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Victorian Intertidal Reef Monitoring Program: The Intertidal Reef Biota of Victoria's Marine Protected Areas

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Parks Victoria Technical Paper Series No. 52

Victorian Intertidal Reef Monitoring Program:

The Intertidal Reef Biota of Central Victoria's 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 again in autumn 2007.

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. identify any unusual biological phenomena, interesting or unique communities or species; and
4. 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*, the limpet *Siphonaria* spp and barnacles. There were differences in assemblages between the outer coast sites. The western sites from Barwon Bluff to Point Addis were reasonably similar with one another, as well as with the Port Phillip Heads sites. The Bunurong and Mushroom reef site pairs were relatively different to the other open coast sites.

The differences and similarities in assemblage structure between sites was generally maintained over time. There were temporal variations in structure, but the magnitude of these were less than the between-site differences.

Within Port Phillip Bay, the brown alga Neptune's necklace *Hormosira banksii* covered areas low on the shore at some sites. The ephemeral green algae *Ulva* spp and *Enteromorpha* spp occurred as small patchily distributed tufts. *Galeolaria caespitosa* was the most common and occurred at most sites in low density. The top shell *Austrocochlea porcata* was the most common mobile invertebrate species at almost all sites. The variegated limpet *Cellana tramoserica* was also relatively common, as was the conniwink *Bembicium* spp. Less common species in varying abundances included the warrener *Turbo undulatus*, the black nerite *Nerita atramentosa* and the carnivorous gastropods *Lepsiella vinosa* and *Cominella lineolata*.

Outside Port Phillip Bay, *Hormosira banksii* was the dominant algae most sites. Patches of small coralline and filamentous turfing species were also common. Mat forming mussels were components of more intertidal reef communities outside Port Phillip Bay than inside the bay. On the open coast the pulmonate limpet *Siphonaria* spp, striped conniwink *Bembicium nanum* and *C. tramoserica* were all moderate to highly abundant. *Austrocochlea constricta*, *Notoacmea mayi*, *Clypidina rugosa, Nodilittorina unifasciata* and *N. acutispira* also occurred at most sites, but with a wide range of abundances being observed throughout their ranges.

The results in this report present a snapshot in time for community structures and species-population trends, which operate over long time scales. As monitoring continues and longer-term data sets are accumulated (over multiple years to decades) the program will be able to more adequately assess trends and ecological patterns occurring in the system.

CONTENTS

INDEX OF FIGURES AND TABLES

FIGURES

TABLES

Table 12.2. Density of megafaunal invertebrates per 0.25 m^{-2} at Barwon Beach and Barwon Bluff. 90

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 conniwinks *Bembicium* spp. Molluscan predators include *Cominella lineolata* and *Lepsiella vinosa*. The small mussel *Xenostrobus pulex* and tubeworms such as *Galeolaria caespitosa* create encrusting mats on the surface of the reef. Other invertebrates on intertidal reefs include small crustaceans such as crabs, as well as sessile animals including anemones. Fishes move in over the reef as the tide rises and can be important structuring components of intertidal reef communities.

Intertidal reefs are the most accessible component of marine environments and consequently these habitats have important social and cultural values. Intertidal reefs are sometimes subject to human pressures, including collection of animals for food and fishing bait, trampling and pollution from catchment discharges.

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.

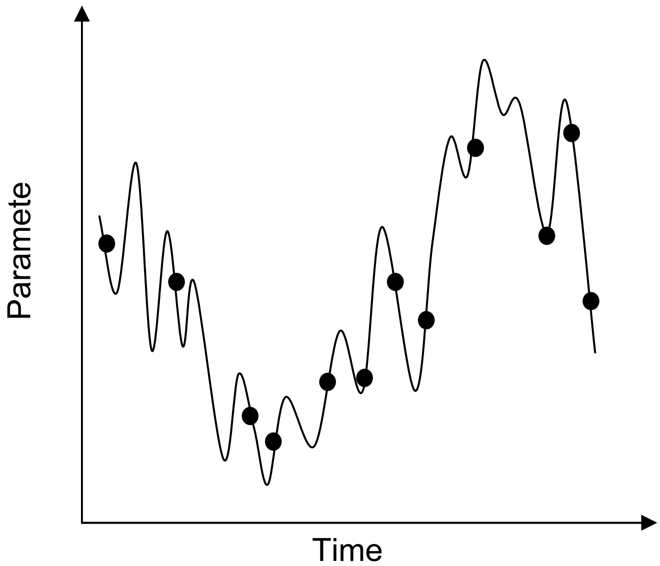


Figure 1.1. An example plot depicting change in an environmental, population or community variable over time (days, months or years). The black circles denote examples of monitoring times. Note how data from these times may not necessarily reflect patterns over shorter time periods, or true maxima or 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). 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.

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 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 and any changes over time;
3. identify any unusual biological phenomena, interesting or unique communities or species; and
4. identify any introduced species at the monitoring locations.

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

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 Sections 4 to 12.

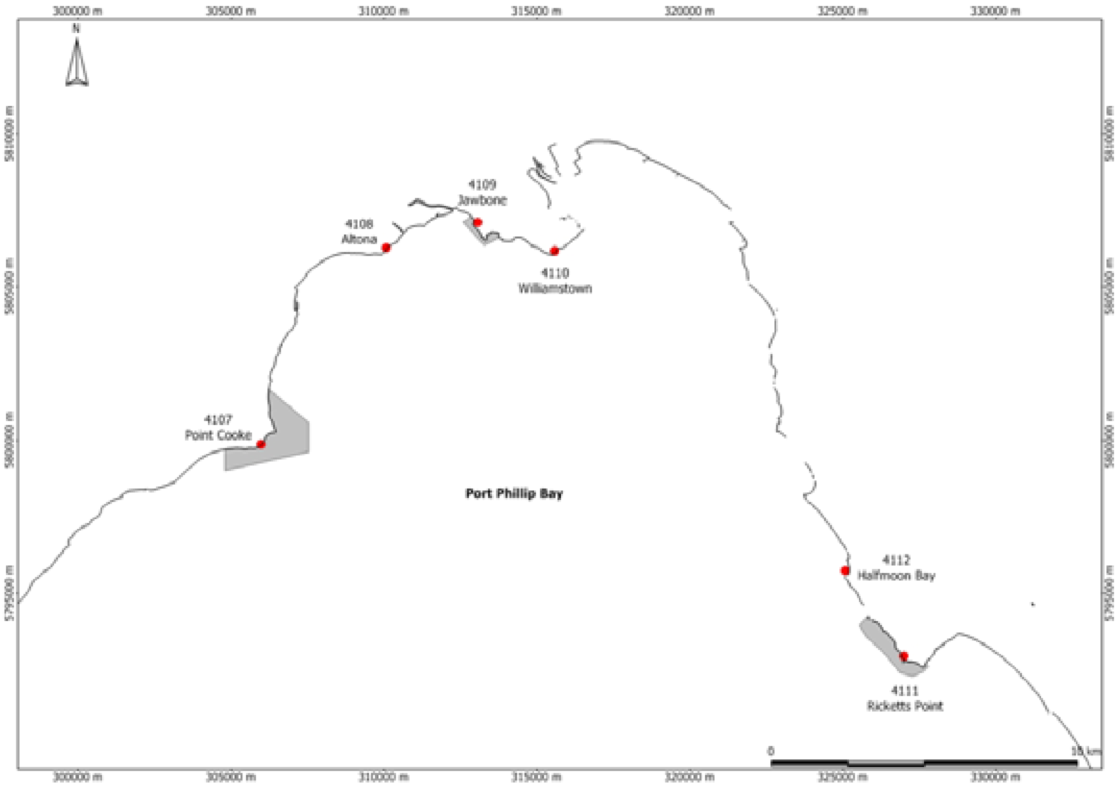


Figure 2.1. Location of intertidal monitoring sites in northern Port Phillip Bay. Marine Sanctuary areas are indicated by grey shading.

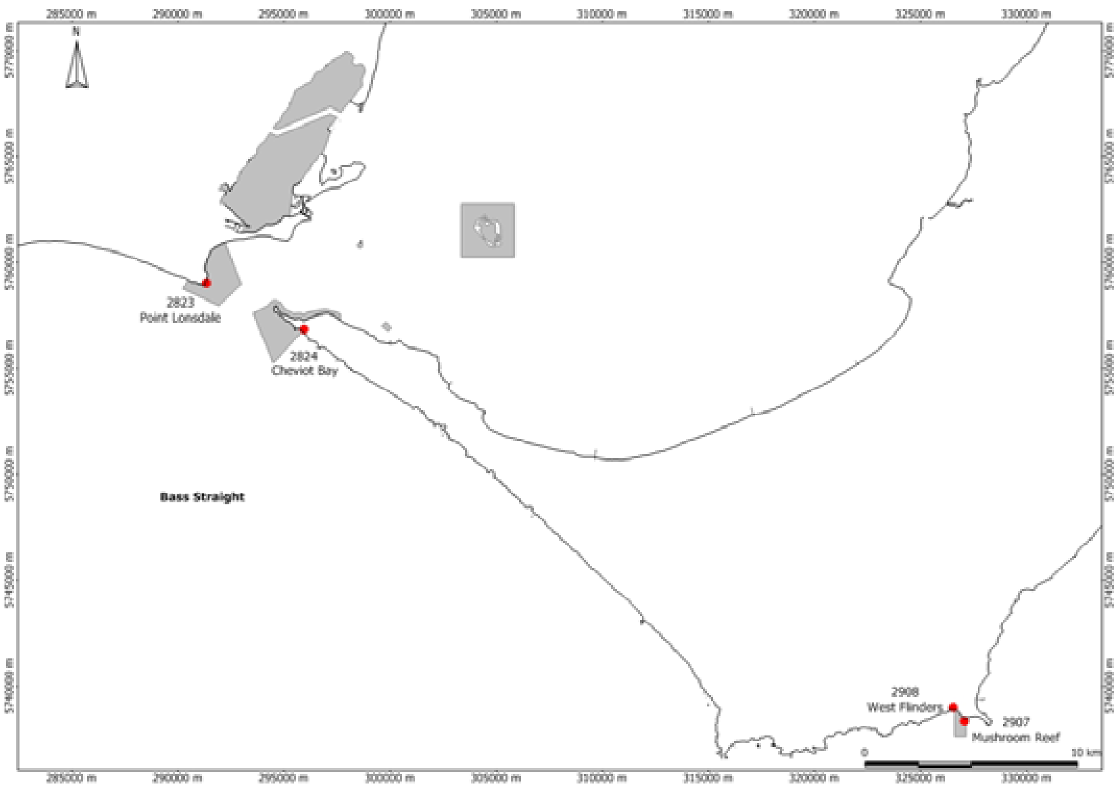


Figure 2.2. Location of intertidal monitoring sites along the eastern coastline of central Victoria (excluding Bunurong Marine National Park). Marine protected areas are indicated by grey shading.

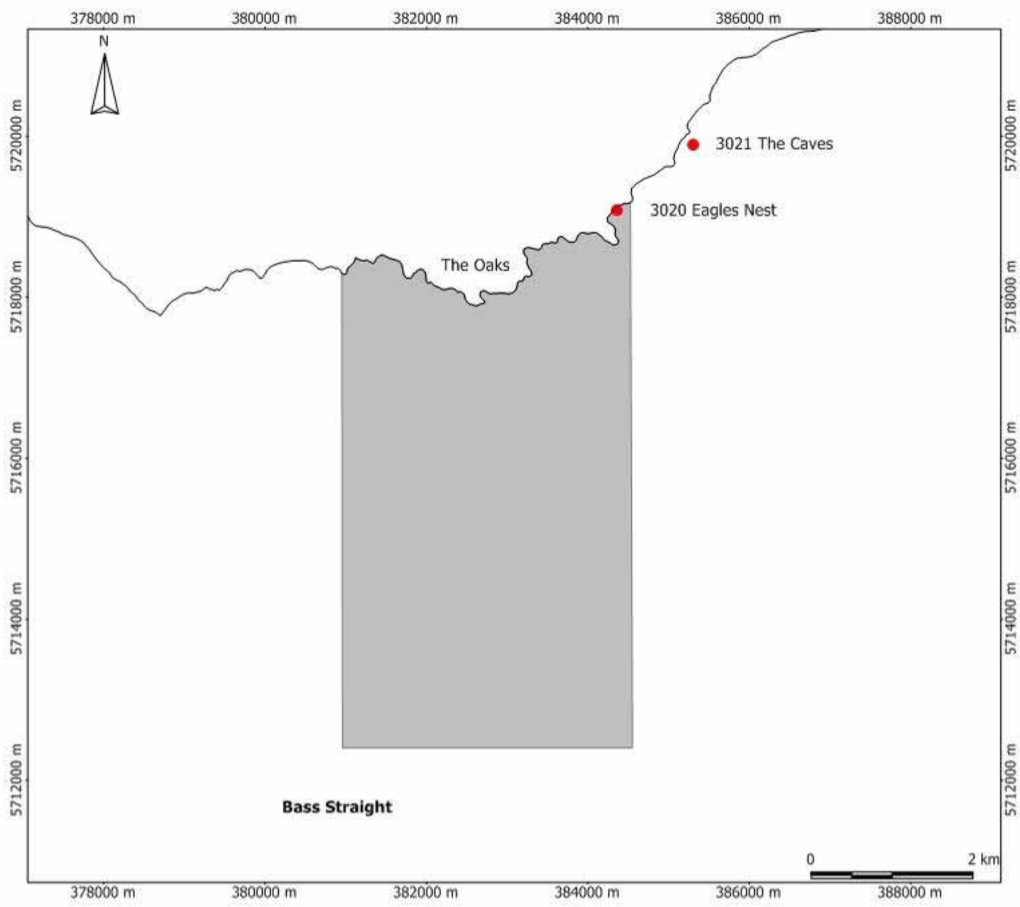


Figure 2.3. Location of intertidal monitoring sites at Bunurong Marine National Park. Marine National Park areas are indicated by grey shading.

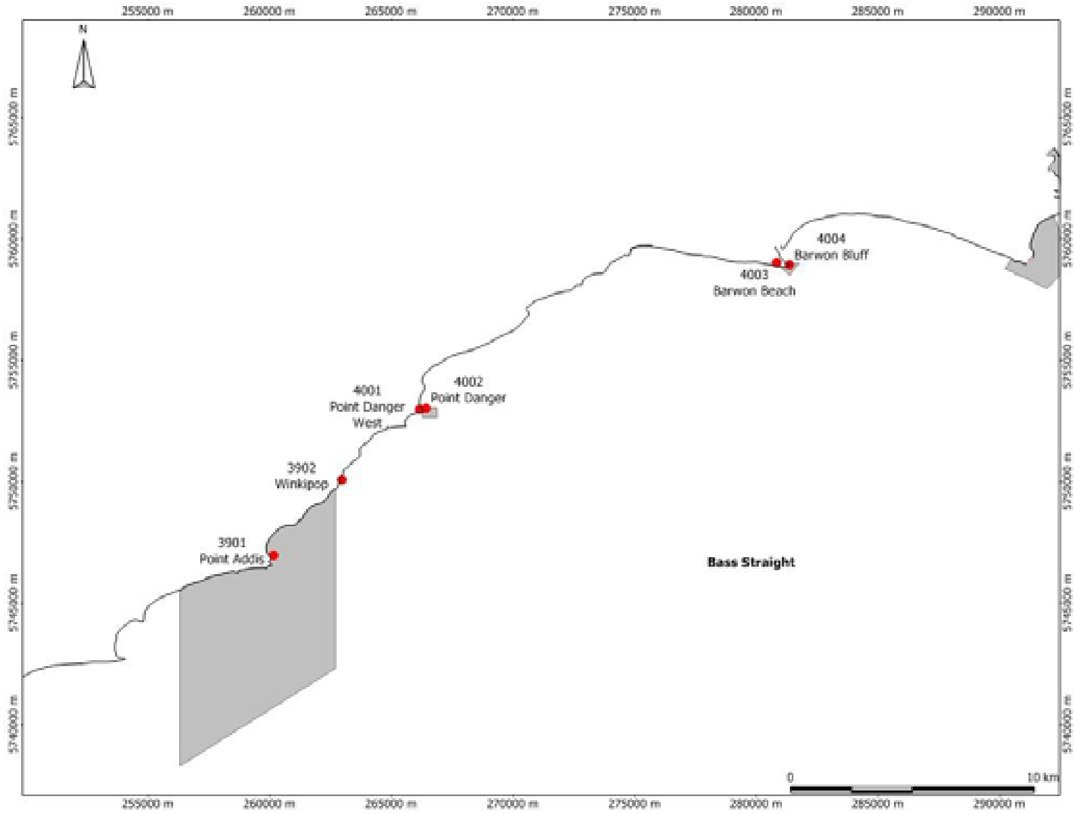


Figure 2.4. Location of intertidal monitoring sites along the western coastline of central Victoria. Marine protected areas' boundaries are indicated by grey shading.

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

Table 2.2. Survey dates of intertidal monitoring sites.

Sites	Survey 1 2003	Survey 2 2004	Survey 3 2004/05	Survey 4 2005/06	Survey 5 2007
4107 Point Cooke	21-04-03	07-05-04	14-04-05		01-06-07
4108 Altona	22-04-03	13-05-04	01-04-05		04-05-07
4109 Jawbone	19-04-03	11-05-04	04-04-05		03-05-07
4110 Williamstown	23-04-03	12-05-04	04-04-05		04-05-07
4111 Ricketts Point	20-04-03	20-05-04	18-04-05		18-05-07
4112 Halfmoon Bay	20-04-03	21-05-04	26-04-05		18-05-07
2823 Point Lonsdale			09-12-04	23-09-05	12-05-07
2824 Cheviot Bay			22-12-04	21-09-05	11-05-07
2907 Mushroom Reef	25-04-03	08-06-04	15-02-05	13-12-05	08-06-07
2908 West Flinders	25-04-03	09-06-04	15-02-05	13-12-05	08-06-07
3020 Eagles Nest			01-02-05	06-01-06	07-06-07
3021 Caves			01-02-05	06-01-06	07-06-07
3901 Point Addis			17-12-04	17-11-05	24-05-07
3902 Winkipop			20-12-04	18-11-05	24-05-07
4001 Point Danger West	09-07-03		17-01-05	01-12-05	23-05-07
4002 Point Danger	08-07-03		14-01-05	01-12-05	23-05-07
4003 Barwon Beach	24-04-03		21-01-05	30-11-05	09-05-07
4004 Barwon Bluff	24-04-03	25-05-04	18-01-05	30-11-05	09-05-07

2.1.1 General Description of 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 (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.

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 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.

Surveys of biota occur in quadrats, randomly placed during each survey at five fixed sampling locations (2 x 2 m area) along each transect (Figure 2.6). The fixed sampling locations are positioned to distribute sampling effort along each transect and to encompass any changes in substratum height across the reef.

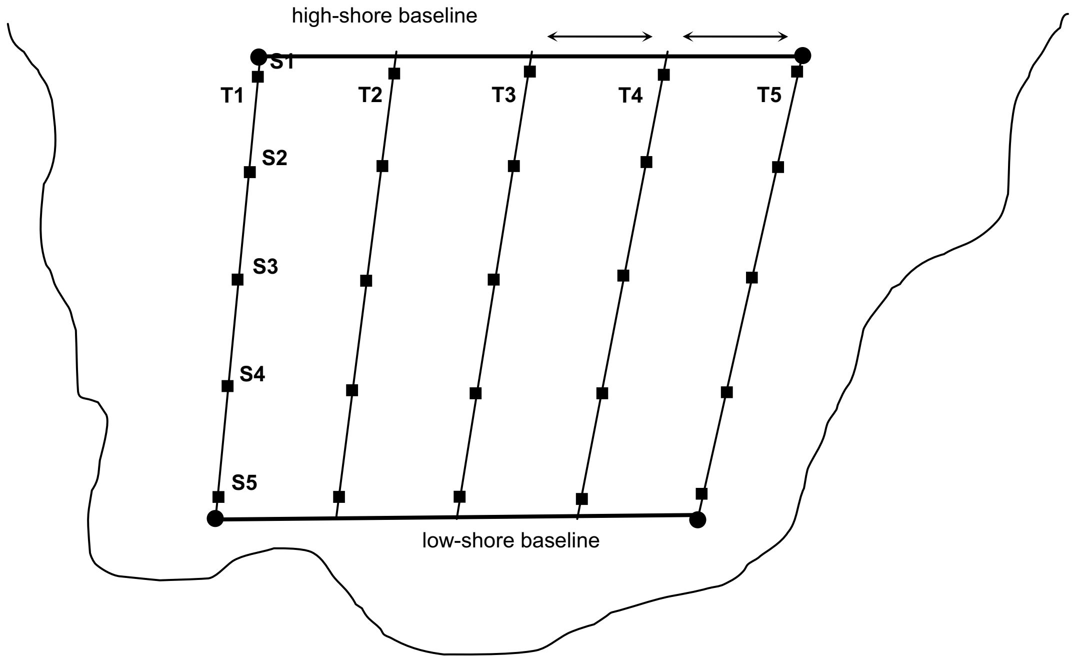


Figure 2.5. Example layout of high and low shore baselines and transects on an intertidal reef. Transects (T1-T5) run across the shore from right to left when looking towards the water. Endpoints of each transect are equidistant along each of the baselines. Sampling locations (S1-S5) are arranged down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

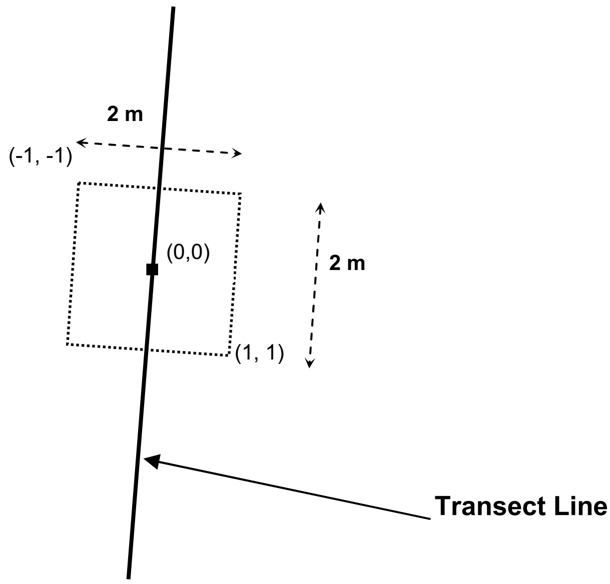


Figure 2.6. Configuration of a sampling location along a transect. Each 2 x 2 m sampling location is centred on a point along the transect line. A quadrat is placed randomly within the sampling location using random x- and y-coordinates between -1 and 1.

