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Victorian Intertidal Reef Monitoring Program

The Intertidal Reef Biota of Central Victoria's Marine Protected Areas (Volume 2)

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October 2007

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Victorian Intertidal Reef Monitoring Program:

The Intertidal Reef Biota of Central Victoria's Marine Protected Areas

Patrick Gilmour

Matt Edmunds

Australian Marine Ecology

October 2007

Parks VICTORIA

EXECUTIVE SUMMARY

Intertidal reefs in Victoria are typically 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). Over time, the IRMP will provide information on the status of Victorian intertidal reef flora and fauna and determine 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.

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 generally few species and sparse cover of macroalgae on all intertidal reefs surveyed in the north of the Bay. The brown alga Neptune's necklace *Hormosira banksii* covered substantial areas low on the shore at most sites. The green algae *Ulva* spp and *Enteromorpha* spp occurred as small patchily distributed tufts. The locations surveyed along the open coastline generally had a higher species richness and cover of algae. As with the Port Phillip Bay sites, *Hormosira banksii* was the dominant algae at all sites. Patches of small filamentous turfing species also occurred at most locations, but in low abundance.

Sessile aggregating invertebrates were more abundant components of the intertidal reefs outside Port Phillip Bay than on the intertidal reefs inside the bay. *Galeolaria caespitosa*

occurred at most sites in low density. The mat forming mussels such as *Xenostrobus pulex* and *Brachidontes rostratus* were abundant at several locations.

The intertidal invertebrate communities of Port Phillip Bay were generally composed of few species. They were generally very distinct from the locations along the open coastline, which had a higher richness and abundance of species.

The top shell *Austrocochlea porcata* was the most common species at almost all sites within Port Phillip Bay. 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, 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.

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1 INTRODUCTION

1.1 Intertidal Reef Ecosystems

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

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

Molluscs tend to be the dominant faunal component on intertidal reefs. Herbivorous species include the limpet *Cellana tramoserica*, as well as other species such as top shells *Austrocochlea* spp and 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.

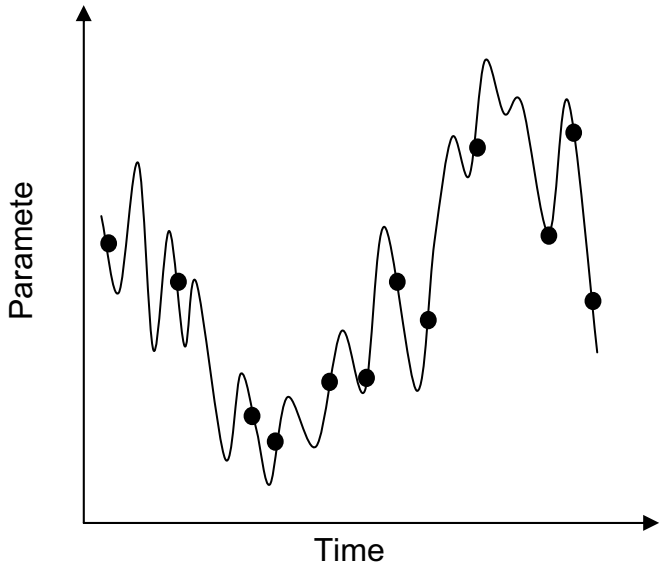


Figure 1.1. An example plot depicting change in an environmental, population or community variable over time (days, months or years). The black circles denote examples of monitoring times. Note how data from these times may not necessarily reflect patterns over shorter time periods, or true maxima or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

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;
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. This included: 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, Mushroom Reef Marine Sanctuary (Figure 2.2) and 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). A reference site was established in association with each of these marine protected areas.

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.

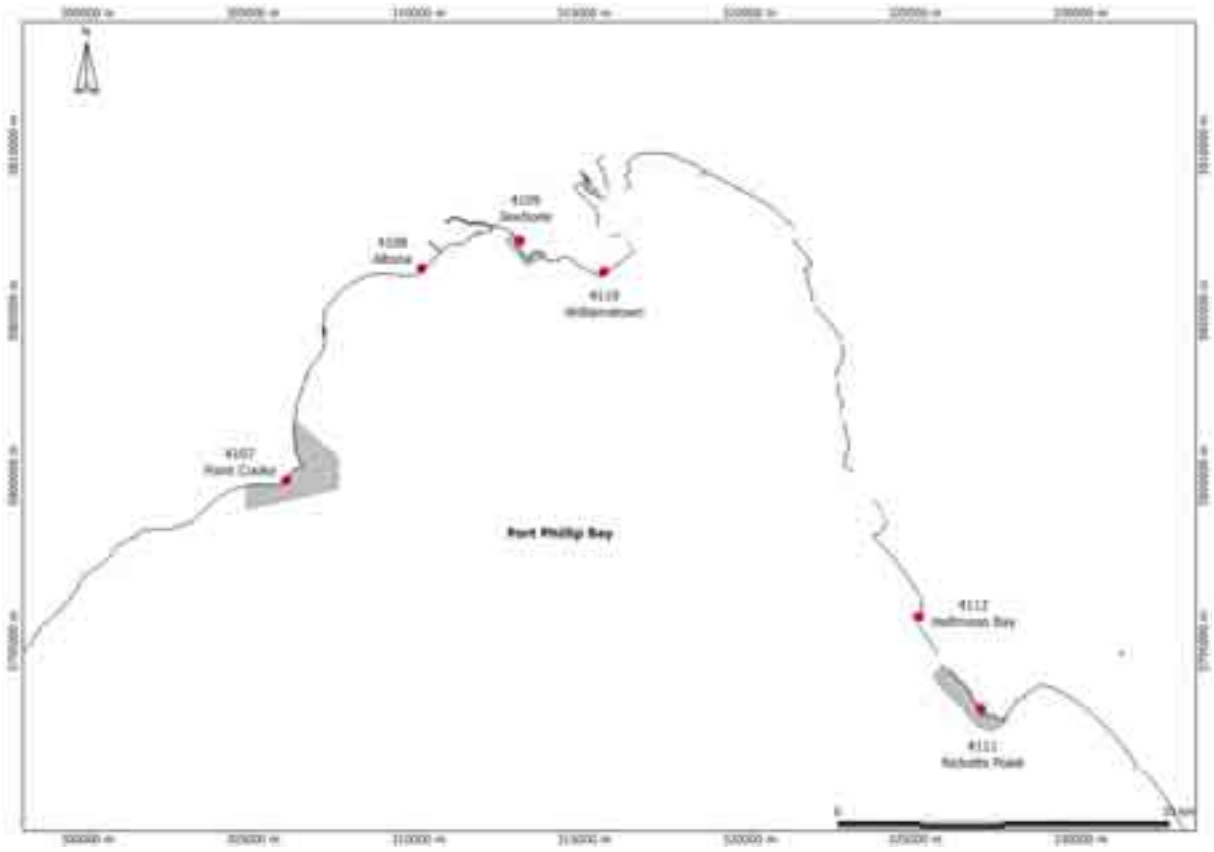


Figure 2.1. Location of intertidal monitoring sites in northern Port Phillip Bay. Marine Sanctuary areas are indicated by grey shading.

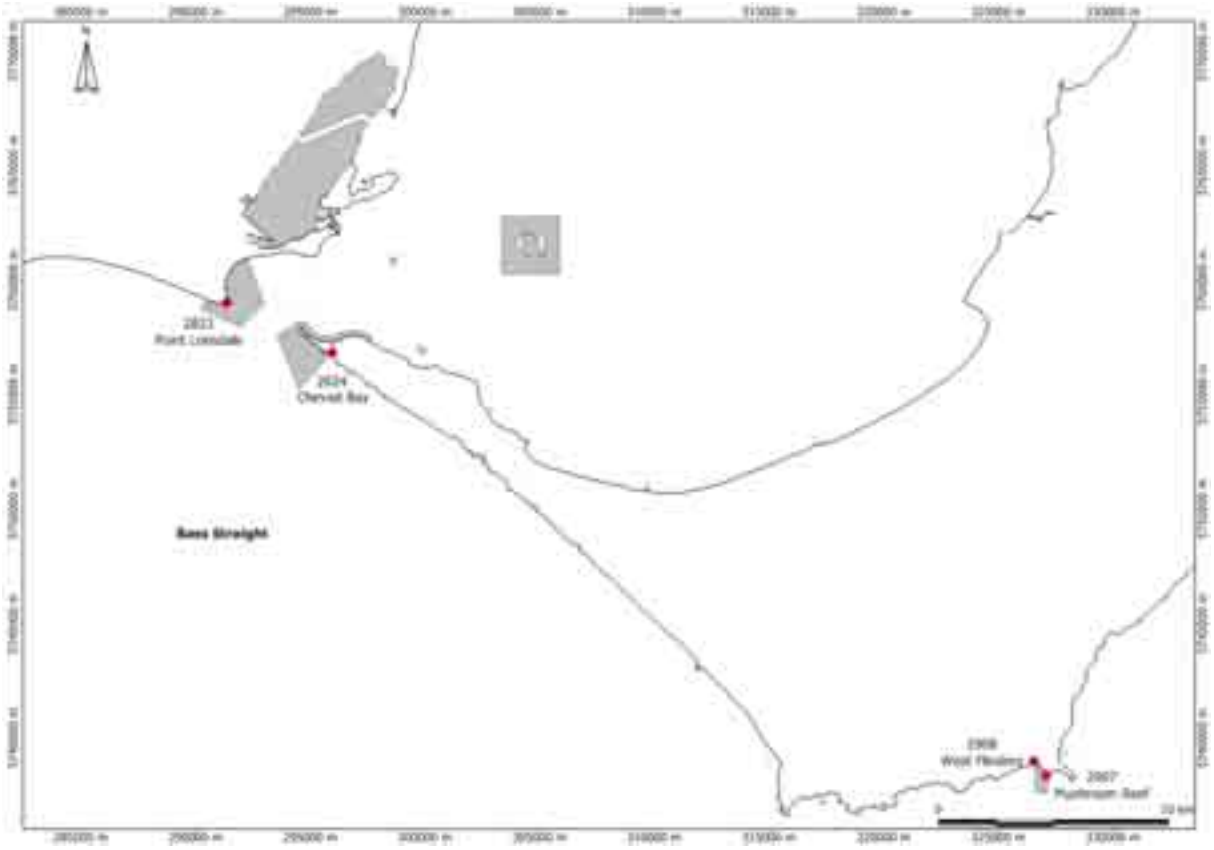


Figure 2.2. Location of intertidal monitoring sites along the eastern coastline of central Victoria (excluding Bunurong Marine National Park). Marine protected areas are indicated by grey shading.

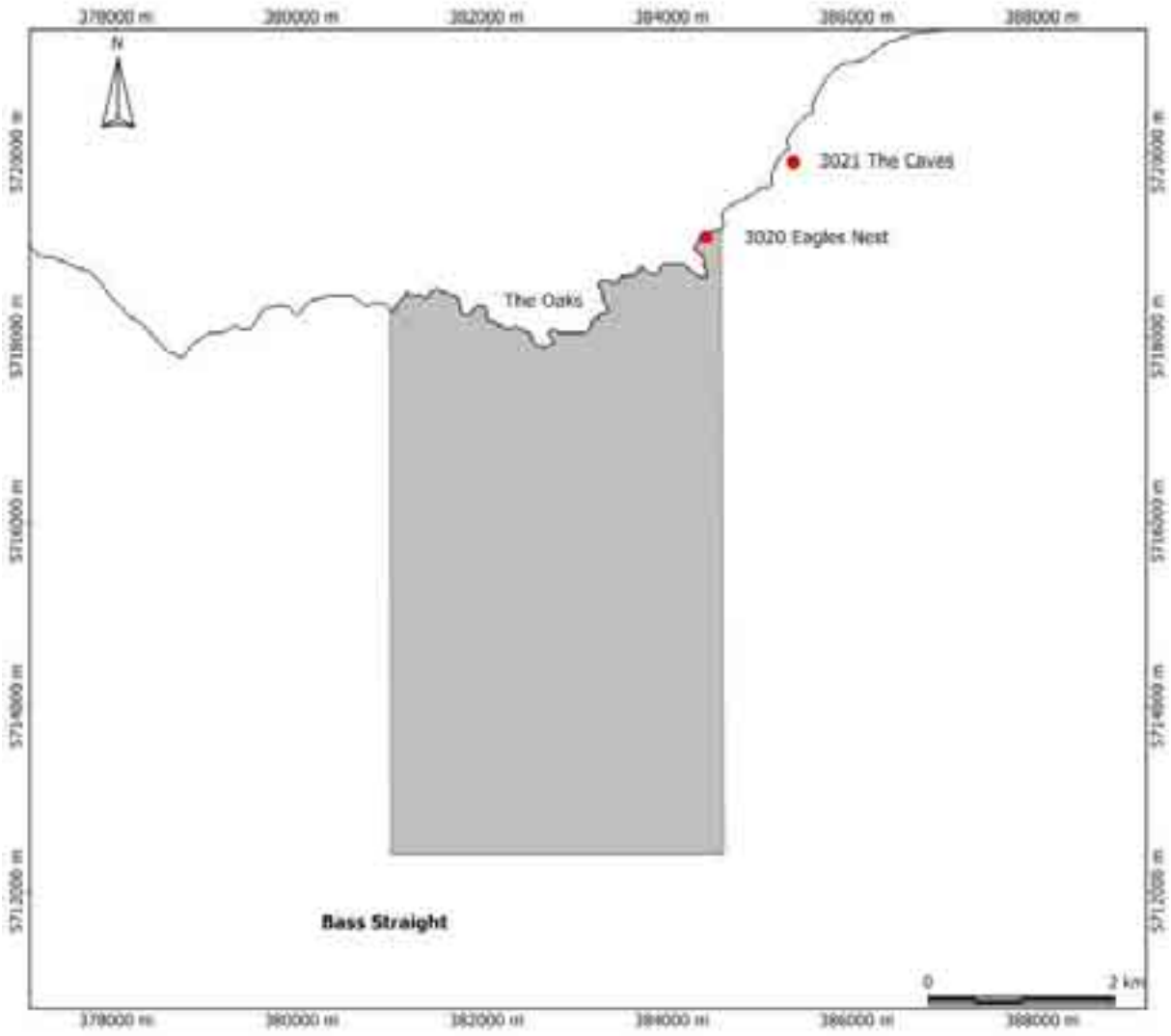


Figure 2.3. Location of intertidal monitoring sites at Bunurong Marine National Park. Marine National Park areas are indicated by grey shading.

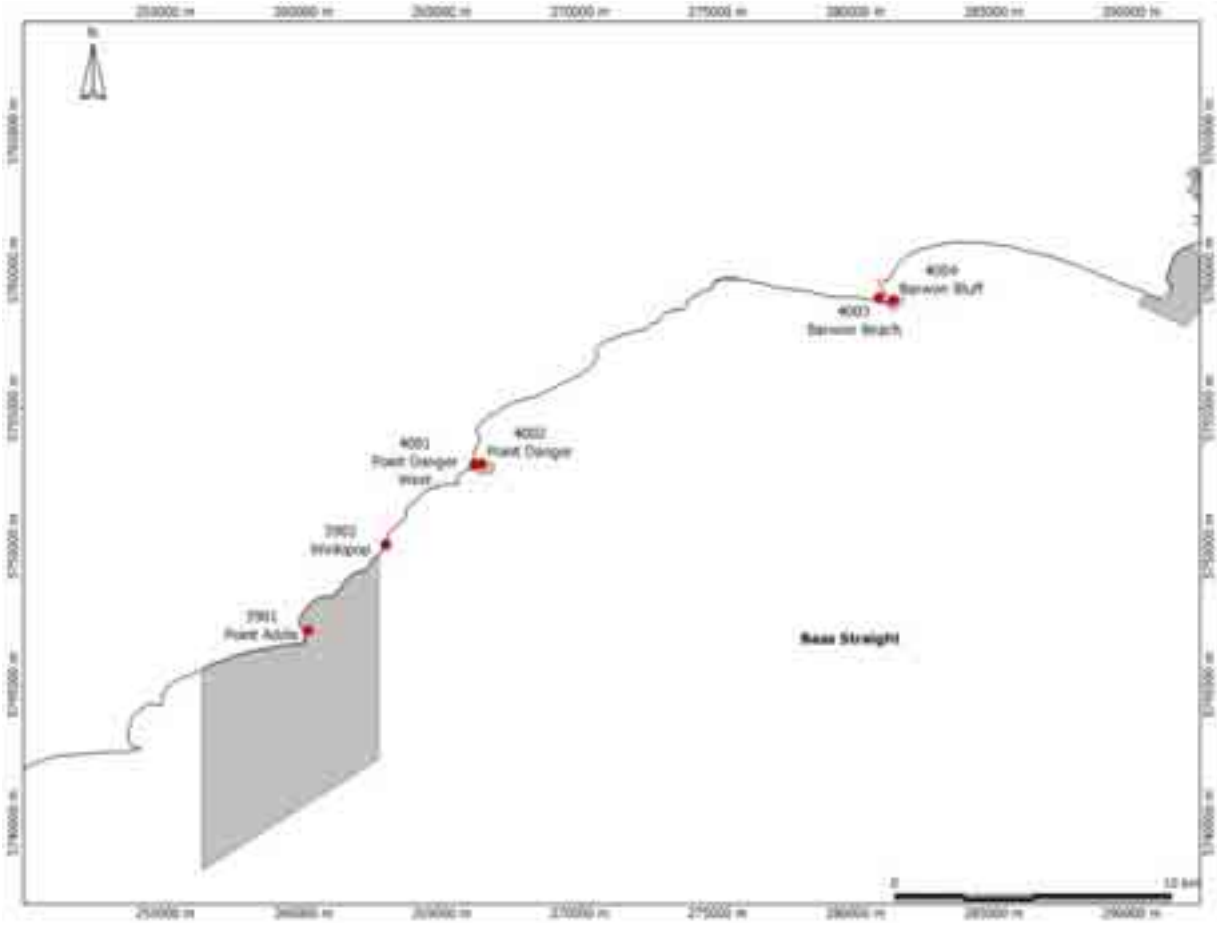


Figure 2.4. Location of intertidal monitoring sites along the western coastline of central Victoria. Marine protected areas' boundaries are indicated by grey shading.

Table 2.1. Intertidal reef monitoring sites. Coordinates in Map Grid of Australia 1996.

