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Victorian Intertidal Reef Monitoring Program

The Intertidal Reef Biota of Northern Port Phillip Bay Marine Sanctuaries

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Victorian Intertidal Reef Monitoring Program:

The Intertidal Reef Biota of Northern Port Phillip Bay Marine Sanctuaries

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March 2005

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 Cook, Jawbone and Ricketts Point. Reference sites were also surveyed in association with each of these sanctuaries.

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. All existing monitoring sites were resurveyed in 2004 using the revised standard operating procedures.

The objectives of this report are to:

~~1.~~provide an overview of the methods used for the IRMP;

~~2.~~provide general descriptions of the biological communities and species populations at each monitoring site in May 2004;

identify any unusual biological phenomena, interesting or unique communities or species; and

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 covering substantial areas low on the shore at most sites and the green algae Ulva spp and Enteromorpha spp occurred as small patchily distributed tufts. Extensive quantities of drift algae washed onto shore at Point Cook.

Small aggregations of sessile animals were present, including the calcareous tube-worm Galeolaria caespitosa and the mussel Mytilus edulis.

The intertidal invertebrate communities of Port Phillip Bay were generally composed of few species and there were no clear community patterns across the intertidal sites. Most sites were dominated by the herbivorous species Austrocochlea porcata, Bembicium nanum and the limpet Cellana tramoserica, in varying abundances between sites. In addition, the carnivorous gastropods Lepsiella vinosa and Cominella lineolatus were generally present at most sites, in low densities.

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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1.0 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 sp. 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 Austrocochlea porcata and Bembicium nanum. 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 and amphipods, 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, especially in relation to identified threats to these environments like human trampling, 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 at 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.

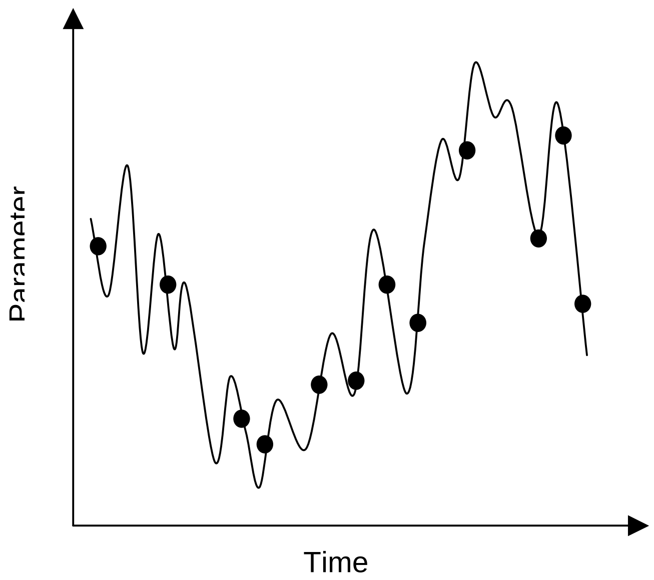


Figure 1.1 An example plot depicting change in an environmental, population or community variable over time (days, months or years). The black circles denote examples of monitoring times. Note how data from these times may not necessarily reflect patterns over shorter time periods, or true maxima or 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 uses standardised visual census methods for surveying invertebrates and macroalgae on intertidal reefs. Details of standard operational procedures (SOP) and quality control protocols are described in Hart and Edmunds (Hart & Edmunds 2005).

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 Cook Marine Sanctuary;

- Jawbone Marine Sanctuary;
- Ricketts Point Marine Sanctuary; and
- Mushroom Reef Marine Sanctuary.

The Intertidal Standard Operating Procedures (Edmunds et al. 2003) were peer reviewed after the first survey of reefs in 2003. The SOP was modified in consultation with Parks Victoria and according to recommendations made during the peer review process.

All existing monitoring sites were resurveyed in 2004 using the revised standard operating procedures. In addition, sites were established and surveyed at Bunurong Marine National Park and Port Phillip Heads Marine National Park (Point Lonsdale).

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

1.2.3 Monitoring in the Northern Port Phillip Bay Marine Sanctuaries

This report describes the intertidal reef monitoring program and results from surveys in northern Port Phillip Bay at Point Cook, Jawbone and Ricketts Point Marine Sanctuaries and the corresponding reference sites. The objectives of this report are to:

1. provide an overview of the methods used for the IRMP;

2. provide general descriptions of the biological communities and species populations at each monitoring site in May 2004;

3. identify any unusual biological phenomena, interesting or unique communities or species; and

4. identify any introduced species at the monitoring locations.

2.0 METHODS

2.1 Site Selection and Survey Times

Intertidal survey sites were established on intertidal reefs in the northern Port Phillip Bay at Point Cook, Jawbone and Ricketts Point Marine Sanctuaries. A reference site was established in association with each of these marine protected areas (Table 2.1; Figure 2.1). Each site was assigned a number in accordance with the Parks Victoria and Department of Sustainability and Environment database system for marine monitoring. A description of each intertidal reef and sampling considerations at each site is given separately for each marine sanctuary in Sections 4 to 6.

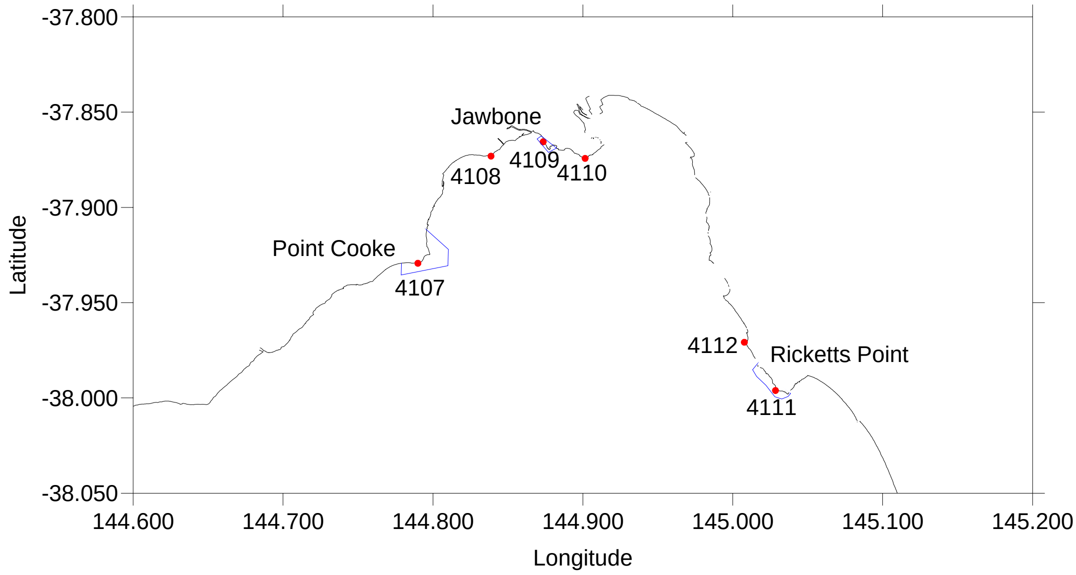


Figure 2.1 Location of intertidal monitoring sites in northern Port Phillip Bay. Marine Sanctuary boundaries are outlined.

