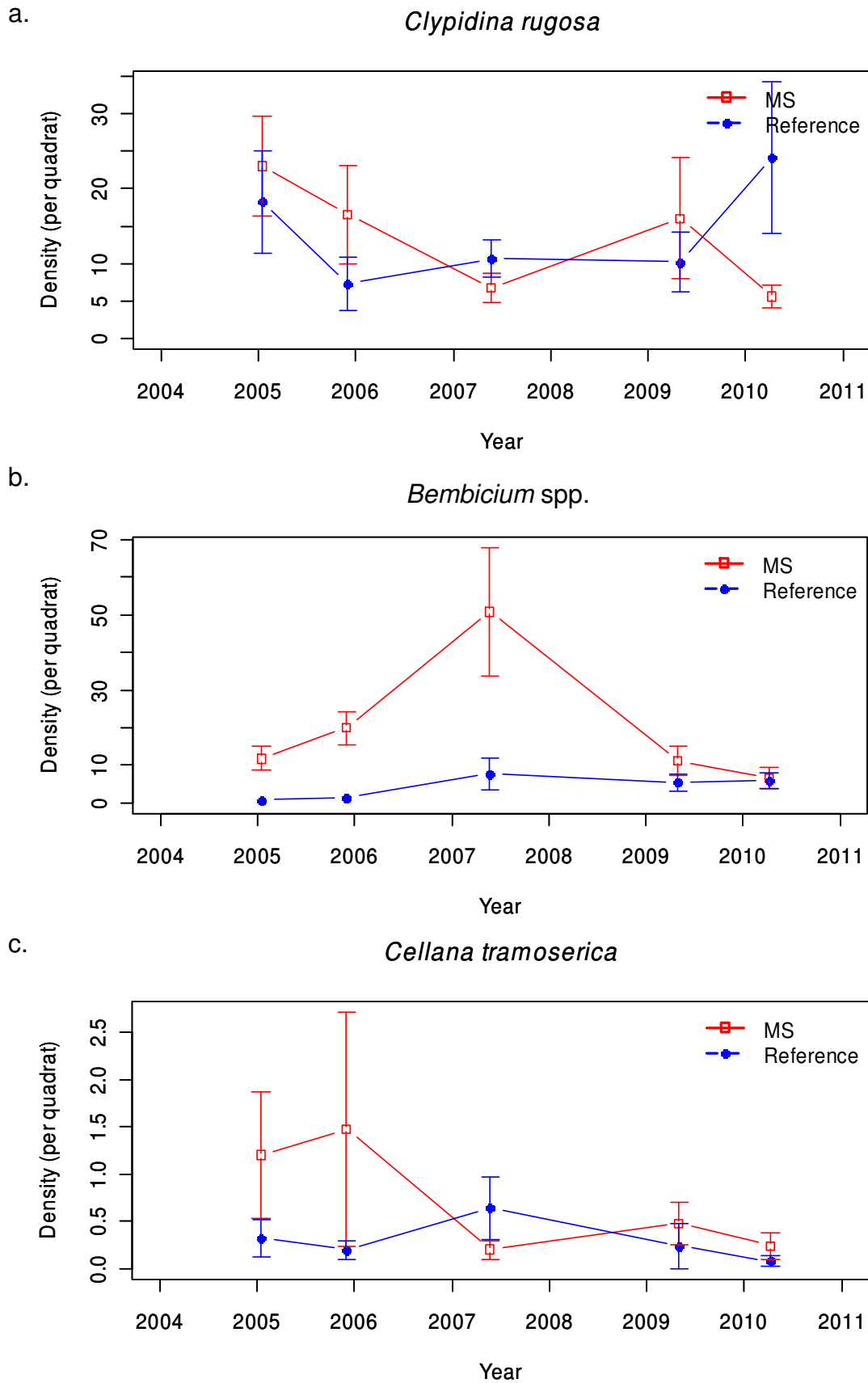


Figure 10.9. Mean Density (\pm Standard Error) of: (a) the limpet *Clypidina rugosa*; (b) the striped conniwink *Bembicium nanum*; and (c) the limpet *Cellana tramoserica* at Point Danger, within the Point Danger MS, and Point Danger the West reference site.

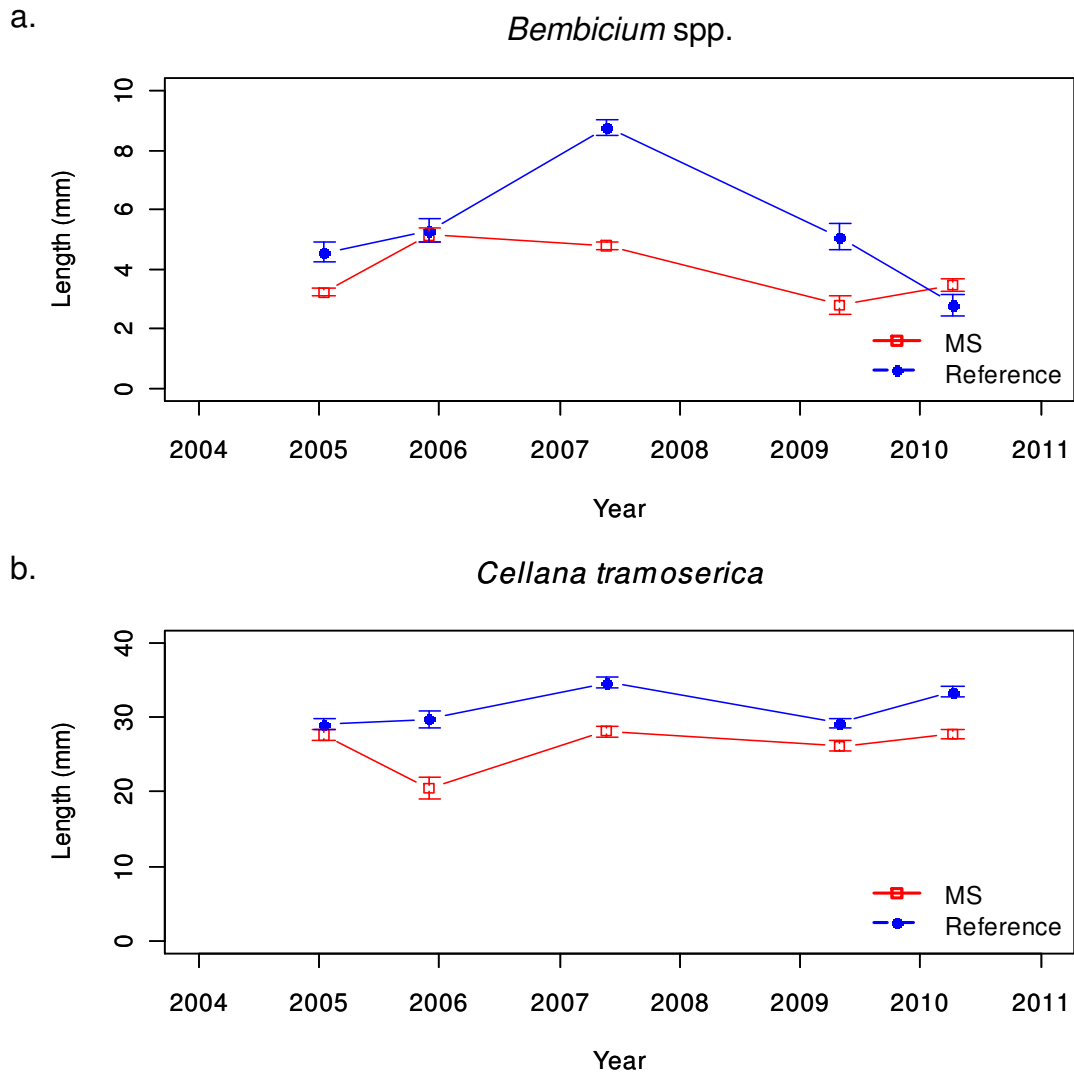


Figure 10.10. Mean sizes (\pm Standard Error) of the conniwink *Bembicium* spp. and *Cellana tramoserica* at Point Danger, within the Point Danger MS, and the Point Danger West reference site.

10.6 Condition Indicators

Biodiversity

Community composition was within the range of sites and changes previously observed. Mobile invertebrate species richness had increased in 2010 to the highest levels recorded (Figure 10.4). Species diversity had remained stable over surveys with few clear patterns or trends in the data (Figure 10.6 and 10.7).

Introduced Species

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

Ecosystem Function

Total algal cover has been steadily increasing at Point Danger since 2005, in 2010 reaching the highest cover over survey times (Figure 10.10a). Cover of erect coralline algae was consistently low, <1 % cover at both sites (Figure 10.10b). Cover of algal turf at both sites was variable over time showing no clear patterns (Figure 10.10c).