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	2003 Survey	2004 Survey	2004/2005 Survey	2005/2006 Survey
4107 Point Cooke	21-04-03	07-05-04	14-04-05	
4108 Altona	22-04-03	13-05-04	01-04-05	
4109 Jawbone	19-04-03	11-05-04	04-04-05	
4110 Williamstown	23-04-03	12-05-04	04-04-05	
4111 Ricketts Point	20-04-03	20-05-04	18-04-05	
4112 Halfmoon Bay	20-04-03	21-05-04	26-04-05	
2823 Point Lonsdale			09-12-04	23-09-05
2824 Cheviot Bay			22-12-04	21-09-05
2907 Mushroom Reef	25-04-03	08-06-04	15-02-05	13-12-05
2908 West Flinders	25-04-03	09-06-04	15-02-05	13-12-05
3020 Eagles Nest			01-02-05	06-01-06
3021 Caves			01-02-05	06-01-06
3901 Point Addis			17-12-04	17-11-05
3902 Winkipop			20-12-04	18-11-05
4001 Point Danger West	09-07-03		17-01-05	01-12-05
4002 Point Danger	08-07-03		14-01-05	01-12-05
4003 Barwon Beach	24-04-03		21-01-05	30-11-05
4004 Barwon Bluff	24-04-03	25-05-04	18-01-05	30-11-05

2.1.1 General Description of Survey Technique

Surveys occur at a single reef during a single low tide. Surveys target the predominant substratum type at each intertidal reef. At each location, the predominant broad substratum type is recorded (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. If different areas of the shore have different susceptibilities to impacts, then surveys occur on the area most susceptible to impacts.

Within the area to be surveyed, the high and low shore regions are identified. On vertically sloping shores, the high shore corresponds to the area that is submerged for the shortest period of time during each tidal cycle. 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. 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.

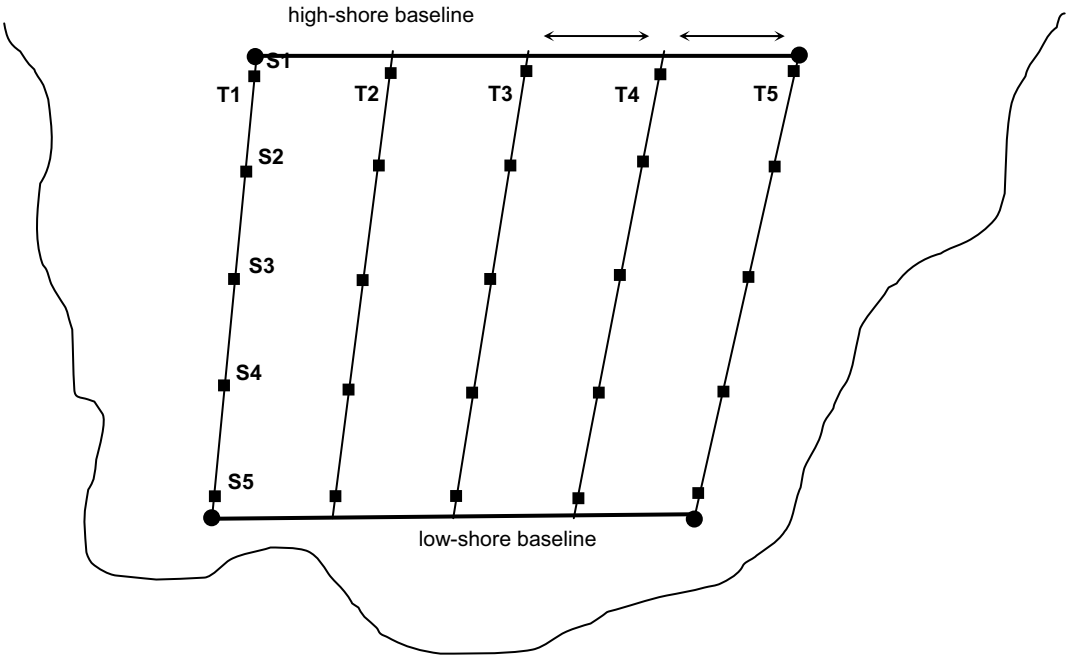


Figure 2.5. Example layout of high and low shore baselines and transects on an intertidal reef. Transects (T1-T5) run across the shore from right to left when looking towards the water. Endpoints of each transect are equidistant along each of the baselines. Sampling locations (S1-S5) are arranged down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

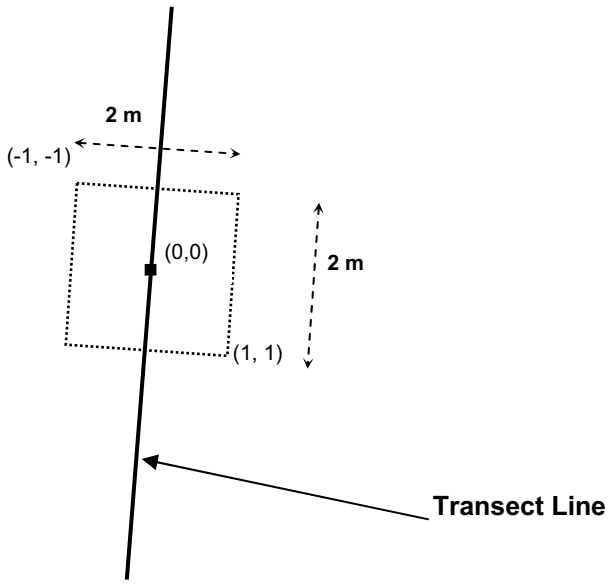


Figure 2.6. Configuration of a sampling location along a transect. Each 2 x 2 m sampling location is centred on a point along the transect line. A quadrat is placed randomly within the sampling location using random x- and y-coordinates between -1 and 1.

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 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	*Chamaesipho 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

Figure 2.9. Examples of typical flora and fauna on intertidal reefs: (a) the green 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/DSimpson = Hill's N2). 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. Because the methodology does not standardise the height of quadrats on the shoreline, 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). Between surveys, species diversity was more consistent than species richness. Changes were recorded at Mushroom Reef, where diversity appeared to increase at both the sanctuary and reference sites. Diversity also appeared to increase at the reference sites Point Danger West (Site 4001) and Altona (Site 4108), but not at the paired sanctuary sites. Species richness appeared to increase at Altona (Site 4108), Cheviot Bay (Site 2824), Flinders West (Site 2908) and Eagle's Nest (Site 3021), but declined at Point Cooke (Site 4107), Mushroom Reef (Site 2907) and Point Lonsdale (Site 2823; Figures 3.4 to 3.6)

Sites in Port Phillip Bay had algal and sessile invertebrate communities that were distinct from sites along the exposed coastline (Figure 3.7). Sea lettuce Ulva spp and the green alga Enteromorpha spp were patchily distributed at most Port Phillip Bay sites. Substantial increases in the abundance of these species at Point Cooke (Site 4107) and Altona (Site 4108) caused shifts in the community structure at these sites between surveys (Figure 3.7). Assemblages at Williamstown (Site 4110) and Ricketts Point (Site 4111) were more similar to sites outside Port Phillip Bay because of a moderately thick cover of Hormosira banksii along the lower shoreline. Patches of small filamentous turfing species also occurred at most locations but in low abundance. Aggregating sessile invertebrates did not tend to be important components of the intertidal assemblages surveyed. The tubeworm Galeolaria caespitosa occurred at several sites but was only found in large encrusting aggregations at Halfmoon Bay (Site 4112).

Outside Port Phillip Bay, assemblages were similar between sites (Figure 3.7). Paired protected area and reference sites were generally closely matched. The most abundant macroalgae was Neptune's necklace Hormosira banksii. There was a high cover of this species at all sites except for Mushroom Reef (Site 2907) where the cover was relatively low. A cover of over 50 % was recorded at Point Lonsdale (Site 2823) and Point Addis (Site 3901) as well as at the corresponding reference sites at Cheviot Bay (Site 2824) and Winkipop (Site 3902). Patches of small filamentous turfing species also occurred at most locations but in low abundance. Sessile invertebrates were more important components of the intertidal reefs outside Port Phillip Bay than on the intertidal reefs inside the bay. Galeolaria caespitosa occurred at most sites in low density. The mat forming mussels such as

Xenostrobus pulex and Brachidontes rostratus were abundant at several locations including Point Danger, Mushroom Reef, Bunurong and Barwon Bluff.

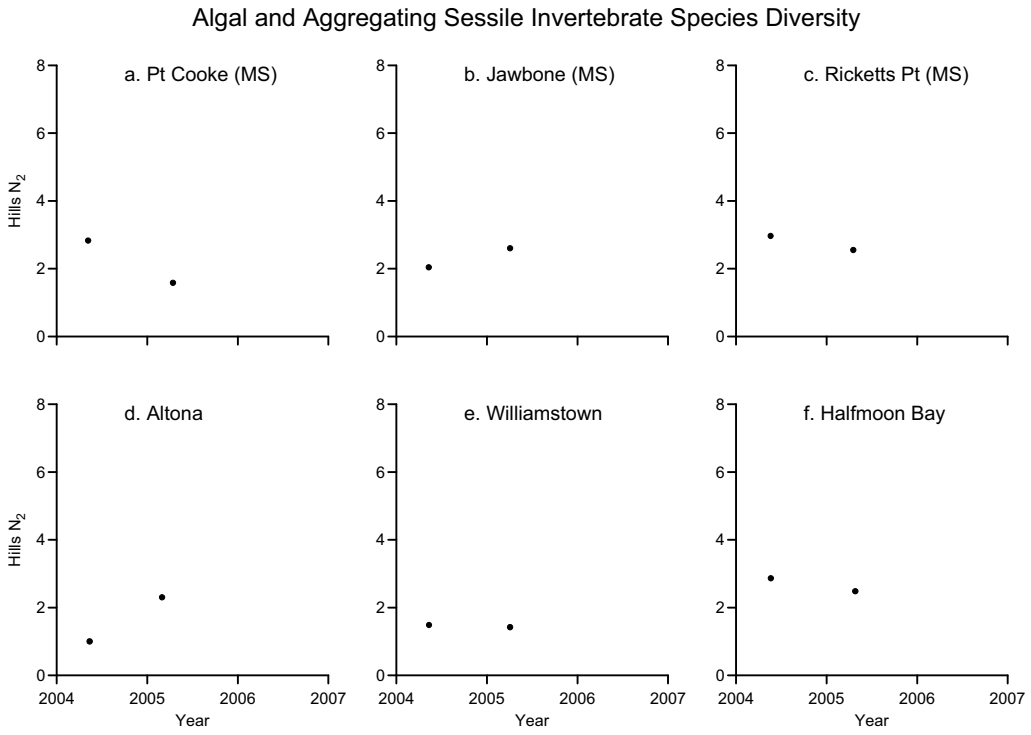


Figure 3.1. Algal and aggregating sessile invertebrate diversity (Hill's N_2) of intertidal sites within Port Phillip Bay.

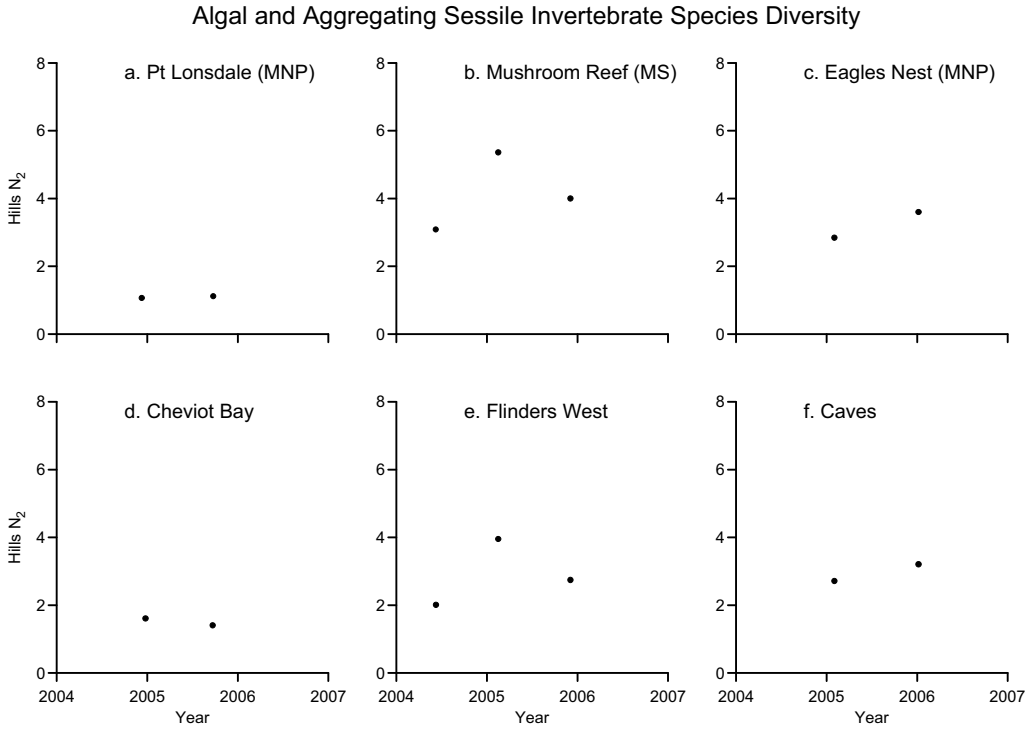


Figure 3.2. Algal and aggregating sessile invertebrate diversity (Hills N_2) of intertidal sites along the eastern Victorian coast.

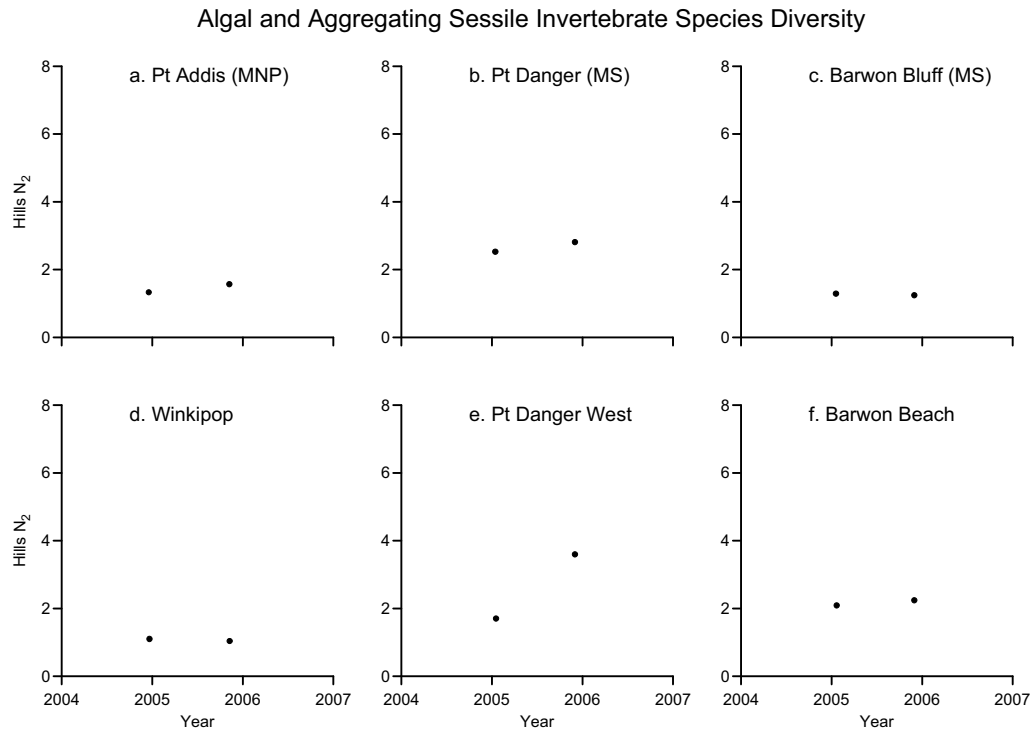


Figure 3.3. Algal and aggregating sessile invertebrate diversity (Hills N_2) of intertidal sites along the western Victorian coast.

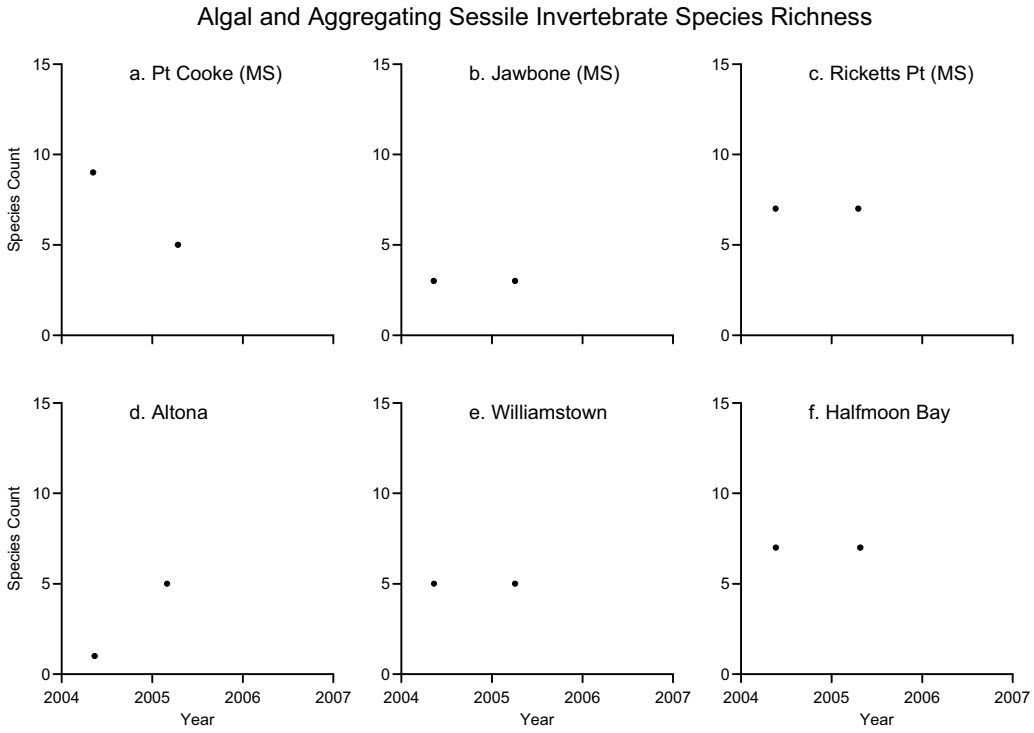


Figure 3.4. Algal and aggregating sessile invertebrate species richness of intertidal sites within Port Phillip Bay.