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 0.5 x 0.5 m quadrats (Figures 2.7, 2.8, 2.9, 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 in northern Port Phillip Bay are likely to comprise 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 most 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..

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 impacts on populations because of illegal shellfish collection. Data collected also provides general information on population size structure and recruitment dynamics. Species measured include those that are commonly collected on intertidal shores for bait or food, such as *Cellana tramoserica* and *Austrocochlea* spp as well as non-collected 'control' species, including *Siphonaria* spp, *Cominella lineolata* and *Bembicium* spp. Individuals are selected randomly by selecting 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 have been shown to respond to changes in nutrient and freshwater inputs on Victorian intertidal reefs (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 not included in analyses.

2.2.3 Video/Photo Quadrats

Whenever weather conditions and time permit, a digital photograph is taken of the substratum and biota at each quadrat position. This is done to provide a permanent qualitative record of the biota and microhabitat conditions. The photograph is taken such that the minimum dimension is 50 cm (*i.e.* at the scale of a quadrat).

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

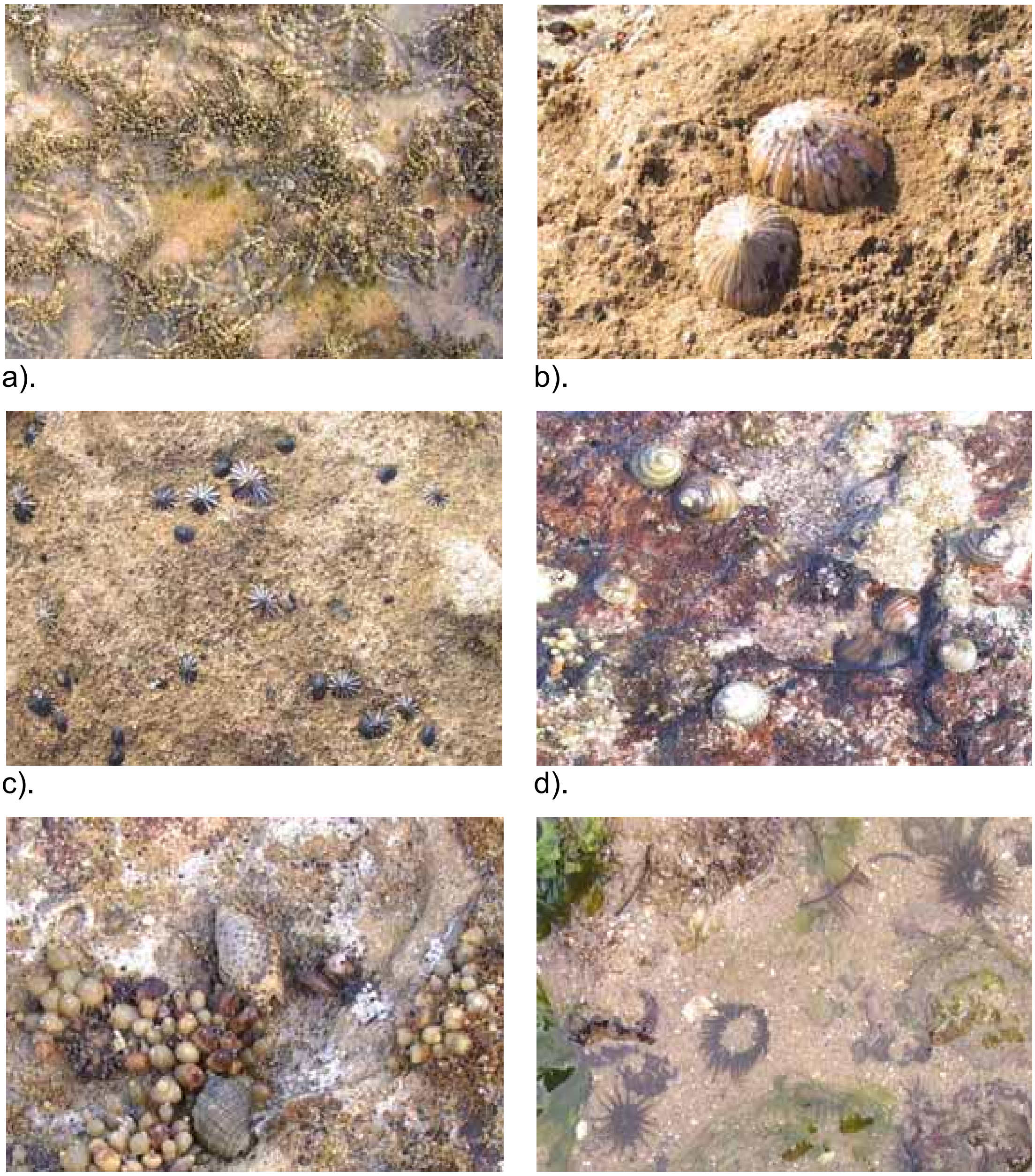
(v) vertical surface, rock side, crevice.

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 biologist counting invertebrates within quadrats during intertidal reef monitoring surveys at Altona.

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

Algae	Sessile Invertebrates	Mobile Invertebrates
Blue-Green Algae	**Tube Worms**	**Limpets**
Rivularia sp.	*Galeolaria caespitosa*	*Clypidina rugosa*
Symploca sp.	*Boccardia proboscidea*	*Patella chapmani*
		Cellana tramoserica
		Patelloida alticostata
Green Algae	**Barnacles**	*Patelloida insignis*
Cladophora prolifera	*Catomerus polymerus*	*Patelloida latistrigata*
Cladophora subsimplex	*Chthamalus antennatus*	*Notoacmea mayi*
Codium spp	*Chaemosipho tasmanica*	*Notoacmea petterdi*
Enteromorpha spp	*Tesseropora rosea*	*Notoacmea* spp
Dictyosphaeria serica	*Tetraclitella purpurascens*	*Siphonaria* spp
Ulva spp		
		Snails
	Bivalves	*Austrocochlea constricta*
Brown Algae	*Mytilus edulis*	*Austrocochlea porcata*
Chordaria cladosiphon	*Xenostrobus pulex*	*Austrocochlea odontis*
Colpomenia sinuosa	*Brachidontes rostratus*	*Austrocochlea concamerata*
Hormosira banksii	*Saccostrea glomerata*	*Turbo undulatus*
Leathesia difformis		*Nerita atramentosa*
Notheia anomala		*Bembicium nanum*
Scytosiphon lomentaria	**Ascidians**	*Bembicium* spp
Splanchnidium rugosum	*Pyura stolonifera*	*Nodilittorina unifasciata*
		Nodilittorina acutispira
		Dicathais orbita
Red Algae	**Anemones**	*Lepsiella vinosa*
Capreolia implexa	*Actinia tenebrosa*	*Cominella lineolata*
Ceramium flaccidum	*Aulactinia veratra*	*Calliostoma armillata*
Corallina officinalis	*Anthothoe albocincta*	*Mitra glabra*
Gracilaria spp	*Oulactis muscosa*	
Laurencia spp		**Sea stars**
		Patiriella exigua
		Patiriella calcar
		Sea Slugs
		Onchidella patelloides
		Sea Hares
		Aplysia gigantea
		Crabs
		Cyclograpsus granulosus
		Paragrapsus gaimardii



a). b).

c). d).

e). f).

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).

Prior to analysis, the data were log transformed to down-weight the influence of highly abundant species in describing community structure, giving a more even weighting between abundant and rarer species (following abundance transformations by Sweatman *et al.* 2000).

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.

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. This value 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 ($1/D_{\text{Simpson}}$ = 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 ($0.25m^{-2}$) for each site. The abundance of common species such as *Austrocochlea* spp and *Cellana tramoserica* were compared between this survey and the previous survey. Abundance was not compared for the initial survey because of differences in survey methodology. The sizes of common species were assessed by calculating mean lengths and size frequency curves for each site where there was a high abundance of individuals.

2.3.4 Initial Analyses

Differences in sampling methodology restricted analyses to only those data collected using the revised standard operating procedures. An exception is size data, which are comparable between both methods. It should be noted that for the initial IRMP surveys there will only be cursory exploration and investigation of the data. When a longer time series is available, there will be more detailed assessments of temporal trends. The analyses do not standardise the height of quadrats on the shoreline, so comparisons between sites should be interpreted with caution.

3 REGIONAL ANALYSIS

3.1 Biogeography

Victoria's marine environment has been classified into five bioregions. These bioregions reflect differences in physical processes such as ocean currents and geology, which in turn influence the distribution of ecosystems and diversity over scales of 100-1000 km.

Point Cooke, Jawbone and Ricketts Point marine sanctuaries are in the Victorian Embayments bioregion (which includes Port Phillip Bay, Westernport Bay and Corner Inlet). Habitats in this bioregion are mostly sheltered from large swells and currents typical of open coastal locations. There also tends to be a larger estuarine influence on habitats in this bioregion.

Point Danger, Barwon Bluff and Mushroom Reef marine sanctuaries and Point Addis, Port Phillip Heads and Bunurong marine national parks are in the Central Victorian bioregion. Habitats in this bioregion are generally exposed to strong winds, large swell and currents that are typical of open coastal locations. Intertidal platforms in this bioregion can also be influenced by sand movement along the open coastline.

3.2 Macroalgae and Aggregating Sessile Invertebrates

Locations surveyed along the open coastline generally had a similar level of diversity, but higher species richness, than sites examined within Port Phillip Bay (Figures 3.1 to 3.6). Species diversity was more consistent than species richness at each site between surveys. Slight increases in diversity were apparent at Altona (Site 4108) and the paired Bunurong sites: Eagles Nest (Site 3020) and Caves (Site 3021; Figures 3.1 and 3.2). Changes were recorded at Mushroom Reef, where diversity appeared to increase considerably at both the sanctuary and reference sites between the 2004 and 2005 surveys, before gradually returning to initial levels by 2007 (Figure 3.2). A similar increase and subsequent decline in diversity was apparent at the reference site Point Danger West (Site 4001), between the 2005 and 2006, but not at the paired sanctuary site (Figure 3.3).

Species richness appeared to increase and then decline at Flinders West (Site 2908), Eagle's Nest (Site 3020) and Point Danger (Site 4002; Figures 3.5 and 3.6). Declines in species richness were apparent at Pt Addis (Site 3901) and Barwon Bluff (Site 4004; Figure 3.6).

Most of the algal and sessile invertebrate communities in Port Phillip Bay were distinct from communities along the exposed coastline (Figure 3.7). Within Port Phillip Bay, Williamstown (Site 4110) and Ricketts Point (Site 4111) had similar assemblages, with a moderate coverage of *Hormosira banksii* making them more like to those of the open coast than other Port Phillip Bay sites. Point Cooke, Jawbone, Altona and, to a lesser extent, Halfmoon Bay showed high temporal variation in assemblage structure (Figure 3.7), probably related to the ephemeral coverage of sea lettuce *Ulva* spp and the green alga *Enteromorpha* spp at these sites.

On the coastline east of Port Phillip Bay, sites had a gradient of algal and sessile invertebrate assemblages (Figure 3.7b). The assemblages at the Flinders sites (Sites 2907 and 2908) overlapped with those of the Port Phillip Heads sites (Sites 2823 and 2824), which in turn overlapped with the Bunurong sites' assemblages (Sites 3020 and 3021). Temporal variation was relatively low and the gradient of assemblages was preserved over time.

Coastal sites west of Port Phillip Bay had a smaller range of assemblages than those on the east coast (Figure 3.7). There was no clear separation of assemblages between west coast sites, and they overlapped with those of Port Phillip Heads sites, reflecting the structural similarity and geographic proximity of these sites.

The most abundant macroalgae on the open coast was Neptune's necklace *Hormosira banksii*. There was a high cover of this species at all coastal sites except for Mushroom Reef (Site 2907) where the cover was relatively low. Patches of small coralline and filamentous turfing species occurred at most coastal locations in low abundance but were relatively abundant at Point Addis (Site 3901), Point Danger (Site 4002) and in particular Flinders West (2908). Mat forming mussels, such as *Xenostrobus pulex* and *Brachidontes rostratus*, were abundant at several locations including Barwon Bluff (Site 4004), Point Danger (Sites 4001 and 4002), Mushroom Reef (Site 2907) and Bunurong (Sites 3020 and 3021).

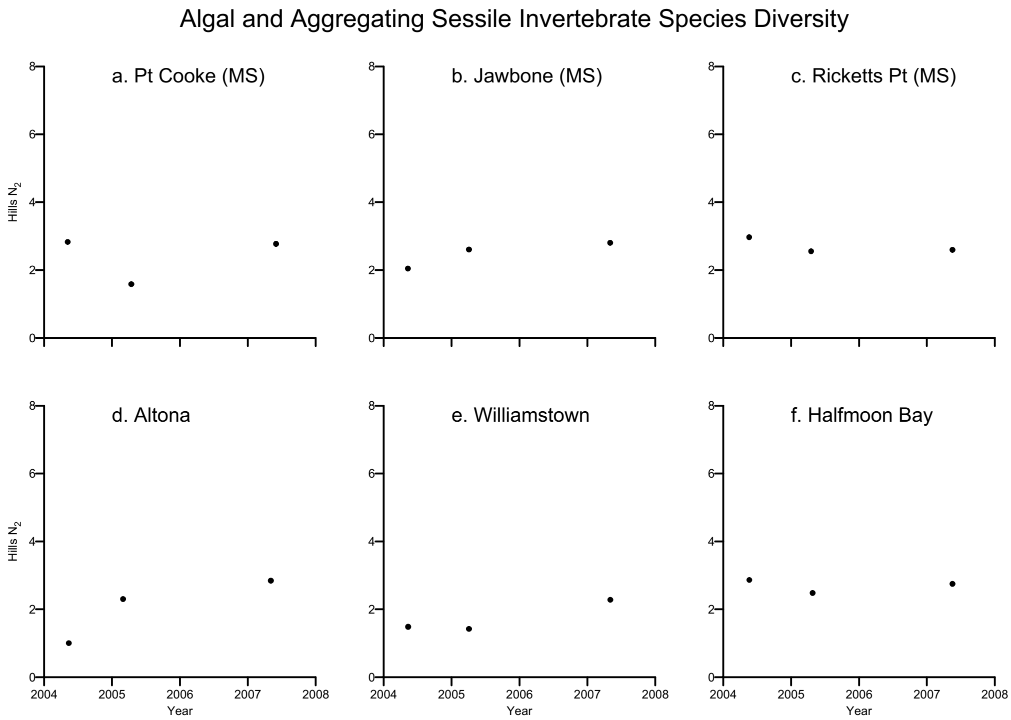


Figure 3.1. Algal and aggregating sessile invertebrate diversity (Hill's N_2) of intertidal sites within Port Phillip Bay.

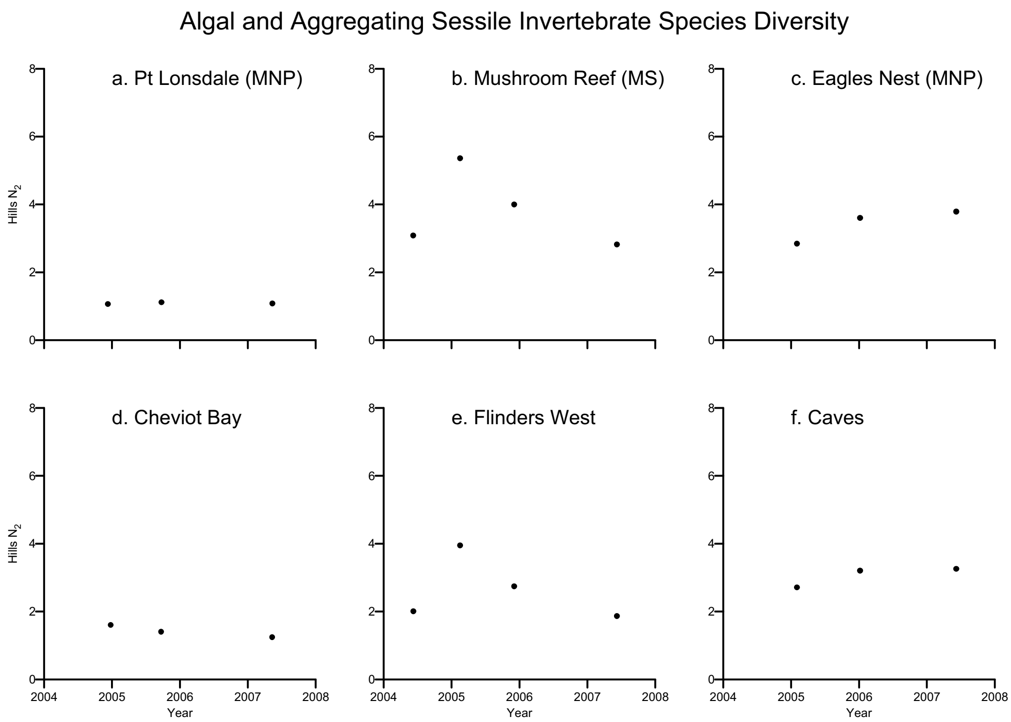


Figure 3.2. Algal and aggregating sessile invertebrate diversity (Hills N_2) of intertidal sites along the eastern Victorian coast.

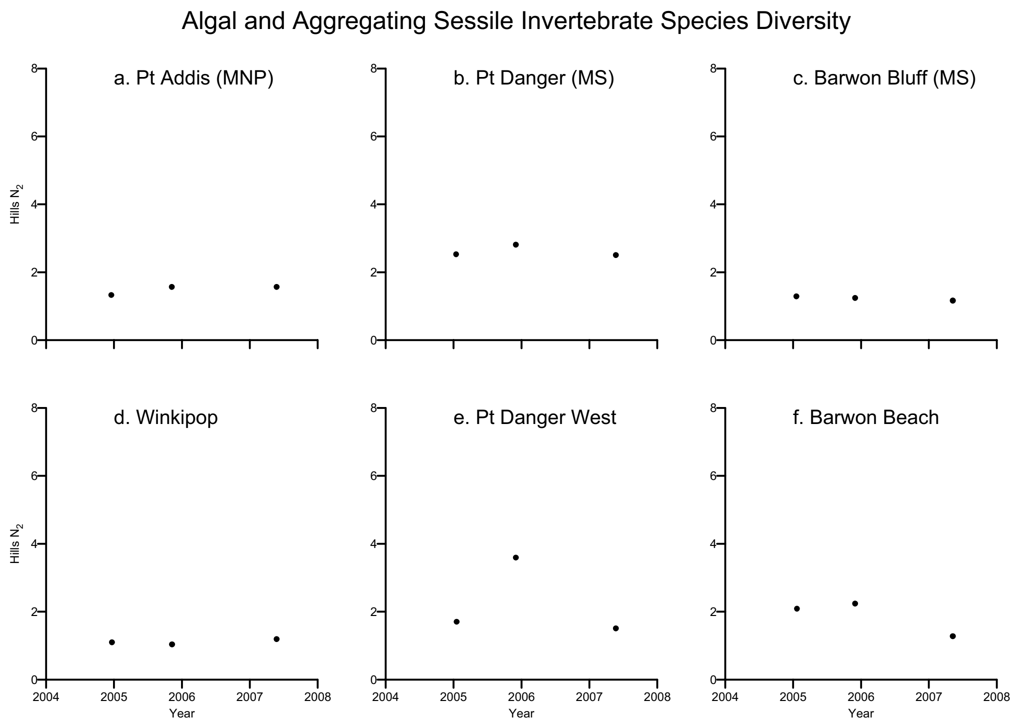


Figure 3.3. Algal and aggregating sessile invertebrate diversity (Hills N_2) of intertidal sites along the western Victorian coast.

