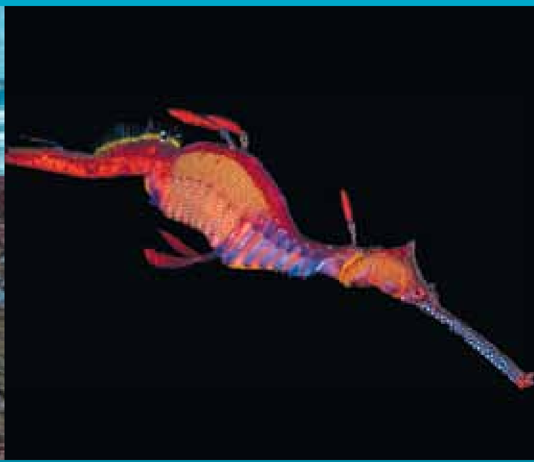

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Victorian Subtidal Reef Monitoring Program: The Reef Biota in the Port Phillip Bay Marine Sanctuaries

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Abstract

Parks Victoria has a long-term Subtidal Reef Monitoring Program (SRMP) in Victoria. The primary objective of the SRMP is to provide information on the status of Victorian reef flora and fauna (macroalgae, macroinvertebrates and fish) and to monitor the nature and magnitude of trends in species populations and species diversity through time. Six sites were established in March-April 2003. There have been four surveys of these reefs; the first occurring in March-April 2003, the second in April 2004, the third in April 2005 and the most recent in April 2009. Summaries of the data are presented to examine spatial and temporal trends in assemblage structure, species diversity, population abundances and population size structures.

Keywords

Subtidal Reef Monitoring Program, SRMP, macroalgae, invertebrates, fish, subtidal reef, reef communities Point Cooke Marine Sanctuary, Ricketts Point Marine Sanctuary, Jawbone Marine Sanctuary, reference sites.

Citation

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Victorian Subtidal Reef Monitoring Program:

The Reef Biota in the Port Phillip Bay Marine Sanctuaries

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Kim Stewart
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Australian Marine Ecology Pty Ltd

July 2011

Executive Summary

Shallow reef habitats cover extensive areas along the Victorian coast and are dominated by seaweeds, mobile invertebrates and fishes. These reefs are known for their high biological complexity, species diversity and productivity. They also have significant economic value through commercial and recreational fishing, diving and other tourism activities. To effectively manage and conserve these important and biologically rich habitats, the Victorian Government has established a long-term Subtidal Reef Monitoring Program (SRMP). Over time the SRMP will provide information on the status of Victorian Reef Flora and Fauna and determine the nature and magnitude of trends in species populations and species diversity through time.

The Subtidal Reef Monitoring Program is established throughout Victoria for all relevant marine protected areas. This report describes the fourth (2009) survey of the Northern Port Phillip Bay sites associated with the Point Cooke, Jawbone and Ricketts Point Marine Sanctuaries.

The Subtidal Reef Monitoring Program uses standardised underwater visual census methods to survey algae, macroinvertebrates and fish. For northern Port Phillip Bay, the sites are in shallow water between 2 and 4 m deep. This report aims to:

- provide general descriptions of the biological communities and species populations at each monitoring site in April 2009;
- identify any unusual biological phenomena such as interesting communities and species;
- describe ecologically significant temporal changes in comparison with reference areas; and
- identify any new introduced species, and any trends in existing introduced species populations, at the monitoring locations.

The surveys were along a 200 m transect line. Each transect was surveyed for:

1. abundance and size structure of large fishes;
2. abundance of cryptic fishes and benthic invertebrates;
3. percentage cover of macroalgae; and
4. density of string kelp species.

There have been four surveys in the Port Phillip Bay Marine Sanctuaries over the past seven years: March-April 2003; April 2004; April 2005; and April 2009.

Point Cooke Marine Sanctuary

Marine Sanctuary – Point Cook Pines

Marked increase in *Caulerpa remotifolia* coverage and absence of *Ecklonia radiata*. The introduced Japanese Wakame *Undaria pinnatifida* was formally observed for the first time at Point Cooke. Abalone *Haliotis rubra* abundances decreased and the median size changed from 84-89 to 63 mm length. The abundance of Eleven-armed Seastars *Coscinasterias muricata* increased.