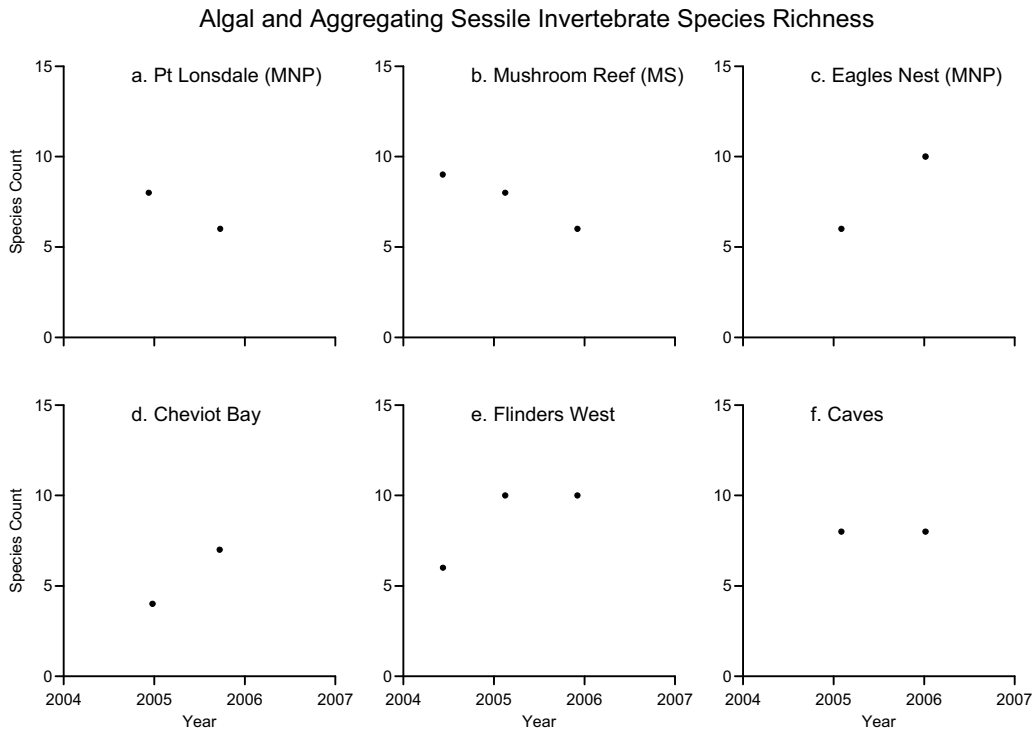


Figure 3.5. Algal and aggregating sessile invertebrate species richness of intertidal sites along the eastern Victorian coast.

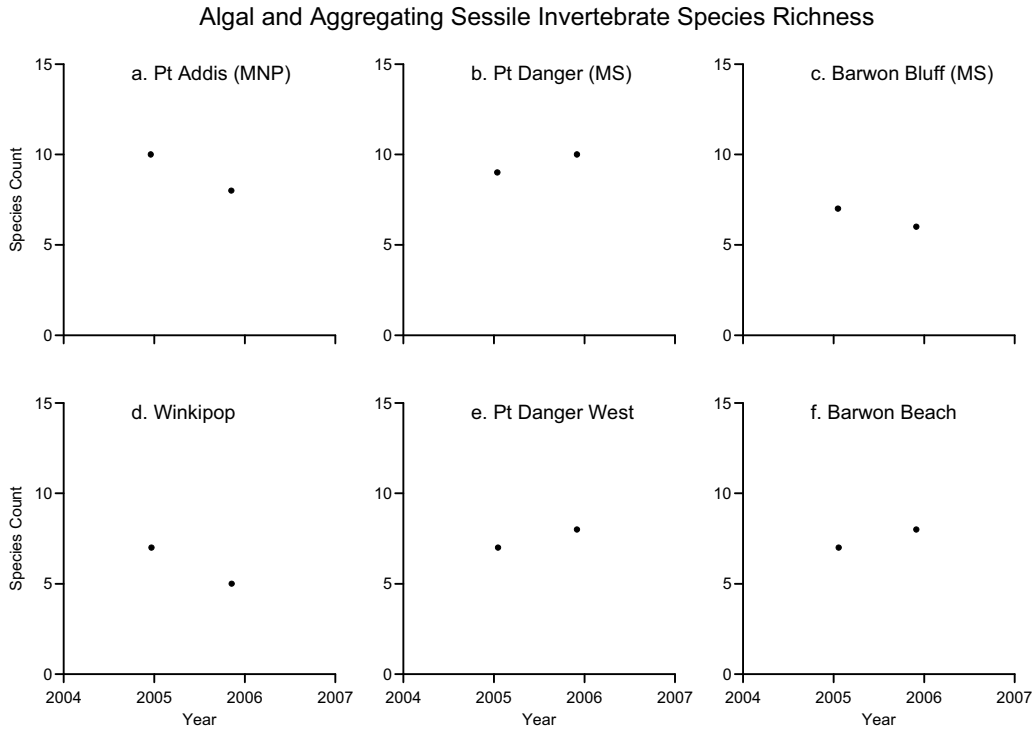


Figure 3.6. Algal and aggregating sessile invertebrate species richness of intertidal sites along the western Victorian coast.

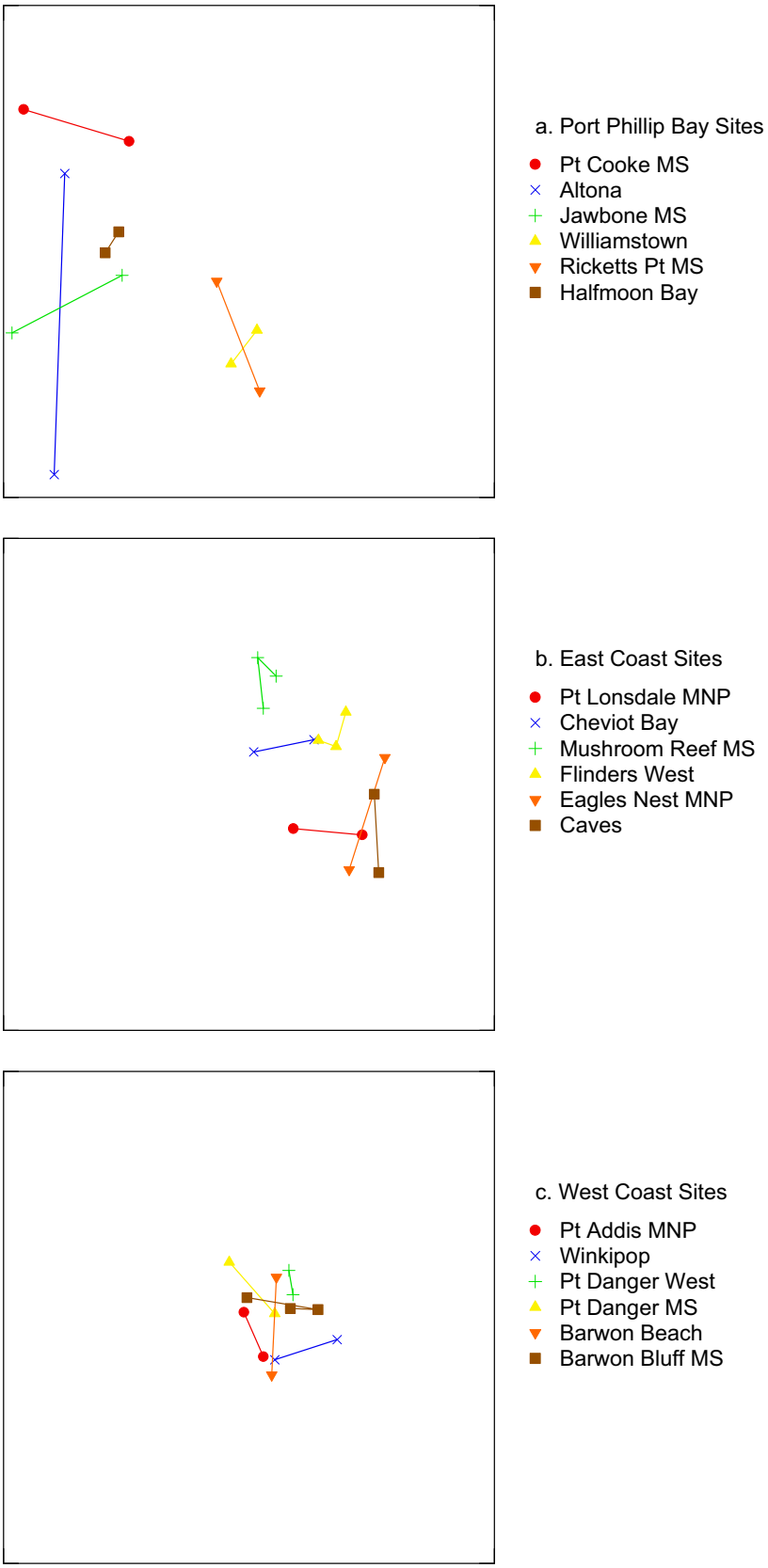


Figure 3.7. Two dimensional MDS plot of algal and sessile invertebrate assemblages on intertidal reefs in (a) northern Port Phillip Bay; (b) Port Phillip Heads and the eastern Victorian coastline; and (c) western Victorian coastline. Lines connect sites examined during consecutive surveys. Kruskal stress = 0.17.

3.3 Invertebrates

Locations surveyed along the open coastline generally had a higher richness and abundance of 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 also showed an apparent decline between surveys. Barwon Bluff (Site 4004), Cheviot Bay (Site 2824) and Point Addis (Point 3901) showed apparent increases in invertebrate species diversity between surveys (Figures 3.8 to 3.10). These trends were also observed in species richness at the same sites (Figures 3.11 to 3.13).

Within Port Phillip Bay, the sites at Halfmoon Bay (Site 4112) and Point Cooke (Site 4107) had assemblages that clearly distinguished them from the other sites (Figure 3.14). The low species richness and abundance at Point Cooke and conversely, the high richness and abundance of species at Halfmoon Bay, are likely to have made the communities distinct (Figures 3.8 to 3.13).

The top shell Austrocochlea porcata was the most common species at almost all sites. 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.

Bembicium spp in northern Port Phillip Bay is 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 and have therefore been grouped as Siphonaria spp.

Along the coastline east of Port Phillip Bay, paired park and reference sites were closely aligned with each other (Figure 3.14). Assemblages along the western coastline were more similar between locations and pairing of protected and reference sites was less apparent.

The pulmonate limpet Siphonaria spp, striped conniwink Bembicium nanum and variegated limpet Cellana tramoserica were all moderate to highly abundant at all sites surveyed outside Port Phillip Bay. Austrocochlea constricta, Notoacmea mayi, Clypidina rugosa, Nodilittorina unifasciata and N. acutispira also occurred at most sites, with a wide range of abundances observed throughout their ranges. As with intertidal reefs in Port Phillip Bay, there was a range of less common species which occurred in varying abundances: Turbo undulatus; Nerita atramentosa; Lepsiella vinosa; Cominella lineolata; Dicathais orbita; Austrocochlea odontis; and Patelloida alticostata.

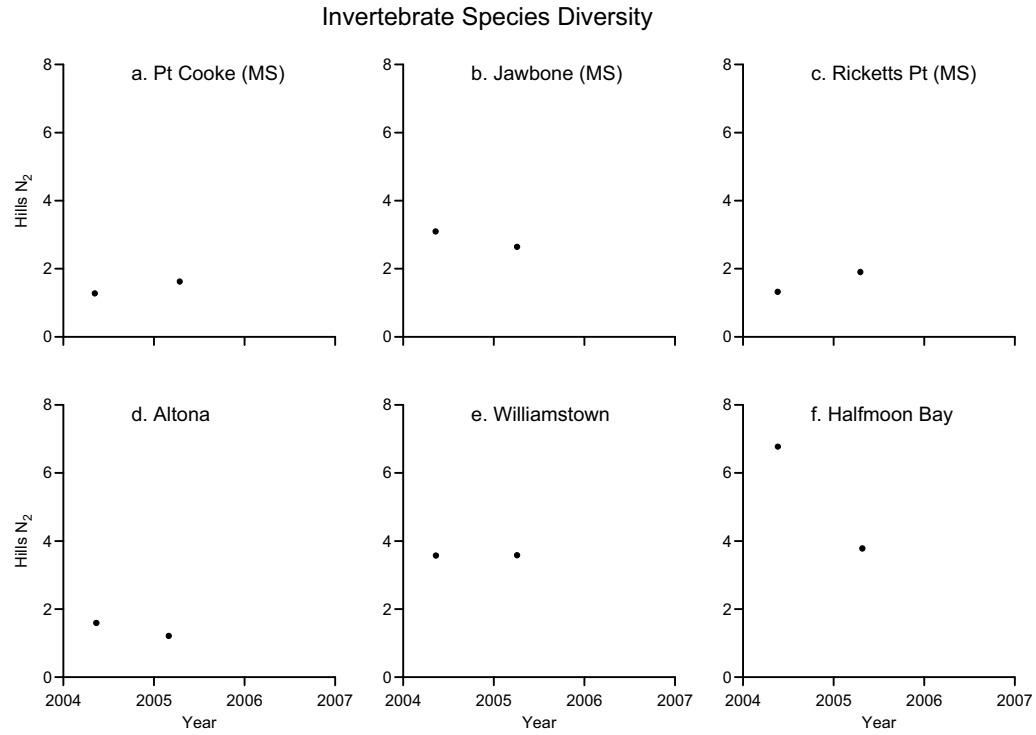


Figure 3.8. Invertebrate species diversity (Hills N_2) of intertidal sites within Port Phillip Bay.

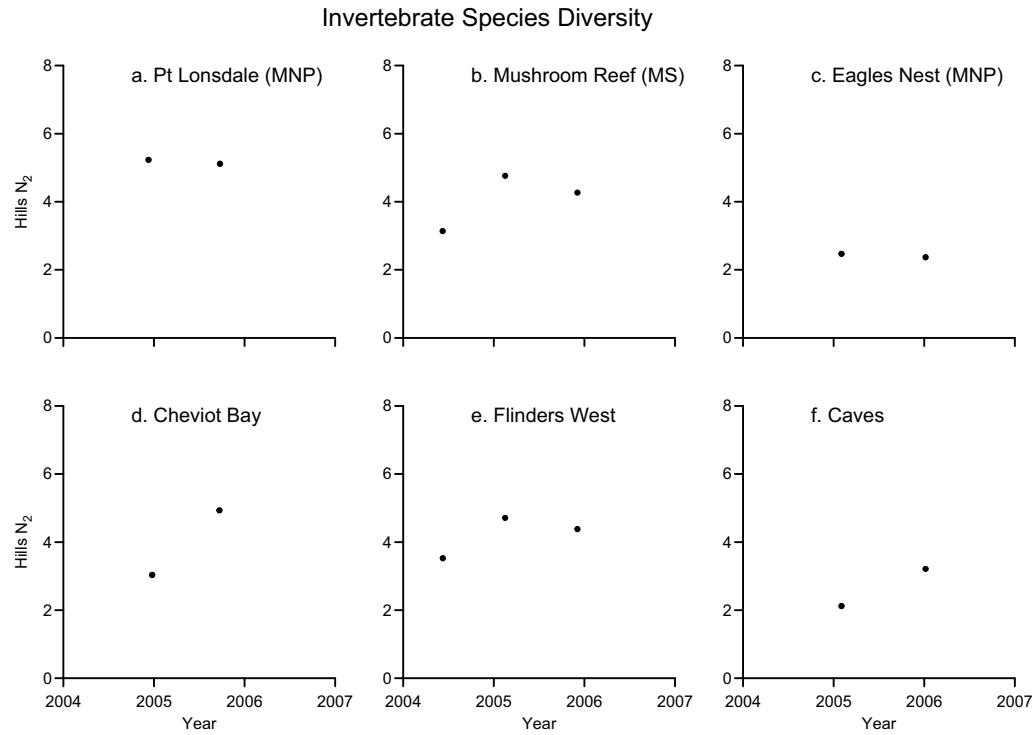


Figure 3.9. Invertebrate species diversity (Hills N_2) of intertidal sites along the eastern Victorian coast.

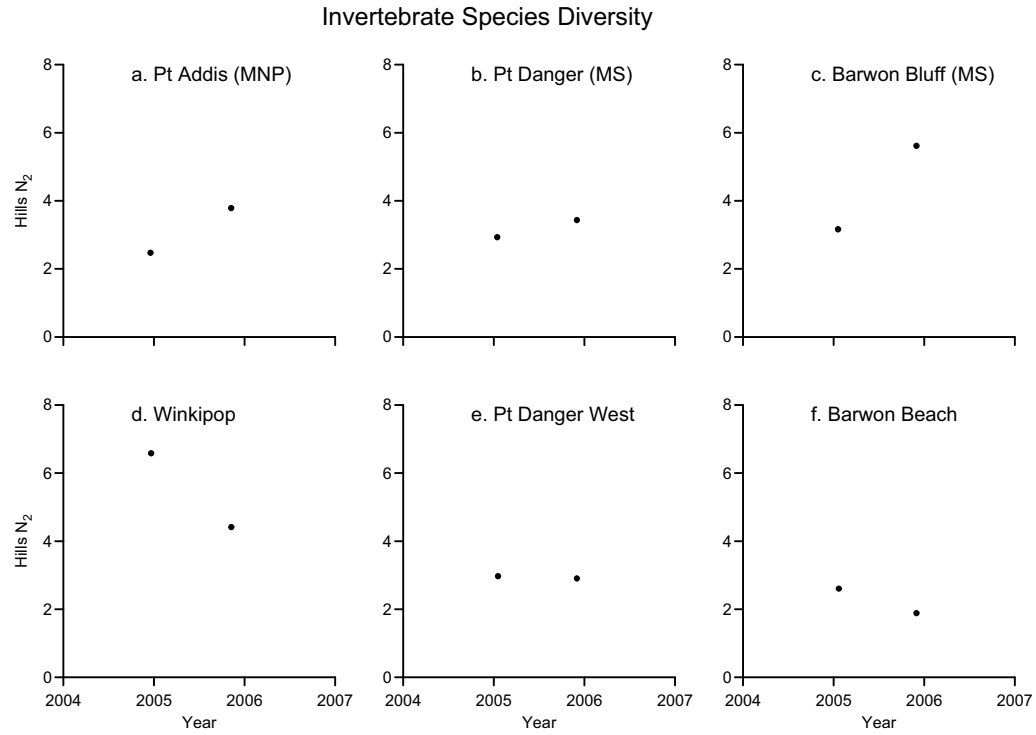


Figure 3.10. Invertebrate species diversity (Hills N_2) of intertidal sites along the western Victorian coast.