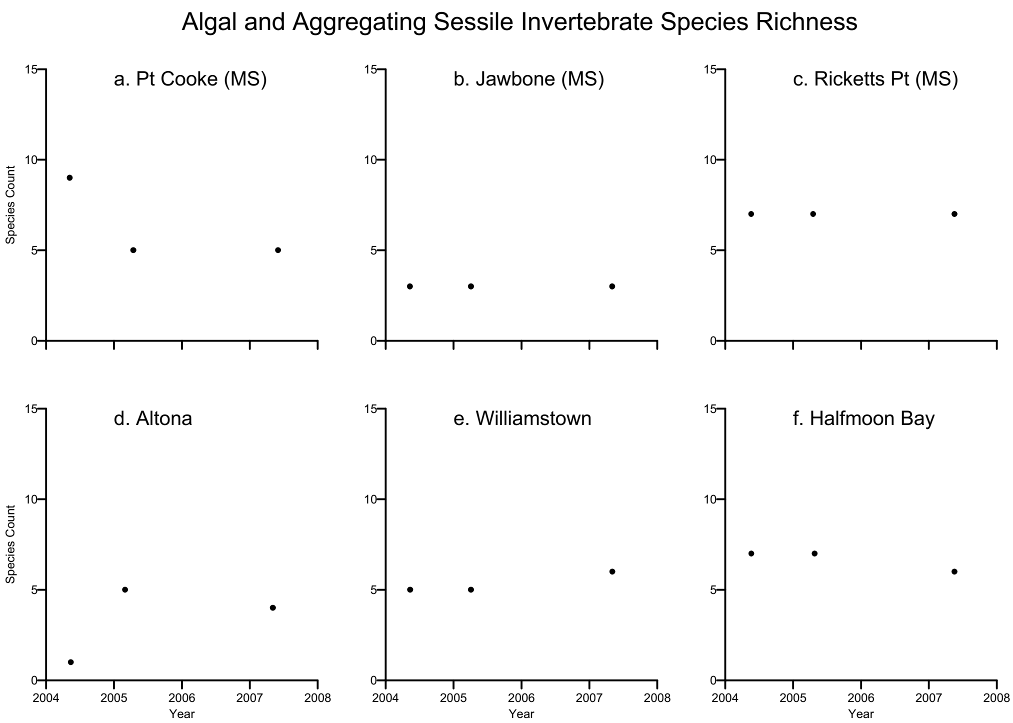


Figure 3.4. Algal and aggregating sessile invertebrate species richness of intertidal sites within Port Phillip Bay.

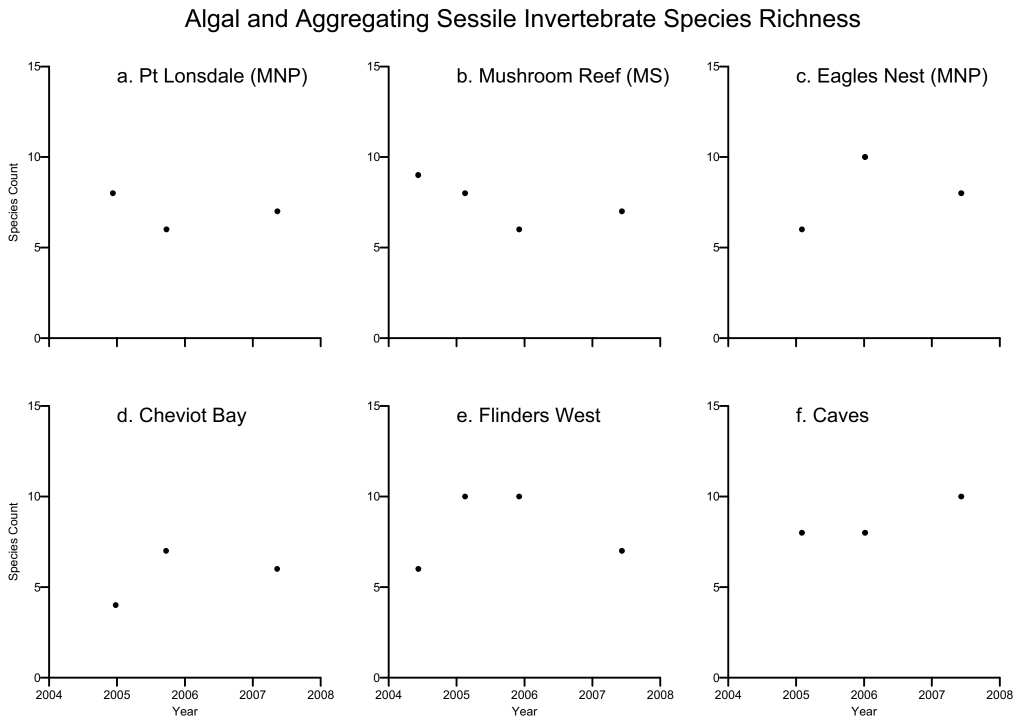


Figure 3.5. Algal and aggregating sessile invertebrate species richness of intertidal sites along the eastern Victorian coast.

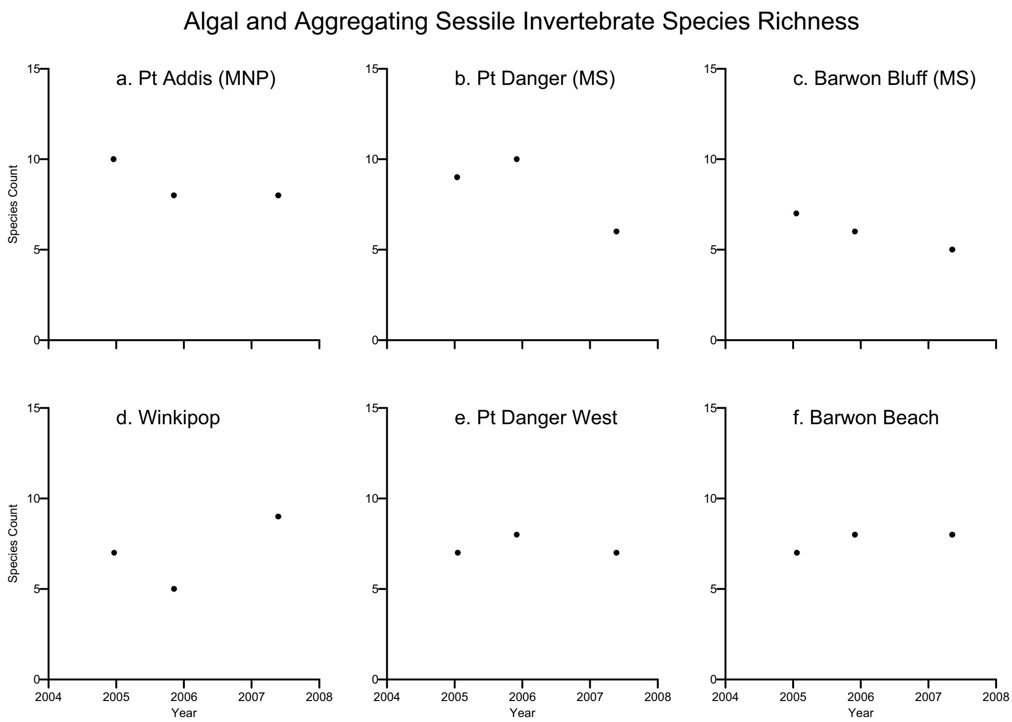


Figure 3.6. Algal and aggregating sessile invertebrate species richness of intertidal sites along the western Victorian coast.

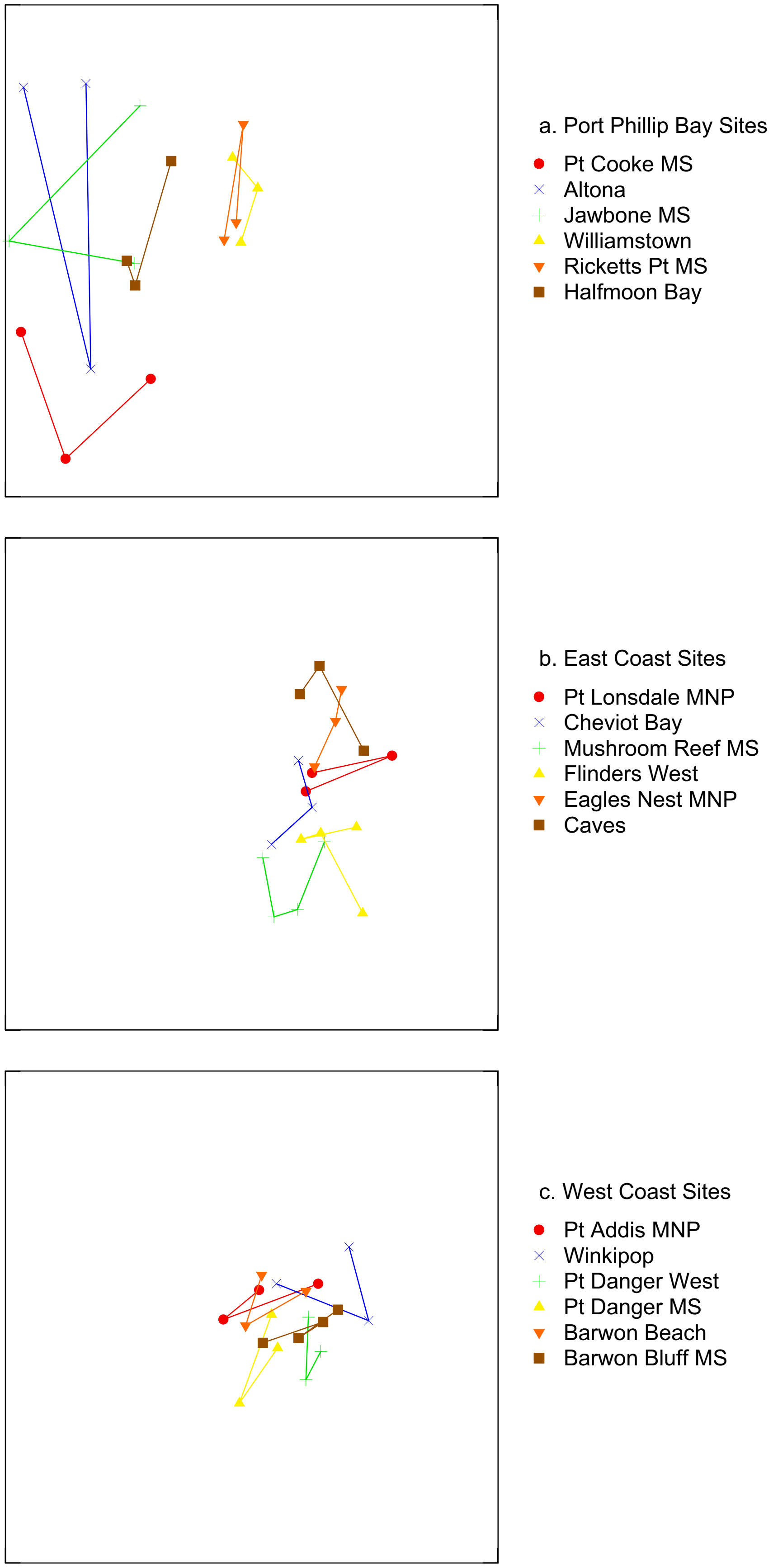


Figure 3.7. Two dimensional MDS plot of algal and sessile invertebrate assemblages on intertidal reefs in (a) northern Port Phillip Bay; (b) Port Phillip Heads and the eastern Victorian coastline; and (c) western Victorian coastline. Lines connect sites examined during consecutive surveys. Kruskal stress = 0.19.

3.3 Mobile Invertebrates

Sites along the open coastline generally had a higher richness and diversity of mobile invertebrate species than sites in Port Phillip Bay (Figures 3.8 to 3.13). Within Port Phillip Bay, Halfmoon Bay (Site 4112) had the highest species diversity, but this site also had a decline over time (Figure 3.8). Point Danger West (Site 4001) had an apparent increase in invertebrate species diversity over time, while diversity at Winkipop (Site 3902) and Point Lonsdale (Site 2823) declined (Figures 3.9 and 3.10). Species diversity and richness appeared to increase then decrease sharply at Barwon Bluff (Site 4004; Figure 3.10).

Species richness appears to have increased and subsequently declined slightly at many sites, including Barwon Beach (Site 4003), Point Danger (Site 4002), Point Danger West (Site 4001), Point Addis (Site 3901), Mushroom Reef (Site 2907), Flinders West (Site2908) and Williamstown (Site 4110; Figures 3.11 to 3.13). Conversely, species richness at Halfmoon Bay and to a lesser extent Ricketts Point declined and then rose again (Figure 3.11). A decline in species richness was observed at Eagle’s Nest (Site 3020; Figure 3.12).

The mobile invertebrate communities in Port Phillip Bay were distinct from those on the open coast and encompassed a greater range of assemblage types (Figure 3.14). Within Port Phillip Bay the sites at Altona (Site 4108), Jawbone (Site 4109) and Williamstown (Site 4110) had the most similar mobile invertebrate assemblages, reflecting their geographical proximity. Point Cooke (Site 4107) and Halfmoon Bay (Site 4112) had assemblages that were distinct from other sites (Figure 3.14), due to low species richness and abundance at Point Cooke and conversely, the high species richness and abundance of species at Halfmoon Bay (Figures 3.8 and 3.11). The top shell *Austrocochlea porcata* was the most common species at almost all sites In Port Phillip Bay. *Cellana tramoserica* was also relatively common, as was *Bembicium* spp. Less common species, in varying abundances, included the warrener *Turbo undulatus*, the black nerite *Nerita atramentosa* and the carnivorous gastropods *Lepsiella vinosa* and *Cominella lineolata.*

For sites outside Port Phillip Bay there was no apparent separation between mobile invertebrate assemblages from the east and west coasts. Sites east of Port Phillip Bay had a gradient of assemblages (Figure 3.14b), from those of the Flinders sites (Sites 2907 and 2908) through to the Port Phillip Heads’ assemblages (Sites 2823 and 2824), with the Bunurong sites (Sites 3020 and 3021) intermediate between these locations. Assemblages from sites west of Port Phillip Bay showed no clear distinctions, though assemblages at Winkipop (Site 3902) and Barwon Bluff (Site 4004) showed greater temporal variation (Figure 3.14c).

The pulmonate limpet *Siphonaria* spp, striped conniwink *Bembicium nanum* and variegated limpet *Cellana tramoserica* were all relatively abundant at all sites surveyed along the open coast. *Austrocochlea constricta*, *Clypidina rugosa, Nodilittorina unifasciata*, *N. acutispira*, *Lepsiella vinosa* and *Cominella lineolata* were also common, but their abundances varied widely across sites.

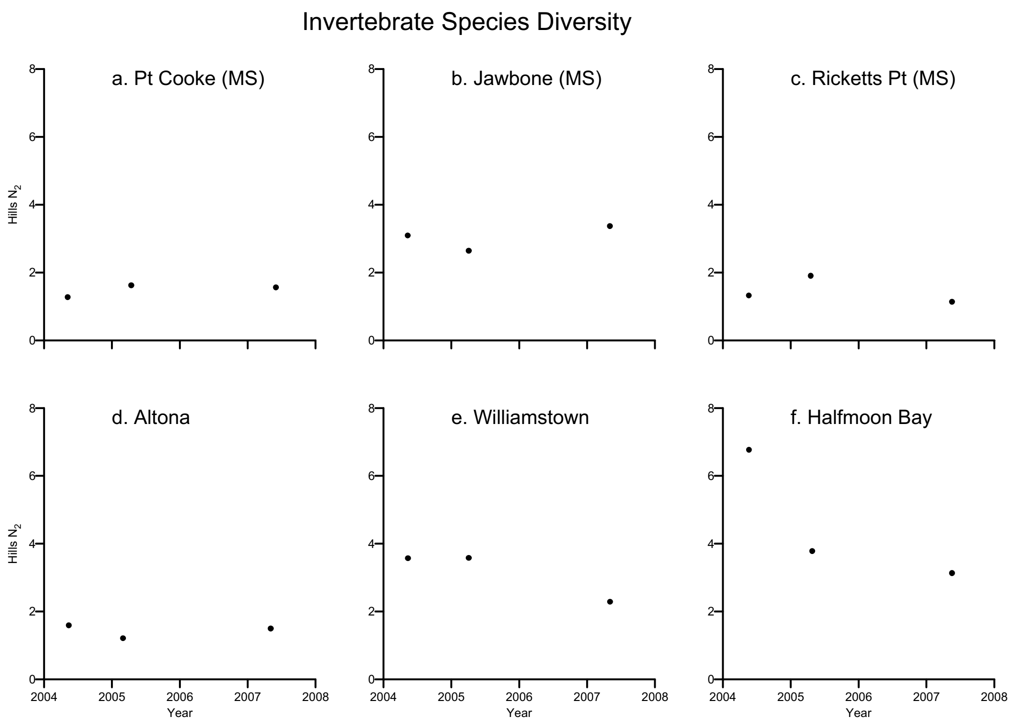


Figure 3.8. Invertebrate species diversity (Hills N_2) of intertidal sites within Port Phillip Bay.

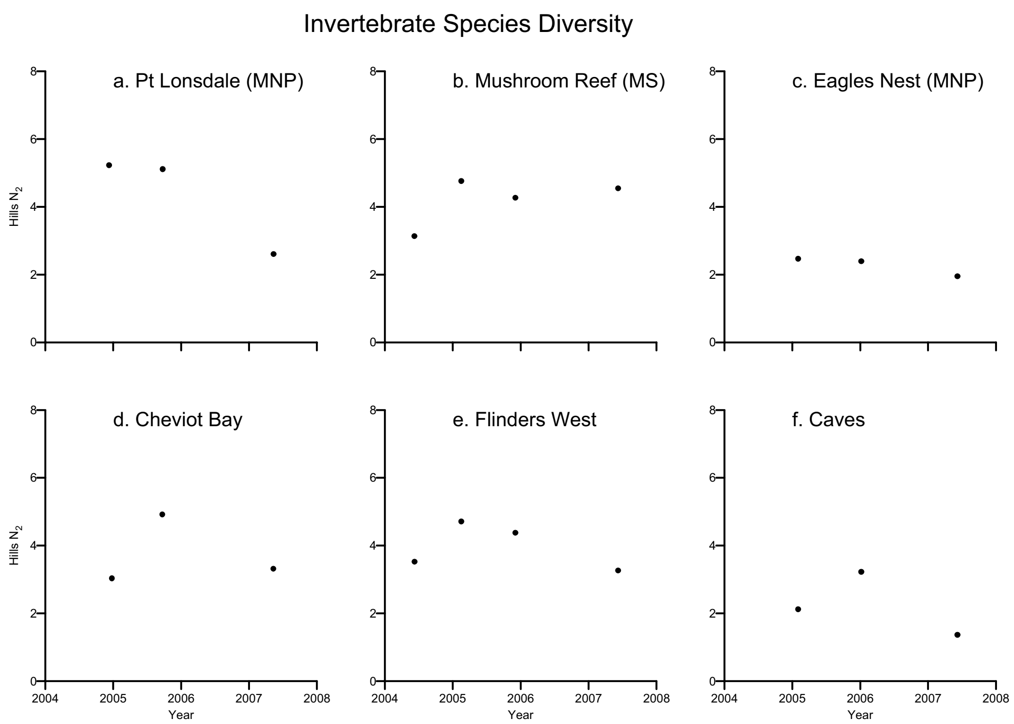


Figure 3.9. Invertebrate species diversity (Hills N_2) of intertidal sites along the eastern Victorian coast.