With the exception of the 2010 survey Point Danger had consistently higher abundances of grazers and predators. Total abundance of grazers had been variable through survey times showing no clear patterns (Figure 10.11a). Total predators abundances had remained stable until the 2010 survey before dropping at Point Danger and coincidentally increasing at Point Danger West (Figure 10.11b).

Climate Change

There were no species typically of adjacent bioregions observed during the intertidal reef surveys in this area.

Harvesting

There were no major changes in the structure of mean sizes between the 2009 and 2010 survey at both Point Danger and Point Danger West. There were no indications of increasing harvesting pressure based on mean sizes.

Trampling

The fluctuation of *Hormosira banksii* densities indicating trampling is not presently a constraining factor to the population.

Environment

The cover of green algal species, potentially indicative of nutrient loading was relatively high at Point Danger, increasing in 2010 beyond previous records (Figure 10.13a). At Point Danger West cover remained relatively low over survey times. Sediment cover had remained

variable at both sites over survey times, variability interrupting any patterns in the data (Figure 10.13b).

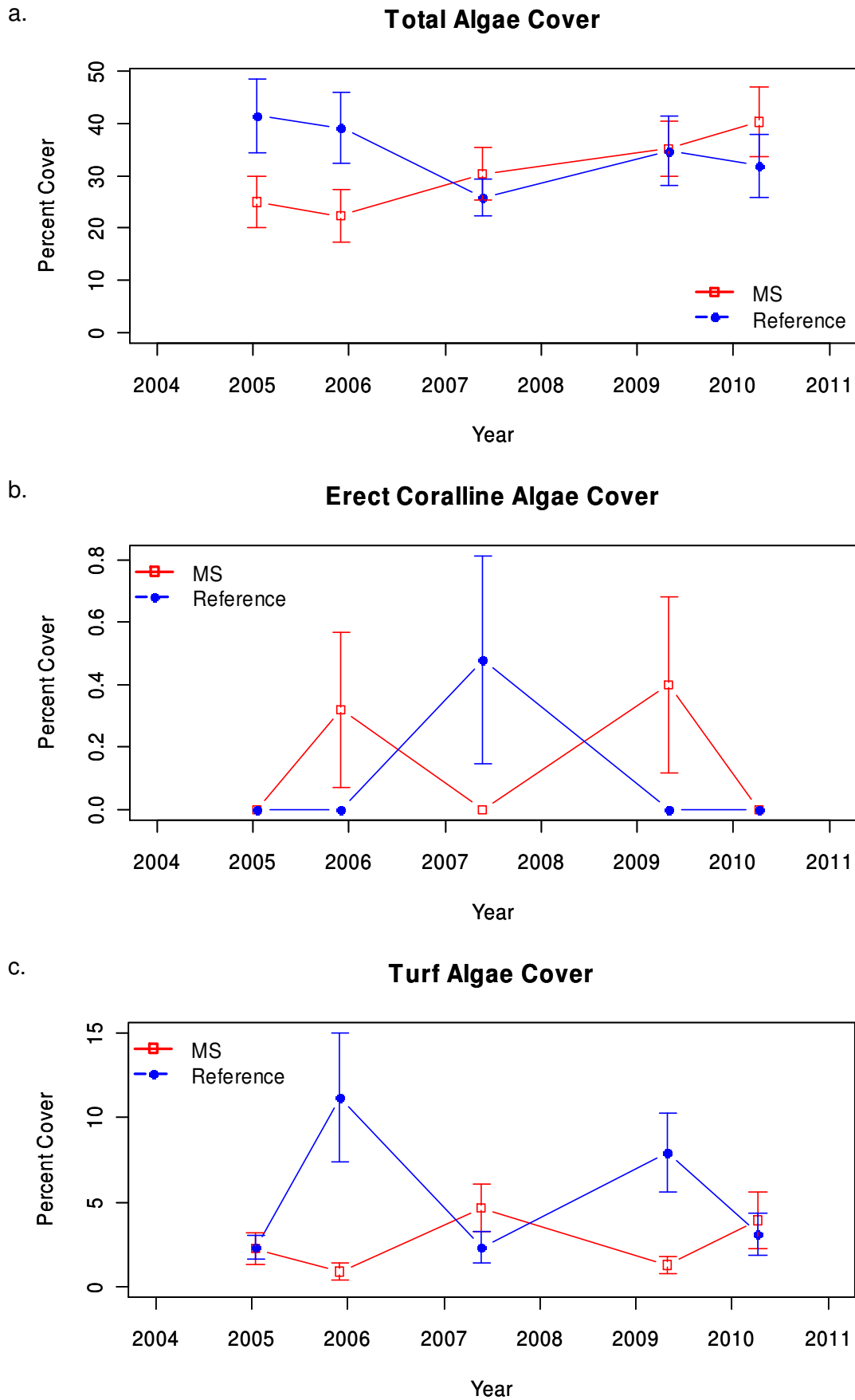
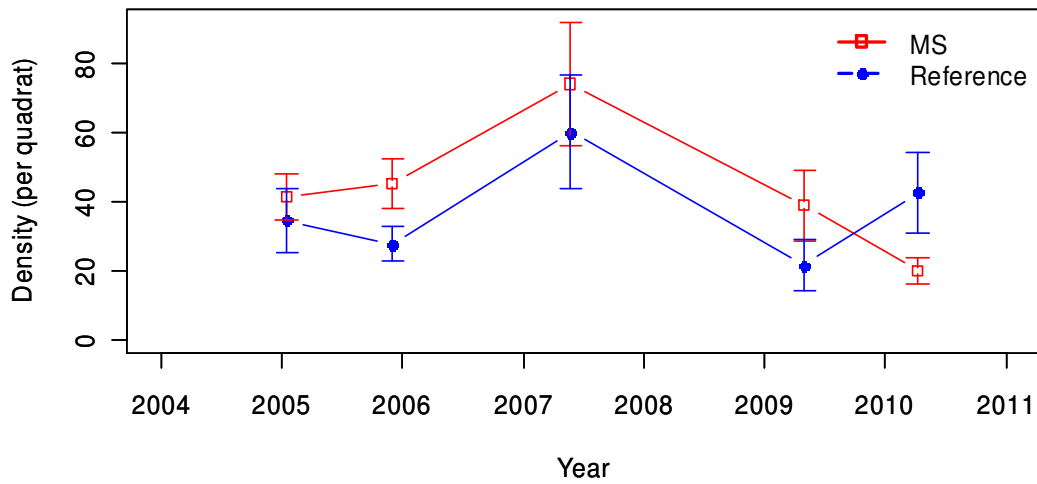


Figure 10.11. Mean cover (\pm Standard Error) of: (a) all algae; (b) erect coralline algae; and (c) turfing algae at Point Danger, within the Point Danger MS, and Point Danger the West reference site.

a.

Total Grazers



b.

Total Predators

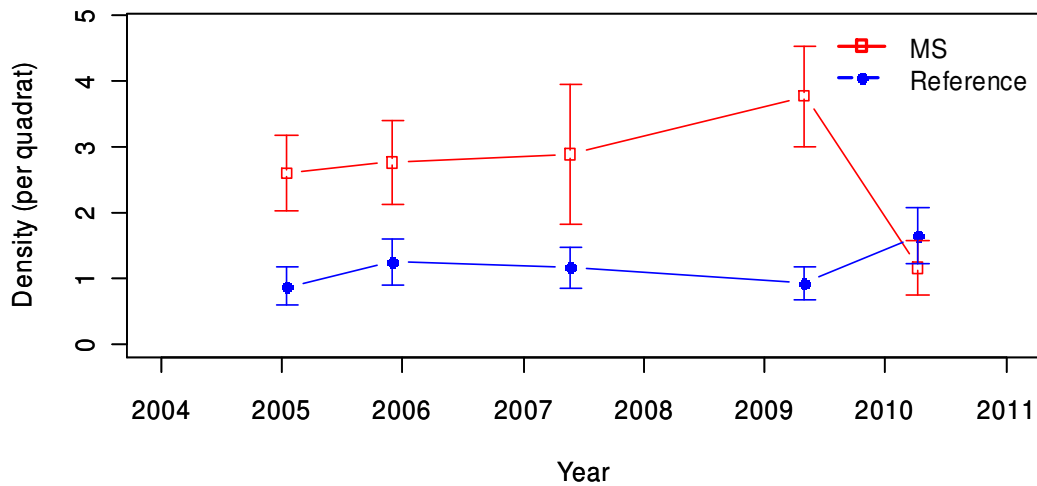
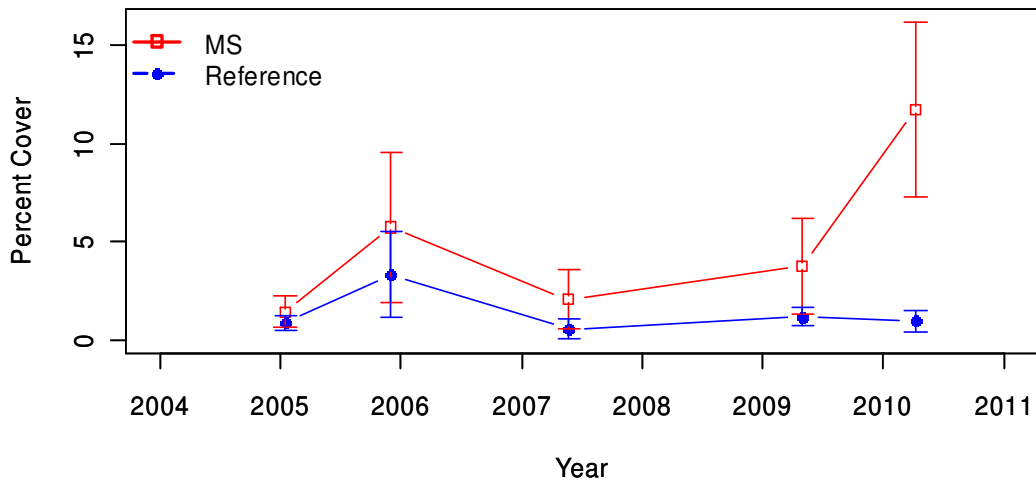