Table 2.1 Intertidal reef monitoring sites in northern Port Phillip Bay.

Site No.	Site Name	Status	Easting (MGA)	Northing (MGA)
Point Cook MS				
4107	Point Cook	Sanctuary	305876	5799893
4108	Altona	Reference	309907	5806049
Jawbone MS				
4109	Jawbone	Sanctuary	313062	5807137
4110	Point Gellibrand	Reference	315545	5806228
Ricketts Point MS				
4111	Ricketts Point	Sanctuary	326889	5792768
4112	Halfmoon Bay	Reference	325005	5795539

2.2 General Description of Survey Technique

Surveys occur at a single reef during a single low tide. Surveys are targeted to 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 2.2). 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 a GPS, photographed and permanently marked using minimally invasive techniques (providing appropriate approval has been provided). If approval has not been provided then endpoints are not marked.

Five fixed transects, each running from high to low shore, are positioned across the intertidal area to be surveyed (Figure 2.2). 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, which are randomly placed during each survey, at five fixed sampling locations (2 m x 2 m area) along each transect (Figure 2.2). The fixed sampling locations are positioned to distribute sampling effort along each transect and to encompass any changes in substratum height across the reef.

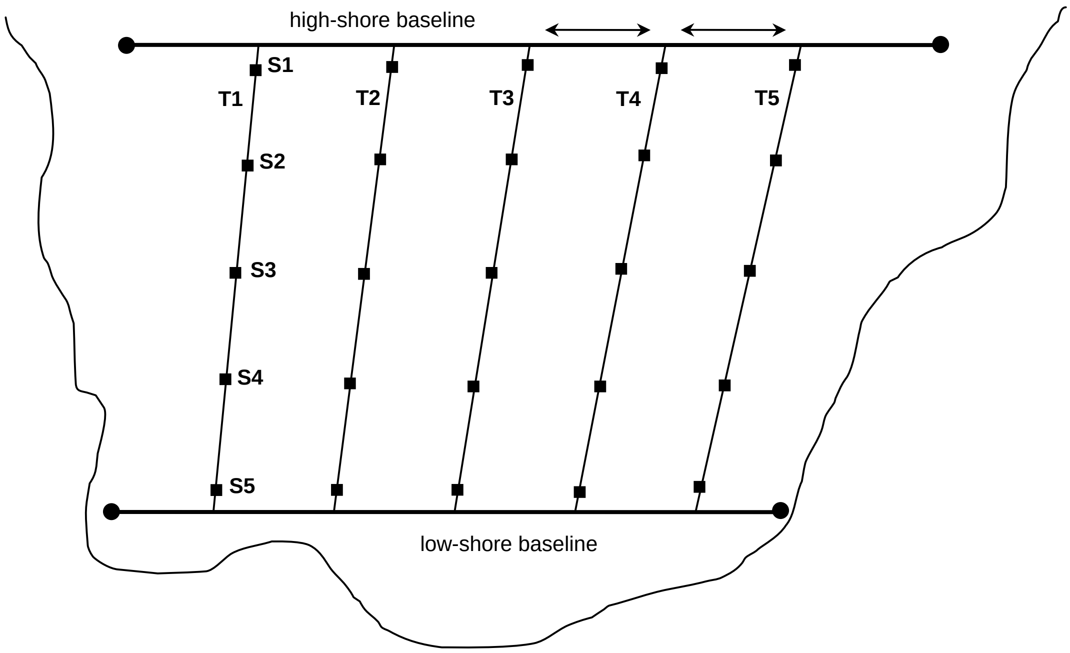


Figure 2.2 Example layout of high and low shore baselines and transects on an intertidal reef. Transects (T1-T5) run across the shore from right to left when looking towards the water. Endpoints of each transect are equidistant along each of the baselines. Sampling Locations (S1-S5) are arranged downshore along each transect and encompass differences in substratum height down the shore.

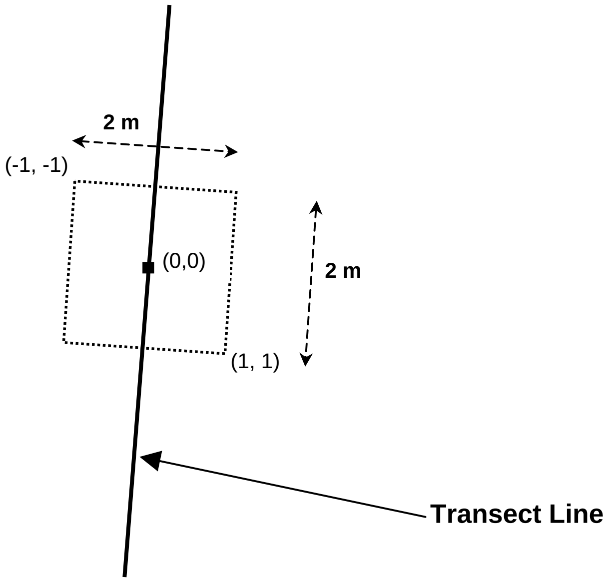


Figure 2.3 Configuration of a sampling location along a transect. Each 2 x 2 m sampling location is centred on a point along the transect line. A quadrat is placed randomly within the sampling location using random x- and y-coordinates between -1 and 1.

2.3 Visual Census Techniques

2.3.1 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 2.4, 2.5; Table 2.2). The observer counts all observable individuals on the rock surface or within crevices and algal fronds. 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 porcata* as well as non-collected 'control' species, including *Siphonaria diamenensis, Cominella lineolata* and *Bembicium nanum*. 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.

2.3.2 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 2.4). 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 rigida*, *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).

2.3.3 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).

2.3.4 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; and

(v) vertical surface, rock side, crevice.

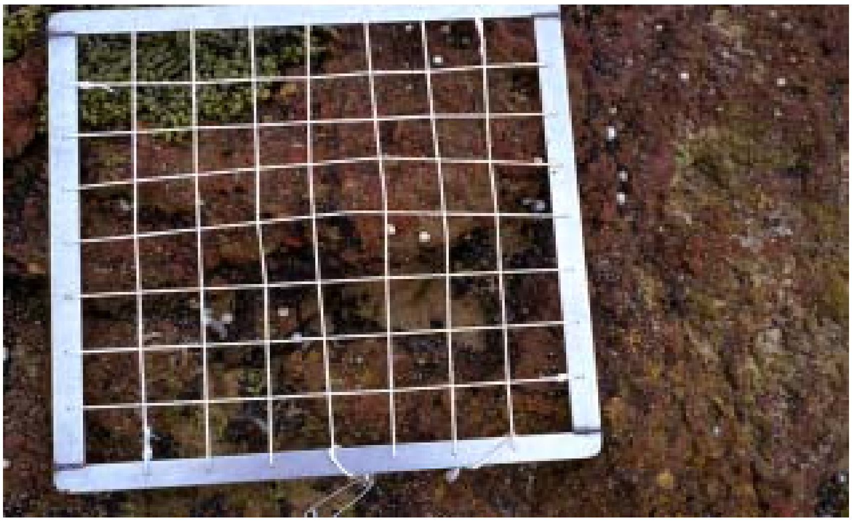


Figure 2.4 Quadrat with the alga *Hormosira banksii* and snail *Bembicium nanum*. The abundance of each gastropod is counted within the quadrat. The cover of macrophytes and highly aggregated animals is measured by the number of points intersecting each species on the quadrat grid.