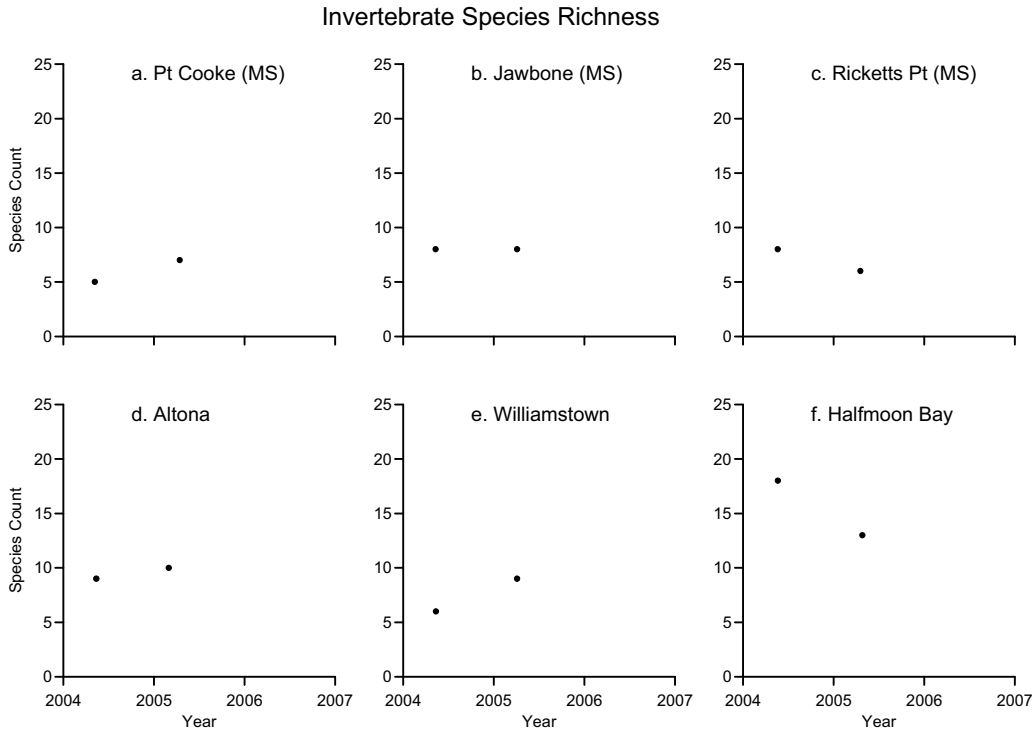


Figure 3.11. Invertebrate species richness of intertidal sites within Port Phillip Bay.

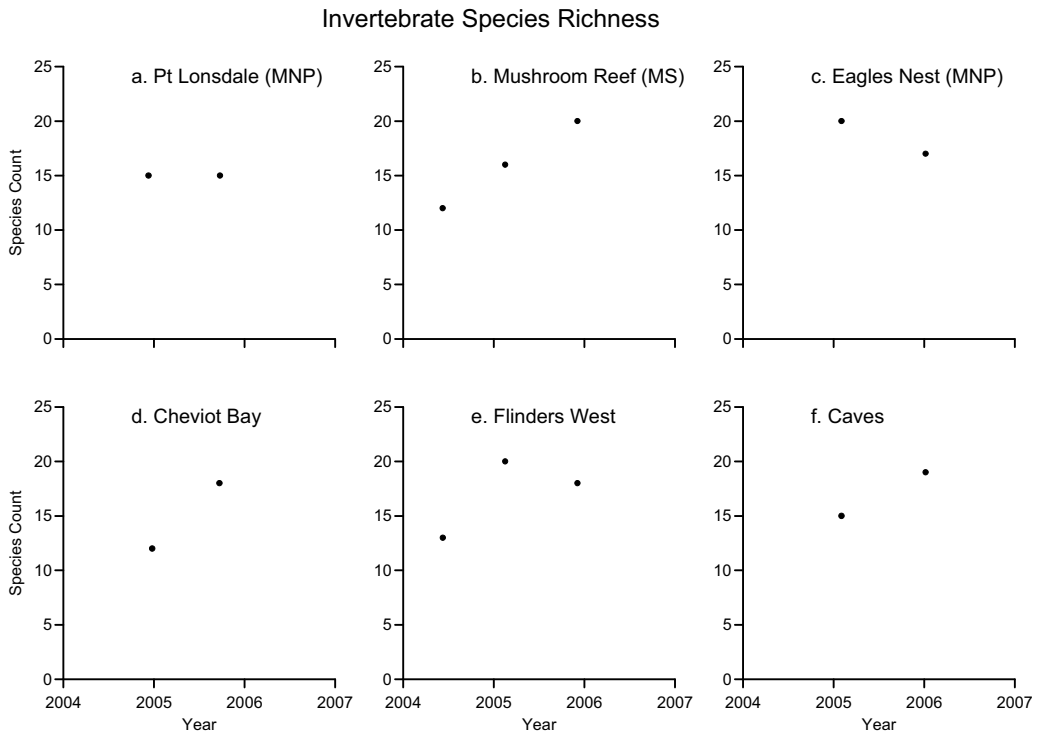


Figure 3.12. Invertebrate species richness of intertidal sites along the eastern Victorian coast.

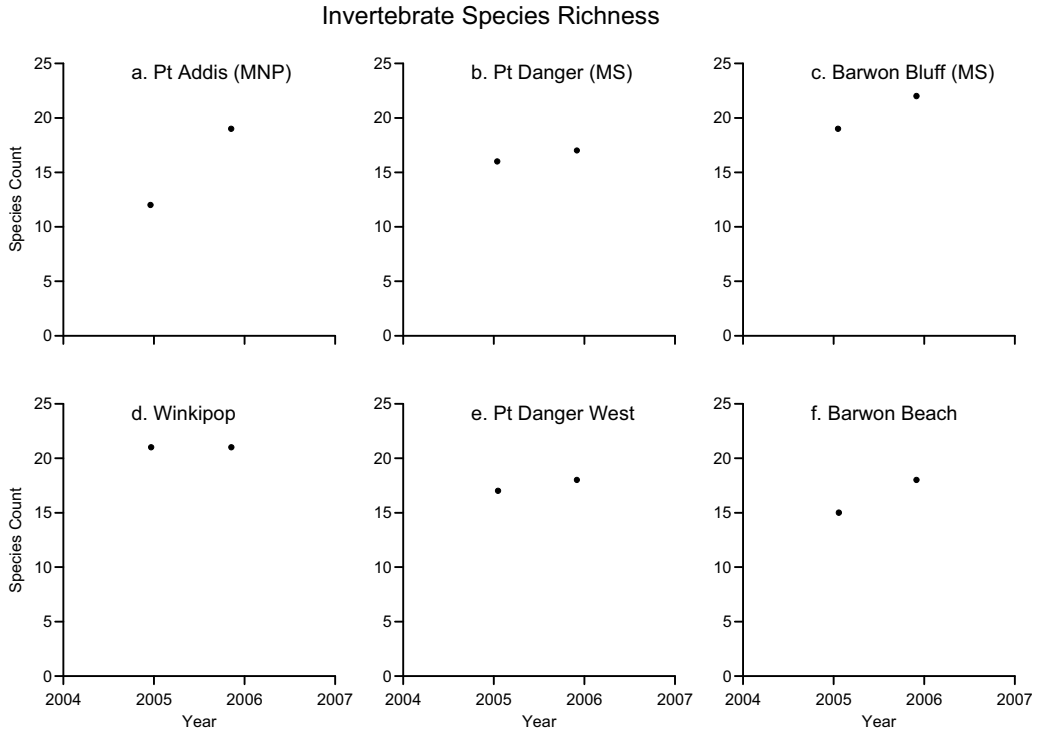


Figure 3.13. Invertebrate species richness of intertidal sites along the western Victorian coast.

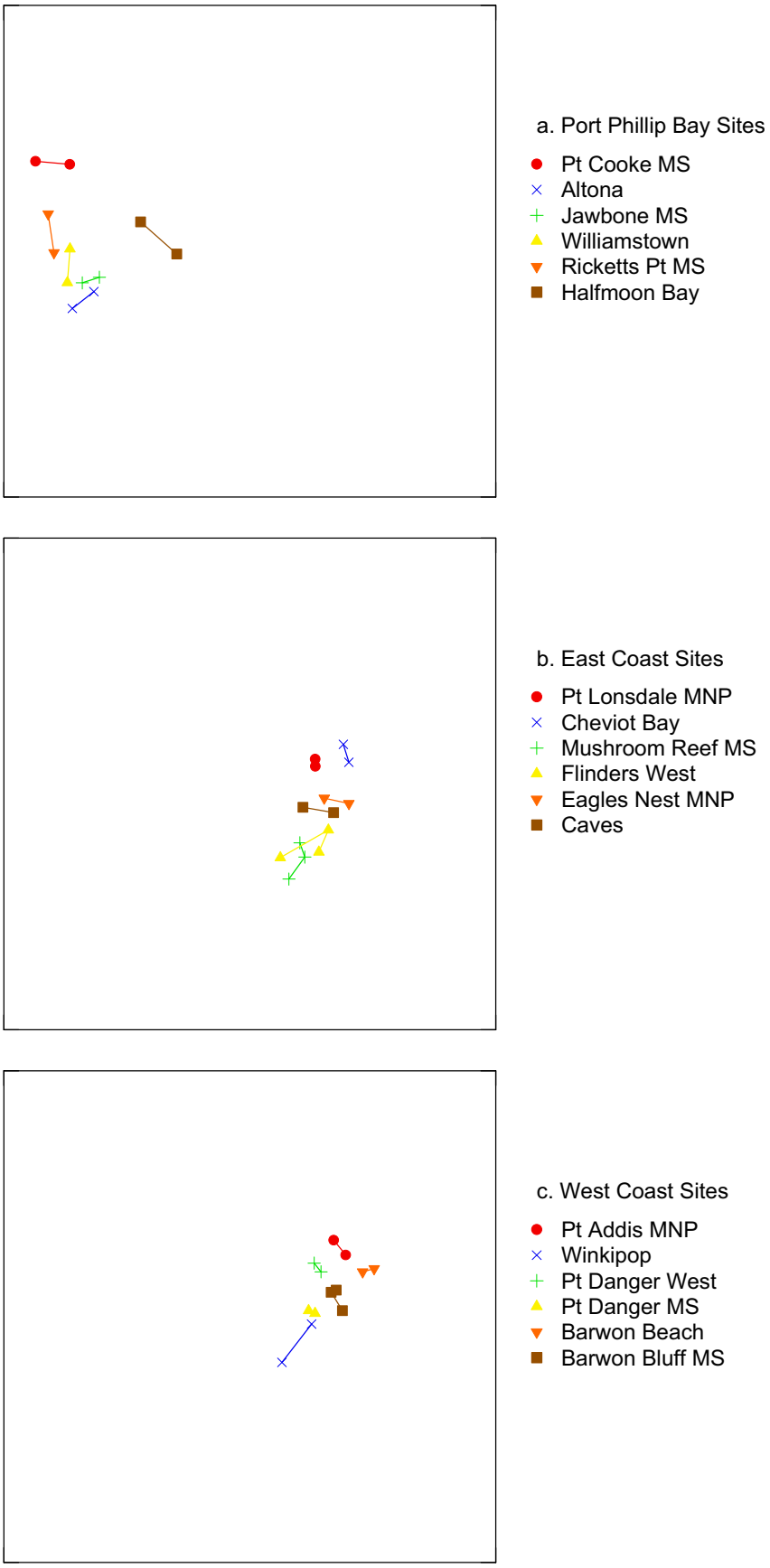


Figure 3.14. Two dimensional MDS plot of invertebrate assemblages on intertidal reefs in (a) northern Port Phillip Bay; (b) Port Phillip Heads and the eastern Victorian coastline; and (c) western Victorian coastline. Lines connect sites during consecutive surveys. Kruskal stress = 0.11.

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 and Coastal Park also form part of a RAMSAR site and are an important habitat for migratory shorebirds. The intertidal area is 300-400 m long, extending from just north of Point Cooke to the south and west. Large patches of sand and intertidal seagrass Zostera muelleri occur predominantly across the northeastern 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. 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. Five transects placed between the baselines were between 30 m and 35 m long and were equidistant from each other. Quadrats were placed at roughly equal distances along each transect.

4.1.2 Altona Reference (Site 4108)

A suitable 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. 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.

4.2 Macroalgae and Aggregating Sessile Invertebrates

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. Unlike the previous survey in May 2004, drift macroalgae was not a prominent feature when surveyed in April 2005. A small patch of the seagrass Zostera muelleri was recorded in a single quadrat low on the shore.

Less macroalgal cover was recorded at Altona than at Point Cooke (Table 4.1). Again, the dominant species were Ulva spp and Enteromorpha spp however, the total cover of Ulva spp were substantially less than at Point Cooke.

Aggregating sessile invertebrates did not contribute greatly to the structure of either reefs other than small patches of Galeolaria caespitosa. The edible mussel Mytilis edulis was found at Point Cooke in small quantities low on the shore.

Sand inundation was much greater at Point Cooke than Altona.

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

Species	Point Cooke MS (Site 4107)		Altona (Site 4108)	
	Survey		Survey	
	2	3	2	3
Macrophytes				
Enteromorpha spp	2.60	14.08		9.12
Ulva spp	8.90	59.44		9.84
Ceramium flaccidum	0.20			
Corallina officinalis	1.20	+		0.64
Corallines unidentified				0.40
Encrusting corallines		+		+
Filamentous red algae	0.60			
Grateloupia filicina	0.10			
Hypnea sp.	1.00			
Laurencia botryoides		0.24		
Algal turf	1.20			
Symploca sp.				+
Heterozostera muelleri		2.80		
Sessile Invertebrates				
Galeolaria caespitosa		+	2.00	0.40
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	15.0	10.64	18.5	0.48

4.3 Invertebrates

Large mobile invertebrates were low in density at Point Cooke (Table 4.2). The low number of individuals recorded means that interpretation of the results must be cautious. Most mobile invertebrates occurred in higher abundances lower on the shore. The herbivorous gastropod *Austrocochlea porcata* was the most abundant invertebrate, with greater abundances occurring low on the shore. The abundance of this species appears to have declined since the last survey. Two carnivorous gastropods were in low densities on the shore: *Cominella lineolata* and *Lepsiella vinosa*. Both species appear to have declined in abundance between surveys. The conniwink *Bembicium* spp and warrener *Turbo undulatus* were recorded in low densities this survey but were not recorded during the previous survey. Edmunds *et al.* (2004) recorded *T. undulatus* low on the shore in 2003 at 0.50 individuals 0.25 m^{-2}.

Densities of invertebrates, particularly gastropod molluscs, were considerably higher at Altona. As at Point Cooke, *Austrocochlea porcata* was the most abundant species. Densities of *A. porcata* were higher at Altona than at Point Cooke, with more than 27 individuals per 0.25 m^{-2}. This is an increase in abundance compared to the previous survey (Table 4.2). At Altona, *A. porcata* was relatively evenly distributed along and down the shore.

The limpet *Cellana tramoserica* is a common invertebrate on southern Australian reefs. This species was present at low densities at Altona, but was not recorded at Point Cooke.

The carnivorous gastropods *Cominella lineolata* and *Lepsiella vinosa* occurred at Altona in similar densities to those found at Point Cooke. As with these species at Point Cooke, there also appears to have been a decrease in their abundance at Altona compared to the previous year's survey.

The seastar *Patiriella exigua* occurred on the seaward edge of the intertidal reef at Altona in low densities. This species was not recorded at Point Cooke.

The herbivorous gastropod *Austrocochlea porcata* was the only species abundant enough to assess size trends between the sites. The first two surveys indicated the mean size at Point Cooke was higher than at Altona (Figure 4.1). Since then, there has been an appreciable decrease in the mean size of *A. porcata* at Point Cooke to 14 mm. This is comparable to Altona where the mean size was 15 mm during the most recent survey.

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

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

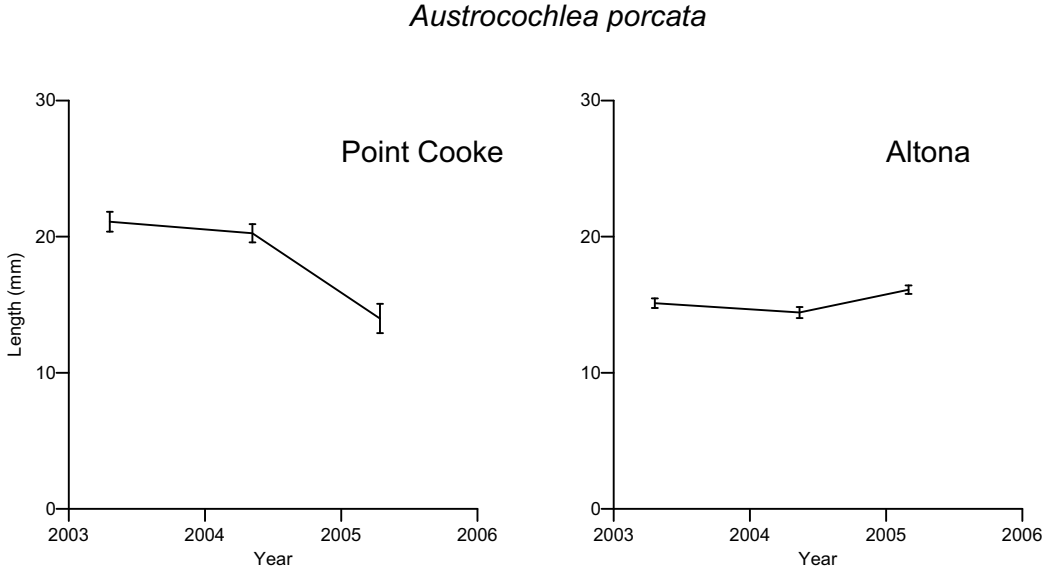


Figure 4.1. Mean sizes (± 95 % confidence intervals) of *Austrocochlea porcata* at Point Cooke and Altona.

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. 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 laid approximately parallel to shore. The five transects placed between the baselines were 6-18 m in length and were equidistant from each other. Quadrants were placed at similar distances apart along each transect.

5.1.2 Williamstown Reference (Site 4110)

The reference site for the Jawbone Marine Sanctuary was the intertidal reef at Point Gellibrand, Williamstown (site 4110). The intertidal area is similar to Jawbone Marine Sanctuary in being composed of a fractured basalt reef and boulder field. The size of the boulders were smaller at Williamstown. Consequently there was less vertical structure and fewer crevices. The intertidal reef has a south-westerly aspect.

The curved nature of the shore line at the survey site restricted the length of the high-shore baseline to 62 m. The low-shore baseline was 100 m in length. The five transects established were 30-44 m in length and were equidistant from each other but, because of differences in baseline lengths, were not parallel. Quadrants were placed at similar distances along each transect.

5.2 Macroalgae and Aggregating Sessile Invertebrates

The abundance of macroalgae and sessile invertebrates was low at both sites (Table 5.1). The green alga sea lettuce Ulva spp, comprised the majority of the algal cover at Jawbone (Site 4109), albeit in low abundances.

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 on established reef. The density of H. banksii appeared to be similar to that recorded in the previous survey.

The only aggregations of sessile animals observed were small patches of the calcareous tube-worm Galeolaria caespitosa. This species made up a very small percentage of the total cover at both sites. Galeolaria caespitosa was present across the shore but were higher in abundance in the lower shore region. Barnacles were present at Jawbone but in such low densities that they did not fall under any quadrat points. An unidentified mussel was present at Williamstown, but again in such low densities that it did not fall under any quadrat points.