Figure 10.12. Mean abundance (\pm Standard Error) of: (a) all grazers; and (b) all predators at Point Danger, within the Point Danger MS, and Point Danger the West reference site.

a.

Green Algae Cover



b.

Sediment Cover

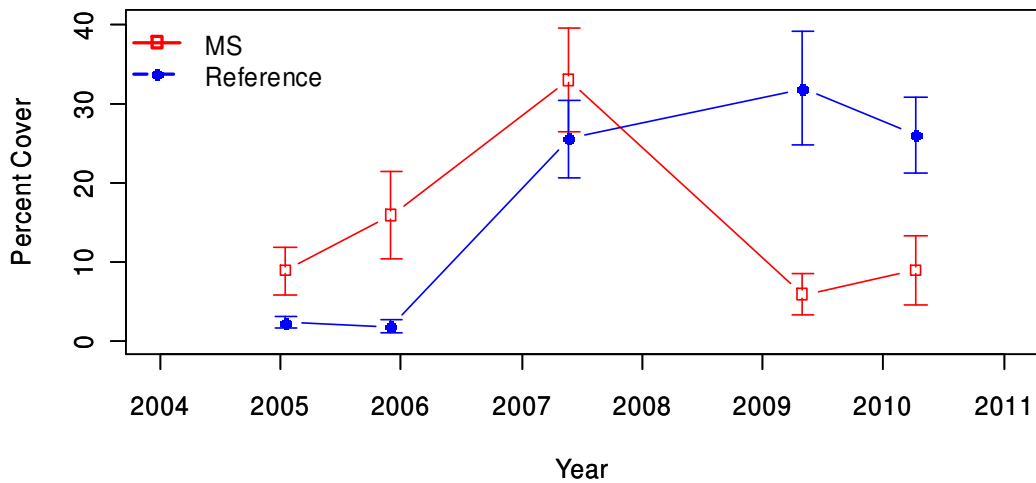


Figure 10.13. Mean cover (\pm Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Point Danger, within the Point Danger MS, and Point Danger the West reference site.

11 BARWON BLUFF MARINE SANCTUARY

11.1 Site Description and Transect Layout

11.1.1 Barwon Bluff Marine Sanctuary (Site 4004)

The intertidal reef at Barwon Bluff is composed of sections of sandstone and basalt reef. The intertidal rock platform extends from the end of Barwon Bluff as a pincer-shaped reef. The north-eastern section of the pincer is a basalt platform and boulder reef. This section of the reef is relatively protected from swell but has a large estuarine influence from the adjacent mouth of the Barwon River. The south-western section of the pincer 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. This has been encompassed by the high shore baseline which follows this contour for 52 m. The low shore baseline borders rockpools on the south-western corner and is 53 m long. Transect lengths range from 47 m at Transect 1 to 49 m at Transect 5.

Only Barwon Bluff (Site 4004) was surveyed during Survey 2, May 2004.

11.1.2 Barwon Beach Reference (Site 4003)

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). The high shore baseline runs parallel to the shore for 45 m and follows the same

shore height contour as at Barwon Bluff. The low shore baseline is 37 m long and is angled back towards shore such that Transect 1 is 33 m long and Transect 5 is 24 m long.



a.



b.

Figure 11.1. Intertidal reef at Barwon Bluff Marine Sanctuary: (a) 30 November 2005; and (b) 1 May 2009.

11.2 Community Structure

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

The MDS analysis of mobile invertebrate community structure reflected the similarity of these sites, placing them close together within the same cluster on the MDS plot. The community structure at Barwon Bluff remained very 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 dipped (Figure 11.2a).

The algal and aggregating sessile invertebrate communities at Barwon Bluff and the Barwon Beach reference site are dominated by the brown algae Neptune's necklace *Hormosira banksii*. Mat forming mussel *Xenostrobus pulex*, the calcareous tube-worm *Galeolaria caespitosa* and algal turf are also present at lower abundances. The MDS analysis located the two sites closely together on the MDS plot, reflecting their similarity (Figure 11.2b). The analysis also shows a similar amount of variation over times for both sites.

11.3 Diversity

Mobile invertebrate species richness has been stable at the Barwon Beach reference site (Site 4003), ranging from 15 to 17 species per survey (Figure 11.2). It has been more variable at Barwon Bluff Marine Sanctuary (Site 4004), peaking at 22 species in late 2005 before dropping to 10 in 2007. There were 18 mobile invertebrate species recorded at this site in 2010 (Figure 11.2).

The species richness of the algal and sessile invertebrate communities at Barwon Bluff and Barwon Beach have been similar to each other through time (Figure 11.4).

Mobile invertebrate species diversity increased at Barwon Bluff (Site 4004) in 2010, interrupting a decreasing trend. Diversity at Barwon Beach (Site 4003) has been steadily increasing from a low in 2007 and in 2010 it was at the highest level recorded at this site (Figure 11.4).

Algal and aggregate sessile invertebrate species diversity has been low and relatively stable at both Barwon Bluff and Barwon Beach, with the Hills N_2 statistic ranging between 1 and 2 (Figure 11.4).