Figure 2.5 Marine biologist counting invertebrates within quadrats during intertidal reef monitoring surveys at Altona.

Table 2.2 Intertidal species found 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*	*Patella peronii*
Green Algae	*Boccardia proboscidia*	*Patella chapmani*
Ulva spp	**Barnacles**	*Cellana tramoserica*
Enteromorpha spp	*Catomerus polymerus*	*Patelloida alticostata*
Codium fragile	*Cthamalus antennatus*	*Patelloida latistrigata*
Brown Algae	*Chamaeshipho tasmanica*	*Notoacmea mayi*
Leathesia difformis	*Tesseropora rosea*	*Notoacmea spp*
Splanchnidium rugosum	*Austromegabalanus nigrescens*	*Siphonaria diamenensis*
Scytosiphon lomentaria	*Tetraclitella purpurascens*	*Siphonaria zelandica*
Colpomenia sinuosa	**Bivalves**	*Siphonaria tasmanica*
Notheia anomala	*Mytilus edulis planulatus*	*Siphonaria funiculata*
Hormosira banksii	*Xenostrobus pulex*	
Red Algae	*Brachidontes rostratus*	**Snails**
Gracilaria spp	*Saccostrea glomerata*	*Austrocochlea constricta*
Porphyra lucasii	**Ascidians**	*Austrocochlea porcata*
Porphyra columbina	*Pyura stolonifera*	*Austrocochlea odontis*
Spongites hyperellus	**Anemones**	*Austrocochlea cancamerata*
Capreolia implexa	*Actinia tenebrosa*	*Turbo undulatus*
Corallina officinalis	*Oulactis muscosa*	*Nerita atramentosa*
Ceramium flaccidum	*Aulactinia veratra*	*Bembicium nanum*
Cladophora subsimplex		*Bembicium melanostomum*
		Nodilittorina unifasciata

Sea Slugs	**Sea stars**	**Snails continued**
Onchidella patelloides	*Patiriella exigua*	*Dicathais orbita*
	Patiriella calcar	*Lepsiella vinosa*
		Cominella lineolata

Figure 2.6 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 diemenensis* (centre) and *Notoacmea mayi*; (d) the gastropods *Bembicium namum* (bottom) and *Austrocochlea constricta*; (e) the gastropods *Cominella lineolata* (top) and *Dicathais orbita*; and (f) the anemone *Aulactinia veratra* and the green alga *Ulva* spp in standing water.

2.4 Data Analysis

2.4.2 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.

2.4.3 Species Diversity

Species diversity involves the consideration of two components: species richness and evenness. Species richness is the number of species present in the community while evenness is the degree of similarity of abundances between species. If all species in a community have similar abundances, then the community has a high degree of evenness. If a community has most of the individuals belonging to one species, it has low evenness. Species diversity is a combination of species richness and the relative abundance of each species, and is often referred to as species heterogeneity. Measures of diversity give an indication of the likelihood that two individuals selected at random from a community are different species.

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

2.4.4 Species Populations

The abundances of each species were summarised by calculating the mean density per quadrat ($0.25m^{-2}$) for each site. The variability in density between quadrats was visually examined for the highly abundant species *Austrocochlea porcata* and *Cellana tramoserica* using box plots. The edges of box plots indicate the inter-quartile range and the median is indicated within the box. The whiskers on the boxes indicate values encompassing 1.5 times the inter-quartile range, either side of the median. Outliers are indicated by circles.

The population size structure for *Austrocochlea porcata* and *Cellana tramoserica* was assessed by calculating mean lengths and size frequency curves for each site where there was a high abundance of individuals.

2.4.5 Initial Analyses

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 of data is available, there will be more detailed assessments of temporal trends and differences between sites.

3.0 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 Cook, 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.

3.2 Macroalgae and Aggregating Sessile Invertebrates

There were generally few species and sparse cover of macroalgae on all intertidal reefs surveyed in the north of the Bay. Ricketts Point had the highest cover of attached macroalgae with Neptune's necklace *Hormosira banksii* covering substantial areas low on the shore. *Hormosira banksii* also occurred low on the shore but in lower abundance at Point Gellibrand. The green algae *Ulva* spp and *Enteromorpha* spp occurred as small patchily distributed tufts at most sites. Patches of small filamentous turfing species also occurred at most locations but in low abundance. No macroalgae occurred at Altona.

Point Cook had the highest species richness and diversity of macroalgal species compared with other regions in northern Port Phillip Bay. This was because of a few species of small attached filamentous and thallose red algae distributed across the shore. These species contributed little to total algal cover. Unattached drift algal species covered large areas of the high shore region at Point Cook and caused anoxic conditions on some areas of this shore.

Aggregating sessile invertebrates did not tend to be important components of the intertidal assemblages surveyed. The tubeworm *Galeolaria caespitosa* occurred at several sites but not in large encrusting aggregations.

Table 3.1 Diversity statistics for macroalgae on intertidal reefs in northern Port Phillip Bay.

Site	Species Richness	Heterogeneity $1/D=N_2$	Evenness $E_{1/D}$
Point Cook MS	8	2.73	0.34
Altona	0	-	-
Jawbone MS	3	1.97	0.66
Point Gellibrand	5	1.28	0.26
Ricketts Point MS	4	2.11	0.53
Half Moon Bay	4	1.70	0.43

3.3 Invertebrates

The intertidal invertebrate communities of Port Phillip Bay generally composed of few species. There were no clear community patterns for the intertidal sites (Figure 3.1). Most sites were dominated by the herbivorous species *Austrocochlea porcata*, *Bembicium nanum* and the limpet *Cellana tramoserica* in varying abundances. In addition, the carnivorous gastropods *Lepsiella vinosa* and *Cominella lineolatus* were generally present on the site at low densities.

Halfmoon Bay (S4112) was the most diverse and species rich site by a relatively large margin (Table 3.2). This small site had the only recorded presence of the species *Patelloidea alticosta*, *Notoacmea mayi* and *Onchidella patelloides* which are typical of intertidal reefs on Victoria's exposed coast. Halfmoon Bay had moderate abundances of the common *Austrocochlea porcata* and *Cellana tramoserica*, as well as high abundances of *Turbo undulatus*, *Lepsiella vinosa* and *Nerita atramentosa* which if present, are rare at other sites. Point Cook (S4107) had the lowest richness and diversity of mobile invertebrates with only the commonest species present in low numbers.

Figure 3.1 MDS plot of invertebrate assemblages on intertidal reefs in northern Port Phillip Bay. Legend: Marine Sanctuary = Blue; Reference Sites = Red; Point Cook (S4107) and Altona (S4108) = Circle; Jawbone (S4109) and Point Gellibrand (S4110) = Triangle; Ricketts Point (S4111) and Halfmoon Bay (S4112) = Square. Kruskal stress = 0.06.