Reference – RAAF Base

Latest survey: 24 April 2009. Loss of all thallose seaweeds with development of sea urchin barrens. Increased coverage of encrusting coralline algae. Very high abundances of sea urchin *Heliocidaris erythrogramma*. Although not measured, there was an apparent increase in abundance of sponge colonies. Notable increases in abundance of seastars *Coscinasterias muricata* and *Uniophora granifera*. Very high abundances of Southern Hula fish *Trachinops caudimaculatus*.

Jawbone Marine Sanctuary

Marine Sanctuary - Jawbone

The introduced Japanese Wakame *Undaria pinnatifida* was formally observed at Jawbone for the first time. Higher abundances of *Ecklonia radiata* maintained from previous survey and increased cover of encrusting coralline algae. Large increase in density of sea urchin *Heliocidaris erythrogramma*.

Reference – Point Gellibrand

No obvious temporal changes were found within Point Gellibrand during the latest survey. It was noted filamentous browns (Ectocarpales) were not observed at the site after the initial 2003 survey. Large increase in density of sea urchin *Heliocidaris erythrogramma*.

Ricketts Point Marine Sanctuary

Marine Sanctuary – Ricketts Point Teahouse

Declines in the coverage of green algae *Caulerpa* species. Relatively large increase in cover of brown algae *Sargassum spinuligerum*, from 4 to 22 % cover. Decline in median abalone length of approximately 10 mm. Increases in sea urchin *Heliocidaris erythrogramma* density, but not above density observed during the first, 2003 survey.

Reference – Halfmoon Bay

Declines in the coverage of green algae *Caulerpa* species. Decline in median abalone length of approximately 10 mm. Large increase in sea urchin *Heliocidaris erythrogramma* density and moderate increases in seastars *Coscinasterias muricata* and *Tosia australis*.

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1 Introduction

1.1 SUBTIDAL REEF ECOSYSTEMS OF NORTHERN PORT PHILLIP BAY

Rocky reefs in Port Phillip Bay are generally restricted to the near-shore regions of headlands and points. Reefs in the northwest of the bay, along the Geelong Arm, are predominantly near Point Lillias, Point Wilson and Kirks Point. These reefs occur in short coastal strips from the intertidal zone to 2-4 m depth, bounded by bare sediment and seagrass habitats a short distance from shore (10s of metres). Occasional small patches of reef, 10-50 m across, are present further offshore, particularly between Point Wilson and Kirks Point. These patch reefs are mostly 1-3 m deep.

Along the northern shore of the bay, small patches of shallow reef, interspersed by silty sands, are also present in the vicinity of Point Cooke, Western Beach (north of Point Cooke), Altona, Jawbone (Williamstown Rifle Range), Point Gellibrand and Point Ormond. These reefs are generally no deeper than 4 m. More extensive reef habitat is present from Sandringham to Ricketts Point, extending 50-100 m from the shore and to a depth of approximately 6 m.

In general, the reefs on the north shore of the bay are quite sheltered from the prevailing northwesterly to southwesterly weather and are not subject to large waves, strong currents or swell. Reefs on the northeastern side of the bay, particularly between Halfmoon Bay and Ricketts Point, are exposed to the prevailing westerly weather across a relatively long fetch of water. Consequently, these reefs are occasionally subject to turbulent wind-driven waves. These northeastern reefs are also influenced, to some extent, by the Yarra River plume and east-coast drainages.