Sand inundation at Jawbone, whilst low, was greater than observed in the previous survey. No sand was recorded at Williamstown.

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

Species	Jawbone MS (Site 4109)		Williamstown (Site 4110)	
	Survey		Survey	
	2	3	2	3
Macrophytes				
Codium spp		0.56		
Enteromorpha spp		+	+	0.32
Filamentous green algae			0.1	
Ulva spp	1.3	1.36	0.1	+
Hormosira banksii			6.9	8.48
Corallina officinalis		+		
Corallines unidentified		+		
Encrusting corallines		+		
Algal turf	2.5		0.1	
Symploca sp.		+		0.24
Unidentified lichen		+		
Heterozostera tasmanica	0.2			
Sessile Invertebrates				
Galeolaria caespitosa	0.2	0.72	1.4	0.56
Unidentified barnacles		+		
Unidentified bivalve				+
Other				
Drift seagrass	1.2		0.2	
Sand	0.7	1.84		

5.3 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 and top shell Austrocochlea porcata which occurred mostly in the mid-low shore region. The conniwink Bembicium spp was recorded in reduced numbers compared to the previous survey although this difference may be attributable to the patchiness of their distribution across the shore. The black nerite Nerita atramentosa was found in similar densities to Bembicium spp (Table 5.2). The only carnivorous gastropod present was Lepsiella vinosa.

At Williamstown, the dominant invertebrates were the herbivorous gastropods Bembicium spp and Austrocochlea porcata. Bembicium spp were in much higher densities at Williamstown than at Jawbone and tended to dominate the high shore region. Austrocochlea porcata was in similar numbers at both sites. Austrocochlea porcata appears to have increased in abundance at both sites compared to the previous survey (Table 5.2). There were moderate to low densities of the limpet Cellana tramoserica.

Other species present in low abundances included the warrener Turbo undulatus, the carnivorous gastropod Lepsiella vinosa and the seastar Patiriella exigua (Table 5.2).

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

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

The mean size of Austrocochlea porcata was relatively stable over time at Williamstown (Figure 5.1a). The mean size at Jawbone was more dynamic, with a decrease in mean size between the first and second surveys and an increase in mean size between the second and

third surveys. Austrocochlea porcata remain marginally bigger at Williamstown (mean = 17 mm) compared to Jawbone (mean = 16 mm).

The limpet Cellana tramoserica was variable between sites and survey years (Figure 5.1b). The most recent survey in 2005 recorded a mean size of 33 mm at Jawbone compared to a mean size of 32 mm at Williamston.

The mean size of the conniwink Bembicium spp appears to be increasing at both sites over time (Figure 5.1c). Specimens at Williamstown are larger than at Jawbone with a mean size of 16 mm compared to 13 mm, respectively.

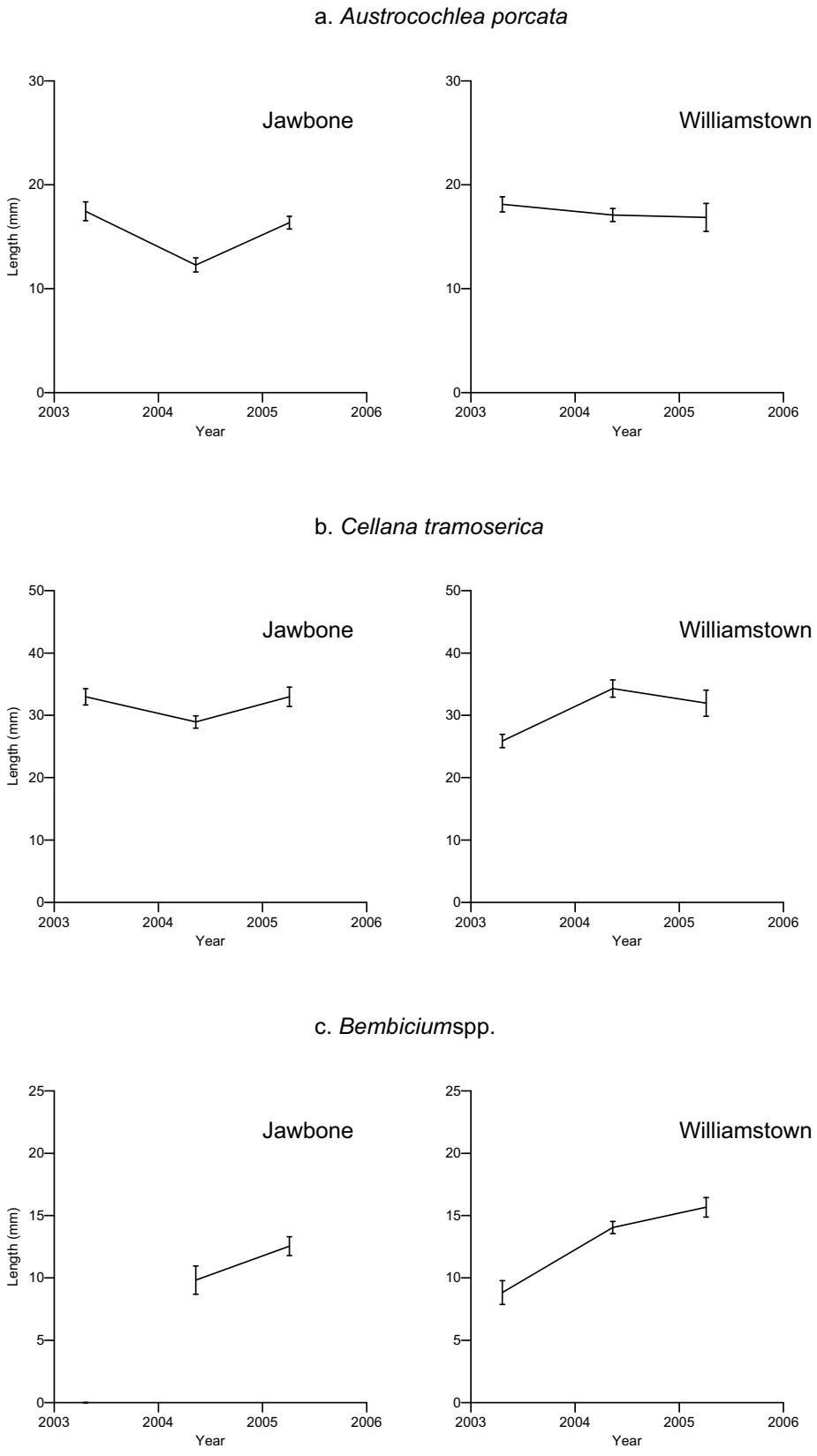


Figure 5.1. Mean sizes (± 95 % confidence intervals) of (a) *Austrocochlea porcata*; (b) *Cellana tramoserica*; and (c) *Bembicium* spp at Jawbone and Williamstown.

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.

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 ephemeral rock pools in this central area with typically very low densities of gastropods. This high central region drops away on almost all sides in one or two sharp steps. Below these rock steps the reef slopes away more gradually towards the subtidal. To the north and south are predominantly cobble field and mud habitats. However, most of the western seaward edge of the platform is fractured basalt reef with small boulders. Across the intertidal area there are prominent solid basalt reef outcrops, which provide 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. The high shore quadrat on each transect was above the rock step, while the lower shore quadrats were mostly below the step.

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 extends as a tongue of relatively flat basalt reef 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 were laid parallel to the 30 m long lower baseline. Transects running between the baselines were approximately 10 m long and 5 m apart (Figure 6.1).

Figure 6.1. The intertidal reef monitoring site at Halfmoon Bay. 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 terrestrial lichens were present and a single quadrat also had the thallus of a salt marsh plant, the beaded glasswort Sarcocornia quinqueflora encroached into the high intertidal area (Table 6.1). Macroalgal cover along the seaward edge of the platform was predominantly the brown alga Neptune's necklace Hormosira banksii. This species is common on intertidal reefs in Victoria and provides important habitat for epiphytic algae and small invertebrates. Patches of algal turf and Enteromorpha spp were also present but in lower abundances compared to the previous survey in 2004 (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. The barnacle Chthamalus antennatus was distributed patchily across the shore and did not form any substantial cover (Table 6.1).

Halfmoon Bay had a lower proportion of macroalgal cover than Ricketts Point and consisted of small patches of algal turf coverage and the green filamentous Enteromorpha spp. The abundance of Enteromorpha spp and algal turf has remained stable between surveys (Table 6.1). Hormosira banksii was absent, even low on the shoreline. Similarly, high on the shoreline there were no terrestrial species as found at Ricketts Point.

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) and Survey 3 (April 2005). '+' = present in quadrats but not observed under any points.

Species	Ricketts Pt MS (Site 4111)		Halfmoon Bay (Site 4112)	
	Survey		Survey	
	2	3	2	3
Macrophytes				
Enteromorpha spp	2.40	0.08	2.08	2.08
Ulva spp	0.40		0.32	1.04
Brown algal turf	0.08			
Hormosira banksii	16.72	5.36		
Notheia anomala		+		
Corallina officinalis			0.24	0.48
Algal turf	6.96	0.24	7.36	7.20
Symploca	2.96	9.60		+
Unidentified lichen	0.48	+		
Sarcocornia quinqueflora		0.80		
Sessile Invertebrates				
Barnacles			0.08	
Chthamalus antennatus		0.16		0.88
Galeolaria caespitosa	2.24	1.52	11.84	18.56
Other				
Drift macroalgae		0.08		
Drift seagrass		+		
Sand		0.96		+

6.3 Invertebrates

At Ricketts Point the megafaunal 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). The conniwink Bembicium spp was the next most abundant species. This was present in low densities on small sections of the high- to mid-shore region.

Lepsiella vinosa was the only carnivorous gastropod on the shore and was found in similar densities to the previous survey (Table 6.2). The warrener Turbo undulatus was recorded for the first time since 2003 (Edmunds et al. 2004), though remained low in density.

In contrast to Ricketts Point, there was a high abundance and species diversity of invertebrates at Halfmoon Bay. The most abundant species were the limpers Cellana tramoserica and Patelloida alticostata (Table 6.2). The abundance of both species increased from the previous survey, particularly P. alticostata. Many small C. tramoserica were recorded across the shoreline while P. alticostata were more abundant low on the shore, often with small specimens interspersed with patches of Galeolaria caespitosa.

The top shell Austrocochlea porcata was moderately abundant, occurring in higher densities than its cogenic species Austrocochlea concamerata and A. odontis which were found in similar areas. The density of Bembicium spp appears to have decreased since the previous survey. Nerita atramentosa and Notoacmea mayi were low in density in 2004 but were not

recorded in the April 2005 (Table 6.2). The distribution of these species was concentrated in small areas across the platform.

The carnivorous gastropods Lepsiella vinosa and Cominella lineolata had a much higher abundance at Halfmoon Bay than at Ricketts Point and were present in similar abundances to the May 2004 survey (Table 6.2).

The anemone Actinia tenebrosa and seastar Patiriella calcar were present at Halfmoon Bay in small rock pools on the seaward edge of the intertidal reef.

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

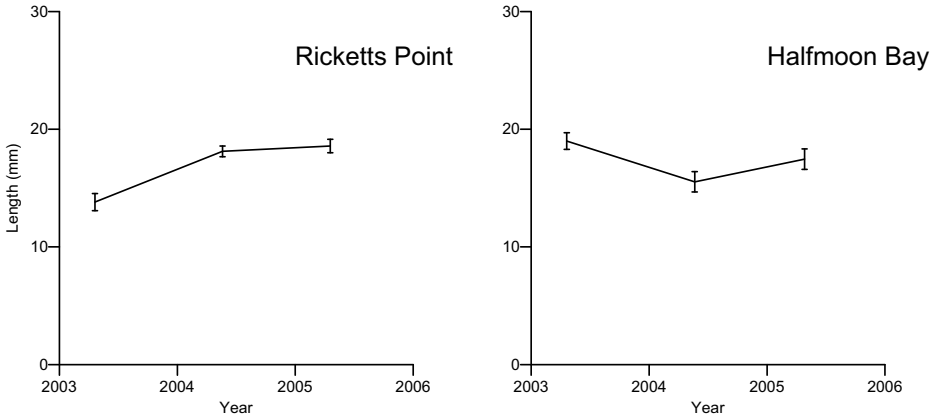
Species	Ricketts Pt MS (Site 4111)		Halfmoon Bay (Site 4112)	
	Survey		Survey	
	2	3	2	3
Cnidaria				
Actinia tenebrosa			0.40	0.04
Mollusca				
Austrocochlea concamerata		0.16		0.32
Austrocochlea odontis	0.10	0.48	0.10	0.24
Austrocochlea porcata	13.70	9.00	9.40	5.88
Bembicium spp	1.50	2.84	6.10	1.40
Cellana tramoserica	0.20		7.60	12.32
Cominella lineolata			0.60	0.48
Lepsiella vinosa	0.30	0.24	2.00	2.16
Nerita atramentosa			2.00	
Notoacmea mayi			2.40	
Onchidella patelloides			0.40	
Patelloida alticostata			1.70	10.16
Siphonaria spp			0.20	0.08
Turbo undulatus		0.32	0.90	0.32
Unidentified chiton			0.10	0.04
Echinodermata				
Patiriella calcar			0.30	0.04

The mean size of Austrocochlea porcata (Figure 6.1a) was higher at Ricketts Point (mean = 19) than at Halfmoon Bay (mean = 17). While the mean size of Austrocochlea porcata increased from 2003 to 2004, this trend appears to have plateaued between 2004 and 2005 (Figure 6.1a).

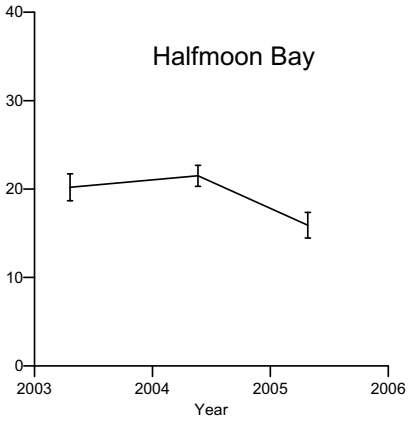
Cellana tramoserica was not abundant enough at Ricketts Point to analyse size over time. At Halfmoon Bay, there has been a decrease in mean size since the last survey to 16 mm (Figure 6.1b). This may relate to the high abundance of small individuals, rather than a decrease in the mode of the larger size classes.

The mean size of Bembicium spp appears to be increasing over time (Figure 6.1c). The population at Ricketts Point appears to be larger than Halfmoon Bay with a mean sizes of 16 mm and 13 mm, respectively.

a. *Austrocochlea porcata*



b. *Cellana tramoserica*



c. *Bembicium*spp.

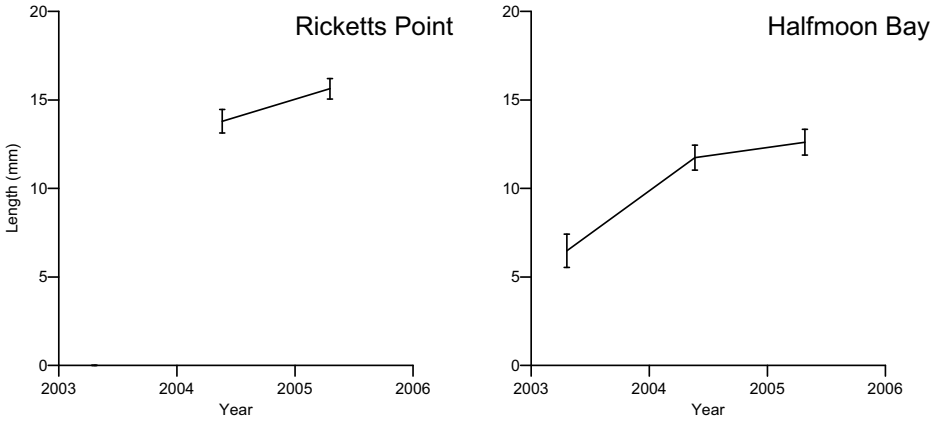


Figure 6.2. Mean sizes (± 95 % confidence intervals) of (a) *Austrocochlea porcata*; (b) *Cellana tramoserica*; and (c) *Bembicium* spp at Ricketts Point and Halfmoon Bay. Note that *C. tramoserica* density was too low at Ricketts Point to analyse over time.

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.

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.

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 was higher at Point Lonsdale but remained relatively constant at both sites between surveys (Table 7.1). Although more Ulva spp, turfing algae and coralline algae was found at Cheviot Bay, a high richness of other algal species was present at Point Lonsdale which did not intersect with any quadrat points (Table 7.1).

The sessile invertebrates Galeolaria caespitosa and Xenostrobus pulex were present at both sites in very low abundances. They were more abundant at Cheviot Bay during the most recent survey (Table 7.1). Sand inundation appeared to be higher at Cheviot Bay than Point Lonsdale and appears to have increased at both sites between surveys (Table 7.1).

Table 7.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Point Lonsdale and Cheviot Bay during Survey 1 (December 2004) and Survey 2 (September 2005). '+' = present in quadrats but not observed under any points.

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

7.3 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). At Point Lonsdale, the most common species were the striped conniwink Bembicium nanum and the pulmonate limpet Siphonaria spp (Table 7.2). While Siphonaria spp was distributed across the shore, B. nanum occurred more commonly towards the mid to high shore level. Low to moderate densities of other gastropods were recorded, including the cone shell Conus anemone (Table 7.2).

Lower abundances of Siphonaria spp were recorded in the most recent survey whilst the abundance of the slit limpet Clypidina rugosa increased. Densities of Bembicium nanum and the variegated limpet Cellana tramoserica remained relatively constant (Table 7.2). The small (approximately 1-2 mm shell length), black periwink Nodilittorina acutipira was recorded at both Point Lonsdale and Cheviot Bay at moderate to high density in the September 2005 survey, but had not been previously recorded in the December 2004 survey.

High densities of Clypidina rugosa occurred across the shore at Cheviot Bay, but appeared to be more common at the western end of the site towards Transects 1 and 2. Siphonaria spp appeared to be more evenly spread transversely across the shore. Although Siphonaria spp densities remained at a similar level between surveys, there appeared to be a decrease in the density of Clypidina rugosa (Table 7.2). Conversely, there was a large increase in the abundance of the small limpet Notoacmea mayi. Other gastropod species were evident in comparable densities to those found at Point Lonsdale and previous surveys.

Table 7.2. Density of megafaunal invertebrates per 0.25 m^{-2} at Point Lonsdale and Cheviot Bay during Survey 1 (December 2004) and Survey 2 (September 2005).