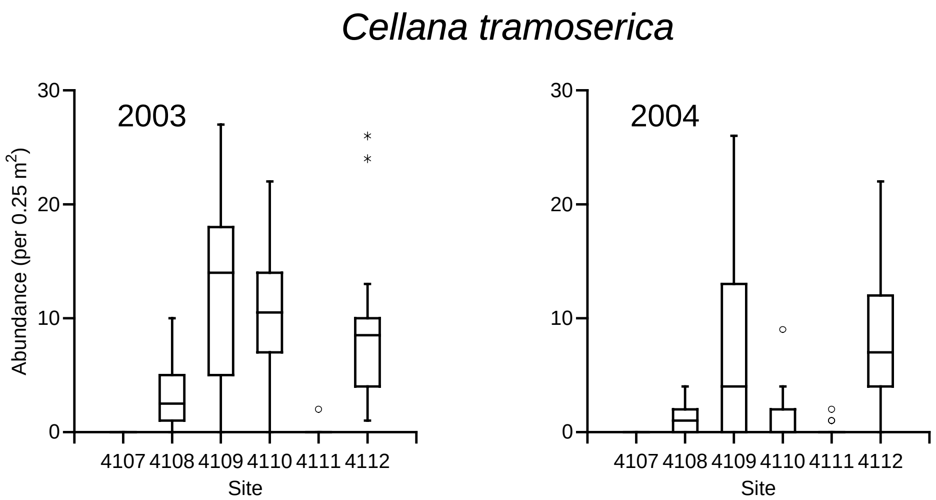
Table 3.2 Diversity statistics for invertebrates on intertidal reefs in northern Port Phillip Bay.

Site	Species Richness	Heterogeneity $1/D=N_2$	Evenness $E_{1/D}$
Point Cook	5	1.27	0.25
Altona	9	1.59	0.18

Jawbone	8	3.09	0.39
Point Gellibrand	6	3.57	0.59
Ricketts Point	8	1.32	0.17
Halfmoon Bay	18	6.77	0.38

3.4 Species Populations

The densities of the common species *Cellana tramoserica* and *Austrocochlea porcata* changed little between the two survey periods. The limpet *Cellana tramoserica* showed similar means and variance in density per 0.25 m² for most sites. Changes were observed at Jawbone (Site 4109) where although the range of densities encountered was similar, the mean dropped between the years. At Point Gellibrand (Site 4110) there was an overall decrease in both mean and range of density. For the abundant gastropod *Austrocochlea porcata*, the mean densities and range were similar for all but one site. At Ricketts Point (Site 4111), there was a substantial drop in the mean density and range between the two years.



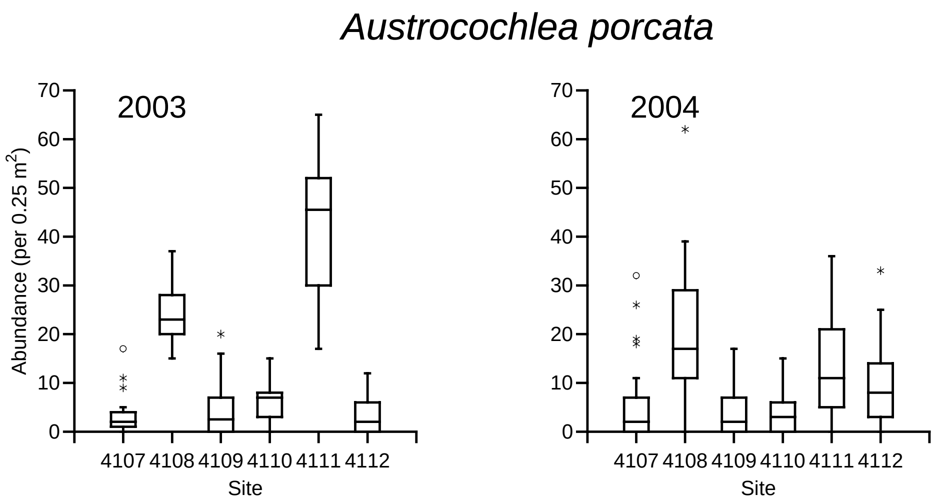


Figure 3.2 Box plots of abundance (per 0.25 m²) of common intertidal gastropods *Cellana tramoserica* and *Austrocochlea porcata*

4.0 POINT COOK MARINE SANCTUARY

4.1 Site Description and Transect Layout

4.1.1 Point Cook Marine Sanctuary (Site 4107)

The intertidal area at Point Cook is an extensive basalt rock platform and basalt boulder and cobble field. The intertidal area is 300-400 m long, extending from just north of Point Cook to the south and west. Large patches of sand and intertidal seagrass *Zostera marina* 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 Cook. Both the high-shore and low-shore baselines were 100 m long and were approximately parallel. During the 2004 survey, a large amount of drift algae was present along the high shore, covering a large area of intertidal reef. The high shore baseline was placed across the drift algae during this survey. 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 Cook could not be found. However, the intertidal area at Altona was established in 2003 as a reference site for Point Cook Marine Sanctuary. The intertidal monitoring site at Point Gellibrand (Site 4110; Section 5.1.2) would also be used as a long-term reference site for Point Cook.

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 Cook. 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

There was a very large amount of drift algae smothering the higher shore areas of the intertidal reef at Point Cook during May 2004. This drift algal mat was up to 40-50 cm thick. The high shore baseline traversed the drift algal mat and consequently, there was 100 % cover of drift algae in all quadrats placed high on the shore (Table 4.1). Any biota occurring on the reef below the drift algal mat was completely smothered by drift algae during this survey. Drift algal mats commonly occur subtidally along the northwestern shore of Port Phillip Bay and are periodically washed ashore during strong windy conditions. The drift algal mat consisted of two portions of algae in very different stages of decay. This appeared to indicate that most of the drift algae had been washed ashore during two separate events. Although the drift algal mat was confined mostly to the higher regions of the shore, its influence extended further seaward. Large areas of reef and rock pools adjacent to the algal mat were clearly anoxic and large numbers of dead shells and little attached algae occurred in these areas.

There was a relatively high total cover of the green alga *Ulva* spp. and *Enteromorpha* spp. at Point Cook. The distribution of these species was patchy along the shore but with higher abundances occurring in the lower shore regions. Small attached thallose and filamentous red algal species such as *Ceramium flaccidum* and *Grateloupa filicina* also occurred at Point Cook.

There was no attached macroalgal cover at Altona. There was a relatively small amount of drift algae (mostly large brown algal species such as *Sargassum* spp and *Cystophora* spp) and drift seagrass at this site.

There was a relatively large amount of sand inundation at both sites.

Table 4.1 Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Point Cook and Altona in May 2004.

Species	Point Cook MS	Altona (reference)
Macrophytes		
Algal turf	1.2	
Ceramium flaccidum	0.2	
Grateloupia filicina	0.1	
Hypnea sp.	1.0	
Filamentous red algae	0.6	
Corallina officinalis	1.2	
Enteromorpha spp.	2.6	
Ulva spp.	8.9	
Drift macroalgae	20.0	0.1
Drift seagrass		2.7
Sessile Invertebrates		
Mytilus edulis	0.1	
Galeolaria caespitosa		2.0
Other sponges	0.2	0.2
Other		
Sand	15.0	18.5

4.3 Invertebrates

Large mobile invertebrates were in low densities at Point Cook (Table 4.2). Most mobile invertebrates occurred in higher abundances lower on the shore. Anoxic sediments and large numbers of dead shells were observed higher on the shore because of the influence of the drift algal mat. The herbivorous gastropod *Austrocochlea porcata* was the most abundant invertebrate with highest abundances occurring low on the shore. There were very low densities of a similar species, *Austrocochlea odontis*. This species is typically in lower abundance than its congeners on intertidal reefs. Two carnivorous gastropods were in low densities on the shore: *Cominella lineolata* and *Lepsiella vinosa*.