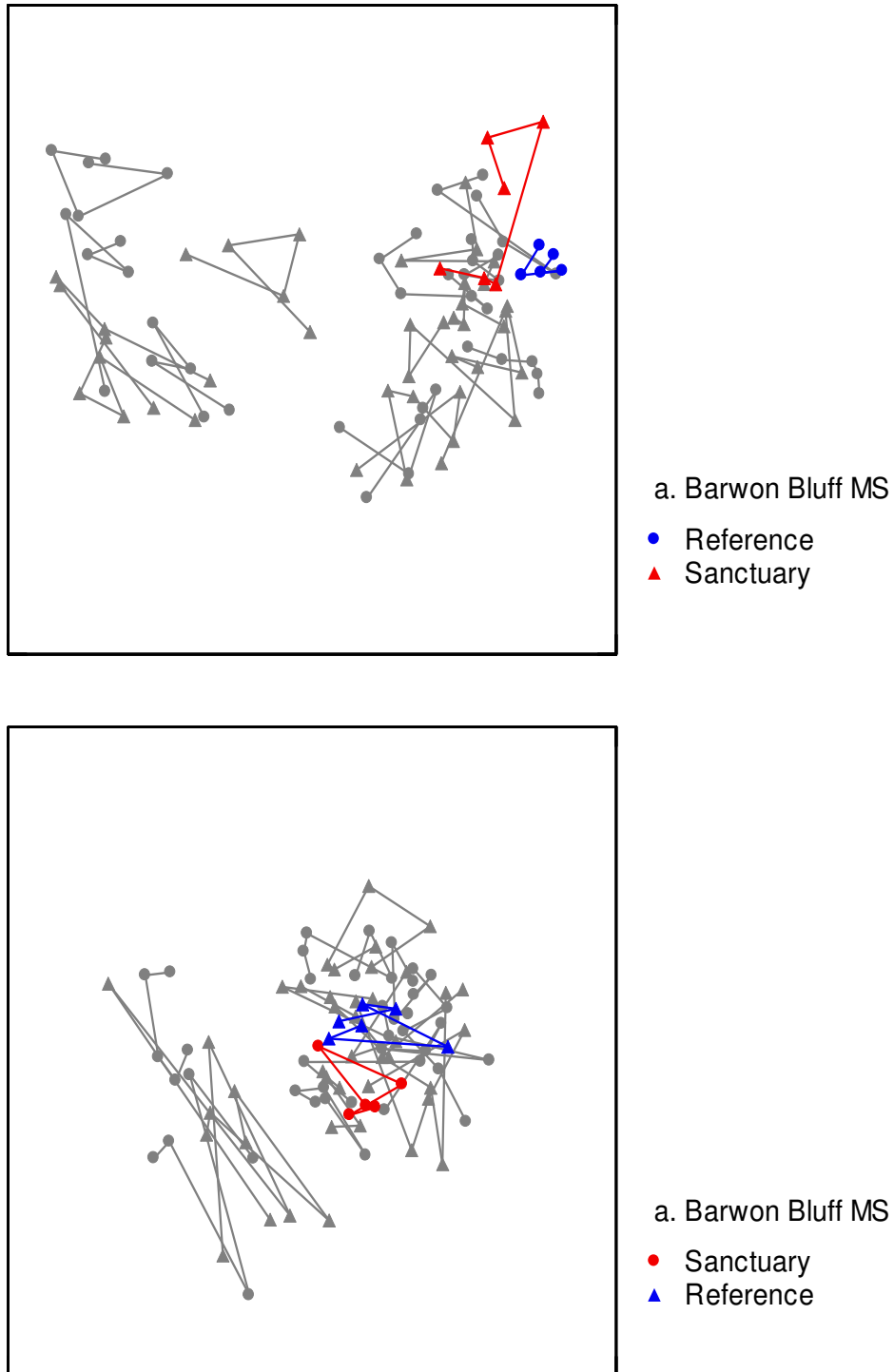


Figure 11.2. Two dimensional MDS plot of invertebrate assemblages on intertidal reefs at Barwon Bluff, within the Barwon Bluff MS, and the reference Barwon Bluff site. (a) Mobile Invertebrate, Kruskal stress = 0.17 and (b) Macroalgae and Aggregating Sessile Invertebrates, Kruskal stress = 0.08. The grey lines represent data from all other intertidal sites used in the MDS analysis.

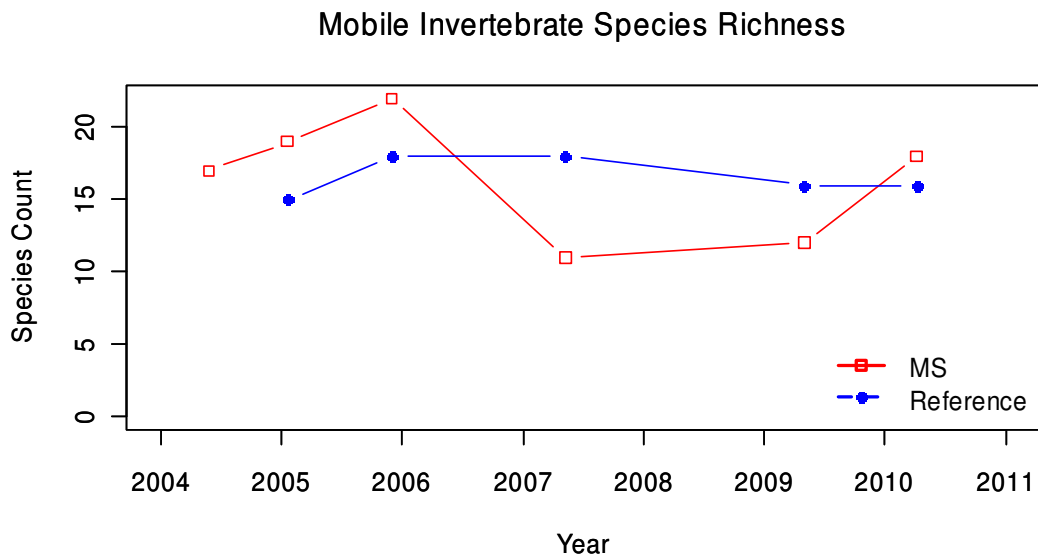


Figure 11.3. Mobile invertebrate species richness at Barwon Bluff within the Barwon Bluff MS, and the Barwon Beach reference site.

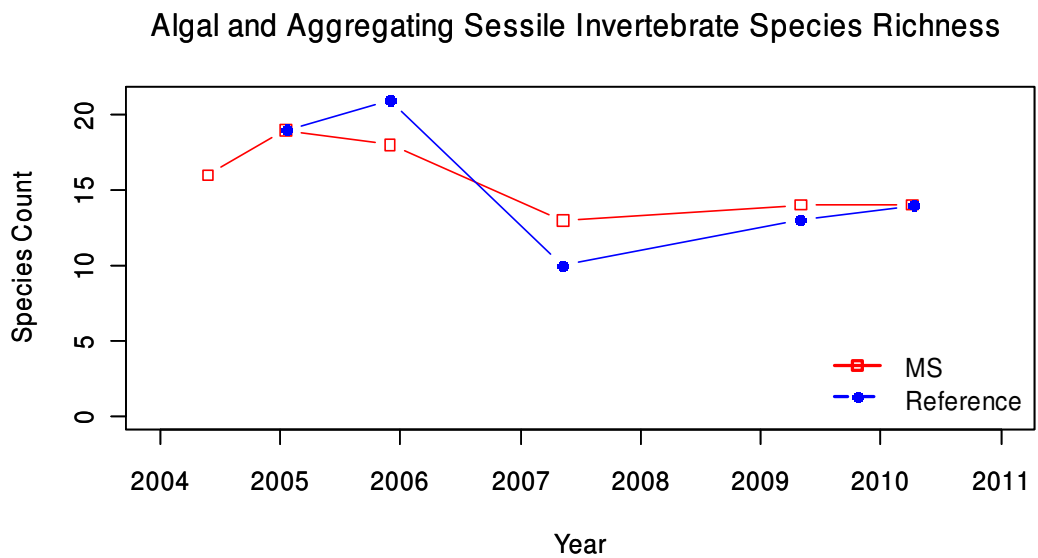


Figure 11.4. Algal and aggregating sessile invertebrate species richness of intertidal sites at Barwon Bluff within the Barwon Bluff MS, and the Barwon Beach reference site.

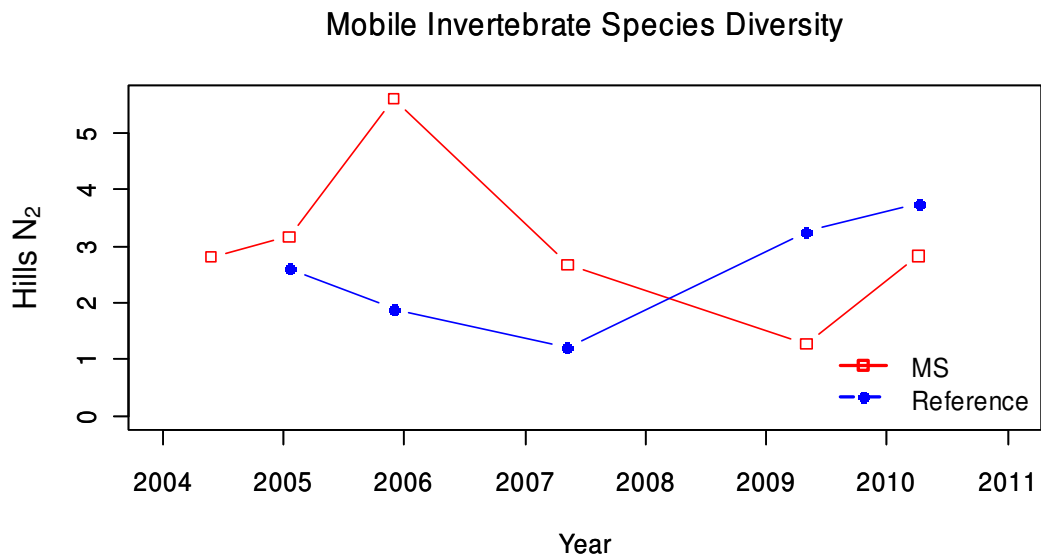


Figure 11.5. Mobile invertebrate diversity (Hills N₂) of intertidal sites at Barwon Bluff within the Barwon Bluff MS, and the Barwon Beach reference site.