Species	Point Lonsdale MS (2823)		Cheviot Bay (2824)	
	Survey		Survey	
	1	2	1	2
Cnidaria				
Oulactis muscosa	0.16			
Unidentified anemone		0.04		
Mollusca				
Austrocochlea constricta	1.76	0.96	0.36	0.44
Austrocochlea odontis	0.52	0.80		
Bembicium nanum	11.08	15.84	4.48	3.60
Calliostoma armillata				0.04
Cellana tramoserica	5.72	5.28	3.48	1.84
Clypidina rugosa	1.64	12.96	22.36	14.44
Cominella lineolata	0.80	0.44	0.04	0.88
Conus anemone	0.04			
Dicathais orbita	0.20	0.12	0.20	0.24
Lepsiella vinosa		0.28		0.12
Nodilittorina acutispira		13.24		16.80
Notoacmea mayi		0.64	0.08	9.32
Notoacmea petterdi	3.20			
Onchidella patelloides	0.04			
Patella chapmani			0.08	
Patelloida alticostata	1.24	0.80	1.88	1.72
Patelloida insignis				0.08
Patelloida latistrigata				2.92
Siphonaria spp	10.28	2.88	27.16	27.48
Turbo undulatus	1.72	2.96	2.08	1.76
Unidentified nudibranch		0.04		
Unidentified chiton				0.2
Crustacea				
Unidentified crab	0.04		0.04	

Austrocochlea constricta size has increased at both Point Lonsdale and Cheviot Bay. This increase was more pronounced at the reference site (Figure 7.1a). Cellana tramoserica remained relatively constant, with a mean size of 19 mm at Point Lonsdale and 26 mm at Cheviot Bay (Figure 7.1).

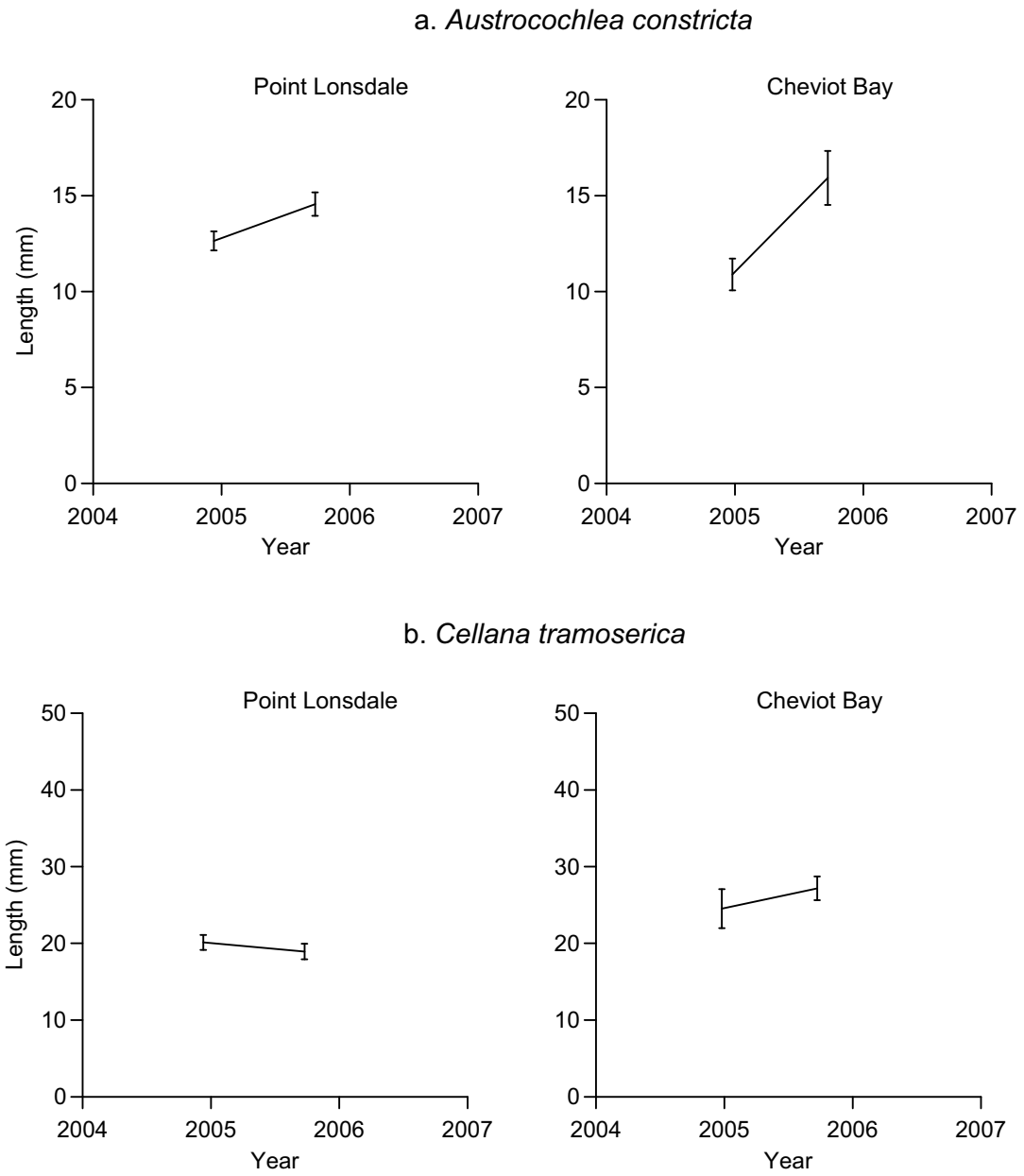


Figure 7.1. Mean sizes (± 95 % confidence intervals) of (a) *Austrocochlea constricta* and (b) *Cellana tramoserica* at Point Lonsdale and Cheviot Bay.

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. Sections of the isthmus tend to inundate with water soon after the tide begins to rise. The head of the mushroom is low-relief but uneven basalt reef with some pebbles and boulders. The highest section of the reef is the centre of the head of the mushroom. This area slopes away gently to the subtidal at its outer edge. Mushroom Reef is exposed on all sides, but is protected from large swell by 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 vertical steps and boulder outcrops. Patches of sand covered areas at the lowest reef extent. As with Mushroom Reef, Flinders West has a south-easterly aspect and is moderately sheltered from wind and waves from the southwest. It is also protected from large swell by 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.

8.2 Macroalgae and Aggregating Sessile Invertebrates

Macroalgal cover at Mushroom Reef was relatively low (Table 8.1). Coralline algae were the dominant species with Corallina officinalis, encrusting coralline algae and unidentified erect coralline algae comprising most of the algal cover on the reef. Neptune's necklace Hormosira banksii was recorded low on the shoreline. This species declined in abundance between the June 2004 and February 2005 surveys and has since increased in the December 2005 survey. Abundances still remained lower than initially recorded (Table 8.1). Similarly, the abundance of sea lettuce Ulva spp decreased during Survey 3, but has since returned to densities observed during Survey 2. Patches of coralline algae seem to have increased in abundance during the two most recent surveys.

The mussel Xenostrobus pulex was the only aggregating sessile invertebrate to form quantifiable patches on the shoreline.

The reference site at Flinders West had a moderate cover of Hormosira banksii which had increased in abundance over the last two surveys (Table 8.1). Algal turf was also in moderate abundance at Flinders West and had peaked in abundance in Survey 3. As with Mushroom Reef, coralline algae were present in low to moderate abundance at Flinders West. Ulva spp was recorded at low densities during the last survey, but previously had only been recorded as present.

More aggregating sessile invertebrates were present at Flinders West than at Mushroom Reef (Table 8.1). Mats of the mussels Xenostrobus pulex and Brachidontes rostratus were spread across the shore, as were small clumps of the tube worm Galeolaria caespitosa. Three species of barnacle have been recorded, but in low abundances (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) and Survey 4 (December 2005). '+' = present in quadrats but not observed under any points.

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

8.3 Invertebrates

The invertebrate communities at Mushroom Reef and Flinders West were both rich with species and highly diverse (Table 8.2). The pulmonate limpet Siphonaria spp was the most abundant species at Mushroom Reef, occurring in dense patches across the shoreline. The striped conniwink Bembicium nanum and top shell Austrocochlea constricta were also present in high densities. Of these, Siphonaria spp was the only species that had substantially changed in abundance over time, with a large increase in density since Survey 2. The black nerite Nerita atramentosa also increased in density over time.

The predatory gastropods Lepsiella vinosa and Cominella lineolata were both present in the most recent survey.

Crabs Cyclograpsus granulosus have been recorded in cobble microhabitat, although none were observed during Survey 4. The seastar Patiriella exigua was common in shallow stands of water on the reef and appears to have increased in abundance since Survey 2 (Table 8.2).

A similar community of species was present at Flinders West (Table 8.2). In contrast to previous surveys, Siphonaria spp was not the most abundant species, showing a decline in density since Survey 3 (Table 8.2). The periwinkle Nodilittorina unifasciata increased greatly in density and was the most abundant species at the site, despite being concentrated high on the shore. Austrocochlea constricta and Bembicium spp were not as abundant as at Mushroom Reef but were primary components of the Flinders West reef. Nerita atramentosa was recorded at similar densities to the sanctuary site and also showed the same increase in abundance over time.

The predatory gastropods Cominella lineolata, Lepsiella vinosa and Dicathais orbita were recorded at similar densities to those observed at Mushroom Reef.

As with Mushroom Reef, low numbers of crabs such as Paragrapsus gaimardii were recorded in past surveys. None were observed in the most recent survey (Table 8.2). 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) and Survey 4 (December 2005).

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

Austrocochlea constricta were larger at Mushroom Reef than Flinders West with mean sizes of 15 mm and 12 mm respectively (Figure 8.1a). Although the mean size of A. constricta appeared to be gradually increasing at Mushroom Reef, the mean size at Flinders West showed a decline since the first records in Survey 2.

The mean size of Cellana tramoserica at Mushroom Reef returned to 28 mm during the December 2005 survey, after dropping to 18 mm between 2004 and 2005 (Figure 8.1b). This large decrease in mean size was not observed at the reference site at Flinders West where the mean size remained relatively stable at 22 mm.

Bembicium nanum mean size previously showed relatively little change at Mushroom Reef. The mean size declined slightly during the December 2005 survey to a mean of 6 mm (Figure 8.1c). At Flinders West, however, there was an appreciable decline between 2004 and 2005, before stabilising at a mean size of 7 mm during 2005.

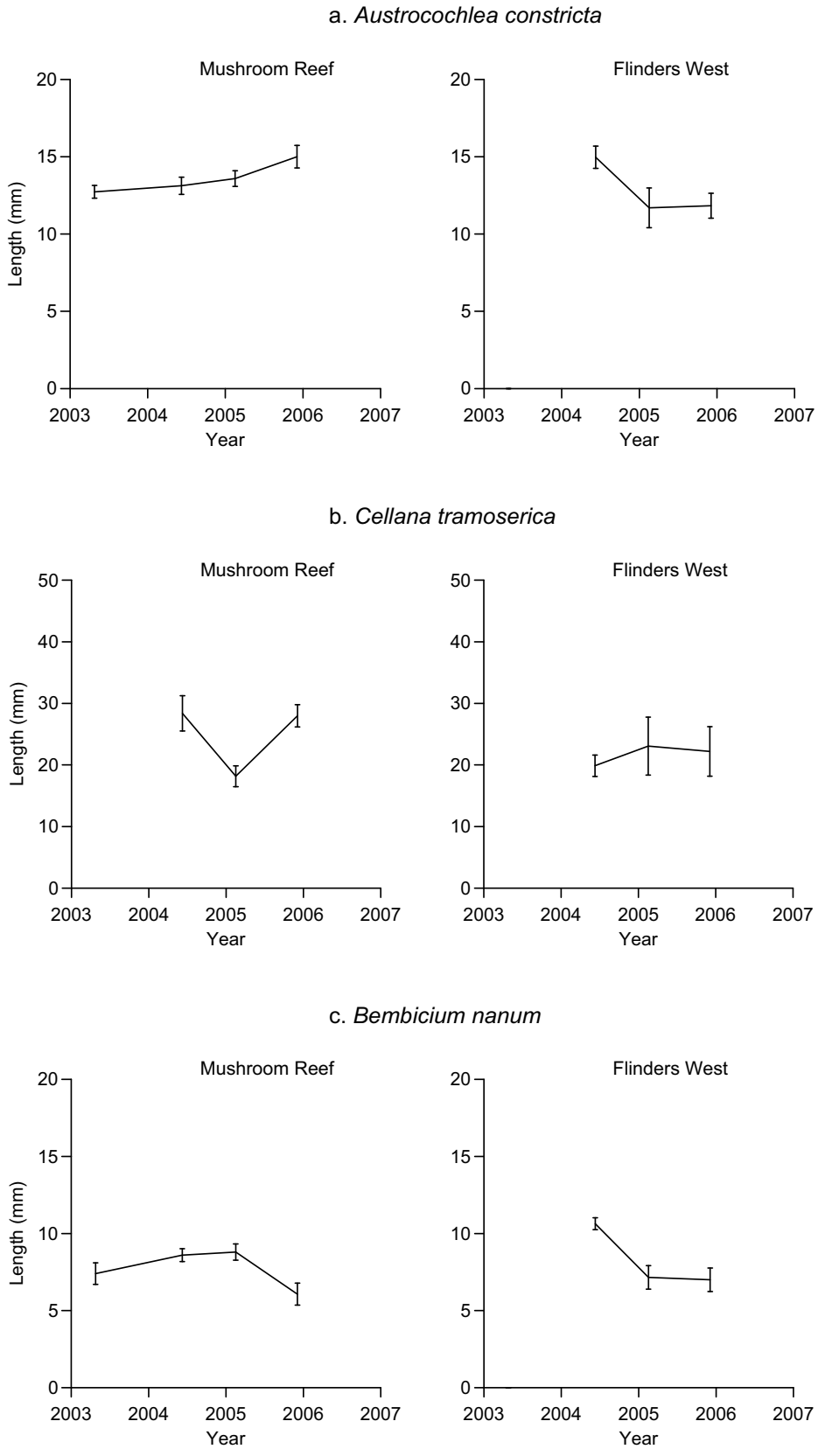


Figure 8.1. Mean sizes (± 95 % confidence intervals) of (a) *Austrocochlea constricta*; (b) *Cellana tramoserica*; and (c) *Bembicium nanum* at Mushroom Reef and Flinders West.

9 BUNURONG MARINE NATIONAL PARK

9.1 Site Description and Transect Layout

9.1.1 Eagles Nest (Site 3020)

There were a number of potential intertidal reefs within the Bunurong Marine National Park that could have been surveyed. The sandstone reefs of the area form large intertidal platforms that extend subtidally. 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 sheltered it from the north and west. It is exposed to large swells from the southeast, but not directly exposed to the prevailing south and southwest swell. The reef platform is relatively flat with little relief. Channels have been formed in the reef where water drains across the platform at low tide.

High and low shore baselines were 56 m and 48 m, respectively. They spread out in an easterly direction with the transects increasing in length from 25 m at Transect 1 to 50 m at Transect 5.

9.1.2 Caves Reference (Site 3021)

The reference site for the Eagles Nest 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 soft sandstone, has an east facing aspect and is sheltered from the north and west by the Caves headland. The reef is exposed to southeast and southerly swell but is more sheltered from direct exposure to the prevailing southwest swell.

The intertidal platform is extensive. To cover the same heights across the shoreline as at the Eagles Nest site, the survey area covered large swathes of the reef with transect up to 100 m in length. The reef is relatively flat, with little rugose structure or relief. On the eastern end of the survey area (Transect 5), there is more structure with large rocky outcrops towards the high shore level. Baselines were 48 m long and transects ranged from 80 m in length at Transect 1 to 100 m in length at Transect 5.

9.2 Macroalgae and Aggregating Sessile Invertebrates

Macroalgal cover at Eagles Nest was dominated by a low cover of Neptune's necklace Hormosira banksii (Table 9.1). This brown alga comprised the majority of algal cover at the site and did not change in abundance between surveys. Small patchily distributed algal turf and the blue-green algae Symploca sp. were the only other algae present during the first survey. Low abundances of other species such as Enteromorpha compressa, Nothea anomala and Corallina officinalis were recorded during the second survey (Table 9.1).

The mat forming mussel Xenostrobus pulex was a commonly occurring aggregating sessile invertebrate, recorded in patches across the shore in both surveys. With the exception of Hormosira banksii, it accounted for more cover than all algal species combined (Table 9.1). Sand inundation was low at the site during the first survey (less than 2 %), however it increased substantially between surveys to over 11 % cover.

The reference site at the Caves had a similar assemblage of macroalgal and aggregating sessile invertebrates (Table 9.1). Hormosira banksii was the dominant algae. Abundances were comparable to that recorded at Eagles Nest and had not changed between surveys. Lichen was found high on the shore during both surveys.

The tube worm Galeolaria caespitosa was recorded at both Caves and Eagles Nest but in very low densities (Table 9.1). As at Eagles Nest, the mat forming mussel Xenostrobus pulex was moderately abundant across the shoreline. Three species of barnacles were recorded at this site, though as at Eagles Nest, were low in abundance. Sand inundation was lower at this site and there was not a notable increase between surveys as observed at Eagle's Nest.

Table 9.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Eagles Nest and Caves during Survey 1 (February 2005) and Survey 2 (January 2006). '+' = present in quadrats but not observed under any points.

Species	Eagles Nest MPA (3020)		The Caves (3021)	
	Survey		Survey	
	1	2	1	2
Macrophytes				
Enteromorpha compressa		0.08		
Enteromorpha spp	+			
Green algae unidentified		0.32		+
Ulva spp	+		+	
Brown algae unidentified		+		+
Chordaria cladosiphon				0.48
Filamentous brown algae				0.48
Hormosira banksii	11.60	10.48	8.24	7.68
Leathesia difformis			+	
Notheia anomala		1.04	+	0.40
Corallina officinalis	+	0.32	+	
Corallines unidentified				+
Cystophora spp		+		
Encrusting corallines	+		0.24	+
Laurencia spp		+		
Algal turf	1.44	2.56	0.88	2.00
Blue-green algae unidentified		2.16		+
Rivularia sp.	+	0.56	+	+
Symploca	0.80	0.40	1.28	
Unidentified lichen			0.24	0.80
Zostera meulleri	2.72			
Sessile Invertebrates				
Galeolaria caespitosa	+	0.16	+	0.16
Catomerus polymerus				0.08
Chthamalus antennatus	+	+	0.08	+
Chamaesipho tasmanica			0.24	
Tetraclitella purpurascens	0.08			+
Xenostrobus pulex	6.08	5.92	8.64	4.88
Other				
Drift macroalgae				0.32
Drift seagrass	+			
Sand	1.76	11.28	2.56	4.40

9.3 Invertebrates

The periwinkle Nodilittorina unifasciata was the most common species at Eagles Nest with a density of 598 m-2. This species was more common at the high shore end and often co-occurred with a similar but smaller species Nodilittorina acutispira, which was found at moderate densities (Table 9.2). Densities of both specie substantially increased between surveys. The striped conniwink Bembicium nanum was another abundant species which occurred across the shore in high densities and had increased slightly in density between surveys. Less dense was the pulmonate limpet Siphonaria spp, which occurred across the shoreline.