Densities of invertebrates, particularly gastropod molluscs, were considerably higher at Altona. As at Point Cook, *Austrocochlea porcata* was the most abundant species. However, in contrast to Point Cook, there was a much higher density of this species at Altona with more than 20 individuals per 0.25 m^{-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 in moderate abundance at Altona but was not present within the quadrats at Point Cook. Two species of *Bembicium* were also in moderate numbers at this site. The species of herbivorous gastropods at Altona did not appear to be separated across the shore but tended to occur together in survey quadrats.

There were low abundances of the carnivorous gastropods *Cominella lineolata* and *Lepsiella vinosa* at Altona. The eleven individuals of *Lepsiella vinosa* that were recorded during this survey occurred in a single quadrat.

The seastar *Patiriella exigua* occurred on the seaward edge of the intertidal reef at Altona in moderate densities.

Table 4.2 Density of megafaunal invertebrates per 0.25m-2 at Point Cook and Altona in May 2004.

Species	Point Cook MS	Altona (reference)
Austrocochlea odontis	0.2	0.0
Austrocochlea porcata	5.8	20.5
Turbo undulatus	0.0	0.0
Bembicium melanostomum	0.0	1.0
Bembicium nanum	0.0	0.6
Nerita atramentosa	0.0	0.0
Nodilittorina unifasciata	0.0	0.2
Cellana tramoserica	0.0	2.7
Cominella lineolata	0.4	0.1
Lepsiella vinosa	0.2	0.4
Patiriella exigua	0.0	0.6
Capreolia implexa	0.1	0.0

The sizes of the herbivorous gastropod *Austrocochlea porcata* varied between the two sites (Figure 4.1). At Point Cook, the mean shell length was approximately 20 mm in 2003 and 2004, although more smaller individuals were detected in 2004. At Altona, mean shell length was much smaller (15 mm) and not as variable between individuals (Figure 4.1).

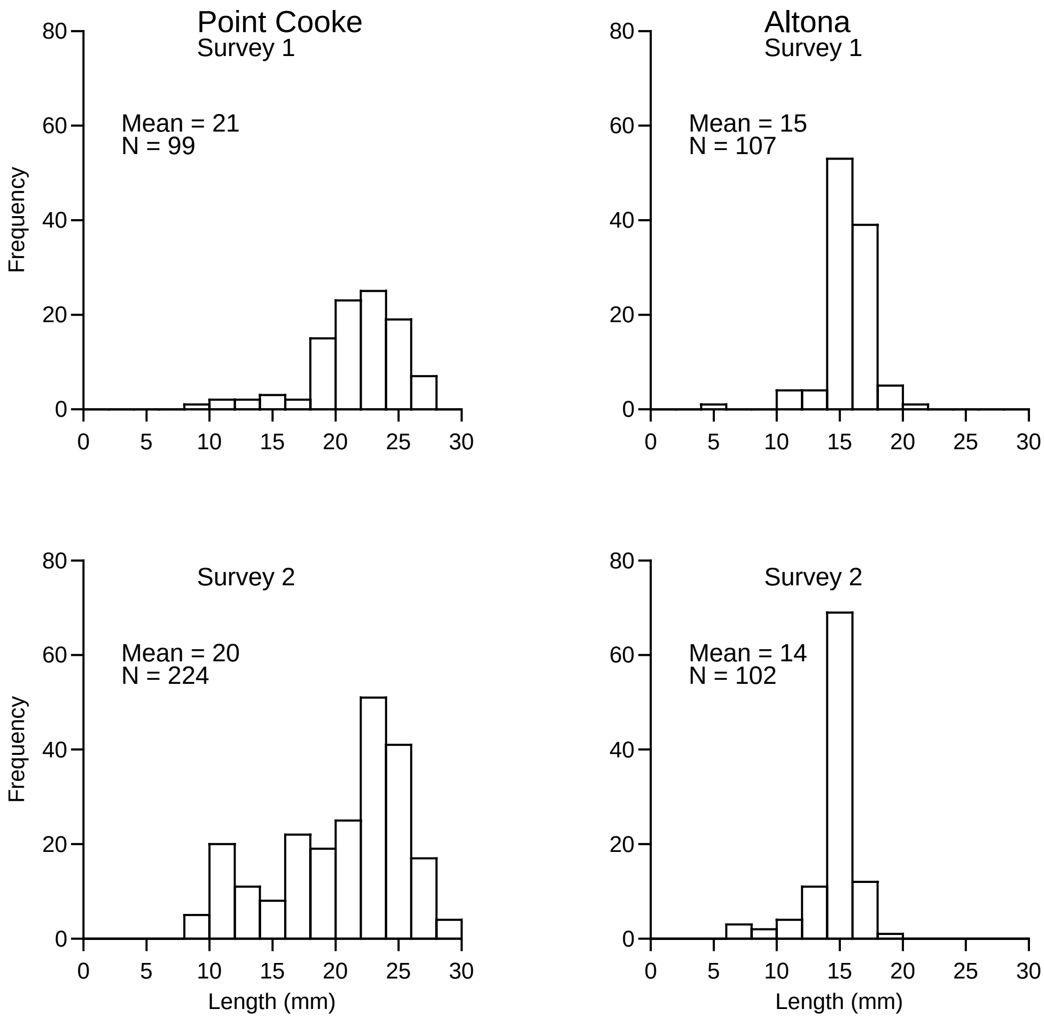


Figure 4.1 Size frequency histograms of *Austrocochlea porcata* for Survey 1 (2003) and Survey 2 (2004) at Point Cook and Altona.

5.0 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 boundary of the Sanctuary to the southwest. 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 establishment of the survey site on the intertidal reef at Jawbone was uncomplicated. The high-shore and low-shore baselines were run parallel to each other and the shore and were 100 m in length. Five transects were placed from the high-shore baseline to the low-shore baseline, at equidistant intervals along the shore. These transects were 6 to 18 m in length.

5.1.2 Point Gellibrand Reference (Site 4110)

The reference site for the Jawbone Marine Sanctuary was the intertidal reef at Point Gellibrand, Williamstown (site 4110). The intertidal area at Point Gellibrand is similar to Jawbone Marine Sanctuary in being composed of a fractured basalt reef and boulder field. The size of the boulders was much smaller at Point Gellibrand and consequently there is less vertical structure and fewer crevices at Point Gellibrand. The intertidal reef at Point Gellibrand 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 the difference in baseline lengths, were not parallel. Quadrats were placed at similar distances along each transect.