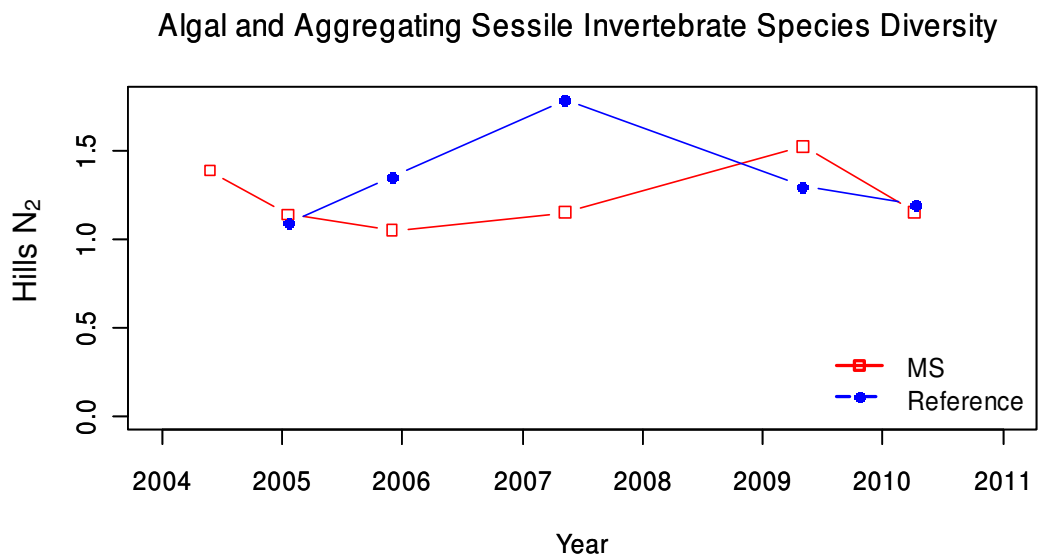


Figure 11.6. Algal and aggregating sessile invertebrate diversity (Hill's N₂) of intertidal sites at Barwon Bluff within the Barwon Bluff MS, and the Barwon Beach reference site.

11.4 Macroalgae and Aggregating Sessile Invertebrates

As with most 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 in 2007 when cover dipped at both sites. In 2010, the cover of *H. banksii* increased from 31 % to 57 % at Barwon Bluff, and from 28 % to 40 % at Barwon Beach (Figure 11.7). The only other macroalgae which occurred in appreciable quantities on the shore were turf forming species. Algal turf cover was higher at Barwon Beach than Barwon Bluff, covering up to 12 % of the reef.

Sand inundation was consistently higher at Barwon Bluff, but decreased from 20 % to 9 % over the last four surveys. Sand inundation at the Barwon Beach site was lower than at Barwon Bluff, and was not recorded at Barwon Beach during 2010. Sand inundation is expected to vary considerably over shorter time scales at these sites, being influenced by prevailing weather conditions.

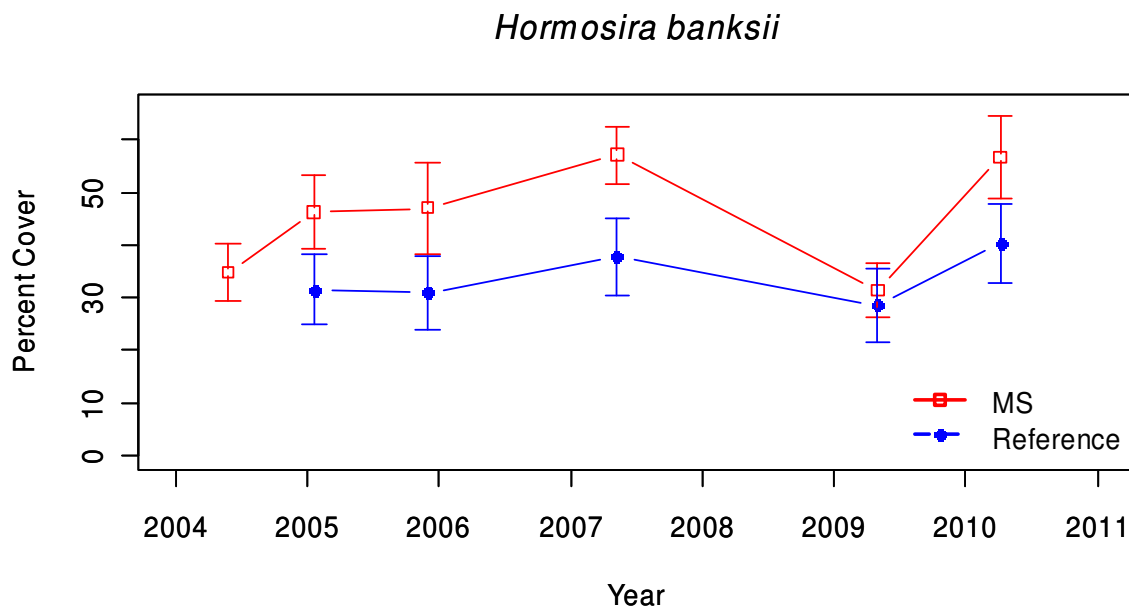


Figure 11.7. Mean percent cover (\pm Standard Error) of Neptune's necklace *Hormosira banksii* at Barwon Bluff within the Barwon Bluff MS, and the Barwon Beach reference site.

11.5 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*, coniwinks *Bembicium nanum*, and periwinkles *Nodilittorina acutispira* and *N. unifasciata*.

The periwinkle *Nodilittorina 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 in 2007. The abundance of *N. acutispira* decrease drastically to 2009, and it was not recorded at either site during the 2010 survey (Figure 11.8). The highly variable abundance of this species has also been observed at other sites during the monitoring program.

The limpet *Clypidina rugosa* was the most consistently abundant species at both sites, although it decreased in abundance by around 50 % in 2010. There was a steady decrease in the abundance of *Siphonaria* spp. at Barwon Bluff; from 43 per 0.25 m² in January 2005 to just 2 per 0.25 m² in May 2009. Abundances then rose sharply to 25 per 0.25 m² in 2010.

Abundances of *Cellana tramoserica* were relatively stable throughout the monitoring period and were consistently higher at Barwon Bluff (Figure 11.10). The predatory gastropods *Cominella lineolata* and *Dicathais orbita* were low in abundance at both sites during all surveys.

Between 2004 and 2009, the mean length of *Cellana tramoserica* at Barwon Bluff increased steadily from 17 mm to 36 mm. A slight decrease in 2010 interrupted this trend. The mean size coincidentally increased during 2010 at there reference Barwon Beach site from 20 to 26 mm (Figure 11.9).

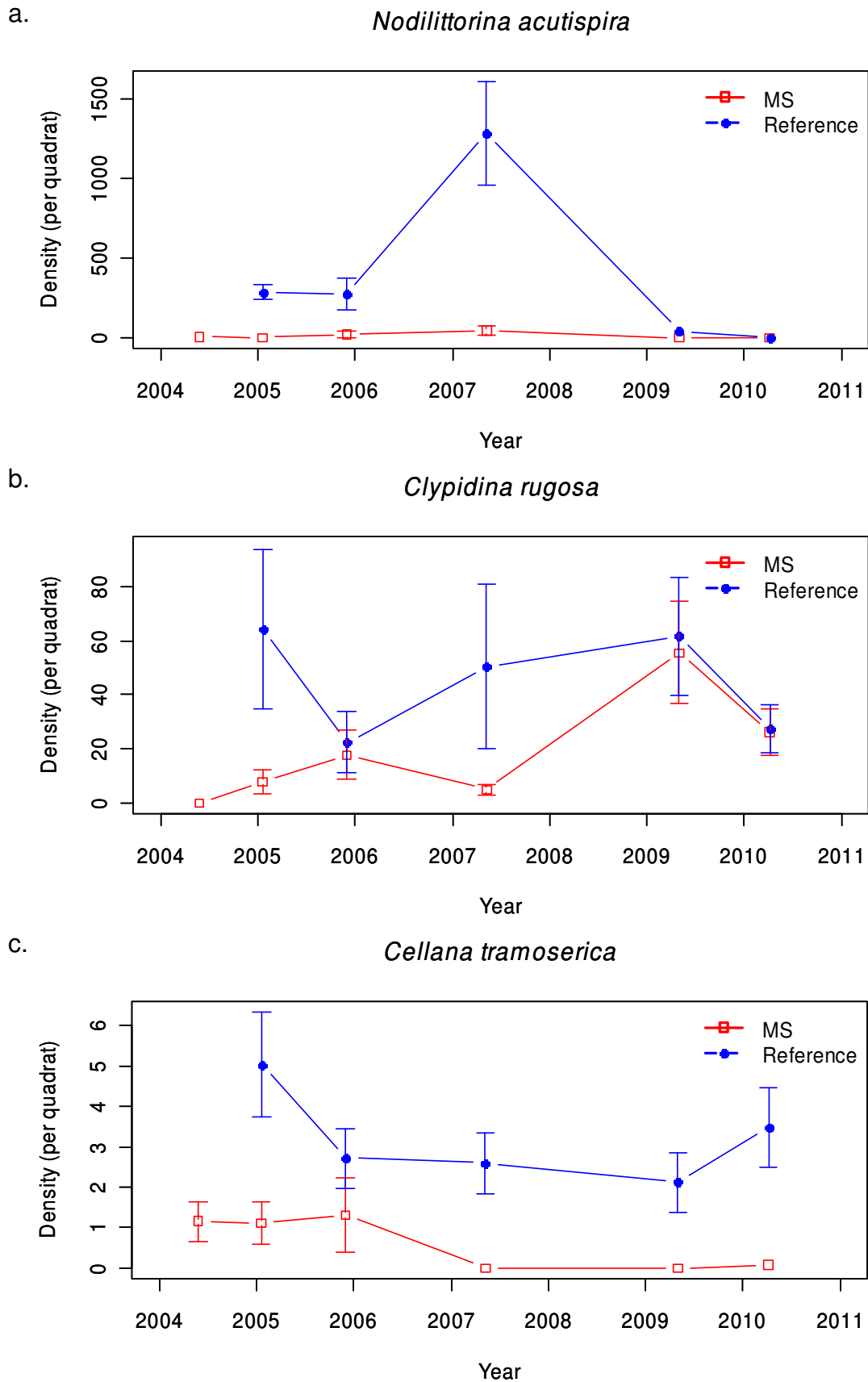


Figure 11.8. Mean Density (\pm Standard Error) of: (a) *Nodilittorina acutispira*; (b) the limpet *Clypidina rugosa*; and (c) the limpet *Cellana tramoserica* at Barwon Bluff within the Barwon Bluff MS, and the Barwon Beach reference site.