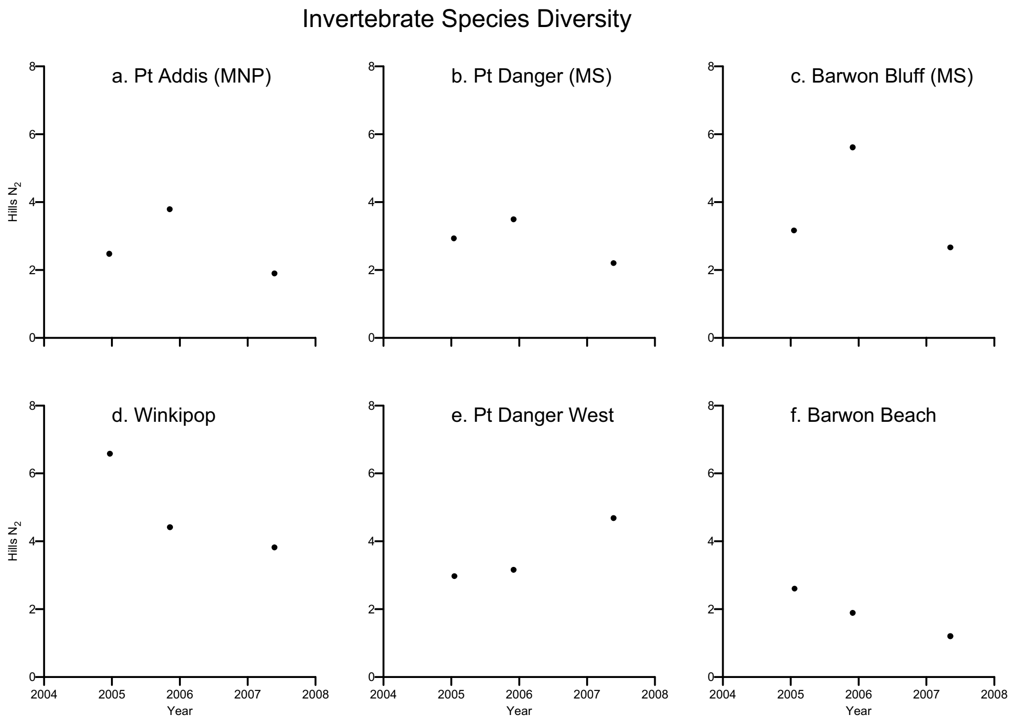


Figure 3.10. Invertebrate species diversity (Hills N_2) of intertidal sites along the western Victorian coast.

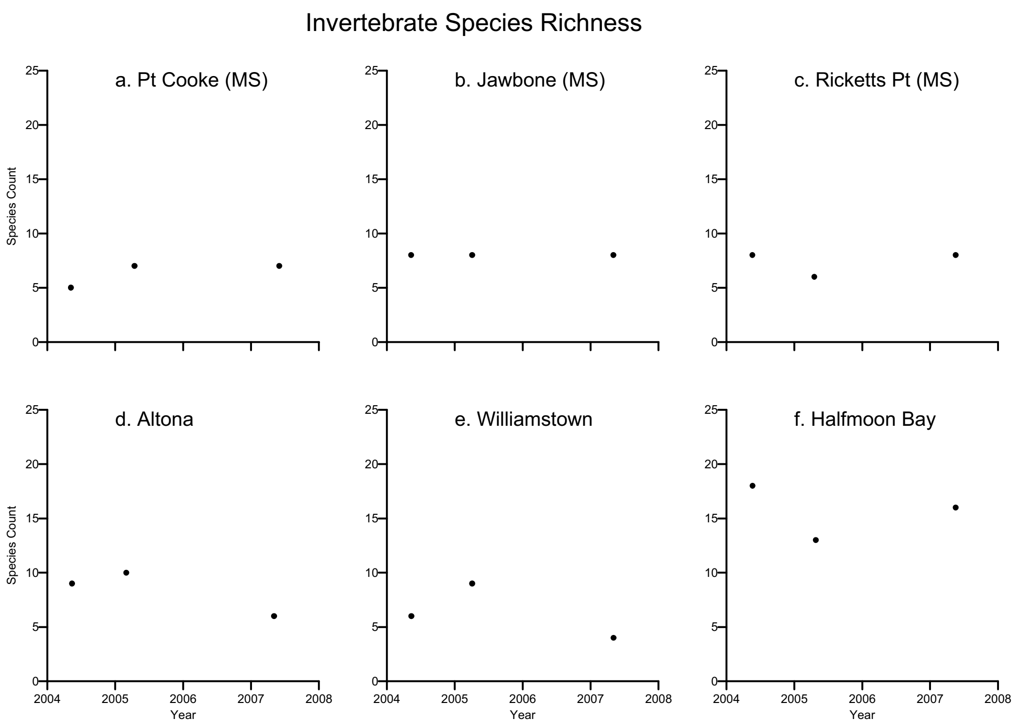


Figure 3.11. Invertebrate species richness of intertidal sites within Port Phillip Bay.

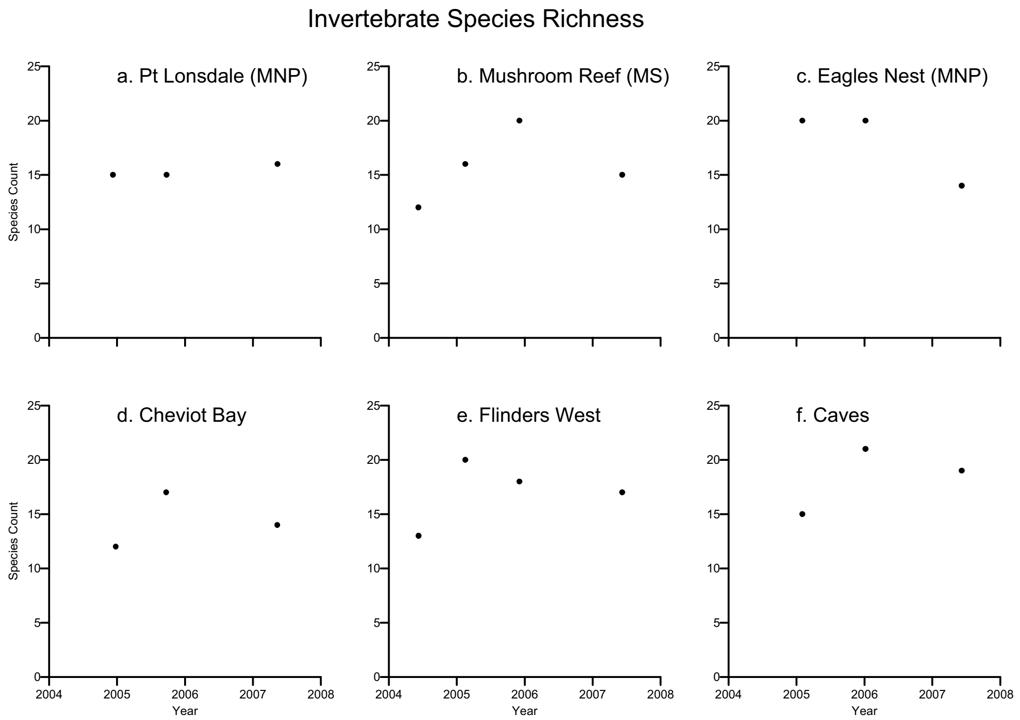


Figure 3.12. Invertebrate species richness of intertidal sites along the eastern Victorian coast.

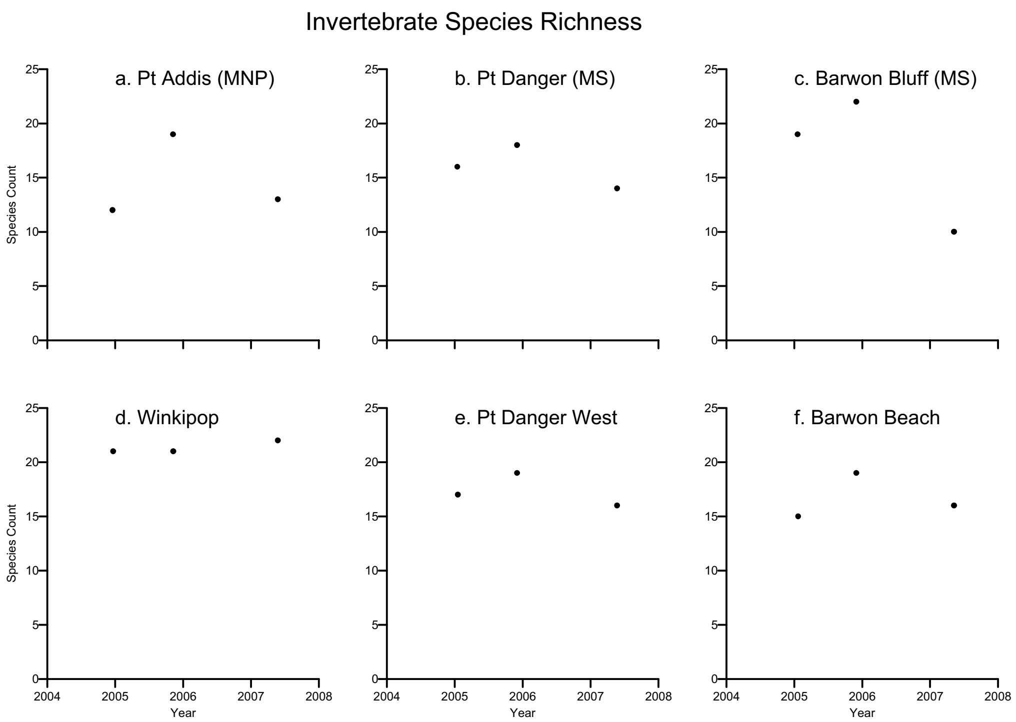


Figure 3.13. Invertebrate species richness of intertidal sites along the western Victorian coast.

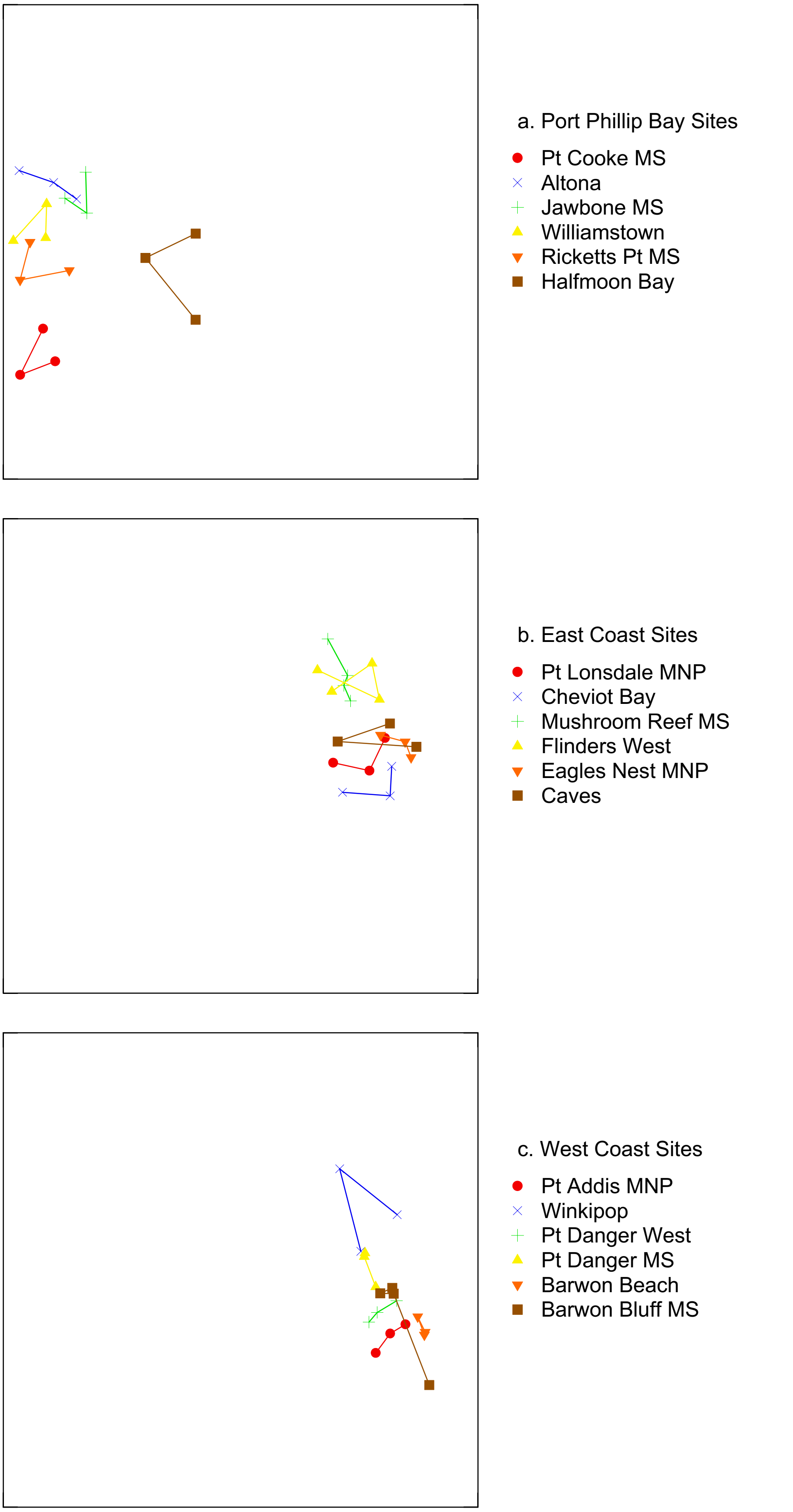


Figure 3.14. Two dimensional MDS plot of invertebrate assemblages on intertidal reefs in (a) northern Port Phillip Bay; (b) Port Phillip Heads and the eastern Victorian coastline; and (c) western Victorian coastline. Lines connect sites during consecutive surveys. Kruskal stress = 0.12.

4 POINT COOKE MARINE SANCTUARY

4.1 Site Description and Transect Layout

4.1.1 Point Cooke Marine Sanctuary (Site 4107)

The intertidal area at Point Cooke is an extensive basalt rock platform and basalt boulder and cobble field. The Point Cooke Marine Sanctuary also forms part of a RAMSAR site and contributes habitat for migratory shorebirds. The intertidal area is 300-400 m long, extending from just north of Point Cooke to the south and west. Patches of sand and intertidal seagrass *Zostera muelleri* occur predominantly across the north-eastern section of the intertidal area, with more continuous patches of reef occurring further south and west. The intertidal reef is generally flat. 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 4.1). 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.

4.1.2 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 5.1.2) would also be used as a long-term reference site for Point Cooke.

The intertidal area at Altona consists of basalt reef and boulder fields interspersed with sand and seagrass flats (Figure 4.2). The 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).

c).

Figure 4.1. Intertidal reef habitat and biota at Point Cooke, 1 June 2007; a) *Ulva* spp and filamentous red algae, b) the anemone *Aulactinia veratra* and c) the study area.

Figure 4.2. Intertidal reef at Altona, 4 May 2007.

4.2 Macroalgae and Aggregating Sessile Invertebrates

In May 2004 and April 2005, a large percentage of the Point Cooke intertidal reef was covered with *Ulva* spp which was relatively evenly spread across the survey area. *Enteromorpha* spp also occurred in moderate quantities and was similarly distributed across the reef. By June 2007 the cover of *Ulva* spp had decreased, a previously small patch of sand and *Zostera muelleri* seagrass had extended across a wide band of the study area and the coverage of filamentous red algae had increased from none to almost 9 %. The high amounts of drift macroalgae observed in 2004 were not present in either 2005 or 2007.

Altona had less macroalgal cover than Point Cooke (Table 4.1). No algae was recorded in the study area in May 2004. In April 2005 *Ulva* spp and *Enteromorpha* spp each covered nearly 10 %, though this had almost disappeared by May 2007. A low coverage of coralline algal species was also observed in the 2005 and 2007 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 *Mytilis edulis* was found at Point Cooke in small numbers, also low on the shore.

Waves and currents can deposit sand and shell material in the intertidal zone, inundating areas of reef. The amount of sand inundation was similar at both sites in 2004, it was much greater at Point Cooke than Altona during the 2005 and 2007 surveys. Both sites showed a large increase in the percent cover of sand and shell material between 2005 and 2007.

Table 4.1 Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Point Cooke and Altona during Survey 2 (May 2004), Survey 3 (April 2005) and Survey 5 (May-June 2007). '+' = present in quadrats but not observed under any points.

Species	Point Cooke MS (Site 4107)			Altona (Site 4108)		
	Survey			Survey		
	2	3	5	2	3	5
Macrophytes						
Algal turf	1.20					
Ceramium flaccidum	0.20					
Corallina officinalis	1.20	+	+		0.64	0.9
Corallines unidentified					0.40	
Encrusting corallines		+	0.08		+	+
Enteromorpha spp	2.60	14.08			9.12	1.2
Filamentous red algae	0.60		8.7			
Grateloupia filicina	0.10					
Hypnea sp.	1.00					
Laurencia botryoides		0.24				
Symploca sp.					+	2.1
Ulva spp	8.90	59.44	3.4		9.84	+
Zostera muelleri		2.80	3.1			
Sessile Invertebrates						
Galeolaria caespitosa		+	1.2	2.00	0.40	1.2
Mytilus edulis	0.10	0.32				
Sponges	0.20				0.20	
Other						
Drift macroalgae	20.0	0.16		0.10	0.16	
Drift seagrass				2.70		+
Sand/Shell material	15.0	10.64	33.1	18.5	0.48	6.9

4.3 Mobile Invertebrates

Mobile invertebrates were lower in density at Point Cooke than Altona (Table 4.2). The low densities of individuals recorded means that interpretation of the results must be cautious. 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, but occurred at much higher densities at Altona (Table 4.2). The abundance of *A. porcata* increased substantially at Point Cooke between 2005 and 2007, only a slight increase was observed at Altona.

The conniwink *Bembicium* spp and limpet *Cellana tramoserica* were consistently present in low densities at Altona, but have only been recorded at very low densities at Point Cooke, in 2005 and 2007 respectively.

The warrener *Turbo undulatus* was recorded in low densities on the low shore at Point Cooke in 2005 and 2007. A similar density of *T. undulatus*, 0.50 per 0.25 m^2, was recorded at this location in 2003 (Edmunds *et al.* 2004).

The carnivorous gastropods *Cominella lineolata* and *Lepsiella vinosa* occurred at Altona in similar densities to those found at Point Cooke during the 2004 and 2005 surveys, however neither species was observed at Altona during the 2007 survey.

The seastar *Patiriella exigua* occurred on the seaward edge of the intertidal reef at Altona in low densities during surveys 2004 and 2005. During the 2007 survey, the density of *Patiriella exigua* at Altona was more than ten times greater than in 2005. This species has not been recorded at Point Cooke during any of the surveys to date.

The herbivorous gastropod *Austrocochlea porcata* was the only species abundant enough to assess size trends within the sites. At Point Cooke a decrease in mean size was observed between the 2004 and 2005 surveys, though it had increased again by 2007 (Figure 4.3). The mean size of *A. porcata* was smaller at Altona, where it remained stable between 2003 and 2005 then decreased between 2005 and 2007.

Table 4.2. Density of megafaunal invertebrates per 0.25 m^2 at Point Cooke and Altona Survey 2 (May 2004), Survey 3 (April 2005) and Survey 5 (May-June 2007).

Species	Point Cooke MS (Site 4107)			Altona (Site 4108)		
	Survey			Survey		
	2	3	5	2	3	5
Cnidaria						
Aulactinia veratra			3.24			
Oulactis muscosa		0.20				
Unidentified anemone		0.36				
Mollusca						
Austrocochlea odontis	0.20					
Austrocochlea porcata	5.80	2.92	14.24	20.50	27.40	29.88
Bembicium spp		0.08		1.60	0.72	2.52
Cellana tramoserica			0.08	2.70	0.32	0.44
Cominella lineolata	0.40	0.12	0.04	0.10	0.04	
Lepsiella vinosa	0.20	0.04	0.12	0.40	0.04	
Mitra glabra					0.04	
Mytilus edulis			0.04			0.04
Nerita atramentosa					1.12	0.12
Nodilittorina unifasciata				0.20		
Turbo undulatus		0.04	0.48		0.12	
Unidentified chiton					0.04	
Echinodermata						
Patiriella exigua				0.60	0.32	4.00

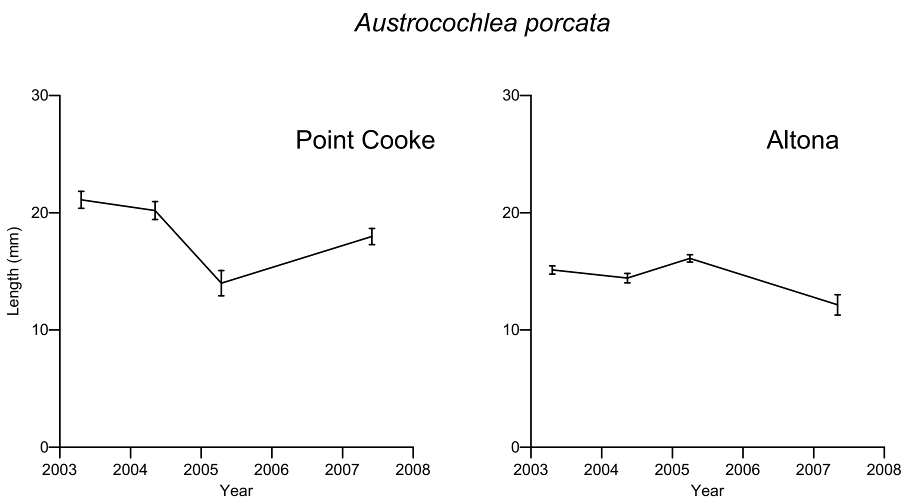


Figure 4.3. Mean sizes (± 95 % confidence intervals) of *Austrocochlea porcata* at Point Cooke and Altona.

5 JAWBONE MARINE SANCTUARY

5.1 Site Description and Transect Layout

5.1.1 Jawbone Marine Sanctuary (Site 4109)

There is an extensive area of fractured basalt reef and 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.

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.