Reef habitats in the north of Port Phillip Bay are different from the predominant reef habitats in Victoria, which occur on exposed open coasts. The recent, prolonged drought has meant reduced freshwater input into Port Phillip Bay and, as a result, much of the bay has been hyper-saline for several years. The northern bay reefs are in estuarine conditions and are subject, at times, to lower salinities from coastal runoff, rivers and drains, as well as considerable temperature ranges (as low as 8° C in winter and as high as 23° C in summer). These reefs are also frequently subject to turbid conditions from phytoplankton blooms and disturbance of moderate to fine sediments. While there are similar species inhabiting both sheltered reefs in the north of the bay and reefs on more exposed coasts, there are substantial and important differences in community structure between the bay and open coast reef environments. Seaweeds are the predominant biological habitat providers in both locations however the importance of large canopy forming species such as crayweed

Phyllospora comosa and common kelp *Ecklonia radiata* is much reduced on reefs in the bay. Smaller species of brown algae (10–30 cm high), such as *Sargassum* spp., *Dictyota dichotoma* and Caulerpa green algae are often the dominant habitat providers on reefs in the bay (Figure 1.1). Species of *Caulerpa* can form large patches of mixed-species assemblages, creating meadow-like habitat in some locations. Grazed algal turfs and hard encrusting layers of coralline algae are also important species growing directly over the rocky substratum. The introduced Japanese Wakame seaweed *Undaria pinnatifida* has been present in northern Port Phillip Bay since the early 1990's and has been spreading ever since.

Mobile invertebrates are prominent animal inhabitants of the reef (Figure 1.2). Large grazing species such as the urchin *Heliocidaris erythrogramma* and blacklip abalone *Haliotis rubra* can occur in very high densities and are productive components of the bay's reef communities. These species can significantly influence the growth and survival of habitat forming algal species and so are important habitat modifiers of reef communities. Important predatory invertebrates include octopus such as *Octopus berrima* and seastars including *Coscinasterias muricata* and *Uniophora granifera.* Predatory gastropod molluscs (shellfish) include the dogwhelk *Dicathais orbita* and *Pleuroploca australasia*.

Filter feeding species feed on phytoplankton and detritus and can be important for transferring nutrients and energy from the water column to other species directly inhabiting reefs. Filter feeding species on reefs in the north of the bay include aggregations of mussels *Mytilus galloprovincialis*, ascidians such as *Herdmania momus* sponges and the introduced European Fanworm *Sabella spallanzanii*. Other filter feeders are colonial species including sponges, bryozoans, the soft corals *Erythropodium hicksoni* and the stony coral *Plesiastrea versipora.*

Fish are usually dominant components of reef ecosystems both in terms of biomass and ecological function (Figure 1.3). Reef fish assemblages include predators such as snapper *Pagrus auratus*, omnivores including Zebrafish *Girella zebra*, planktivores such as the Southern Hulafish *Trachinops caudimaculatus* and picker-feeders such as Horseshoe Leatherjacket *Meuschenia hippocrepis*. Schools of small baitfish, particularly Tommy Rough, sardines, pilchards and sprats are common over reef habitats in the north of the bay. The reef communities in the north and east of the bay provide important habitat for juveniles of many fish species including snapper *Pagrus auratus.* Many fish species play a substantial ecological role in the functioning and structuring of reef ecosystems. Reef fish assemblages in the north of Port Phillip Bay are different to those in exposed coastal waters, which tend to have higher abundances of wrasses (labrids), cales (odacids) and leatherjackets (monocanthids).

Although shallow reef ecosystems in Victoria are dominated, in terms of biomass and production, by seaweeds, mobile invertebrates and fishes, there are many other important biological components to the reef ecosystem. These include small species of crustaceans and molluscs from 0.1 to 10 mm in size (mesoinvertebrates), occupying various niches as grazers, predators and detritivores. At the microscopic level, films of microalgae, fungi and bacteria on the reef surface are also important.

Victoria’s shallow reefs are a very important component of the marine environment because of their high biological complexity, species diversity and productivity. Subtidal reef habitats have important social and cultural values, which incorporate aesthetic, recreational, commercial and historical aspects. Shallow subtidal reefs also have significant economic value, through commercial fishing of reef species such as abalone and sea urchins, as well as recreational fishing, diving and other tourism activities. Reefs in the north of Port Phillip Bay are highly accessible components of the marine environment because of their proximity to the large population centres of Melbourne and surrounding suburbs. Consequently, these reef ecosystems are subject to particular pressures arising from urban human activities.