A range of other herbivorous gastropods were recorded in low abundances (Table 9.2). The predatory gastropods Dicathais orbita, Cominella lineolata and Lepsiella vinosa were present but in low densities.

Invertebrate community structure was similar at the reference site at the Caves, although generally in higher abundances. High abundances of Nodilittorina unifasciata and Bembicium nanum dominated the site. A large increase in the abundance of B. nanum between surveys was observed at this site. Many of the individuals counted were very small (<2 mm), indicating a recent recruitment event. Siphonaria spp was recorded in moderate densities and had also increased substantially in abundance between surveys. Nodilittorina acutispira occurred in much lower densities at the Caves compared to Eagle's Nest.

The seastar Pateriella exigua was recorded at Eagle's Nest during both surveys, but was not recorded during either survey at the Caves.

Table 9.2. Density of megafaunal invertebrates per 0.25 m^{-2} at Eagles Nest and Caves during Survey 1 (February 2005) and Survey 2 (January 2006).

Species	Eagles Nest MPA (3020)		The Caves (3021)	
	Survey		Survey	
	1	2	1	2
Cnidaria				
Actinia tenebrosa	0.04			
Aulactinia veratra	0.04	0.20		0.16
Mollusca				
Austrocochlea constricta	1.32	0.56	1.96	3.12
Austrocochlea odontis	0.4		0.32	0.08
Bembicium nanum	33.52	42.84	46.88	150.36
Cellana tramoserica	2.6	1.68	0.72	2.48
Clypidina rugosa	0.04			0.20
Cominella lineolata	0.4	0.20	0.08	0.04
Dicathais orbita	0.12	0.12	0.08	
Lepsiella vinosa	0.12	0.04	0.72	0.40
Nerita atramentosa	0.2	0.16	0.32	0.80
Nodilittorina acutispira	12.04	40.32	0.60	2.88
Nodilittorina unifasciata	84.8	149.44	116.6	157.24
Notoacmea mayi	0.2	0.40	1.04	6.96
Patelloida alticostata	0.8	0.40	0.52	0.84
Patelloida insignis	0.04			
Patelloida latistrigata		0.28	0.24	0.04
Siphonaria spp	7.44	10.68	13.88	24.76
Turbo undulatus	0.72	0.16	0.04	0.12
Echinodermata				
Patiriella exigua	0.08	0.04		
Crustacea				
Unidentified crab	0.08			0.04

The mean size of Austrocochlea constricta was higher within the Marine National Park (Figure 9.1a) at Eagles Nest (mean = 12 mm) than outside the park at the Caves (mean = 10 mm). This was consistent across both surveys.

The mean size of Cellana tramoserica was greater at the Caves compared to Eagles Nest (Figure 9.1b). A decline in size at Eagles Nest reduced the mean length to 15 mm compared to 21 mm at the Caves.

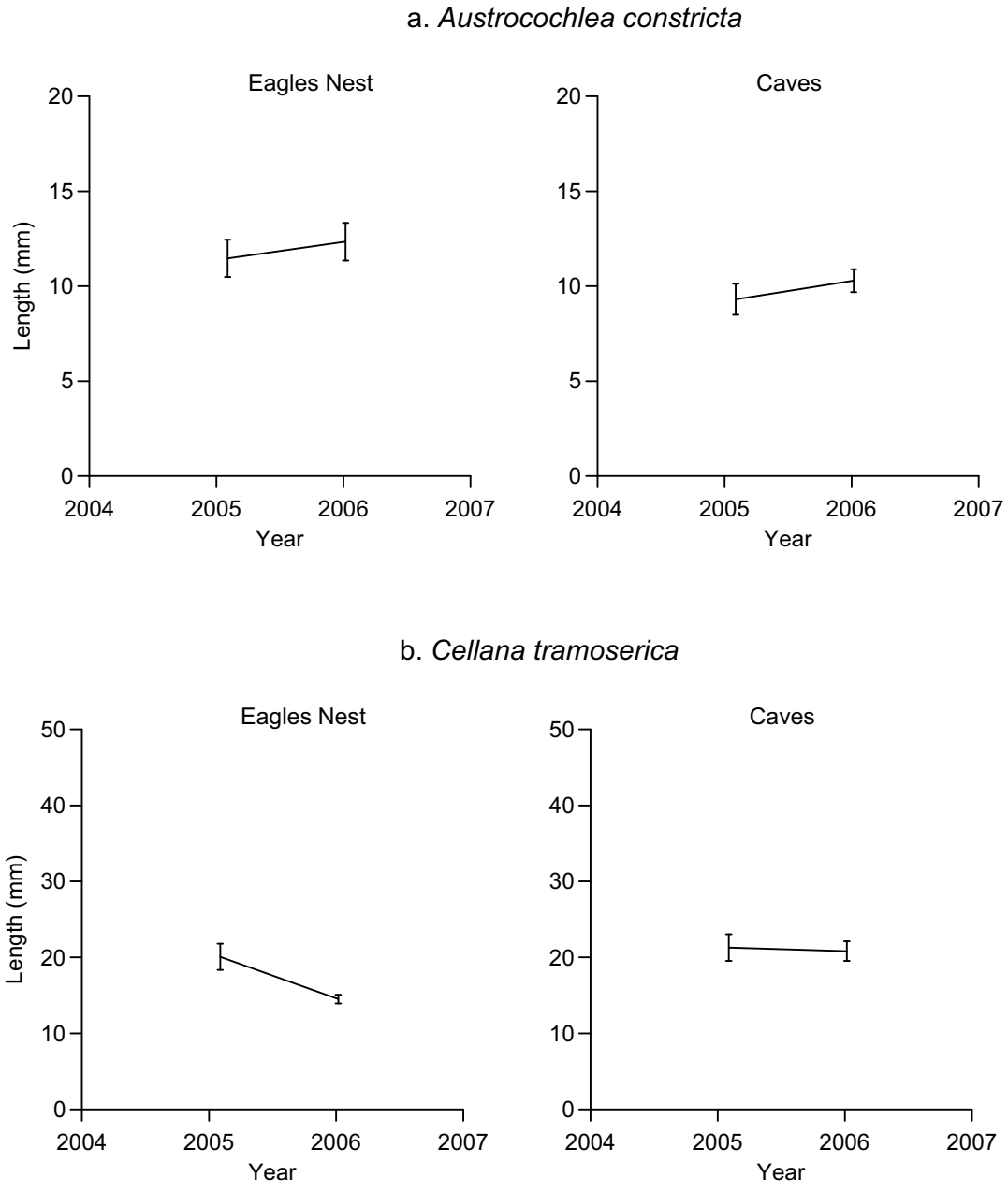


Figure 9.1. Mean sizes (± 95 % confidence intervals) of (a) *Austrocochlea constricta*; and (b) *Cellana tramoserica* at Eagles Nest and Caves.

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. Large areas of this reef remain inundated during many tidal cycles and this reef appears to be exposed to more wave action. The survey site is on a smaller patch of reef that directly fringes the smaller coastal cliffs. It is a low-relief, uneven reef that drops more steeply at its edge into subtidal habitat. Undulations in the reef caused by weathering create patches of standing water.

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

The survey area bridges a large channel that intersects the baselines. Additional coordinates of this were recorded and the affected transects shifted appropriately. The high and low baselines were 74 m and 81 m respectively. Transects increased 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. The area exposed at low tide is between 30 to 50 m wide. This area is exposed to large southerly swell. The intertidal reef may be relatively sheltered from most of the wave energy because of its gently sloping nature well out into the subtidal. 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.

Establishment of the survey site was simple at this site. 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.

10.2 Macroalgae and Aggregating Sessile Invertebrates

The dominant algal species at Point Addis was Neptune's necklace Hormosira banksii (Table 10.1). The percentage cover of this species was high at 60 %. This brown alga was much more abundant than any other species. There was little change in cover between December 2004 and November 2005. Algal turf was recorded in low abundances across the shoreline. This group of algae had more than doubled in abundance between surveys. Several green algae were present including Ulva spp and Enteromorpha spp. Both species increased in abundance between surveys. The epiphytic brown algae Nothea anomala, which is found on H. banksii, increased in abundance during the most recent survey.

Several aggregating sessile invertebrates were recorded at Point Addis. The predominant species was Galeolaria caespitosa which formed small patches in the mid to high shore region. This species showed no change in cover between surveys. The mat forming mussels Xenostrobus pulex and Brachidontes rostratus, which were recorded under points in the December 2004 survey, were present, but not recorded under any points during the most recent survey.

The reference site at Winkipop had a higher density of Hormosira banksii than at Point Addis (Table 10.1). A marginal increase in cover was recorded between surveys (6 % increase). All other algal species occurred in low densities and were generally the same species as recorded at Point Addis.

Only very low cover of the tube worm Galeolaria caespitosa was recorded at Winkipop during the December 2004 survey, with no substantial mussel mats observed (Table 10.1). No G. caespitosa was observed in the November 2005 survey. Sand inundation at the Winkipop site was similar to that at Point Addis, having not increased as much between surveys.

Table 10.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Point Addis and Winkipop during Survey 2 (December 2004) and Survey 3 (November 2005). '+' = present in quadrats but not observed under any points.

Species	Point Addis MNP (3901)		Winkipop (3902)	
	Survey		Survey	
	2	3	2	3
Macrophytes				
Caulerpa brownii				+
Chaetomorpha coliformis	1.04			
Cladophora prolifera				+
Codium pomoides				+
Codium spp				+
Dictyosphaeria serica		+		+
Enteromorpha spp	+	0.24	+	+
Filamentous greens	0.16			
Ulva spp	0.24	1.36	0.08	+
Brown algae unidentified		0.24	+	+
Cystophora spp				0.16
Hormosira banksii	59.68	58.24	79.76	85.52
Leathesia difformis		+		+
Notheia anomala	+	1.12		+
Sargassum sp		+		+
Scytosiphon lomentaria		0.48		
Corallines unidentified	+	+	0.24	0.56
Encrusting corallines	+	+	+	+
Laurencia spp			+	+
Laurencia botryoides		+		
Algal turf	5.60	12.48	2.40	0.80
Unidentified lichen	+			
Amphibolis antarctica				+
Rivularia spp	+	0.40	+	+
Sessile Invertebrates				
Galeolaria caespitosa	1.12	1.12	0.40	
Chthamalus antennatus	0.72	+	0.72	
Brachidontes rostratus	0.08			
Xenostrobus pulex	0.20	+	+	0.08
Other				
Drift macroalgae	0.08	+	0.24	
Drift seagrass	+	+		
Sand	3.20	8.72	6.40	8.48

10.3 Invertebrates

The pulmonate limpet Siphonaria spp was the most abundant species at Point Addis. The limpet Notoacmea mayi was also found in dense patches at all shore heights. Both species showed relatively little change in density between surveys. Gastropods common at other intertidal locations surveyed, such as Austrocochlea constricta, Cellana tramoserica and Bembicium nanum, were recorded at low densities at this site. The small periwinkles Nodilittorina acutispira and N. unifasciata were recorded at moderate densities, high on the shore during the November 2005 survey. Neither species was recorded during previous survey at the site.

The beach slug Onchidella patelloides, which usually shelters during daylight, was common across the shore. This may relate to the low light levels caused by late-afternoon shading of the reef.

The anemone Actinia tenebrosa was recorded during both surveys at the site, but in low densities (Table 10.2).

The invertebrate species diversity was higher at the reference site Winkipop than, at Point Addis (Table 10.2). There was a greater number of species, all at relatively low abundances (Table 10.2). Between surveys, the dominant species changed, with the previously abundant limpets Clypidina rugosa and Notoacmea mayi and the pulmonate limpet Siphonaria spp all decreasing in density. The conniwink Bembicium nanum was the most abundant gastropod, having increased in abundance between surveys. The top shell Austrocochlea constricta was also abundant, with little change in abundance since the previous survey.

As at Point Addis, the periwinkle Nodilttorina acutispira was only recorded during the November 2005 survey, but in very low densities. Nodilittorina unifasciata, which was recorded in December 2004, was not recorded during the most recent survey. The distribution of these species appeared to be patchy across high-shore areas of these reefs.

Four different species of anemone, Actinia tenebrosa, Anthothoe albocincta, Aulactinia veratra and Oulactis muscosa were recorded at Winkipop in small patches of standing water. Two sea star species and several crabs were also found in this microhabitat (Table 10.2).

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

Species	Point Addis MNP (3901)		Winkipop (3902)	
	Survey		Survey	
	2	3	2	3
Cnidaria				
Actinia tenebrosa	0.08	0.04	0.24	0.28
Anthothoe albocincta				1.20
Aulactinia veratra	0.08		0.08	0.16
Oulactis muscosa			0.28	0.28
Mollusca				
Austrocochlea constricta			2.20	2.64
Austrocochlea odontis		0.12	0.20	0.16
Austrocochlea porcata			0.08	
Bembicium nanum	0.20	1.20	2.12	7.12
Calliostoma armillata		0.04		
Cellana tramoserica	0.68	0.80	0.52	0.36
Clypidina rugosa	2.32	0.88	3.60	
Cominella lineolata	0.04	0.08	0.20	0.80
Dicathais orbita	0.16	0.04	0.08	0.36
Lepsiella vinosa			0.04	0.40
Nodilittorina acutispira		12.16		0.08
Nodilittorina unifasciata		1.16	2.36	
Notoacmea mayi	13.28	11.04	2.60	0.32
Onchidella patelloides	0.20	1.76		0.08
Patella chapmani			0.04	
Patelloida alticostata	1.40	1.56	0.08	0.04
Patelloida insignis		0.04		
Patelloida latistrigata		0.16		
Siphonaria spp	21.64	23.04	6.00	0.12
Turbo undulatus	0.08	0.24	0.20	0.76
Unidentified chiton		0.12		
Echinodermata				
Patiriella exigua			0.72	0.80
Patiriella calcar			0.04	0.16
Crustacea				
Unidentified crab			0.04	0.12
Cyclograpsus granulosus				0.28

The size of Cellana tramoserica at Point Addis and Winkipop remained relatively constant through time (Figure 10.1). Individuals were slightly larger at Point Addis than Winkipop, with mean lengths of 29 mm and 27 mm respectively (Figure 10.1). Low numbers of individuals at Winkipop meant insufficient size data was collected during Survey 1.

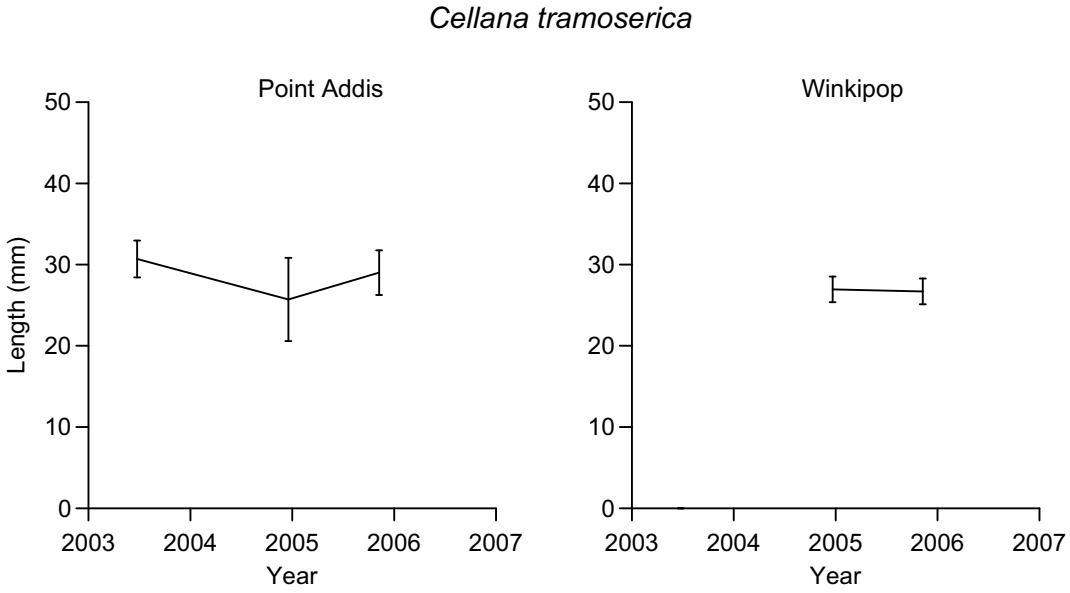


Figure 10.1. Mean sizes (± 95 % confidence intervals) of *Cellana tramoserica* at Point Addis and Winkipop.

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. The reef is exposed to the north, east and south, however most of the prevailing weather and waves are from the south and southwest. Most of the intertidal area is relatively sheltered from large waves due to the large size of the platform. There are large areas of sandy beach to the west and north of the platform.

The reef is a relatively level sandstone platform which quickly drains or floods with the tide. There is low rugose structure across the reef with a high-low 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. Site establishment was simple with high and low-shore baselines running approximately parallel to the headland. Baseline lengths were 46 m each, with transects of 41-43 m forming an approximately 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. This intertidal area is a low-relief sandstone reef that has been weathered to create an uneven surface at the scale of 10s centimetres. This reef has a southerly aspect and is probably more exposed to waves than the Point Danger platform. This reef is subject to significant sand inundation because of its proximity to high energy sandy beaches.

Site establishment was simple with parallel baselines of approximately 50 m and transects of 30 m.

11.2 Macroalgae and Aggregating Sessile Invertebrates

Macroalgal species richness and diversity at Point Danger (Site 4002) were relatively low during the January 2005 survey but increased during Survey 3 in December 2005 (Table 11.1). The brown algae Neptune's necklace Hormosira banksii was the most abundant algal species on the intertidal platform with 14 % cover (Table 11.1). This was less than recorded during the January 2005 survey. Conversely, the abundance of sea lettuce Ulva spp increased substantially between surveys. All other macroalgal cover was sparse and patchy.

The mat forming mussel Xenostrobus pulex accounted for more cover than all algal species combined, excluding Hormosira banksii. It formed dense patches which were distributed in the mid- to high-shore level. Higher cover was recorded in the December 2005 survey than in the previous survey of the site. A similar mat forming mussel Brachidontes rostratus was also found at this site, but was not as high in abundance.

Sand inundation at this reef was relatively high, with 16 % cover (Table 11.1). This was almost double that recorded during the previous survey.

The reference site at Point Danger West (Site 4001) had a similar community of algal species (Table 11.1). Hormosira banksii was the dominant algae and although was higher in

cover that at Point Danger, had reduced between surveys. There was a large increase in abundance of algal turf between surveys, resulting in a much higher level of cover at the reference site. Enteromorpha spp also increased in abundance between surveys.