5.1.2 Williamstown Reference (Site 4110)

The reference site for the Jawbone Marine Sanctuary was intertidal reef at Point Gellibrand, Williamstown (site 4110). As at 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.

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 5.1. Intertidal reef at Jawbone, 3 May 2007.

Figure 5.2. Intertidal reef at Williamstown, 4 May 2007.

5.2 Macroalgae and Aggregating Sessile Invertebrates

The abundance of macroalgae and sessile invertebrates was very low at the Jawbone Marine Sanctuary, covering less than 5 % of the study area (Site 4109; Table 5.1). Lichen and turfing algae comprised the majority of the meagre cover. The green alga sea lettuce *Ulva* spp was also present, but in very low densities.

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 this species has steadily increased at this site since 2004. Turfing algae was present in much higher densities in 2007 than had been previously been recorded, covering more than 13 % of the study area.

The calcareous tube-worm *Galeolaria caespitosa* has been consistently present at both sites, but covers only a very small percentage (<1%) of the study areas. *Galeolaria caespitosa* was higher in abundance in the lower shore region.

The coverage of sand and shell material was much increased at both sites in 2007. The greater percentage cover of sand, 9 %, was seen at Williamstown, where no sand had been previously recorded.

Table 5.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Jawbone and Williamstown during Survey 2 (May 2004), Survey 3 (April 2005) and Survey 5 (May 2007). '+' = present in quadrats but not observed under any points.

Species	Jawbone MS (Site 4109)			Williamstown (Site 4110)		
	Survey			Survey		
	2	3	5	2	3	5
Macrophytes						
Algal turf	2.50		1.12	0.10		13.44
Codium spp		0.56				0.24
Corallina officinalis		+				0.16
Corallines unidentified		+				
Encrusting corallines		+	+			+
Enteromorpha spp		+		+	0.32	
Filamentous green algae				0.10		
Heterozostera tasmanica	0.20					
Hormosira banksii				6.90	8.48	13.28
Leathesia difformis						+
Notheia anomala						+
Symploca sp.		+			0.24	
Ulva spp	1.30	1.36	+	0.10	+	0.8
Unidentified lichen		+	1.44			+
Sessile Invertebrates						
Galeolaria caespitosa	0.20	0.72	0.72	1.40	0.56	0.64
Unidentified barnacles		+				
Unidentified bivalve					+	
Other						
Drift seagrass	1.20		0.56	0.20		
Sand/Shell material	0.72	1.84	5.28			8.56

5.3 Mobile Invertebrates

The intertidal reef invertebrate communities at Jawbone Marine Sanctuary (Site 4109) and at the reference site at Williamstown (Site 4110) were similar in species density and community structure (Table 5.2). The mobile invertebrate population structure at Jawbone was dominated by a high abundance of the variegated limpet *Cellana tramoserica*, the conniwink *Bembicium* spp, and the top shell *Austrocochlea porcata*. The black nerite *Nerita atramentosa* was found in moderately low densities (Table 5.2). The only carnivorous gastropod recorded was *Lepsiella vinosa* and this species was not observed in the study area during the 2007 survey.

At Williamstown, the dominant invertebrates were the herbivorous gastropods *Bembicium* spp and *Austrocochlea porcata*. *Bembicium* spp were in higher densities at Williamstown than at Jawbone and tended to dominate the high shore region. *Austrocochlea porcata* was seen in similar numbers at both sites during the 2004 and 2005 surveys; however there was a marked decrease in the abundance of this species at Williamstown during the 2007 survey (Table 5.2). The limpet *Cellana tramoserica* was present but at much lower densities than at Jawbone.

Table 5.2. Density of megafaunal invertebrates per 0.25 m^{-2} at Jawbone and Williamstown during Survey 2 (May 2004), Survey 3 (April 2005) and Survey 5 (May 2007).

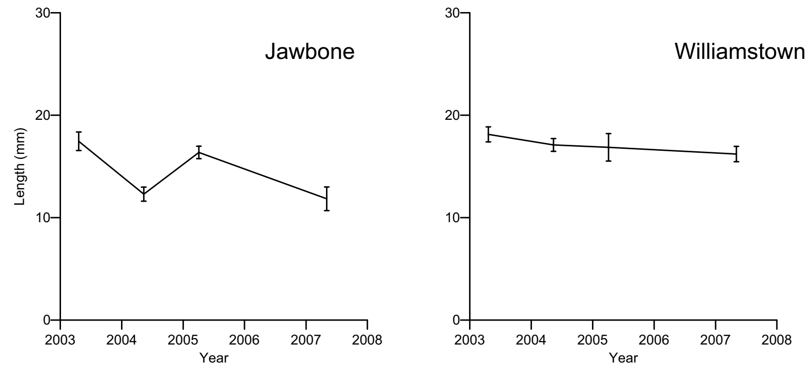
Species	Jawbone MS (Site 4109)			Williamstown (Site 4110)		
	Survey			Survey		
	2	3	5	2	3	5
Mollusca						
Austrocochlea odontis	0.08					
Austrocochlea porcata	4.40	7.24	7.20	3.60	8.88	2.52
Bembicium spp	2.12	0.80	3.28	8.84	5.60	4.12
Cellana tramoserica	6.32	4.76	3.00	1.12	0.96	0.6
Clypidina rugosa					0.08	
Cominella lineolata				0.04		
Lepsiella vinosa	0.08	0.16		0.04	0.04	
Nerita atramentosa	1.08	0.84	1.88		0.12	
Notoacmea mayi		0.16	0.32			0.12
Patelloida alticostata		0.04				
Siphonaria spp	0.04		0.08			
Turbo undulatus	0.04	0.20	0.04	0.48	0.08	
Echinodermata						
Patiriella exigua			0.12	0.08	0.28	

The mean size of *Austrocochlea porcata* was relatively stable over time at Williamstown (Figure 5.3a). At Jawbone Marine Sanctuary the mean size was more variable, with a decrease in mean size between 2003 and 2004 surveys, an increase in mean size between the 2004 and 2005 surveys, and another decrease in size between the 2005 and the 2007 survey. *Austrocochlea porcata* were bigger at Williamstown (mean = 16 mm) compared to Jawbone (mean = 12 mm).

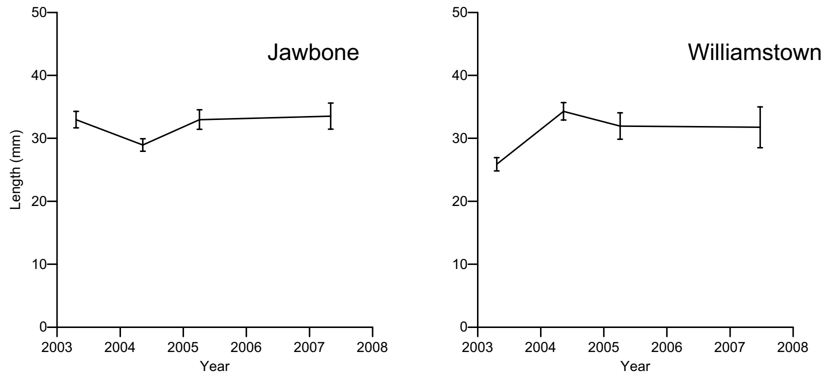
The mean size of the limpet *Cellana tramoserica* was also relatively stable, between 30 and 35 mm (Figure 5.3b). The most recent survey in 2007 recorded a mean size of 34 mm at Jawbone compared to a mean size of 31 mm at Williamston.

The mean size of the conniwink *Bembicium* spp showed a decrease at both sites during the 2007 survey, after increasing over the preceding surveys (Figure 5.3c). Specimens at Williamstown are larger than at Jawbone with a mean size of 15 mm compared to 11 mm, respectively.

a. *Austrocochlea porcata*



b. *Cellana tramoserica*



c. *Bembicium*spp.

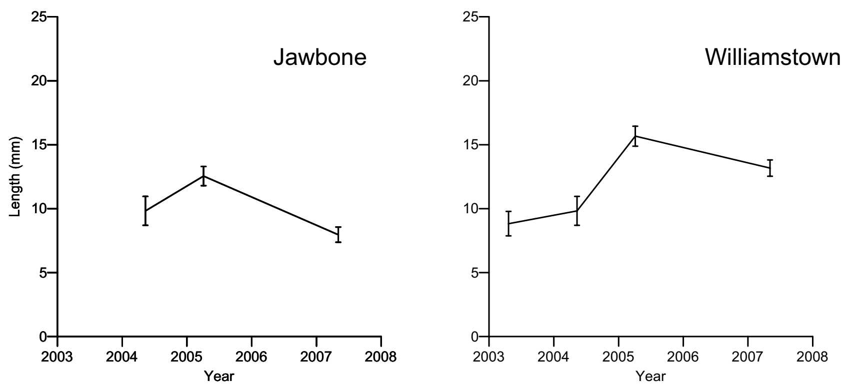


Figure 5.3. Mean sizes (± 95 % confidence intervals) of (a) *Austrocochlea porcata*; (b) *Cellana tramoserica*; and (c) *Bembicium* spp at Jawbone and Williamstown.

6 RICKETTS POINT MARINE SANCTUARY

6.1 Site description and Transect layout

6.1.1 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 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 (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. To the west, on the seaward edge of the platform, the reef 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 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.

6.1.2 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 6.1. Intertidal reef at Ricketts Point, 20 April 2003.

Figure 6.2. The intertidal reef monitoring site at Halfmoon Bay, 21 May 2004. The high-shore baseline is at the right of the reef. Transects 2-5 can be seen running towards the low shore baseline at left.

6.2 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. Patches of the blue-green algae *Symploca* sp. and lichens were present (Table 6.1). The percentage cover of *Symploca* sp. recorded at Ricketts Pt decreased ten-fold between the 2005 and 2007 surveys. Macroalgal cover along the seaward edge of the platform was predominantly the brown alga Neptune's necklace *Hormosira banksii*. Patches of algal turf and *Enteromorpha* spp were present in higher abundances in 2007 than had been recorded in 2005 (Table 6.1).

The only aggregations of sessile animals observed were small patches of the calcareous tube-worm *Galeolaria caespitosa*. These patches were higher in abundance low on the shore (Table 6.1).

Halfmoon Bay had a lower proportion of algal cover than Ricketts Point and this consisted almost entirely of small patches of algal turf (Table 6.1). The percentage cover of algal turf at Halfmoon Bay increased markedly between the 2005 and 2007 surveys. *Hormosira banksii* was absent at this site, even low on the shoreline. Patches of the blue-green algae *Symploca* sp. were present in low abundance.

The filter-feeding polychaete *Galeolaria caespitosa* was abundant at Halfmoon Bay forming aggregations in some areas of the low shore region. This contrasted with the low coverage of *G. caespitosa* at Ricketts Point.

Table 6.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Ricketts Point and Halfmoon Bay during Survey 2 (May 2004), Survey 3 (April 2005) and Survey 5 (May 2007). '+' = present in quadrats but not observed under any points.

Species	Ricketts Pt MS (Site 4111)			Halfmoon Bay (Site 4112)		
	Survey			Survey		
	2	3	5	2	3	5
Macrophytes						
Algal turf	7.04	0.24	2.4	7.36	7.20	12.00
Corallina officinalis			0.16	0.24	0.48	1.12
Encrusting corallines						+
Enteromorpha spp	2.40	0.08	1.76	2.08	2.08	
Hormosira banksii	16.72	5.36	11.36			
Notheia anomala		+				
Sarcocornia quinqueflora		0.80				
Sargassum spp						0.16
Symploca spp	2.96	9.60	0.96		+	3.44
Ulva spp	0.40		0.16	0.32	1.04	+
Unidentified lichen	0.48	+				
Sessile Invertebrates						
Chthamalus antennatus		0.16			0.88	
Unidentified Barnacles				0.08		+
Galeolaria caespitosa	2.24	1.52	2.64	11.84	18.56	13.84
Xenostrobus pulex						0.04
Other						
Drift macroalgae		0.08				
Drift seagrass		+				
Sand/Shell material		0.96	0.48		+	0.32

6.3 Mobile Invertebrates

At Ricketts Point the mobile invertebrate community had low species richness and diversity. The herbivorous gastropod *Austrocochlea porcata* was the most abundant species and was distributed relatively evenly across and down the shoreline (Table 6.2). There was a five fold increase in the abundance of this species between the 2005 and 2007 surveys, from 9 to 45 individuals 0.25 m^{-2}. The limpet *Cellana tramoserica* and the carnivorous gastropods *Lepsiella vinosa* and *Cominella lineolata* occurred at low densities (Table 6.2).

In contrast to Ricketts Point, there was a high abundance and species diversity of invertebrates at Halfmoon Bay. In 2007 the most abundant species was the limpet *Notoacmea mayi*, a species which had not been observed at this site during previous surveys. The limpet *Cellana tramoserica* and the herbivorous gastropod *Austrocochlea porcata* were also seen in moderate abundances, (Table 6.2).

The density of *Bembicium* spp consistently declined since the 2004 survey, from 6 individuals 0.25 m^{-2} to less than 1per 0.25 m^2 in 2007. *Nerita atramentosa* was low in density in 2004 and was not recorded in either 2005 or 2007 (Table 6.2).

The carnivorous gastropod *Lepsiella vinosa* had a much higher abundance at Halfmoon Bay than at Ricketts Point and had increased in abundance been the 2005 and 2007 surveys (Table 6.2).

The anemone *Actinia tenebrosa* and seastars *Patiriella calcar* and *Coscinasterias muricata* were present at Halfmoon Bay in small rock pools on the seaward edge of the intertidal reef (Table 6.2).

The mean size of *Austrocochlea porcata* (Figure 6.3a) was higher at Ricketts Point (mean = 16 mm) than at Halfmoon Bay (mean = 12 mm). While the mean size of *Austrocochlea porcata* increased from 2003 to 2004, this trend appears to have reversed between 2005 and 2007 (Figure 6.3a).

There were insufficient *Cellana tramoserica* at Ricketts Point to analyse size over time. At Halfmoon Bay, there has been an increase in mean size since the last survey from 16 mm to 22 mm (Figure 6.3b). There was a high abundance of small individuals during the 2005 survey, suggestion a recent recruitment event. This pattern was not seen in 2007.

The mean size of *Bembicium* spp decreased markedly at both sites between the 2005 and 2007 surveys (Figure 6.3c). This is due to a large number of small new recruits being present in 2007, leading to a decrease in the mean size measured.

Table 6.2. Density of megafaunal invertebrates per 0.25 m^2 at Ricketts Point and Halfmoon Bay during Survey 2 (May 2004), Survey 3 (April 2005) and Survey 5 (May 2007).

Species	Ricketts Pt MS (Site 4111)			Halfmoon Bay (Site 4112)		
	Survey			Survey		
	2	3	5	2	3	5
Cnidaria						
Actinia tenebrosa				0.40	0.04	1.28
Aulactinia veratra						0.04
Mollusca						
Austrocochlea concamerata		0.16			0.32	
Austrocochlea odontis	0.10	0.48		0.10	0.24	
Austrocochlea porcata	13.70	9.00	45.48	9.40	5.88	5.88
Bembicium spp	1.50	2.84	0.12	6.10	1.40	0.92
Cellana tramoserica	0.20		0.44	7.60	12.32	10.08
Cominella lineolata			0.28	0.60	0.48	0.28
Lepsiella vinosa	0.30	0.24	0.72	2.00	2.16	6.64
Nerita atramentosa				2.00		
Notoacmea mayi				2.40		35.72
Notoacmea spp			0.76			
Onchidella patelloides				0.40		1.16
Patelloida alticostata				1.70	10.16	3.6
Patelloida latistrigata						0.28
Siphonaria spp				0.20	0.08	0.08
Turbo undulatus		0.32	0.6	0.90	0.32	0.32
Unidentified chiton			0.04	0.10	0.04	0.04
Echinodermata						
Coscinasterias muricata						0.04
Patiriella calcar				0.30	0.04	1.6

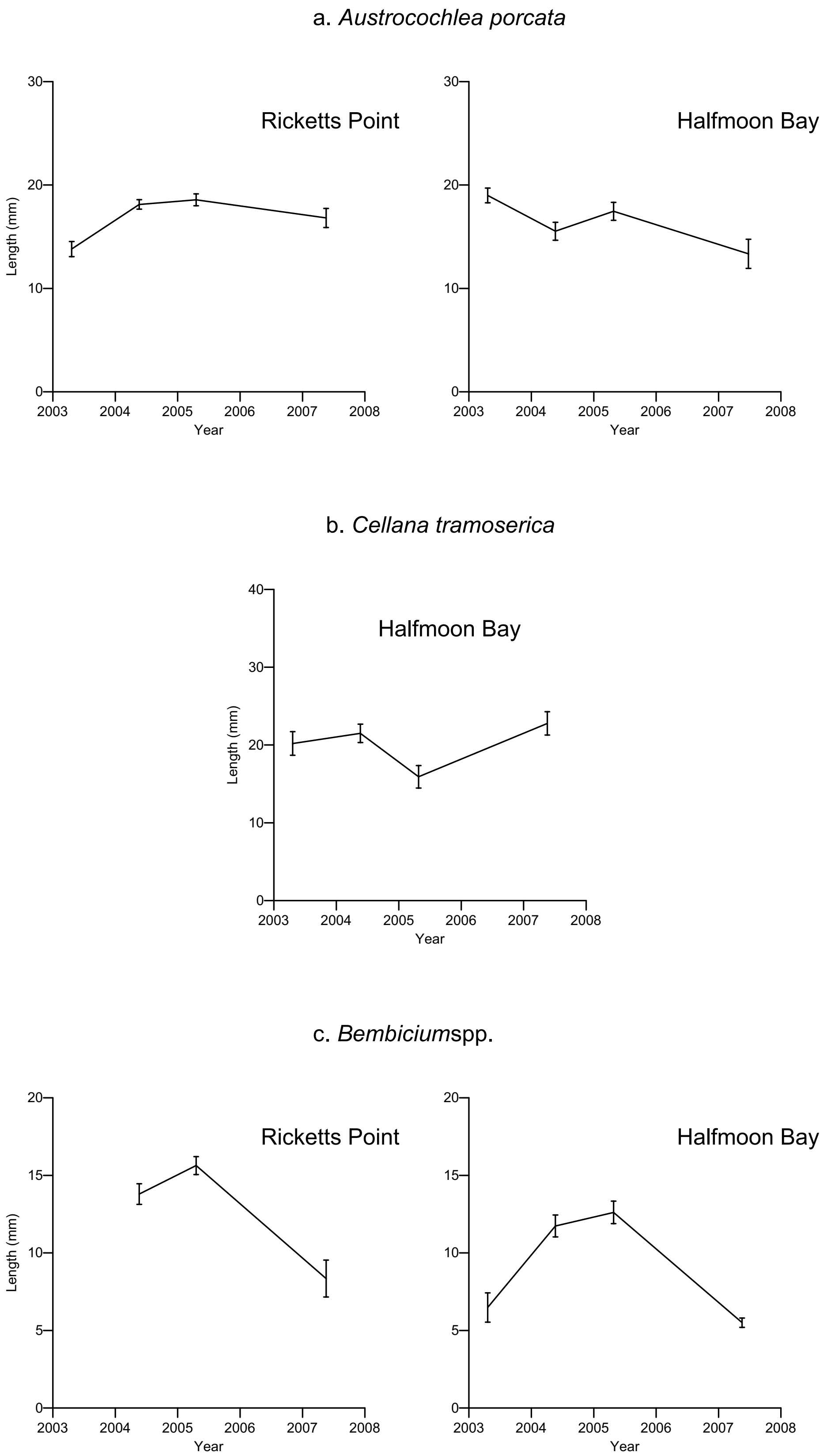


Figure 6.3. Mean sizes (± 95 % confidence intervals) of (a) *Austrocochlea porcata*; (b) *Cellana tramoserica*; and (c) *Bembicium* spp at Ricketts Point and Halfmoon Bay. Note that *C. tramoserica* density was too low at Ricketts Point to analyse over time.

7 PORT PHILLIP HEADS MARINE NATIONAL PARK

7.1 Site Description and Transect Layout

7.1.1 Point Lonsdale (Site 2823)

The intertidal reef surveyed for the Port Phillip Heads Marine National Park was located at Point Lonsdale. 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.

The survey area is on the southern expanse of reef, exposed to swell and wind from the prevailing southern quarter. Transect layout was simple with high and low shore baselines of 100 m, separated by 50-60 m long transects.

Figure 7.1. Intertidal reef at Point Lonsdale, 9 December 2004.

7.1.2 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. 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.

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 7.2. Intertidal reef at Cheviot Bay, 22 December 2004.

7.2 Macroalgae and Aggregating Sessile Invertebrates

The small change in shore height across both platforms and low relief of the reefs resulted in a macroalgal community dominated by Neptune's necklace *Hormosira banksii*. Cover of this brown alga has remained constant at both sites, though it was higher at Point Lonsdale (Table 7.1). Coralline and turfing algae were consistently more abundant at Cheviot Bay, though they were present at only low densities.