5.2 Macroalgae and Aggregating Sessile Invertebrates

The abundance of macroalgae and sessile invertebrates was very low at both sites (Table 5.1). Smaller patches of filamentous algal turf at Jawbone (Site 4109) contributed most of the observed algal cover. There was also a low abundance of the green sea lettuce *Ulva* spp. These small patches of attached algae occurred in the lower shore region of the survey site. There was a relatively small amount of unattached drift seagrass in small sections along the shore at Jawbone.

In contrast to Jawbone, macroalgal cover at Point Gellibrand (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. A low abundance of *Ulva* spp and algal turf also contributed to the macroalgal cover.

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. It was present across the shore but was higher in abundance in the lower shore region.

Table 5.1 Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Jawbone and Point Gellibrand in May 2004.

Species	Jawbone Marine Sanctuary	Pt Gellibrand Reference
Macrophytes		
Algal turf	2.5	0.1
Ulva spp	1.3	0.1
Enteromorpha sp.		+
Filamentous greens		0.1
Hormosira Banksii		6.9
Heterozostera tasmanica	0.2	
Drift seagrass	1.2	0.2
Sessile Invertebrates		
Galeolaria caespitosa	0.2	1.4
Other		
Sand	0.7	

5.3 Invertebrates

The intertidal reef invertebrate communities at Jawbone Marine Sanctuary (Site 4109) and at the reference site at Point Gellibrand (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 limpet *Cellana tramoserica* and top shell *Austrocochlea porcata* which occurred mostly in the mid-low shore region. *Austrocochlea odontis* had a much lower abundance in comparison to its congener *A. porcata*. A small area higher on the shore had an intermediate density of the herbivorous gastropod *Bembicium nanum.* The only carnivorous gastropod present was *Lepsiella vinosa* which was only observed twice over the survey area.

At Point Gellibrand, the dominant invertebrates were the herbivorous gastropods *Bembicium nanum* and *Austrocochlea porcata*. *Bembicium nanum* was in higher densities at Point Gellibrand than at Jawbone and tended to dominate the high shore region. *Austrocochlea porcata* was in similar numbers at both sites and was most abundant on the mid to low shore areas. There were moderate to low densities of the limpet *Cellana tramoserica*.

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

Table 5.2 Density of megafaunal invertebrates per 0.25 m-2 at Jawbone and Point Gellibrand in May 2004.

Species	Jawbone Marine Sanctuary	Pt Gellibrand Reference
Austrocochlea odontis	0.08	
Austrocochlea porcata	4.40	3.60
Bembicium nanum	2.12	8.84
Nerita atramentosa	1.08	
Turbo undulatus	0.04	0.48
Cellana tramoserica	6.32	1.12
Siphonaria diamenensis	0.04	
Lepsiella vinosa	0.08	0.04
Cominella lineolata		0.04
Patiriella exigua		0.08

The size structure of the limpet *Cellana tramoserica* was variable between sites and survey years (Figure 5.1). In 2004, fewer larger individuals were detected, decreasing the mean length slightly from 33 mm to 29 mm. At Point Gellibrand, a high number of larger individuals were observed in the second survey, increasing the mean length from 26 mm to 34 mm.

For the gastropod *Austrocochlea porcata*, the size distribution was variable between sites and times, although the mean was only different at Jawbone for the second survey (12 mm *c.f.* 17-18 mm; Figure 5.2).

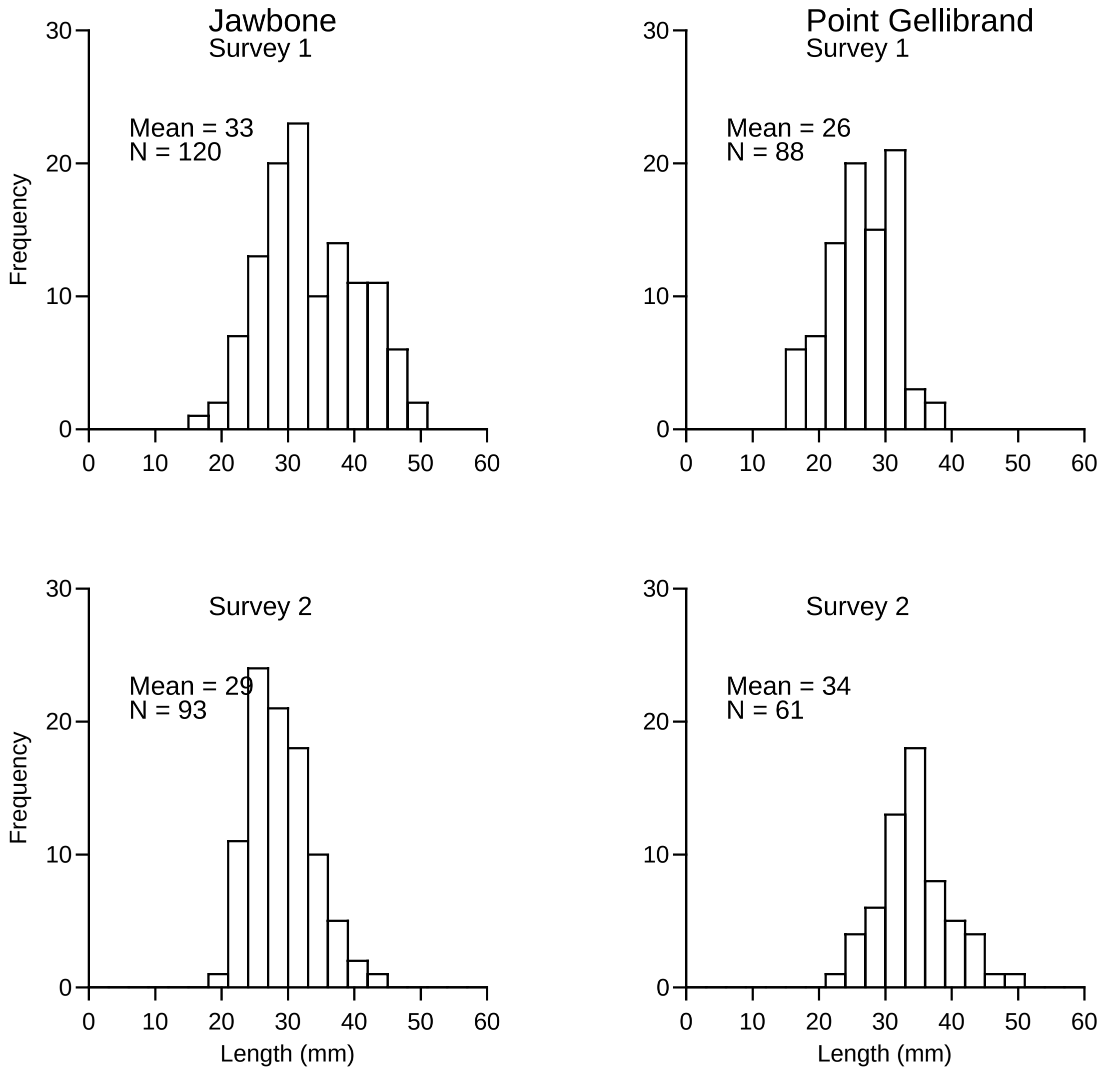


Figure 5.1 Size frequency histograms of *Cellana tramoserica* for Survey 1 (2003) and Survey 2 (2004) at Jawbone and Point Gellibrand.