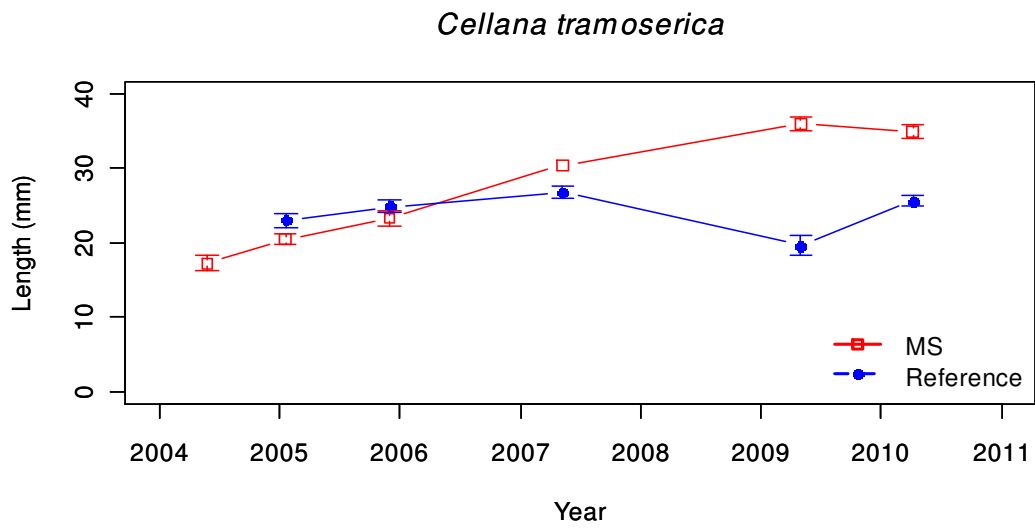


Figure 11.9. Mean sizes (\pm Standard Error) of the limpet *Cellana tramoserica* at Barwon Bluff, within the Barwon Bluff MS, and the Barwon Beach reference site.

11.6 Condition Indicators

Biodiversity

Community composition was within the range of states and changes previously observed. Species richness and diversity levels were also within the range previously observed at these sites.

Introduced Species

There were no introduced species detected for these sites.

Ecosystem Function

Total algal cover increased at both site from 2009 to 2010 and is high within the range previously observed (Figure 11.10a). Erect coralline algae cover was low and variable at both sites (Figure 11.10b). There has been a decreasing trend in the cover of turfing algae at both sites (Figure 11.10c).

The total abundance of grazers has remained relatively stable at Barwon Bluff over the monitoring period, ranging between 50 and 80 per 0.25 m² (Figure 11.11a). The Total abundance of grazers at Barwon Beach has been more variable and decreased from 1400 to 80 per 0.25 m² between 2007 and 2010 (Figure 11.11a). This is primarily due to changes in the abundance of the periwinkle *Nodilittorina acutispira*.

Total predator abundance has been low and variable at both sites, and in 2010 it was within the range previously observed.

Climate Change

Two individuals of the sea hare *Aplysia gigantea* were found in a single quadrat at Barwon Bluff in January 2005. This species is often washed ashore on the New South Wales coast during summer, after spawning in shallow water. No individuals were recorded in any of the following surveys.

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 evidence is inconclusive and the decline is likely to have been for other reasons. There were no indications of increasing harvesting pressure based on mean sizes.

Trampling

There is no evidence that trampling is a constraining factor on algal cover at either site.

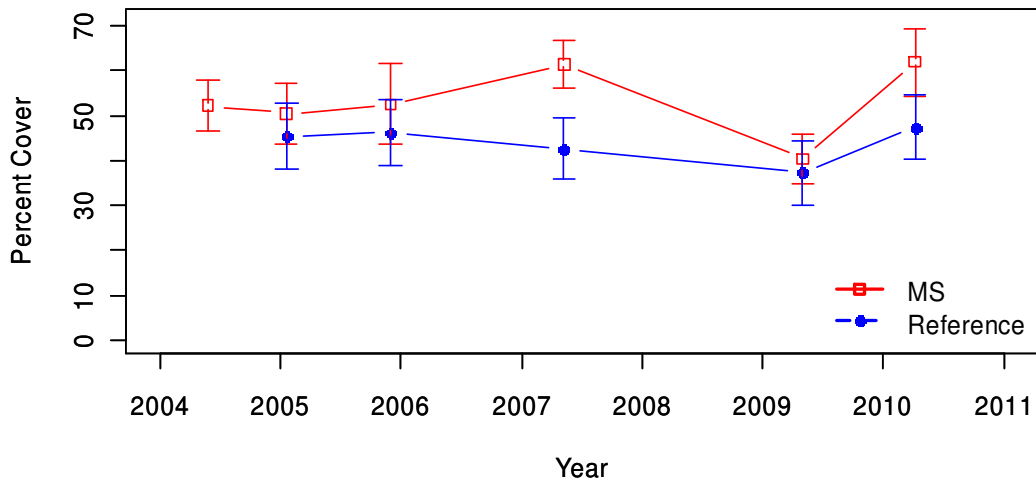
Environment

The cover of green algal species indicative of nutrient loading was relatively low, < 2 % cover, at both sites during all surveys (Figure 11.12a).

Sediment cover has steadily decreased at Barwon Bluff, from 20 % in 2006 to 10 % in 2010 (Figure 11.12b). Sediment cover at Barwon Beach has been 5 % lower than at Barwon Bluff during the three most recent surveys.

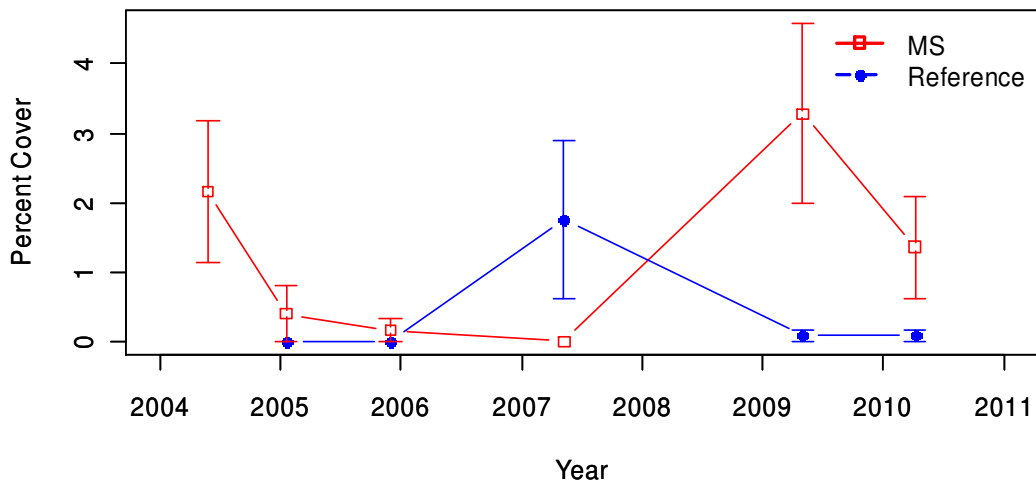
a.

Total Algae Cover



b.

Erect Coralline Algae Cover



c.