The sessile invertebrates *Galeolaria caespitosa* and *Xenostrobus pulex* were present at both sites in very low abundances. Sand inundation appeared to be higher at Point Lonsdale than at Cheviot Bay and has steadily increased at Point Lonsdale since monitoring began, while decreasing at Cheviot Bay between 2005 and 2007 (Table 7.1).

Table 7.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Point Lonsdale and Cheviot Bay during Survey 3 (December 2004), Survey 4 (September 2005) and Survey 5 (May 2007). '+' = present in quadrats but not observed under any points.

Species	Point Lonsdale MS (2823)			Cheviot Bay (2824)		
	Survey			Survey		
	1	2	5	1	2	5
Macrophytes						
Algal turf	0.48	1.04	0.8	6.72	5.84	3.2
Caulerpa flexillis		+				
Cladophora prolifera		+			0.40	
Colpomenia sp		+			+	
Corallina officinalis			0.4		2.4	3.52
Corallines unidentified	0.80	0.16		4.64	2.24	
Echinothamnion sp		2.16				
Ectocarpus spp		0.24				
Encrusting corallines		+	+	+	+	+
Enteromorpha spp	0.40	+		+		
Filamentous greens	0.24			+		
Hormosira banksii	78.72	71.04	67.84	56.00	59.12	59.92
Laurencia botryoides					+	
Laurencia spp					+	
Leathesia difformis		+			+	
Notheia anomala		0.40	+			
Scytosiphon lomentaria		+				
Symploca spp			0.08			+
Thallose red algae		+				
Ulva spp	+	+	0.08	4.56	0.08	+
Sessile Invertebrates						
Galeolaria caespitosa	0.24	+	0.08	+	0.08	0.16
Xenostrobus pulex	0.24	+	0.64	+	0.40	0.04
Other						
Drift macroalgae	0.32	+		+	+	
Drift seagrass				+		
Sand	2.32	4.56	7.28	5.12	8.64	4.00

7.3 Mobile Invertebrates

Point Lonsdale and Cheviot Bay had moderate levels of invertebrate species richness compared to other central Victorian sites and relatively high levels of species diversity (Figure 3.9 and 3.12).

The abundance of the slit limpet *Clypidina rugosa* increased markedly between the 2005 and 2007. In 2007 it was the most common species at both sites, though densities at Cheviot Bay were much higher than at Point Lonsdale (51 c.f. 28 per 0.25m^2; Table 7.2). *Siphonaria* spp densities were also higher at Cheviot Bay (Table 7.2). Conversely, the striped conniwink *Bembicium nanum* was more common at Point Lonsdale than Cheviot Bay, though both sites showed a decrease in abundance between the 2005 and 2007 surveys. There was also a declining trend in the abundance of the warrener *Turbo undulatus* at Cheviot Bay and the variegated limpet *Cellana tramoserica* at both sites (Table 7.2).

The small (approximately 1-2 mm shell length), black periwinkle *Nodilittorina acutispira* was recorded at both Point Lonsdale and Cheviot Bay at moderate to high densities in the September 2005 survey, but had not been previously recorded in the December 2004 survey. In May 2007 it was not recorded at Cheviot Bay and there was a corresponding decrease in abundance at Point Lonsdale (Table 7.2).

At Cheviot Bay, new recruits of the black nerite *Nerita atramentosa* were in high abundance during the 2007 survey. These recruits were very small (>1 mm) and it is unlikely that all of them will survive at this site over time

The mean size of *Austrocochlea constricta* increased at both sites between 2004 and 2005. The size of this species was not measured at Point Lonsdale or Cheviot Bay during the 2007 survey due to lower densities and time constraints (Figure 7.3a). *Cellana tramoserica* lengths remained relatively constant, with a mean size of 21 mm at Point Lonsdale and 28 mm at Cheviot Bay in 2007 (Figure 7.3b). There was an increase (2 mm to 6 mm) in the mean size of *Siphonaria* spp measured at Cheviot Bay between 2005 and 2007 (Figure 7.3c).

Table 7.2. Density of megafaunal invertebrates per 0.25 m^{-2} at Point Lonsdale and Cheviot Bay during Survey 3 (December 2004), Survey 4 (September 2005) and Survey 5 (May 2007).

Species	Point Lonsdale MS (2823)			Cheviot Bay (2824)		
	Survey			Survey		
	3	4	5	3	4	5
Cnidaria						
Actinia tenebrosa			0.04			
Oulactis muscosa	0.16					
Unidentified anemone		0.04				0.28
Mollusca						
Austrocochlea constricta	1.76	0.96	0.32	0.36	0.44	0.12
Austrocochlea odontis	0.52	0.80	0.48			
Austrocochlea porcata			0.36			0.04
Bembicium nanum	11.08	15.84	6.32	4.48	3.60	1.2
Calliostoma armillata					0.04	
Cellana tramoserica	5.72	5.28	1.24	3.48	1.84	1.04
Clypidina rugosa	1.64	12.96	27.64	22.36	14.44	51.48
Cominella lineolata	0.80	0.44	0.76	0.04	0.88	0.32
Conus anemone	0.04					
Dicathais orbita	0.20	0.12	0.04	0.20	0.24	
Lepsiella vinosa		0.28	0.16		0.12	
Nerita atramentosa			0.48			33.84
Nodilittorina acutispira		13.24	0.4		16.80	
Notoacmea mayi		0.64	0.72	0.08	9.32	2.92
Notoacmea petterdi	3.20					
Onchidella patelloides	0.04					
Patella chapmani				0.08		
Patelloida alticostata	1.24	0.80	1.28	1.88	1.72	2.12
Patelloida insignis					0.08	
Patelloida latistrigata					2.92	
Siphonaria spp	10.28	2.88	5.88	27.16	27.48	38.2
Turbo undulatus	1.72	2.96	0.76	2.08	1.76	0.08
Unidentified chiton					0.2	0.04
Unidentified nudibranch		0.04				
Crustacea						
Unidentified crab	0.04			0.04		

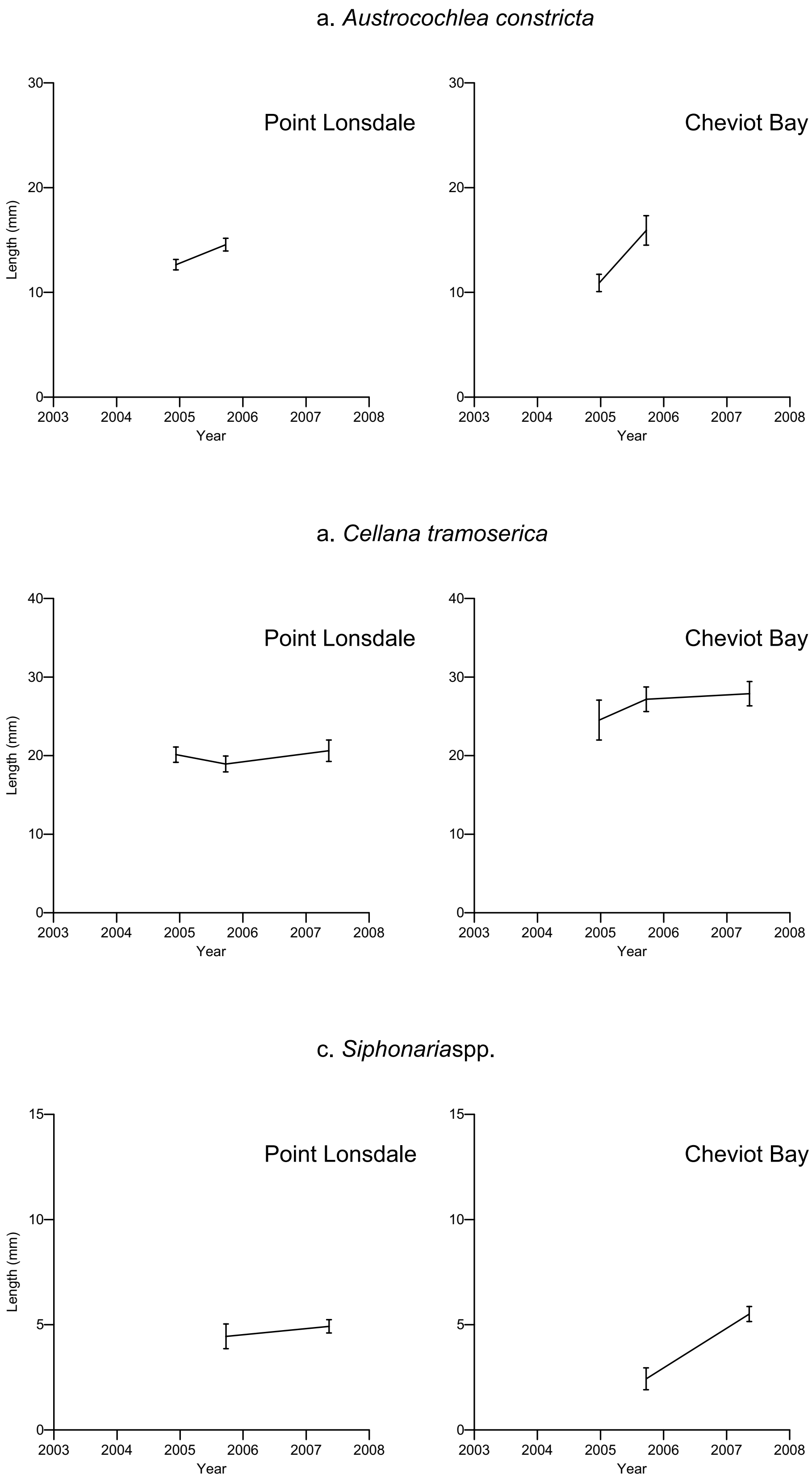


Figure 7.3. Mean sizes (± 95 % confidence intervals) of (a) *Austrocochlea constricta* (b) *Cellana tramoserica* and (c) *Siphonaria* spp. at Point Lonsdale and Cheviot Bay.

8 MUSHROOM REEF MARINE SANCTUARY

8.1 Site Description and Transect Layout

8.1.1 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 8.1a). Sections of the isthmus tend to inundate with water soon after the tide begins to rise. The head of the mushroom is low-relief but uneven basalt reef with some pebbles and boulders (Figure 8.1b). 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 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.

8.1.2 Flinders West Reference (Site 2908)

The reference site for Mushroom Reef was on the nearest intertidal platform to the west of the marine sanctuary. The intertidal area at Flinders West is a low-relief gently sloping basalt reef with occasional small steps and boulder outcrops (Figure 8.2). Patches of sand covered areas at the lowest reef extent. As with Mushroom Reef, Flinders West has a south-easterly aspect and is moderately sheltered from wind and waves from the southwest. It is also protected from large swell by a shallow reef further offshore.

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).

Figure 8.1. Intertidal reef at Mushroom Reef: a) the cobble causeway, 8 June 2004; and b) the reef platform, 8 June 2007.

Figure 8.2. Intertidal reef at Flinders West, 8 June 2007.

8.2 Macroalgae and Aggregating Sessile Invertebrates

Macroalgal cover at Mushroom Reef was relatively low (Table 8.1). Neptune's necklace *Hormosira banksii* was the dominant species, with *Enteromorpha* spp, *Corallina officinalis*, encrusting coralline algae and unidentified erect coralline algae occurring in low densities. *Hormosira banksii* declined in abundance between June 2004 and February 2005 but has since increased. Abundances still remained lower than initially recorded (Table 8.1). The abundance of sea lettuce *Ulva* spp at this site has fluctuated between 8 % and less than 1 %. In 2007 it was present not under any of the sampling points (Table 8.1).

At Flinders West there was a decreasing trend in the abundance of turfing algae and density of *Hormosira banksii* decreased ten-fold between December 2005 and June 2007 (Table 8.1). Conversely, there was a substantial increase in the abundance of coralline algae occurred over the same period. The seagrass *Zostera mullerii* was also present at Flinders West during the 2007 survey, having previously been recorded in February 2005, but not in December 2005 (Table 8.1).

The mussel *Xenostrobus pulex* was the only aggregating sessile invertebrate present in quantifiable patches at either site (Table 8.1).

Table 8.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Mushroom Reef and Flinders West during Survey 2 (June 2004), Survey 3 (February 2005), Survey 4 (December 2005) and Survey 5 (May 2007). '+' = present in quadrats but not observed under any points.

Species	Mushroom Reef MS (Site 2907)				Flinders West (Site 2908)			
	Survey				Survey			
	2	3	4	5	2	3	4	5
Macrophytes								
Algal turf	2.00	0.24	0.40	1.92	5.44	16.16	6.72	1.92
Amphibolis antarctica			1.44					
Brown algae unidentified		+					0.08	
Codium spp						+		
Colpomenia sinuosa				+				
Corallina officinalis	0.72	2.32		0.04	27.44	4.40		
Corallines unidentified		1.52	6.24	1.84		4.24	15.44	30.00
Cystophora spp				+				
Encrusting corallines	0.24	1.44	+	1.20	0.72	0.56	0.48	1.12
Enteromorpha spp	+	+		2.48	+			
Filamentous green algae								+
Filamentous red algae	0.64							
Hormosira banksii	13.36	0.96	3.92	11.52	4.96	17.28	22.80	2.16
Jania spp				+				
Laurencia spp						+	0.08	2.4
Notheia anomala	0.08			+				
Rivularia sp.		0.08	+					
Sargassum spp				+				
Symploca	+	+		+	+	+		
Thallose red algae	3.44				0.40			
Ulva spp	6.24	1.68	7.60	+	+	+	0.24	+
Zostera meulleri						3.28		4.00
Sessile Invertebrates								
Brachidontes rostratus			+			2.08	+	
Catomerus polymerus						0.40		
Chthamalus antennatus		+	+			+	0.24	
Galeolaria caespitosa		+			+	0.32	0.08	+
Tetraclitela purpuracens							0.40	
Xenostrobus pulex	0.16	0.32	2.24	1.12	1.36	0.48	0.48	0.08
Other								
Drift macroalgae					1.44		6.00	
Drift seagrass							0.08	
Sand					0.16		0.32	0.24

8.3 Mobile Invertebrates

The invertebrate communities at Mushroom Reef and Flinders West were both rich with species and highly diverse (Table 8.2). The top shell *Austrocochlea constricta* was the most abundant species at Mushroom Reef, occurring in dense patches across the shoreline. The striped conniwink *Bembicium nanum* and the pulmonate limpet *Siphonaria* spp were also present in high densities. The abundance of the black nerite *Nerita atramentosa* has steadily increased at this site, from 2 per 0.25 m^2 in 2004 to almost 15 per m^2 in 2007 (Table 8.2).

The crab *Cyclograpsus granulosus* has been recorded in cobble microhabitat, although none were observed during recent surveys. The seastar *Patiriella exigua* was common in shallow stands of water on the reef (Table 8.2).

A similar community of species was present at Flinders West (Table 8.2). In 2007 *Austrocochlea constricta* was not as abundant as at Mushroom Reef but still a common species. *Siphonaria* spp was the most abundant species present, showing a increasing in density since December 2005 (Table 8.2). The periwinkle *Nodilittorina unifasciata* was not recorded in 2007, despite being the most common species high on the shore in December 2005. *Bembicium nanum* and *Nerita atramentosa* also showed a decrease in abundance at Flinders West between December 2005 and June 2007.

As with Mushroom Reef, low numbers of crabs such as *Paragrapsus gaimardii* were recorded in past surveys. None were observed in the most recent surveys (Table 8.2). Noticeably lower densities of the seastar *Patiriella exigua* were present at Flinders West than at Mushroom Reef.

Table 8.2. Density of megafaunal invertebrates per 0.25 m^{-2} at Mushroom Reef and Flinders West during Survey 2 (June 2004), Survey 3 (February 2005), Survey 4 (December 2005) and Survey 5 (June 2007).

Species	Mushroom Reef MS (Site 2907)				Flinders West (Site 2908)			
	Survey				Survey			
	2	3	4	5	2	3	4	5
Cnidaria								
Actinia tenebrosa	0.08		0.04			0.20		
Aulactinia veratra		0.04			0.24	2.56	0.16	0.64
Oulactis muscosa					2.04	1.12	0.32	
Mollusca								
Aplysia parvula			0.04					
Austrocochlea constricta	15.32	12.92	15.76	27.24	2.2	3.84	4.24	3.12
Austrocochlea odontis	0.04		0.16	0.08		0.04	0.04	0.04
Bembicium nanum	13.16	15.72	19.00	13.88	5.68	9.92	8.08	0.80
Callistoma armillata					0.12			
Cellana tramoserica	0.64	2.96	0.96	0.32	0.68	1.00	0.96	0.36
Chromodoris tinctoria						0.08		
Clypidina rugosa		0.24	0.04	0.60				0.32
Cominella lineolata	0.04		0.20	0.32	0.36	0.08	0.04	0.52
Dicathais orbita						0.04		
Lepsiella vinosa	1.80	0.92	2.52	2.28	1.52	1.00	0.52	1.08
Mitra glabra							0.04	
Nerita atramentosa	2.08	6.04	8.88	14.56	2.04	7.16	9.56	5.2
Nodilittorina unifasciata			0.20			2.52	18.80	
Notoacmea mayi	0.24	0.36	0.20	0.08		2.04		
Notoacmea spp								0.48
Onchidella patelloides	0.08							0.08
Opalia australis								0.12
Patella chapmani		0.04						
Patelloida alticostata		0.12	0.16	1.92	0.16	0.2	0.24	0.36
Patelloida latistrigata							0.12	
Patelloida insignis			0.28			0.08	0.04	
Siphonaria spp	1.8	20.12	31.68	15.32	13.96	19.64	6.80	13.96
Turbo undulatus		0.12	0.80	0.52				0.32
Unidentified chiton		0.04	0.08		0.04	0.2		0.04
Unidentified limpet		0.04		0.08				
Crustacea								
Cyclograpsus granulosus		0.04						
Paragrapsus gaimardii						0.08		
Unidentified crab							0.04	
Echinodermata								
Patiriella calcar			0.04					
Patiriella exigua	1.00	5.56	4.60	1.76	0.24	0.04	0.16	0.24
Tosia australis			0.04					

Austrocochlea constricta were larger at Flinders West than Mushroom Reef with mean sizes of 15 mm and 12 mm respectively (Figure 8.3a). This is a reversal of the pattern seen during the last survey.

The mean size of *Cellana tramoserica* at Mushroom Reef was not measured during the 2007 survey due to very low densities (Figure 8.3b). The mean size of *C. tramoserica* at the reference site at Flinders West showed a slight increase to 26 mm.

Bembicium nanum mean size previously showed relatively little change at Mushroom Reef. The mean size declined slightly during the December 2005 survey and was similar (5.5 mm) during the most recent survey (Figure 8.3c). The same was seen at Flinders West where the mean size was 6 mm during the current survey.

The mean size of pulmonate limpet *Siphonaria* spp measured at Flinders West showed little change in size since the previous survey, at 7 mm (Figure 8.3d). At Mushroom Reef however the mean size of this species increased from 5 mm to 9 mm.