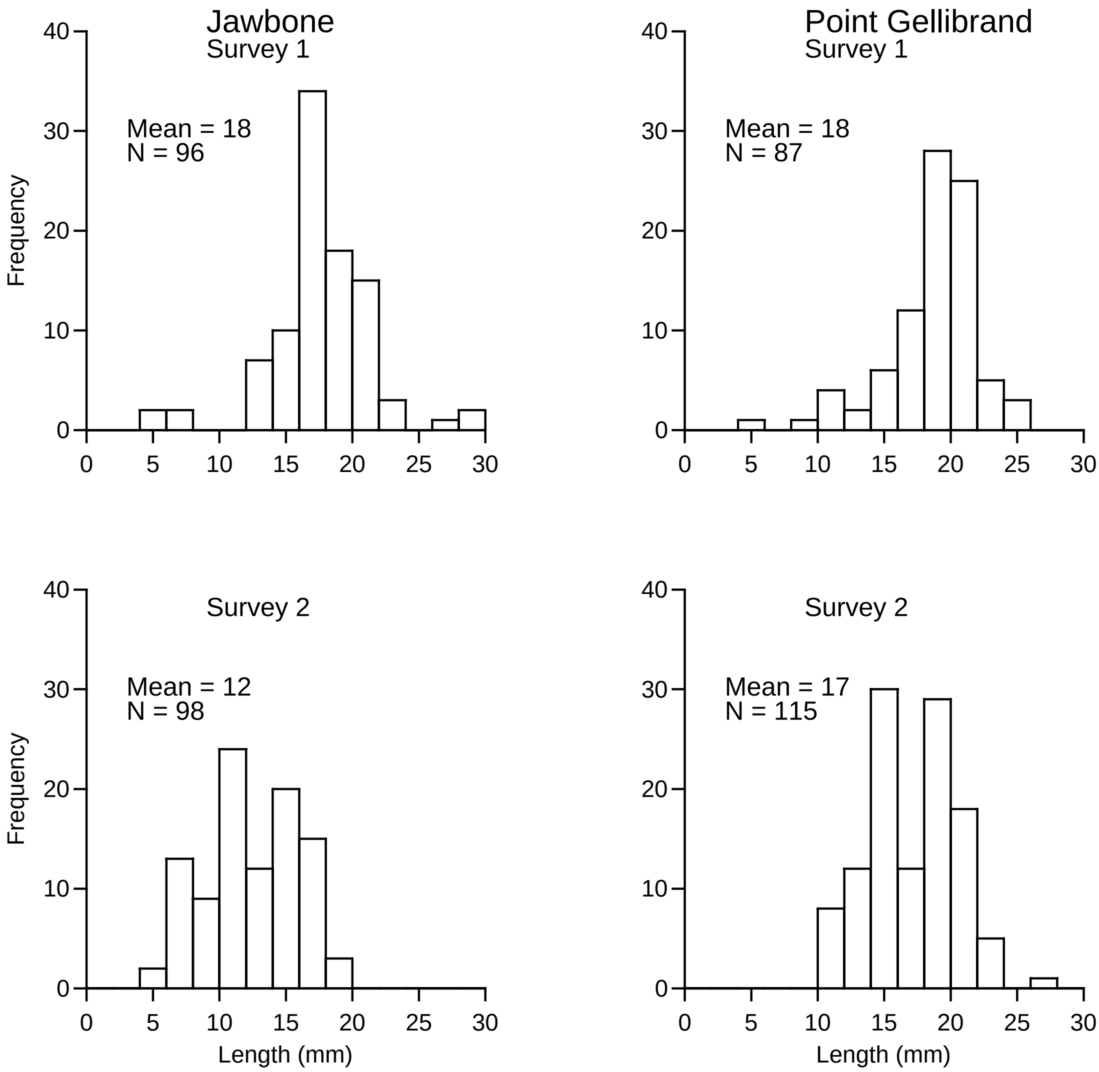


Figure 5.2 Size frequency histograms of *Austrocochlea porcata* for Survey 1 (2003) and Survey 2 (2004) at Jawbone and Point Gellibrand.

6.0 RICKETTS POINT

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 m by 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 salt-tolerant plant samphire *Sarcornia quinqueflora*. There are also small ephemeral rock pools in this central area and 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 ran parallel to the lower baseline which was 30 m long. Transects running between the baselines were approximately 10 m long and 5 m apart (Figure 6.1).

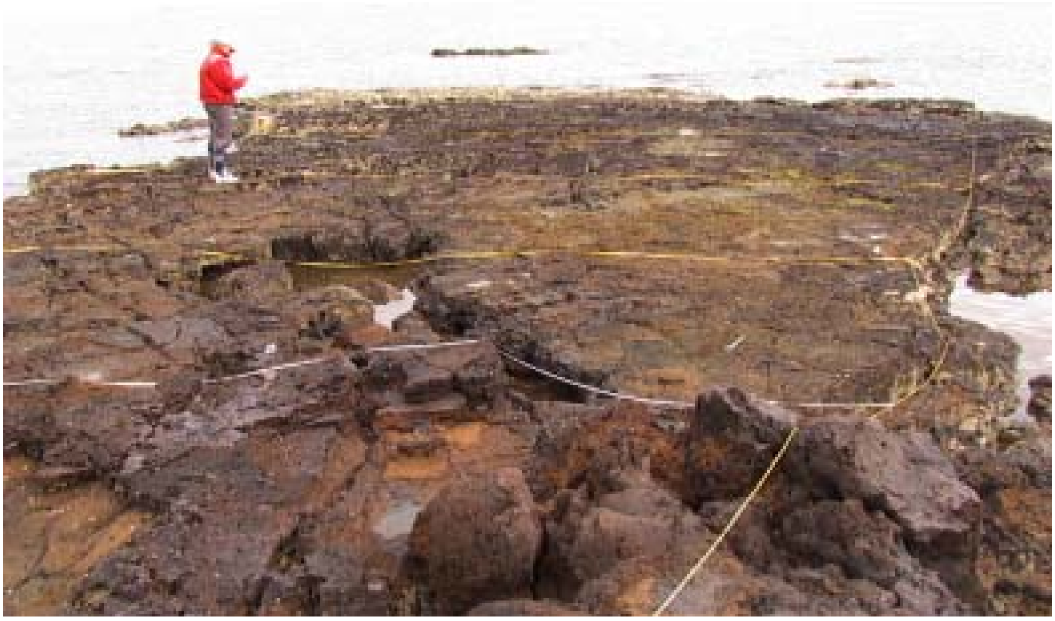


Figure 6.1 The intertidal reef monitoring site at Halfmoon Bay. The high-shore baseline is at the right of the reef. Transects 2-5 can be seen running towards the low shore baseline at left.

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 and as a result there was moderate algal coverage and some terrestrial lichens present (Table 6.1). Macroalgal cover was dispersed along the seaward edge of the platform and 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 tuf and *Enteromorpha* sp. were also present in low abundance.

Cyanobacteria *Symploca* sp was found in the form of small mats, typically in rock pools. The only aggregations of sessile animals observed were small patches of the calcareous tube-worm *Galeolaria caespitosa* that were distributed across the shore but were higher in abundance on the low shore. This made up a very small percentage of the total cover at both sites (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* sp.