Mats of the mussel Xenostrobus pulex formed a large component of the reef cover, although this species was less abundant than at the sanctuary site (Table 11.1). As with the Point Danger site, there was an increase in the abundance of this species between surveys. The barnacle Chthamalus antennatus was recorded in dense patches during both surveys.

Sand inundation was similar between surveys and was much lower at this site than at Point Danger.

Table 11.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Point Danger and Point Danger West during Survey 2 (January 2005) and Survey 3 (December 2005). '+' = present in quadrats but not observed under any points.

Species	Point Danger MS (4002)		Point Danger West (4001)	
	Survey		Survey	
	2	3	2	3
Macrophytes				
Dictyosphaeria serica			+	
Enteromorpha spp	1.12	0.56	0.72	3.20
Green algae unidentified		0.88		2.72
Ulva spp	0.32	5.20	0.16	0.16
Brown algae unidentified		0.56	+	
Hormosira banksii	21.12	13.76	37.28	21.20
Corallina officinalis			+	
Corallines unidentified	+	0.32		
Encrusting corallines	0.24	0.16	0.96	0.72
Algal turf	2.24	0.88	2.32	11.20
Rivularia spp	0.08			+
Symploca spp			+	
Sessile Invertebrates				
Galeolaria caespitosa	0.16	0.08	+	+
Chthamalus antennatus			1.68	0.64
Xenostrobus pulex	12.8	22.32	6.4	10.32
Brachidontes rostratus	1.44	+		
Other				
Drift macroalgae			+	
Drift seagrass		+		
Sand	8.88	15.92	2.32	1.76

11.3 Invertebrates

Invertebrate species richness and diversity were moderate at both Point Danger and Point Danger West (Table 11.2). The most abundant species at Point Danger was the striped conniwink Bembicium nanum which occurred in high densities, commonly high on the shoreline. The slit limpet Clypidina rugosa, was also highly abundant and was found in dense aggregations across the shore. Its low profile, small size and dull colouration made it a difficult species to enumerate. An increase in the density of B. nanum was offset by a decrease in the density of C. rugosa. All other species on the site occurred in low to very low abundances. This included the variegated limpet Cellana tramoserica and top shell Austrocochlea constricta, which unlike C. rugosa are highly visible components of the intertidal community.

Three predatory gastropods were recorded across the site: Lepsiella vinosa; Cominella lineolata; and Dicathais orbita (Table 11.2). All occurred in low densities. Lepsiella vinosa appeared to be associated with Xenostrobus pulex mussel beds.

Low abundances of the anemones Actinia tenebrosa, Oulactis muscosa and Aulactinia veratra were recorded on the site during the January 2005 survey. Only A. tenebrosa was observed during the most recent survey.

The reference site at Point Danger West had a similar community of invertebrates (Table 11.2). The slit limpet Clypidina rugosa was the most abundant species present at this site and had remained at relatively similar densities across surveys. In contrast to Point Danger, Bembicium nanum was only recorded in low abundances at this site. Similarly, Austrocochlea constricta, Cellana tramoserica and Turbo undulatus were found in lower densities. Abundance of the periwinkle Nodilittorina unifasciata, which was recorded at elevated densites during the January 2005 survey, was much reduced in December 2005. Low densities of the small, black periwinkle Nodilittorina acutispira were recorded in the most recent survey.

Predatory gastropods recorded at Point Danger were also found at the reference site (Table 11.2). Of these species, Lepsiella vinosa appeared to occur in substantially lower abundances at Point Danger West. This may relate to the lower abundance of Xenostrobus pulex at this site.

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

Species	Point Danger MS (4002)		Point Danger West (4001)	
	Survey		Survey	
	2	3	2	3
Cnidaria				
Actinia tenebrosa	0.60	0.36	0.16	
Aulactinia veratra	0.12			0.04
Oulactis muscosa	0.08		0.04	0.20
Mollusca				
Austrocochlea constricta	1.48	2.12		0.12
Austrocochlea odontis	0.16	1.20	0.20	0.16
Bembicium nanum	11.76	19.92	0.80	1.36
Cellana tramoserica	1.20	1.48	0.32	0.20
Clypidina rugosa	23.04	16.52	18.24	16.44
Cominella lineolata	0.76	0.40	0.48	0.48
Dicathais orbita	0.68	0.64	0.24	0.48
Lepsiella vinosa	1.16	1.72	0.16	0.28
Nodilittorina acutispira				2.36
Nodilittorina unifasciata	0.12	0.32	8.00	0.20
Notoacmea mayi		0.12	0.40	3.04
Notoacmea petterdi			0.44	
Onchidella patelloides	0.16		0.12	0.80
Patelloida alticostata	0.08	0.40	0.36	0.16
Patelloida insignis		0.12	0.08	
Siphonaria spp	2.84	2.28	5.44	2.80
Turbo undulatus	0.52	0.88	0.16	0.16
Unidentified chiton		0.04		
Crustacea				
Unidentified crab				0.04

The mean size of Cellana tramoserica at Point Danger has declined slightly over time (Figure 11.1a). Individuals at the Point Danger West site were larger with a mean of 30 mm compared to a mean of 20 mm at Point Danger (Figure 11.1a). No decline in size was apparent at the Point Danger West site.

The size of Bembicium nanum at both sites appeared to decrease substantially after the first survey in 2003 (Figure 11.1b). This may relate to the appearance of numerous, small individuals which were not recorded during the initial survey. The size of B. nanum was similar between sites during the December 2005 survey, with mean lengths of 5 mm at both sites.

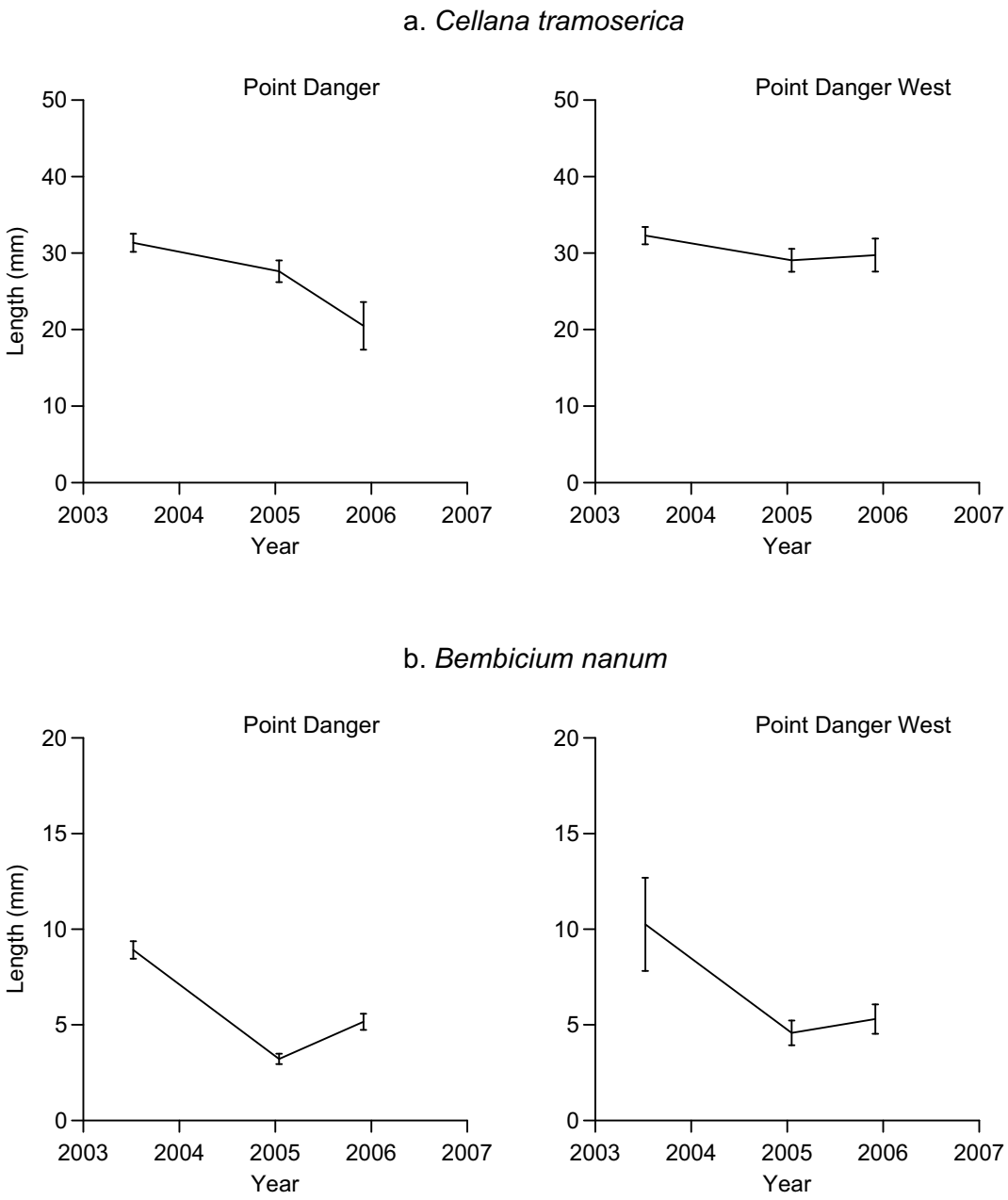


Figure 11.1. Mean sizes (± 95 % confidence intervals) of (a) *Cellana tramoserica*; and (b) *Bembicium nanum* at Point Danger and Point Danger West.

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 northeastern section of the pincer is a basalt platform and boulder reef. This section of the reef is relatively protected from swell but has a large estuarine influence from the adjacent mouth of the Barwon River. The south-western section of the pincer is a relatively flat sandstone reef, which is more exposed to large swells and sand inundation due to its exposure towards the south and proximity to an adjacent surf beach and strong cross-shore currents. The survey site is on the sandstone section of the reef.

The sandstone platform has three large rockpools in the centre of the survey area. The transects 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.

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. Total abundance was high at Barwon Bluff and little change was observed between surveys (Table 12.1). The only other macroalgae which occurred in appreciable quantities across the shore were turf forming species. Red coralline algae were present in small scattered patches. Both sea lettuce Ulva spp and Enteromorpha spp were present. Ulva spp increased in abundance between surveys.

The mat forming mussel Xenostrobus pulex had a low cover across the shore, occupying exposed patches of rock between sand/H. banksii microhabitat (Table 12.1). The cover of

X. pulex decreased between surveys, as did the tubeworm Galeolaria caespitosa, which had a similar distribution during the January 2005 survey.

Sand inundation was high at Barwon Bluff (Table 12.1). The cover across the platform increased between surveys from 13% to 19%. This increase was associated with a drift of sand high on the shore that covered the high-shore baseline. In the January 2005 survey, this baseline was exposed reef. This may account for the observed decrease in X. pulex cover.

As with Barwon Bluff, the reference site at Barwon Beach had a high abundance of Hormosira banksii (Figure 12.1). Although the cover of H. banksii was lower at Barwon Beach, there was a greater abundance of turfing algae. Ulva spp was also higher in abundance than at Barwon Bluff. No red algae was recorded under quadrat points at Barwon Beach although several species were present.

Barnacles were a much more prevalent species at Barwon Beach with both Chthamalus antennatus and Chamaesipho tasmanica present (Table 12.1). Galeolaria caespitosa also formed more significant aggregations at this site.

Sand inundation at Barwon beach was very low compared to Barwon Bluff, despite a small increase between surveys. This is expected to vary considerably depending on prevailing weather conditions, a typical feature of similarly exposed reefs.

Table 12.1. Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Barwon Beach and Barwon Bluff during Survey 2 (January 2005) and Survey 3 (November 2005). '+' = present in quadrats but not observed under any points.

Species	Barwon Bluff MS (4004)		Barwon Beach (4003)	
	Survey		Survey	
	2	3	2	3
Macrophytes				
Enteromorpha spp	+	+	+	+
Green algae unidentified				0.72
Ulva spp	+	0.40	0.08	1.92
Brown algae unidentified				0.16
Colpomenia sinuosa				+
Cystophora retorta	0.16			
Hormosira banksii	46.32	47.04	31.52	30.96
Leathesia difformis			+	+
Nothea anomala		+		
Syctosiphon lomentaria				0.08
Corallina officinalis	0.4	0.16	+	+
Corallines unidentified			+	
Encrusting corallines	0.32	0.40	+	
Filamentous red algae			+	
Laurencia filiformis				+
Algal turf	3.2	4.48	13.84	12.4
Rivularia spp		+		+
Symploca	+		0.24	
Sessile Invertebrates				
Galeolaria caespitosa	0.08		0.64	1.04
Barnacles		+	+	
Chamaesipho tasmanica			1.04	
Chthamalus antennatus		+	0.40	1.56
Xenostrobus pulex	2.24	0.16	+	0.88
Other				
Drift macroalgae	+			
Drift seagrass		+		
Sand	12.72	19.36	0.32	1.12

12.3 Invertebrates

Invertebrate species richness and diversity was high at Barwon Bluff and moderate at Barwon Beach (Table 12.2). High densities of the slit limpet Clypidina rugosa and the pulmonate limpet Siphonaria spp were present across the mid to low region of the intertidal platform at Barwon Bluff. An increase in the density of C. rugosa between surveys contrasted with a decrease in the density of Siphonaria spp. The variegated limpet Cellana tramoserica and conniwink Bembicium nanum occurred in low densities along with a range of other herbivorous gastropods. Two species of periwinkle Nodilittorina unifasciata and N. acutispira, were low in abundance and restricted to the high shore region during the January 2005 survey. There was a large increase in the density of both of these species in the November 2005 survey, particularly of the small, inconspicuous periwinkle, N. acutispira.

Three predatory gastropods were recorded across the site: Lepsiella vinosa; Cominella lineolata; and Dicathais orbita (Table 12.2). All occurred in low densities.

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 the following survey.

The most abundant species at the reference site Barwon West, were the periwinkles Nodilittorina acutispira and N. unifasciata (Table 12.2). Nodilittorina acutispira in particular was very abundant across the entire survey area with over 500 individuals in some quadrats. The small size of this species means that it may often be overlooked as one of the most abundant species on some intertidal reefs. Densities of these species did not change appreciably between surveys. The slit limpet C. rugosa was found in much higher abundances at Barwon Beach than at Barwon Bluff. Clypidina rugosa was one of several species that declined substantially between the surveys. Other species included the conniwink B. nanum, the variegated limpet Cellana tramoserica, the limpet Notacmea mayi and the pulmonate limpet Siphonaria spp.

The predatory gastropods Cominella lineolata and Dicathais orbita were both recorded at the Barwon Beach site, although in lower densities than observed at Barwon Heads.

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

Species	Barwon Bluff MS (4004)		Barwon Beach (4003)	
	Survey		Survey	
	2	3	2	3
Cnidaria				
Actinia tenebrosa		0.20		
Aulactinia veratra	0.56	0.36	0.08	0.08
Anthothoe albocincta	0.04			
Oulactis muscosa				0.04
Mollusca				
Aplysia gigantea	0.08			
Austrocochlea concamerata	0.12			
Austrocochlea constricta	0.72	1.16		0.16
Austrocochlea odontis	0.04	1.56	0.04	
Bembicium nanum	1.56	2.72	8.08	2.64
Calliostoma armillata		0.12		
Cellana tramoserica	1.12	1.32	5.04	2.72
Clypidina rugosa	7.92	17.76	64.4	22.44
Cominella lineolata	0.12	0.48		0.16
Dicathais orbita	0.36	0.88	0.36	0.16
Lepsiella vinosa	0.12	0.16		
Nodilittorina acutispira	0.44	19.52	285.76	271.92
Nodilittorina unifasciata	0.72	4.08	71.0	78.36
Notoacmea mayi	8.68	6.84	39.64	4.00
Notoacmea petterdi	0.04		0.2	
Onchidella patelloides		0.08		
Paragrapsus gaimardii				0.72
Patelloida alticostata	0.92	0.40	1.84	1.00
Patelloida insignis			0.24	0.04
Patelloida latistrigata		0.04	0.36	0.12
Phasianotrochus eximius		0.12		
Siphonaria spp	24.8	11.64	14.16	4.44
Turbo undulatus	0.64	1.96		0.04
Unidentified chiton		0.12	0.08	
Crustacea				
Unidentified crab		0.08		

The mean size of Cellana tramoserica at Barwon Beach was larger than at Barwon Bluff, with means of 25 mm and 24 mm respectively (Figure 12.1). The mean size of limpets appears to have increased at Barwon Bluff since the May 2004 survey. The mean size of C. tramoserica at Barwon Beach did not show any apparent temporal trends.

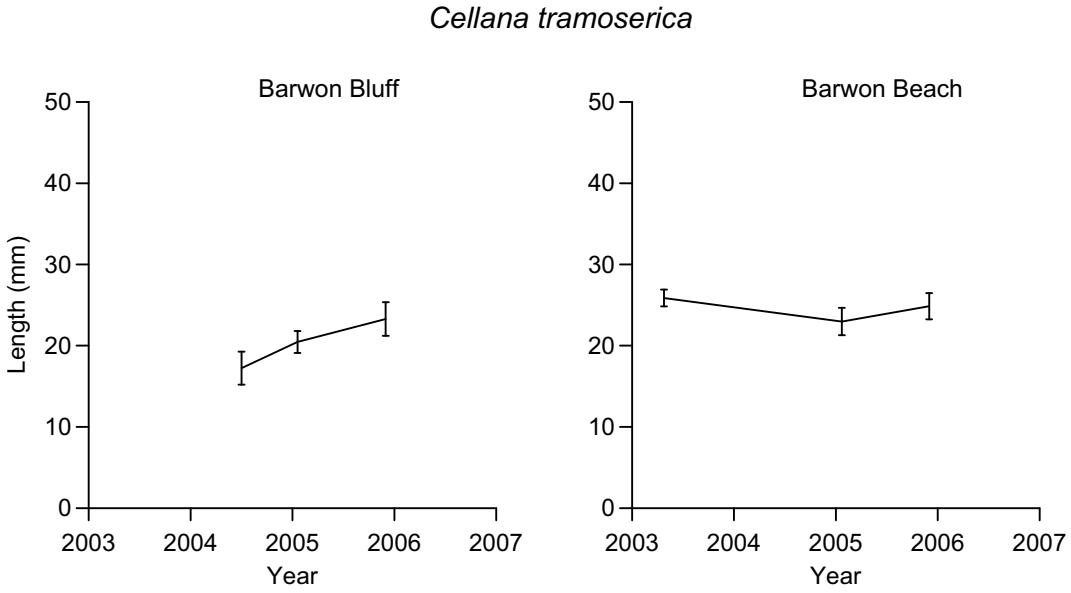


Figure 12.1. Size Mean sizes (± 95 % confidence intervals) of *Cellana tramoserica* at Barwon Bluff MS and Barwon Beach.

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