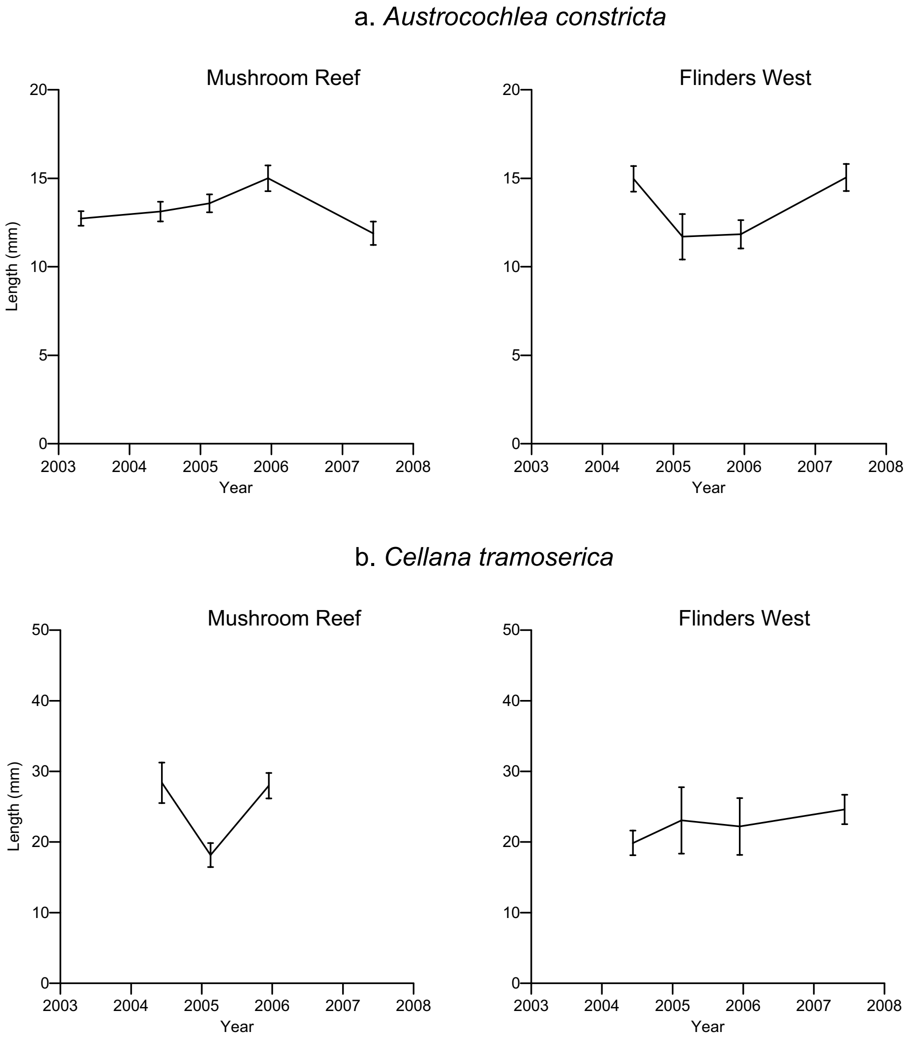
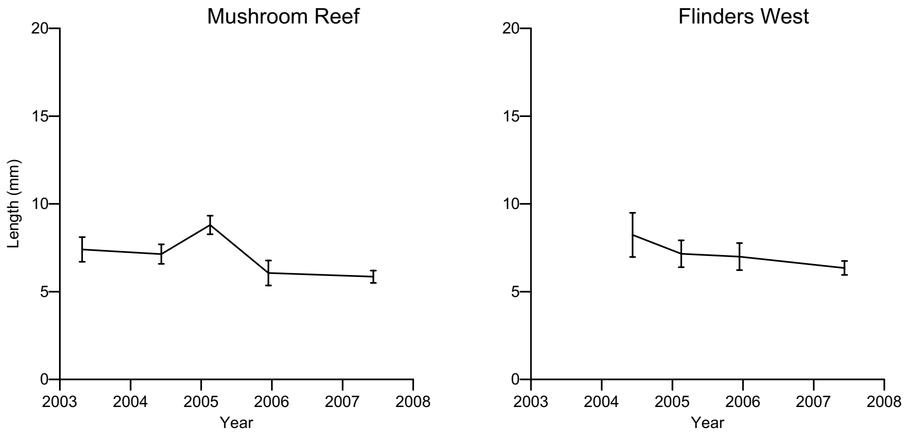


Figure 8.3. Mean sizes (± 95 % confidence intervals) of (a) *Austrocochlea constricta* and (b) *Cellana tramoserica* at Mushroom Reef and Flinders West.

c. *Bembicium nanum*



d. *Siphonaria*spp.

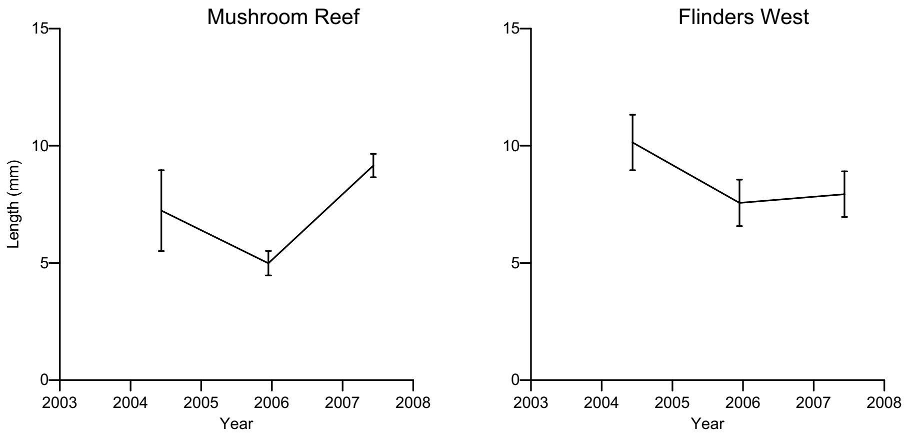


Figure 8.3. (continued). Mean sizes (± 95 % confidence intervals) of (c) *Bembicium nanum* and (d) *Siphonaria* spp. at Mushroom Reef and Flinders West.

9 BUNURONG MARINE NATIONAL PARK

9.1 Site Description and Transect Layout

9.1.1 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 9.1).

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.

9.1.2 Caves Reference (Site 3021)

The reference site is at the Caves (Site 3021), located to the east of Bunurong Marine National Park. The site is 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 9.2). 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 9.1. Intertidal reef at Eagles Nest, 7 June 2007.

a).

b).

Figure 9.2. Intertidal reef at The Caves, 7 June 2007, showing a) the study area and b) the limpet *Cellana tramoserica*.

9.2 Macroalgae and Aggregating Sessile Invertebrates

The species composition and abundances of sessile organisms was generally similar between the two sites. The dominant cover was by the brown alga *Hormosira banksii*, 5-11 % cover, with the mat-forming mussel *Xenostrobus pulex* also being relatively abundant, 1-8 % cover (Table 9.1). Algal turf had the next highest cover, with 1-5 % cover.

There was a small decline in cover of *H. banksii* between November 2005 and May 2007 at Eagles Nest, while the coverage did not vary at The Caves between the surveys (Table 10.1). There was an increasing trend in algal turf abundance at both sites between the January 2005, November 1005 and May 2007 surveys (Table 10.1). *Xenostrobus pulex* varied little between surveys at Eagles Nest, but there was a decreasing trend at The Caves, from 8.6 % cover in January 2005 to 1 % cover in May 2007 (Table 10.1).

There was considerable sand present on Eagles Nest during November 2005, with 11 % cover, but both sites had less than 4 % cover during most surveys (Table 10.1).

Table 9.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Eagles Nest and Caves during Survey 3 (February 2005), Survey 4 (January 2006) and Survey 5 (June 2007). '+' = present in quadrats but not observed under any points.

Species	Eagles Nest MPA (3020)			The Caves (3021)		
	Survey			Survey		
	3	4	5	3	4	5
Macrophytes						
Acrocarpia paniculata						1.52
Algal turf	1.44	2.56	4.64	0.88	2.00	2.72
Brown algae unidentified		+			+	
Corallina officinalis	+	0.32	0.48	+		0.16
Corallines unidentified					+	
Cystophora spp		+				
Chordaria cladosiphon					0.48	
Encrusting corallines	+		0.24	0.24	+	0.08
Enteromorpha compressa		0.08				
Enteromorpha spp	+					+
Filamentous brown algae					0.48	
Green algae unidentified		0.32			+	
Hormosira banksii	11.60	10.48	4.48	8.24	7.68	8.96
Jania spp						0.08
Laurencia spp		+				
Leathesia difformis				+		
Notheia anomala		1.04		+	0.40	0.24
Rivularia sp.	+	0.56		+	+	
Sargassum spp			+			
Symploca sp	0.80	0.40	0.16	1.28		1.2
Ulva spp	+			+		0.16
Unidentified blue-green algae		2.16			+	
Unidentified lichen				0.24	0.80	2.96
Zostera meulleri	2.72					
Sessile Invertebrates						
Catomerus polymerus					0.08	
Chamaesipho tasmanica				0.24		+
Chthamalus antennatus	+	+	+	0.08	+	+
Galeolaria caespitosa	+	0.16	0.16	+	0.16	+
Tetraclitella purpurascens	0.08				+	
Xenostrobus pulex	6.08	5.92	4.00	8.64	4.88	0.88
Other						
Drift macroalgae					0.32	
Drift seagrass	+					0.32
Sand	1.76	11.28	1.04	2.56	4.40	1.92

9.3 Mobile Invertebrates

The species composition of the mobile invertebrates at Eagles Nest and The caves was very similar (Table 9.2). The assemblages were comprised of the snails *Bembicium nanum*, *Austrocochlea constricta*, *Nodilittorina acutispira*, *Nodilittorina unifasciata*, as well as the limpets *Siphonaria* spp, *Cellana tramoserica* and *Patelloida alticostata*. *Bembicium nanum*, *Nodilittorina unifasciata* and *Siphonaria* spp were numerically dominant during all surveys at both sites (Table 9.2).

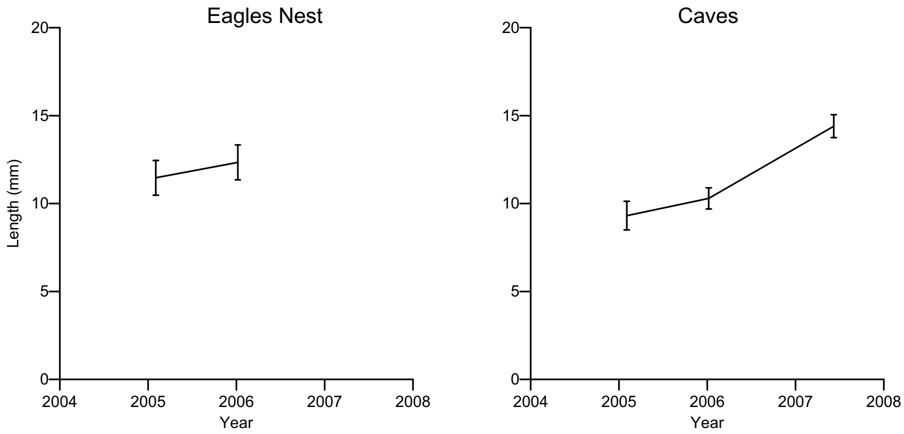
There was a marked increase in abundances of Nodilittorina acutispira between the three surveys at both sites, increasing from 12 to 348 per 0.25 m^2 at Eagles Nest and 0.6 to 828 per 0.25 m^2 at The Caves (Table 9.2). There was also an increase in *Notoacmea mayi* at both sites over the monitoring period. The abundances of B*embicium nanum* were considerably lower during the May 2007 survey than the previous two surveys (Table 9.2).

During May 2007, there were too few *Austrocochlea constricta* individuals above 2 mm in length at Eagles Nest to warrant measurement. Populations of this species were slightly larger in mean size at Eagles Nest than The Caves in 2005, but there was a subsequent increase in mean size at The Caves to May 2007 (Figure 9.3a). There was a slight increase in mean sizes of the limpet *Cellana tramoserica* to May 2007 (Figure 9.3b) but there were no apparent trends in *Siphonaria* size (Figure 9.3c).

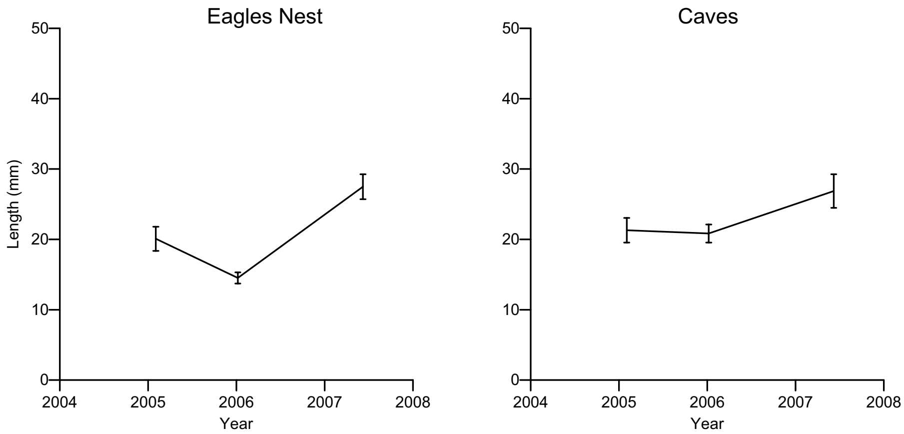
Table 9.2. Density of megafaunal invertebrates per 0.25 m^2 at Eagles Nest and Caves during Survey 3 (February 2005), Survey 4 (January 2006) and Survey 5 (June 2007).

Species	Eagles Nest MPA (3020)			The Caves (3021)		
	Survey			Survey		
	3	4	5	3	4	5
Cnidaria						
Actinia tenebrosa	0.04					0.04
Aulactinia veratra	0.04	0.20	0.68		0.16	0.04
Mollusca						
Austrocochlea constricta	1.32	0.56	4.76	1.96	3.12	2.32
Austrocochlea odontis	0.4			0.32	0.08	0.28
Bembicium nanum	33.52	42.84	24.84	46.88	150.36	19.32
Cellana tramoserica	2.6	1.68	2.20	0.72	2.48	1.12
Clypidina rugosa	0.04		2.56		0.20	0.76
Cominella lineolata	0.4	0.20	0.16	0.08	0.04	0.36
Dicathais orbita	0.12	0.12		0.08		
Lepsiella vinosa	0.12	0.04	0.20	0.72	0.40	0.76
Nerita atramentosa	0.2	0.16	0.04	0.32	0.80	0.04
Nodilittorina acutispira	12.04	40.32	348.88	0.60	2.88	828.96
Nodilittorina unifasciata	84.8	149.44	121.88	116.6	157.24	93.84
Notoacmea mayi	0.2	0.40	2.36	1.04	6.96	4.52
Notoacmea spp						2.88
Patelloida alticostata	0.8	0.40	1.12	0.52	0.84	0.16
Patelloida insignis	0.04					
Patelloida latistrigata		0.28		0.24	0.04	
Prothalotia ramburi						0.04
Siphonaria spp	7.44	10.68	7.32	13.88	24.76	19.6
Turbo undulatus	0.72	0.16		0.04	0.12	
Unidentified Chiton			0.04			
Echinodermata						
Patiriella exigua	0.08	0.04				
Crustacea						
Unidentified crab	0.08				0.04	0.04

a. *Austrocochlea constricta*



b. *Cellana tramoserica*



b. *Siphonaria*spp.

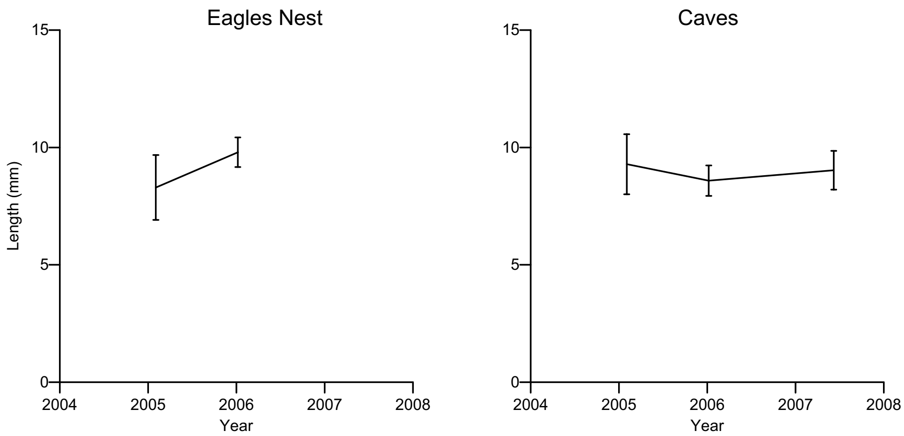


Figure 9.3. Mean sizes (± 95 % confidence intervals) of (a) *Austrocochlea constricta*; (b) *Cellana tramoserica* and (c) *Siphonaria* spp. at Eagles Nest and Caves.

10 POINT ADDIS MARINE NATIONAL PARK

10.1 Site Description and Transect Layout

10.1.1 Point Addis Marine National Park (Site 3901)

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

10.1.2 Winkipop Reference (Site 3902)

The reference site for Point Addis Marine National Park was located to the east of the park at Winkipop reef. The intertidal area at Winkipop is a very low-relief, gently sloping reef (Figure 10.2). The area exposed at low tide is 30 to 50 m wide. This area is exposed to large southerly 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 10.1. Intertidal reef at Point Addis, 17 December 2004.

Figure 10.2. Intertidal reef at Winkipop, 20 December 2004.

10.2 Macroalgae and Aggregating Sessile Invertebrates

The brown alga *Hormosira banksii* was the prevalent sessile organism on both reefs, with 45-60 % cover at Point Addis and 75-85 % cover at Winkipop (Table 10.1). Algal turf was also common at Point Addis, with coverage of 5-12 %. Algal turf was present at Winkipop, but the coverage was low, with 1-2 % cover (Table 10.1). There was a low cover of the tube warm Galeolaria caespitosa at Point Addis, with up to 1 % cover. There was a relatively high species richness of other seaweeds at both Point Addis and Winkipop, although in very low abundances (< 1 % cover; Table 10.1).

There were no marked trends in the abundances of the sessile organisms over time. There was a slight decrease in *H. banksii* cover between November 2005 and May 2007 at Point Addis. There was also a slight increase in cover of algal turf between January 2005 and November 2005 at Point Addis (Table 10.1). The sand cover at Point Addis varied by 5-7 % between surveys (1 to 8 % cover), but was relatively constant at Winkipop, with 6-8 % cover (Table 10.1).

Table 10.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Point Addis and Winkipop during Survey 3 (December 2004), Survey 4 (November 2005) and Survey 5 (May 2007). '+' = present in quadrats but not observed under any points.

Species	Point Addis MNP (3901)			Winkipop (3902)		
	Survey			Survey		
	3	4	5	3	4	5
Macrophytes						
Acrocarpia paniculata						1.76
Algal turf	5.60	12.48	11.76	2.40	0.80	1.92
Amphibolis antarctica					+	
Brown algae unidentified		0.24	0.64	+	+	
Caulerpa brownii					+	
Chaetomorpha coliformis	1.04					
Cladophora prolifera					+	
Codium pomoides					+	
Codium spp					+	
Corallina officinalis						1.12
Corallines unidentified	+	+		0.24	0.56	
Cystophora spp					0.16	0.56
Leathesia difformis		+			+	
Notheia anomala	+	1.12	+		+	0.96
Rivularia spp	+	0.40		+	+	
Sargassum spp		+			+	0.72
Scytosiphon lomentaria		0.48				
Symploca spp			0.08			+
Thallose red algae						+
Ulva spp	0.24	1.36		0.08	+	+
Unidentified lichen	+					
Sessile Invertebrates						
Brachidontes rostratus	0.08					
Chthamalus antennatus	0.72	+	+	0.72		
Galeolaria caespitosa	1.12	1.12	0.16	0.40		0.08

Table 10.1. (continued) Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Point Addis and Winkipop during Survey 3 (December 2004), Survey 4 (November 2005) and Survey 5 (May 2007). '+' = present in quadrats but not observed under any points.

Species	Point Addis MNP (3901)			Winkipop (3902)		
	Survey			Survey		
	3	4	5	3	4	5
Xenostrobus pulex	0.20	+		+	0.08	
Other						
Drift macroalgae	0.08	+	+	0.24		
Drift seagrass	+	+				
Sand	3.20	8.72	0.80	6.40	8.48	6.08

10.3 Mobile Invertebrates

The mobile invertebrate species present at Point Addis and Winkipop were generally similar, but there were considerable differences in abundances. Abundances of the limpet *Siphonaria* spp, *Patelloida alticostata* and *Nodolittorina acutispira* were consistently higher (more than triple) at Point Addis than Winkipop. At Winkipop, *Austrocochlea constricta*, *Bembicium nanum*, sea stars and anemones were more abundant (Table 10.2). Four different species of anemone, *Actinia tenebrosa*, *Anthothoe albocincta*, *Aulactinia veratra* and an unidentified anemone were recorded at Winkipop in small patches of standing water. Two sea star species and an unidentified crab species were also found in this microhabitat (Table 10.2).

Over time, there have been decreases in the abundances of the limpets Clypidina rugosa at both Point Addis and Winkipop, mainly between January 2005 and November 2005. At Point Addis, there was another change between November 2005 and May 2007 with a substantial increase in the density of *Nodilittorina acutispira* and moderate increases in densities of *N. unifasciata*, *Notoacmea mayi* and *Siphonaria* spp (Table 10.2). At Winkipop, there were increases in the density of *Bembicium nanum* and decreases in the density of *Austrocochlea constricta*, *Clypidina rugosa* and *Notoacmea mayi*.

The mean size of *Cellana tramoserica* at Winkipop remained relatively constant through time (Figure 10.3). The mean size at Point Addis increased to a larger size than Winkipop during the May 2007 survey (Figure 10.3).

Table 10.2. Density of megafaunal invertebrates per 0.25 m^{-2} at Point Addis and Winkipop during Survey 3 (December 2004), Survey 4 (November 2005) and Survey 5 (May 2007).