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

Table 6.1 Abundance (percent cover) of macroalgae and aggregating sessile invertebrates at Ricketts Point and Halfmoon Bay in May 2004.

Species	Ricketts Point Marine Sanctuary	Halfmoon Bay Reference
Macrophytes		
Algal turf	6.96	7.36
Brown algal turf	0.08	
Enteromorpha sp.	2.40	2.08
Hormosira banksii	16.72	
Ulva spp	0.40	0.32
Corallina officinalis		0.24
Sessile Invertebrates		
Galeolaria caespitosa	2.24	11.84
Other		
Symploca	2.96	
Unidentified lichen	0.48	

6.3 Invertebrates

At Ricketts Point the mobile invertebrate community had low species diversity. The herbivorous gastropod *Austrocochlea porcata* was the only species at the site that was highly abundant and was distributed relatively evenly along and down the shore (Table 6.2). *Bembicium nanum* was present in low densities on small sections of the high to mid shore region.

Two carnivorous gastropods were in low densities on the shore: *Cominella lineolata* and *Lepsiella vinosa*.

In contrast to Ricketts Point, there was a high abundance and species diversity of mobile invertebrates at Halfmoon Bay. The most abundant species were *Austrocochela porcata* and the limpet *Cellana tramoserica* which were distributed across the platform.

Other herbivorous gastropods including *Bembicium melanostomum*, *Bembicium nanum*, *Nerita atramentosa, Notoacmea mayi* and *Patelloida alticostata* had a moderate abundance. The distribution of these species tended to be concentrated in small areas across the platform. A very high proportion of *B. nanum* were found in a single quadrat on the high shore.

The carnivorous gastropods *Lepsiella vinosa* and *Cominella lineolata* had a higher abundance at Halfmoon Bay than at Ricketts Point and were present in moderate and low densities respectively.

Other distinguishing features of the Halfmoon Bay site included the anemone *Aulactina veratra* and seastar *Patiriella calcar,* which were present in small rock pools on the seaward edge of the intertidal reef, as well as the air-breathing sea slug *Onchidella patelloides* and barnacles.

Table 6.2 Density of megafaunal invertebrates per 0.25 m^{-2} at Ricketts Point Marine Sanctuary and Halfmoon Bay in May 2004.

Species	Ricketts Point Marine Sanctuary	Halfmoon Bay Reference
Austrocochlea odontis	0.1	0.1
Austrocochlea porcata	13.7	9.4
Bembicium melanostomum	1.3	2.5
Bembicium nanum	0.2	3.6
Nerita atramentosa	0.0	2.0
Notoacmea mayi	0.0	2.4
Turbo undulatus	0.0	0.9
Cellana tramoserica	0.2	7.6
Patelloida alticostata	0.0	1.7
Siphonaria diamenensis	0.0	0.2
Barnacles	0.0	1.1
Unidentified chiton	0.0	0.1
Cominella lineolata	0.0	0.6
Lepsiella vinosa	0.3	2.0
Aulactinia veratra	0.0	0.4
Onchidella patelloides	0.0	0.4
Patiriella calcar	0.0	0.3

Size frequency data was compared for *Austrocochlea porcata* for the data from 2003 and 2004. At Ricketts Point the mean size rose from 14 mm to 18 mm (Figure 6.2). At Halfmoon Bay, a single size frequency mode was detected, of approximately 19 mm, suring the first survey. During the second survey, two size frequency modes were evident, with modes of approximately 12 mm and 18 mm (Figure 6.2).

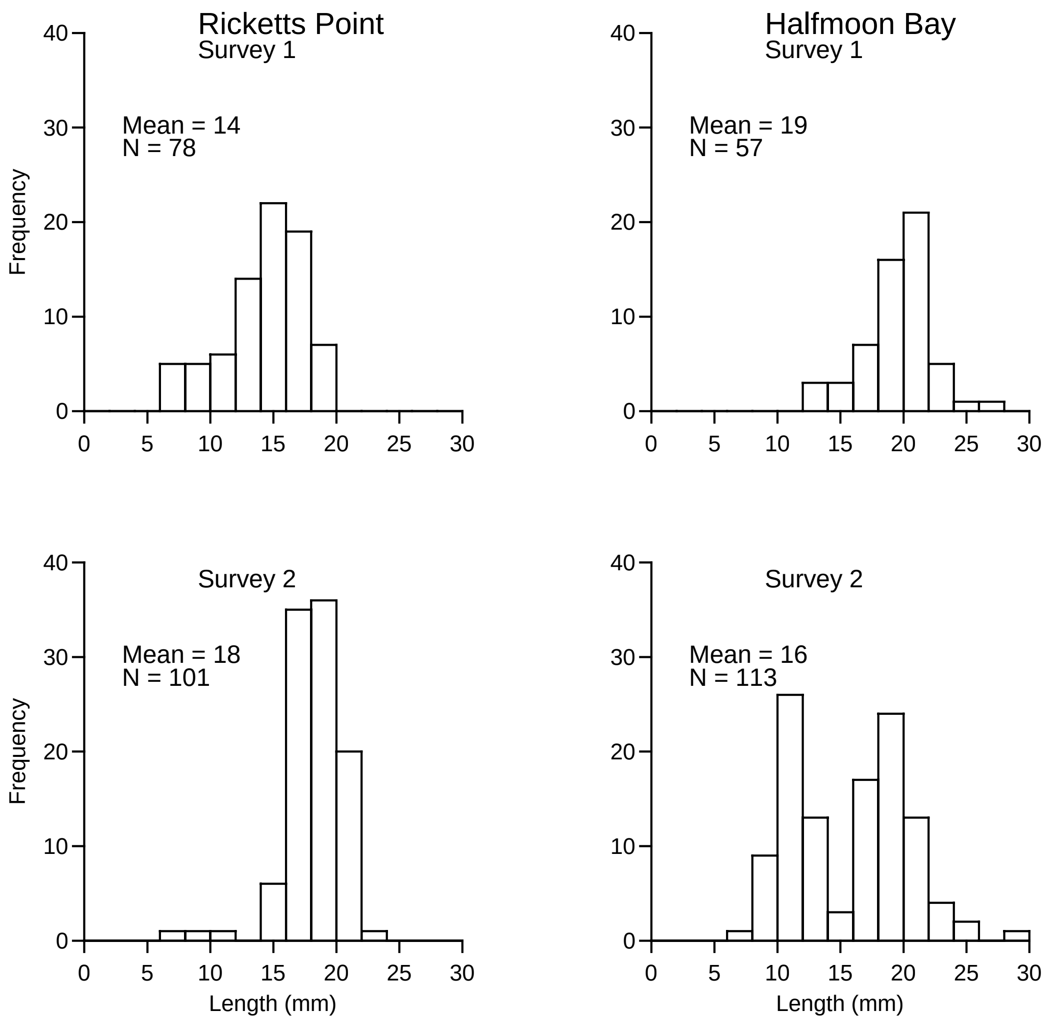


Figure 6.2 Size frequency histograms of *Austrocochlea porcata* for Survey 1 (2003) and Survey 2 (2004) at Ricketts Point and Halfmoon Bay.

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