Turf Algae Cover

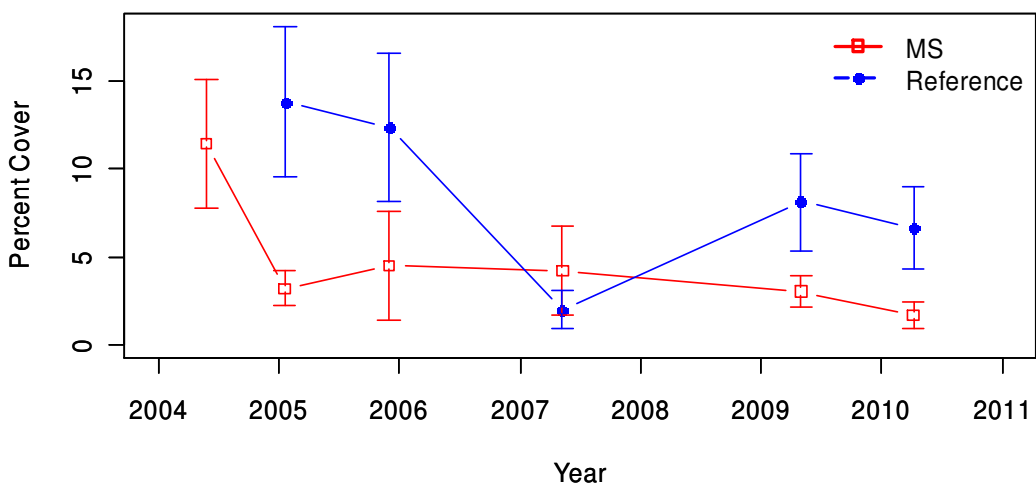
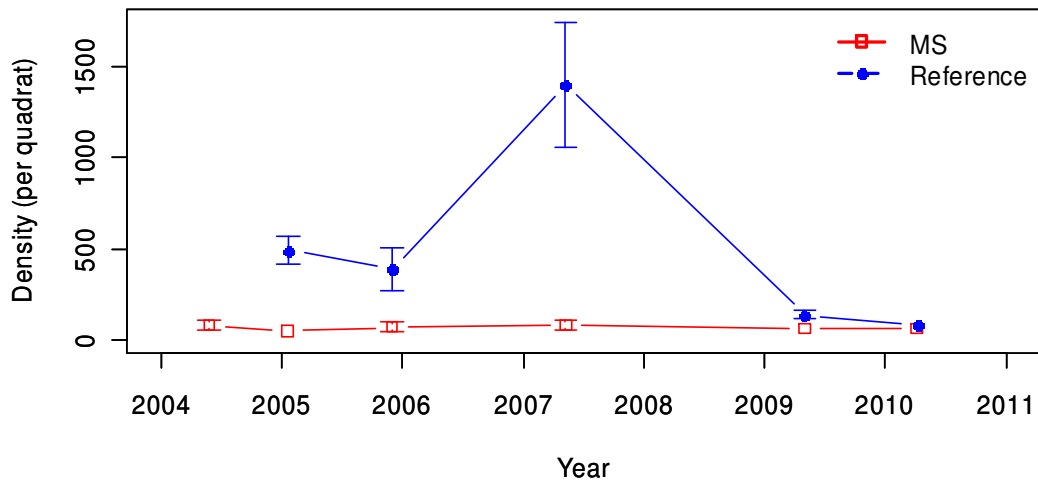


Figure 11.10. Mean cover (\pm Standard Error) of: (a) all algae; (b) erect coralline algae; and (c) turfing algae at Barwon Bluff within the Barwon Bluff MS, and the Barwon Beach reference site.

a.

Total Grazers



b.

Total Predators

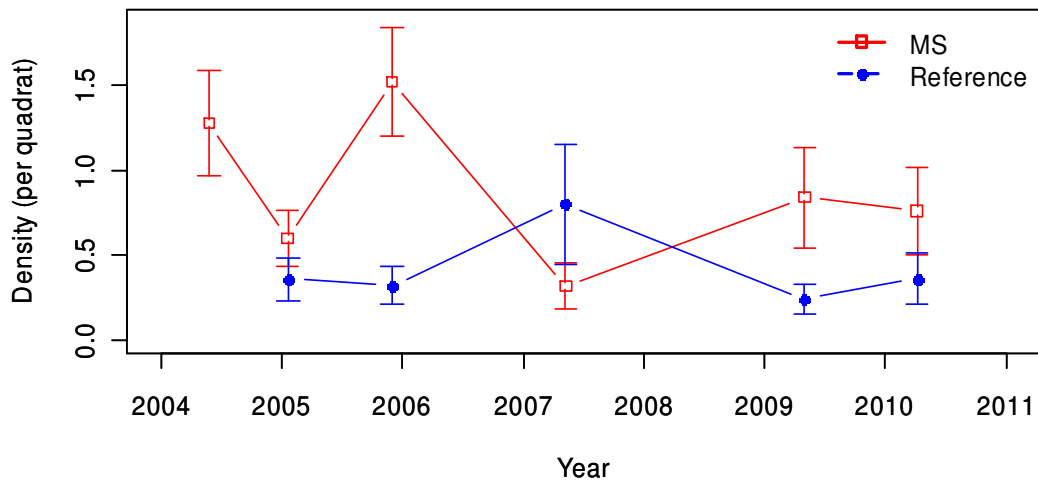
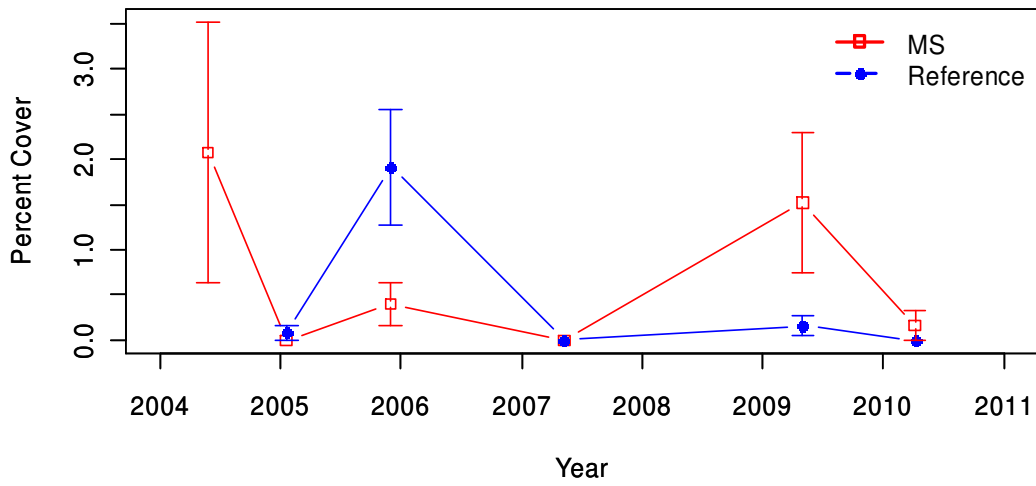


Figure 11.11. Mean abundance (\pm Standard Error) of: (a) all grazers; and (b) all predators at Barwon Bluff within the Barwon Bluff MS, and the Barwon Beach reference site.

a.

Green Algae Cover



b.

Sediment Cover

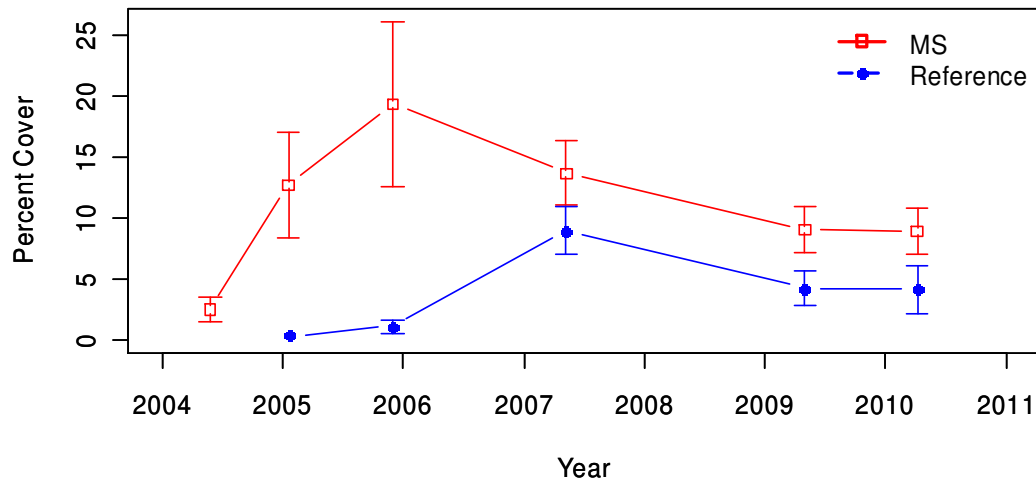


Figure 11.12. Mean cover (\pm Standard Error) of: (a) green algae (*Ulva*, *Enteromorpha* and *Cladophora* species); and (b) sediment at Barwon Bluff within the Barwon Bluff MS, and the Barwon Beach reference site.

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13 ACKNOWLEDGEMENTS

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APPENDIX A – SITE DETAILS

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 4.1). Both the high-shore and low-shore baselines were 100 m long and were approximately parallel. The five transects between the baselines and were between 30 m and 35 m long.