Species	Point Addis MNP (3901)			Winkipop (3902)		
	Survey			Survey		
	3	4	5	3	4	5
Cnidaria						
Actinia tenebrosa	0.08	0.04		0.24	0.28	0.60
Anthothoe albocincta					1.20	0.64
Aulactinia veratra	0.08			0.08	0.16	0.32
Oulactis muscosa				0.28	0.28	
Unidentified anemone						0.12
Mollusca						
Austrocochlea constricta				2.20	2.64	0.40
Austrocochlea odontis		0.12	0.04	0.20	0.16	0.16
Austrocochlea porcata				0.08		
Bembicium nanum	0.20	1.20	2.36	2.12	7.12	7.28
Calliostoma armillata		0.04				
Cellana tramoserica	0.68	0.80	0.88	0.52	0.36	
Clypidina rugosa	2.32	0.88	0.56	3.60		0.76
Cominella lineolata	0.04	0.08	0.20	0.20	0.80	0.32
Cypraea angustata						0.04
Dicathais orbita	0.16	0.04	0.12	0.08	0.36	0.16
Lepsiella vinosa			0.04	0.04	0.40	0.12
Nerita atramentosa						0.12
Nodilittorina acutispira		12.16	176.92		0.08	0.28
Nodilittorina unifasciata		1.16	6.76	2.36		
Notoacmea mayi	13.28	11.04	26.2	2.60	0.32	0.08
Onchidella patelloides	0.20	1.76			0.08	
Patella chapmani				0.04		
Patelloida alticostata	1.40	1.56	1.36	0.08	0.04	0.24
Patelloida insignis		0.04				
Patelloida latistrigata		0.16				
Siphonaria spp	21.64	23.04	35.88	6.00	0.12	4.76
Turbo undulatus	0.08	0.24		0.20	0.76	0.24
Unidentified chiton		0.12	0.04			0.04
Echinodermata						
Patiriella exigua				0.72	0.80	0.48
Patiriella calcar				0.04	0.16	0.04
Crustacea						
Unidentified crab				0.04	0.12	0.04
Cyclograpsus granulosus					0.28	

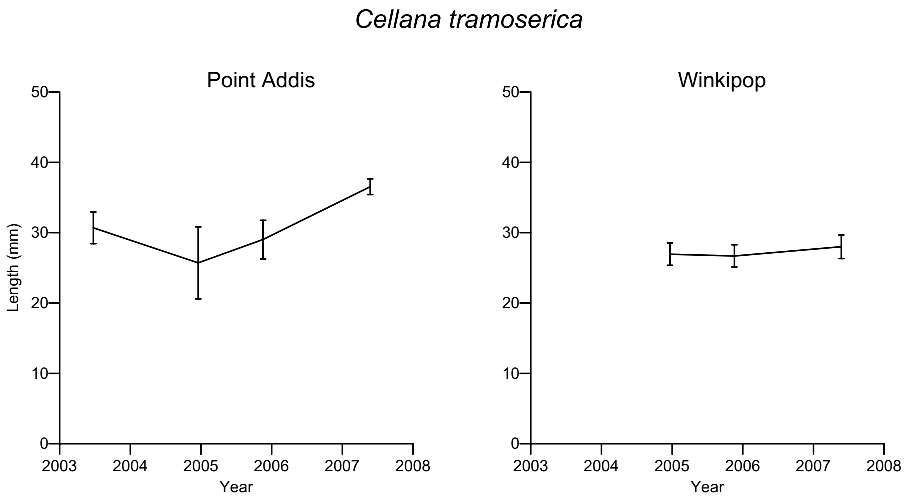


Figure 10.3. Mean sizes (± 95 % confidence intervals) of *Cellana tramoserica* at Point Addis and Winkipop.

11 POINT DANGER MARINE SANCTUARY

11.1 Site Description and Transect Layout

11.1.1 Point Danger Marine Sanctuary (Site 4002)

The intertidal area at Point Danger is a large sandstone reef platform that is an extension of the Point Danger headland (Figure 11.1). The reef is exposed to the north, east and south, however most of the prevailing weather and waves are from the 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.

11.1.2 Point Danger West Reference (Site 4001)

The reference site, Point Danger West, is separated from the Point Danger intertidal platform by a short section of sandy beach. As with Point Danger, the sandstone platform has been eroded to create an uneven surface at the scale of 10s centimetres. This reef is subject to significant sand inundation (Figure 11.2). The site baselines were 50 m, with transects of 30 m.

Figure 11.1. Intertidal reef at Point Danger, 14 January 2005.

Figure 11.2. Intertidal reef at Point Danger West, 17 January 2005.

11.2 Macroalgae and Aggregating Sessile Invertebrates

The predominant sessile species at Point Danger and Point Danger West were the brown alga *Hormosira banksii*, green alga *Enteromorpha* sp, algal turfs and the mat-forming mussel *Xenostrobus pulex* (Table 11.1). A variety of other sessile species were observed, but in low abundances of < 3 % cover, except for occasionally the green alga *Ulva* sp. The only marked temporal changes were higher abundances of the mussel *Xenostrobus pulex* during November 2005 at both Point Danger and Point Danger West. There was also a much higher coverage of algal turf at Point Danger West during that survey.

Sand inundation at both reefs was variable between surveys, 2-30 % cover, with both sites having a much higher cover during the May 2007 survey (Table 11.1).

Table 11.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Point Danger and Point Danger West during Survey 3 (January 2005), Survey 4 (December 2005) and Survey 5 (May 2007). '+' = present in quadrats but not observed under any points.

Species	Point Danger MS (4002)			Point Danger West (4001)		
	Survey			Survey		
	3	4	5	3	4	5
Macrophytes						
Algal turf	2.24	0.88	4.64	2.32	11.20	2.32
Brown algae unidentified		0.56		+		
Corallina officinalis			+	+		0.48
Corallines unidentified	+	0.32				
Dictyosphaeria serica				+		
Encrusting corallines	0.24	0.16	+	0.96	0.72	+
Enteromorpha spp	1.12	0.56	2.08	0.72	3.20	0.56
Filamentous red algae						+
Green algae unidentified		0.88			2.72	+
Hormosira banksii	21.12	13.76	23.68	37.28	21.20	22.56
Rivularia spp	0.08		+		+	
Symploca spp				+		0.48
Ulva spp	0.32	5.20	+	0.16	0.16	+
Sessile Invertebrates						
Brachidontes rostratus	1.44	+	+			
Chthamalus antennatus				1.68	0.64	+
Galeolaria caespitosa	0.16	0.08	0.48	+	+	+
Xenostrobus pulex	12.8	22.32	11.60	6.4	10.32	1.52
Other						
Drift macroalgae				+		
Drift seagrass		+				
Sand	8.88	15.92	33.04	2.32	1.76	25.52

11.3 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 (Table 11.2). Characteristic species were the gastropod snails *Bembicium nanum*, *Dicathais orbita*, *Lepsiella vinosa*, *Turbo undulatus* and the limpets *Clypidina rugosa*, *Patelloida alticostata* and *Siphonaria* spp. The two sites differed predominantly in the abundance of *Bembicium nanum*, with Point Danger having much higher densities than Point Danger West (11-50 *c.f.* 1-8 per 0.25 m^2; Table 11.2).

There was a trend of increasing abundance in the snail *Nodilittorina acutispira* and the limpet *Notoacmea mayi* between November 2005 and May 2007 (Table 11.2). There was also an apparent (but slight) increase in the abundance of *Siphonaria* spp over this period.

The predatory gastropod *Lepsiella vinosa* appeared to be associated with *Xenostrobus pulex* mussel beds.

The mean size of the limpet *Cellana tramoserica* population at Point Danger decreased during the November 2005 survey. At Point Danger West, the mean size was relatively constant of approximately 34 mm (Figure 11.3a).

The mean size of *Bembicium nanum* at both sites decreased substantially (by approximately half) after the 2003 survey (Figure 11.3b). This was likely to relate the recruitment of smaller snails. The mean size of *B. nanum* subsequently increased at both sites, with this trend continuing at Point Danger West such that mean sizes in 2007 were the same as in 2003 (Figure 11.3b).

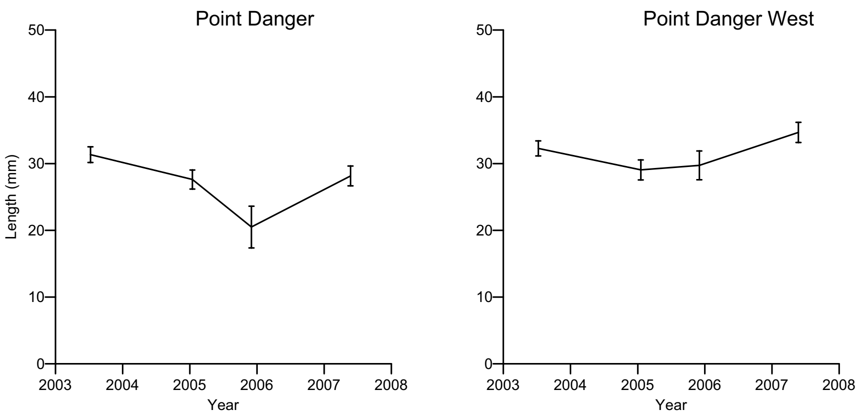
Table 11.2. Density of megafaunal invertebrates per 0.25 m^{-2} at Point Danger and Point Danger West during Survey 3 (January 2005), Survey 4 (December 2005) and Survey 5 (May 2007).

Species	Point Danger MS (4002)			Point Danger West (4001)		
	Survey			Survey		
	3	4	5	3	4	5
Cnidaria						
Actinia tenebrosa	0.60	0.36		0.16		0.48
Aulactinia veratra	0.12				0.04	
Oulactis muscosa	0.08			0.04	0.20	
Mollusca						
Austrocochlea constricta	1.48	2.12	0.76		0.12	0.56
Austrocochlea odontis	0.16	1.20	0.40	0.20	0.16	0.24
Austrocochlea porcata			0.04			
Bembicium nanum	11.76	19.92	50.80	0.80	1.36	7.80
Cellana tramoserica	1.20	1.48	0.20	0.32	0.20	0.64
Clypidina rugosa	23.04	16.52	6.72	18.24	16.44	10.6
Cominella lineolata	0.76	0.40	0.28	0.48	0.48	0.36
Dicathais orbita	0.68	0.64	2.08	0.24	0.48	0.68
Lepsiella vinosa	1.16	1.72	0.52	0.16	0.28	
Nodilittorina acutispira			7.00		2.36	22.28
Nodilittorina unifasciata	0.12	0.32		8.00	0.20	
Notoacmea mayi		0.12	2.48	0.40	3.04	6.96
Notoacmea petterdi				0.44		

Table 11.2. (continued). Density of megafaunal invertebrates per 0.25 m^{-2} at Point Danger and Point Danger West during Survey 3 (January 2005), Survey 4 (December 2005) and Survey 5 (May 2007).

Species	Point Danger MS (4002)			Point Danger West (4001)		
	Survey			Survey		
	3	4	5	3	4	5
Onchidella patelloides	0.16			0.12	0.80	0.24
Patelloida alticostata	0.08	0.40	1.92	0.36	0.16	0.64
Patelloida insignis		0.12		0.08		
Prothalotia ramburi						0.12
Siphonaria spp	2.84	2.28	3.68	5.44	2.80	9.88
Turbo undulatus	0.52	0.88	0.20	0.16	0.16	0.28
Unidentified chiton		0.04				0.12
Crustacea						
Unidentified crab					0.04	

a. *Cellana tramoserica*



b. *Bembicium nanum*

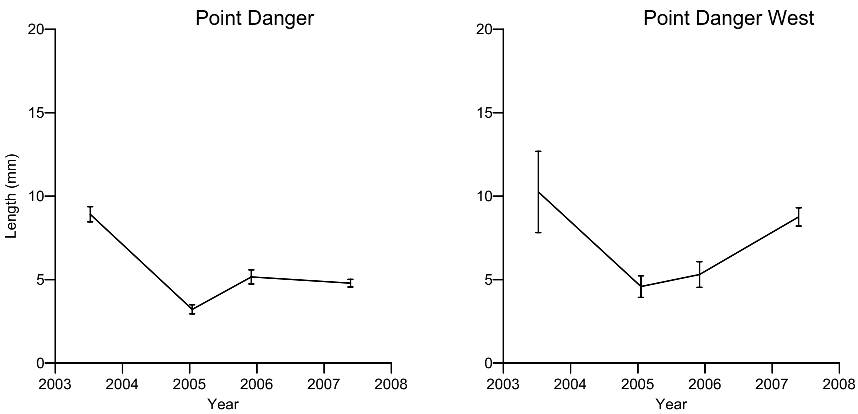


Figure 11.3. Mean sizes (± 95 % confidence intervals) of (a) *Cellana tramoserica*; and (b) *Bembicium nanum* at Point Danger and Point Danger West.

12 BARWON BLUFF MARINE SANCTUARY

12.1 Site Description and Transect Layout

12.1.1 Barwon Bluff Marine Sanctuary (Site 4004)

The intertidal reef at Barwon Bluff is composed of sections of sandstone and basalt reef. The intertidal rock platform extends from the end of Barwon Bluff as a pincer-shaped reef. The north-eastern section of the pincer is a basalt platform and boulder reef. This section of the reef is relatively protected from swell but has a large estuarine influence from the adjacent mouth of the Barwon River. The south-western section of the 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 to 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. 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.

12.1.2 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.

Figure 12.1. Intertidal reef at Barwon Bluff, 30 November 2005.

12.2 Macroalgae and Aggregating Sessile Invertebrates

As with most exposed rock platforms of the central Victorian coast the dominant algae at both Barwon Bluff and the reference site at Barwon Beach was the brown algae Neptune's necklace *Hormosira banksii*. The abundance was 46-57 % cover at Barwon Bluff and 30-40 % cover at Barwon Beach. There was a slight increase at Barwon Bluff between November 2005 and May 2007 (Table 12.1). The only other macroalgae which occurred in appreciable quantities on the shore were turf forming species. Algal turf was 3-4% cover at Barwon Bluff over the last three surveys. At Barwon Beach, the algal turf cover was 13 and 12 % cover in January and November 2005, but was only 2 % cover in May 2007.

The mat forming mussel *Xenostrobus pulex* had a low cover in patches across the shore at both sites, occupying exposed patches of rock between sand/*H. banksii* microhabitat (Table 12.1). The abundance of *X. pulex* did not change markedly between surveys.

Barnacles were a more prevalent species at Barwon Beach with both *Chthamalus antennatus* and *Chamaesipho tasmanica* present, albeit in very low densities (Table 12.1). *Galeolaria caespitosa* was also more abundant at Barwon Beach.

Sand inundation was high at Barwon Bluff but had decreased between the November 2005 survey and the June 2007 survey (Table 12.1). Sand inundation at the Barwon beach site was lower than at Barwon Bluff, despite an increase in cover to the 2007 survey. Sand inundation expected to vary considerably over shorter time scales, being influenced by prevailing weather conditions.

Table 12.1. Mean abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Barwon Beach and Barwon Bluff during Survey 3 (January 2005), Survey 4 (November 2005) and Survey 5 (May 2007). (+) present in quadrats but not observed under any points.

Species	Barwon Bluff MS (4004)			Barwon Beach (4003)		
	Survey			Survey		
	3	4	5	3	4	5
Macrophytes						
Algal turf	3.2	4.48	4.24	13.84	12.4	2.0
Brown algae unidentified					0.16	
Colpomenia sinuosa					+	
Corallina officinalis	0.4	0.16	+	+	+	1.76
Corallines unidentified				+		
Cystophora spp	0.16					0.96
Encrusting corallines	0.32	0.40	+	+		
Enteromorpha spp	+	+		+	+	
Filamentous red algae				+		
Green algae unidentified					0.72	
Hormosira banksii	46.32	47.04	57.20	31.52	30.96	37.76
Laurencia filiformis					+	
Leathesia difformis				+	+	
Nothea anomala		+	+			
Rivularia spp		+	0.04		+	
Syctosiphon lomentaria					0.08	
Symploca	+		+	0.24		
Ulva spp	+	0.40		0.08	1.92	
Sessile Invertebrates						
Chamaesipho tasmanica				1.04		+
Chthamalus antennatus		+		0.40	1.56	+
Galeolaria caespitosa	0.08		+	0.64	1.04	0.16
Unidentified Barnacles		+		+		
Xenostrobus pulex	2.24	0.16	0.16	+	0.88	0.16
Other						
Drift macroalgae	+					0.8
Drift seagrass		+				
Sand	12.72	19.36	13.68	0.32	1.12	8.96

12.3 Mobile Invertebrates

The mobile invertebrates assemblages Barwon Bluff and Barwon Beach sites were both dominated by the gastropod snails *Bembicium nanum*, *Nodilittorina acutispira* and *N. unifasciata* and the limpets *Clypidina rugosa*, *Notoacmea mayi*, *Cellana tramoserica* and *Siphonaria* spp (Table 12.2). The periwinkle *Nodilittorina acutispira* and the limpet *Notoacmea mayi* were present in particularly high densities in the mid to low region of the intertidal platforms. There were increases in abundances of these species between November 2005 and May 2007. Other notable changes were an increase in *Bembicium nanum* and *Clypidina rugosa* at Barwon Beach, with a corresponding decrease of these species at Barwon Bluff over the same period. There was a decreasing trend in Siphonaria abundances at Barwon Bluff from January 2005 to May 2007, with abundances at Barwon Beach also lower in 2007 than 2005 (Table 12.2).

The predatory gastropods *Lepsiella vinosa*, *Cominella lineolata* and *Dicathais orbita* were low in abundance at both sites during all surveys (Table 12.2).

Two individuals of the sea hare *Aplysia gigantea* were found in a single quadrat in January 2005. The quadrat encompassed a small body of standing water adjacent to one of the large rock pools in the middle of the survey area. No individuals were recorded in any of the following surveys.

Table 12.2. Density of megafaunal invertebrates per 0.25 m^{-2} at Barwon Beach and Barwon Bluff during Survey 3 (January 2005) Survey 4 (November 2005) and Survey 5 (May 2007).

Species	Barwon Bluff MS (4004)			Barwon Beach (4003)		
	Survey			Survey		
	3	4	5	3	4	5
Cnidaria						
Actinia tenebrosa		0.20				
Anthothoe albocincta	0.04					
Aulactinia veratra	0.56	0.36	0.12	0.08	0.08	0.40
Oulactis muscosa					0.04	
Mollusca						
Aplysia gigantea	0.08					
Austrocochlea concamerata	0.12					0.28
Austrocochlea constricta	0.72	1.16			0.16	
Austrocochlea odontis	0.04	1.56		0.04		
Bembicium nanum	1.56	2.72	0.76	8.08	2.64	15.04
Calliostoma armillata		0.12				
Cellana tramoserica	1.12	1.32		5.04	2.72	2.60
Clypidina rugosa	7.92	17.76	4.96	64.4	22.44	50.48
Cominella lineolata	0.12	0.48	0.28		0.16	0.12
Dicathais orbita	0.36	0.88	0.04	0.36	0.16	0.36
Lepsiella vinosa	0.12	0.16				
Nodilittorina acutispira	0.44	19.52	43.60	285.76	271.92	1280.80
Nodilittorina unifasciata	0.72	4.08		71.0	78.36	34.44
Notoacmea mayi	8.68	6.84	20.20	39.64	4.00	11.72
Notoacmea petterdi	0.04			0.2		
Onchidella patelloides		0.08	0.16			
Patelloida alticostata	0.92	0.40		1.84	1.00	0.44
Patelloida insignis				0.24	0.04	0.08
Patelloida latistrigata		0.04		0.36	0.12	0.72
Phasianotrochus eximius		0.12				
Prothalotia ramburi						0.32
Siphonaria spp	24.8	11.64	9.60	14.16	4.44	7.04
Turbo undulatus	0.64	1.96			0.04	
Unidentified chiton		0.12		0.08		0.08
Unidentified limpet			0.32			
Crustacea						
Paragrapsus gaimardii					0.72	
Unidentified crab		0.08				

The mean size of *Cellana tramoserica* at Barwon Bluff was larger than at Barwon Beach, with means of 30 mm and 27 mm respectively (Figure 12.2). The mean size of *C. tramoserica* appears to have increased at both sites since the last survey.

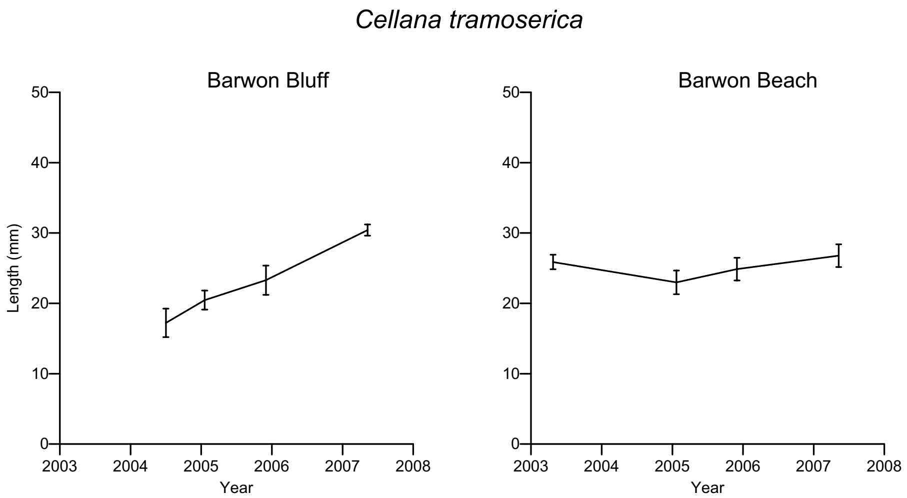


Figure 12.2. Size Mean sizes (± 95 % confidence intervals) of *Cellana tramoserica* at Barwon Bluff MS and Barwon Beach.

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14 ACKNOWLEDGEMENTS

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