Appendix A Table 1.1. Site details for Point Cooke (Site 4107) in Point Cooke MS.

Site:	4107 Pt Cooke				
MPA/Ref:	MPA				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	305876	5799893	144.7913	-37.9278
B	55	305965	5799917	144.7923	-37.9276
C	55	305890	5799858	144.7914	-37.9281
D	55	305966	5799881	144.7923	-37.9279

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 75 m long. Transects ranged from 28 m at the eastern end of the site to 38 m at the western end.

Appendix A Table 1.2. Site details for Altona (Site 4108), the reference site for Point Cooke MS.

Site:	4108 Altona				
MPA/Ref:	Reference				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	310020	5806233	144.84	-37.8716
B	55	310076	5806270	144.8407	-37.8713
C	55	310035	5806204	144.8402	-37.8719
D	55	310091	5806245	144.8409	-37.8715

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 5.1). The intertidal reef at Jawbone Marine Sanctuary has a large estuarine influence because of the proximity of Kororoit Creek and there is an area of mangrove and salt marsh habitat at the eastern end of the sanctuary. This area is also a RAMSAR site and is an important habitat for migratory shorebirds.

Transect Layout

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

Appendix A Table 1.3. Site details for Jawbone (Site 4109) in Jawbone MS.

Site:	4109 Jawbone				
MPA/Ref:	MPA				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	313062	5807137	144.8748	-37.8641
B	55	313136	5807068	144.8757	-37.8647
C	55	313046	5807118	144.8747	-37.8642
D	55	313123	5807057	144.8755	-37.8648

Williamstown – Site 4110

Site Description

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

Transect Layout

The high-shore baseline was 62 m. The low-shore baseline was 100 m in length. The five transects established were 30-44 m in length.

Appendix A Table 1.4. Site details for Williamstown (Site 4110), the reference site for Jawbone MS.

Site:	4110 Williamstown				
MPA/Ref:	Reference				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	315545	5806228	144.9028	-37.8728
B	55	315531	5806210	144.9027	-37.8729
C	55	315579	5806185	144.9032	-37.8732
D	55	315618	5806206	144.9036	-37.873

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 40 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 40 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 and 7 m apart.

Appendix A Table 1.5. Site details for Ricketts Point (Site 4111) in Ricketts Point MS.

Site:	4111 Ricketts Point				
MPA/Ref:	MPA				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	327001	5792953	145.0298	-37.9946
B	55	327034	5792922	145.0302	-37.9949
C	55	326994	5792949	145.0297	-37.9946
D	55	327019	5792910	145.03	-37.995

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 10 m long and 5 m apart.

Appendix A Table 1.6. Site details for Halfmoon Bay (Site 4112), the reference site for Ricketts Point MS.

Site:	4112 Halfmoon Bay				
MPA/Ref:	Reference				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	325118	5795723	145.009	-37.9693
B	55	325097	5795737	145.0088	-37.9692
C	55	325114	5795712	145.009	-37.9694
D	55	325090	5795729	145.0087	-37.9692

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.

Appendix A Table 1.7. Site details for Point Addis (Site 3901) in Point Addis MNP.

Site:	3901 Point Addis				
MPA/Ref:	MPA				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	260162	5746979	144.2538	-38.3933
B	55	260166	5747053	144.2539	-38.3926
C	55	260177	5746972	144.254	-38.3933
D	55	260185	5747055	144.2541	-38.3926

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 evenly spaced every 25 m and each was approximately 35 m in length.

Appendix A Table 1.8. Site details for Winkipop (Site 3902), the reference site for Point Addis MNP.

Site:	3902 Winkipop				
MPA/Ref:	Reference				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	262913	5750014	144.2863	-38.3667
B	55	262948	5750105	144.2867	-38.3659
C	55	262942	5749997	144.2866	-38.3668
D	55	262986	5750086	144.2871	-38.366

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. Baseline lengths were 46 m each, with transects of 41-43 m, forming a square survey area.

Appendix A Table 1.9. Site details for Point Danger (Site 4002) in Point Danger MS.

Site:	4002 Point Danger				
MPA/Ref:	MPA				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	266413	5753027	144.3273	-38.3405
B	55	266446	5753068	144.3277	-38.3401
C	55	266447	5753006	144.3277	-38.3407
D	55	266483	5753039	144.3281	-38.3404

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.

Appendix A Table 1.10. Site details for Point Danger West (Site 4001), the reference site for Point Danger MS.

Site:	4001 Pt Danger West				
MPA/Ref:	Reference				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	266093	5752959	144.3236	-38.341
B	55	266143	5752979	144.3242	-38.3408
C	55	266099	5752928	144.3237	-38.3413
D	55	266144	5752946	144.3242	-38.3411

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 52 m. The low shore baseline borders rockpools on the south-western corner and is 53 m long. Transect lengths range from 47 m at Transect 1 to 49 m at Transect 5.

Appendix A Table 1.11. Site details for Barwon Bluff (Site 4004) in Barwon Bluff MS.

Site:	4004 Barwon Bluff				
MPA/Ref:	MPA				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	281293	5758960	144.4992	-38.2908
B	55	281339	5758952	144.4998	-38.2909
C	55	281289	5758913	144.4992	-38.2912
D	55	281352	5758904	144.4999	-38.2913

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 45 m and follows the same shore height contour as at Barwon Bluff. The low shore baseline is 37 m long and is angled back towards shore such that Transect 1 is 33 m long and Transect 5 is 24 m long.

Appendix A Table 1.12. Site details for Barwon Beach (Site 4003), the reference site for Barwon Bluff MS.

Site:	4003 Barwon Beach				
MPA/Ref:	Reference				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	280828	5759028	144.4939	-38.2901
B	55	280873	5759015	144.4945	-38.2902
C	55	280828	5758994	144.4939	-38.2904
D	55	280864	5758990	144.4943	-38.2904

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.

Appendix A Table 1.13. Site details for Point Lonsdale (Site 2823) in Port Phillip Heads MNP.

Site:	2823 Pt Lonsdale				
MPA/Ref:	MPA				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	291321	5759033	144.6138	-38.2925
B	55	291418	5759009	144.6149	-38.2928
C	55	291301	5758977	144.6136	-38.293
D	55	291397	5758951	144.6147	-38.2933

Cheviot Bay – Site 2824

Site Description

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

Transect Layout

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

Appendix A Table 1.14. Site details for Cheviot Bay (Site 2824), the reference site for Port Phillip Heads MNP.

Site:	2824 Cheviot Bay				
MPA/Ref:	Reference				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	295939	5756879	144.666	-38.313
B	55	296006	5756827	144.6667	-38.3135
C	55	295916	5756854	144.6657	-38.3132
D	55	295983	5756778	144.6664	-38.3139

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 and separated by 25 m.

Appendix A Table 1.15. Site details for Mushroom Reef (Site 2907) in Mushroom Reef MS.

Site:	2907 Mushroom Reef				
MPA/Ref:	MPA				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	327050	5738412	145.0171	-38.4859
B	55	327151	5738408	145.0182	-38.4859
C	55	327054	5738374	145.0171	-38.4862
D	55	327153	5738363	145.0182	-38.4863

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 approximately 55 m long while the low shore baseline was approximately 70 m long. Transects increase in length along these baselines with Transect 1 measuring 27 m and Transect 5 measuring 62 m.

Appendix A Table 1.16. Site details for Flinders West (Site 2908), the reference site for Mushroom Reef MS.

Site:	2908 Flinders West				
MPA/Ref:	Reference				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	326497	5739009	145.0109	-38.4804
B	55	326549	5738995	145.0115	-38.4805
C	55	326496	5739005	145.0109	-38.4804
D	55	326561	5738983	145.0116	-38.4806

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 56 m and 48 m, respectively. The transects range in length from 25 m at Transect 1 to 50 m at Transect 5.

Appendix A Table 1.17. Site details for Eagles Nest (Site 3020) in Bunurong MNP.

Site:	3020 Eagles Nest				
MPA/Ref:	MPA				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	384362	5719082	145.6708	-38.6693
B	55	384326	5719129	145.6703	-38.6689
C	55	384382	5719098	145.671	-38.6692
D	55	384372	5719143	145.6709	-38.6688

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 48 m long and transects ranged from 80 m in length at Transect 1 to 100 m in length at Transect 5.

Appendix A Table 1.18. Site details for the Caves (Site 3021), the reference site for Bunurong MNP.

Site:	3021 Caves				
MPA/Ref:	Reference				
Site coordinates					
Baseline position	MGA Zone	MGA Easting	MGA Northing	Longitude	Latitude
A	55	385203	5719868	145.6805	-38.6623
B	55	385209	5719911	145.6806	-38.6619
C	55	385281	5719858	145.6814	-38.6624
D	55	385304	5719898	145.6817	-38.6621

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