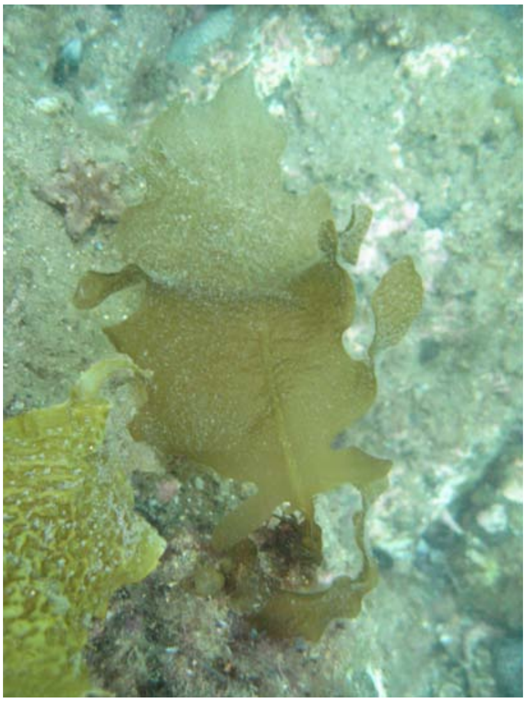
a. *Ulva* sp, Point Cooke.

b. *Caulerpa remotifolia*, Ricketts Point.

c. *Sargassum* sp and Green Stone Coral *Plesiastrea versipora*, Pt Gellibrand.

d. *Caulerpa longifolia*, Point Cooke.

e. Common kelp *Ecklonia radiata*, Point Cooke.



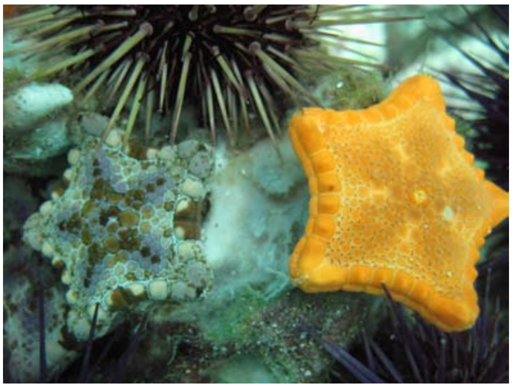
f. Juvenile introduced Japanese wakame seaweed *Undaria pinnatifida*, Jawbone MS.

Figure 1.1. Examples of macroalgae and sessile invertebrates present on subtidal reefs in northern Port Phillip Bay.

a. Eleven-armed Seastar *Coscinasterias muricata*, on yellow hyphae sponge, RAAF Base.

b. Nudibranch *Ceratosoma brevicaudatum*, RAAF Base.

c. Feather Worm *Sabellastarte australiensis*, Point Gellibrand.



d. Biscuit Star *Tosia australis* with sea urchin *Heliocidaris erythrogramma*, RAAF Base.

e. Black lip abalone *Haliotis rubra*, RAAF Base.

f. Sea urchin *Heliocidaris erythrogramma*, Pt Gellibrand.

Figure 1.2. Examples of invertebrate species present on subtidal reefs in northern Port Phillip Bay.

a. Southern Hulafish *Trachinops caudimaculatus*. RAAF Base.

b. Globefish *Diodon nichthemerus*.

c. Banjo Ray *Trygonorrhina fasciata*, Ricketts Pt.

d. Smooth Toadfish *Tetractenos glaber*, Ricketts Pt.

Figure 1.3. Examples of fish species present on subtidal reefs in northern Port Phillip Bay.

1.2 SUBTIDAL REEF MONITORING PROGRAM

1.2.1 Objectives

An important aspect of 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 is important to manage any threats or pressures on the environment to ensure ecosystem sustainability.

Consequently, the Victorian Government has established a long-term Subtidal Reef Monitoring Program (SRMP). The primary objective of the SRMP is to provide information on the status of Victorian reef flora and fauna (focussing on macroalgae, macroinvertebrates and fish). This includes monitoring the nature and magnitude of trends in species abundances, species diversity and community structure. This is achieved through regular surveys at locations throughout Victoria, encompassing both representative and unique habitats and communities.

Information from the SRMP allows managers to better understand and interpret long-term changes in the population and community dynamics of Victoria's reef flora and fauna. As a longer time series of data is collected, the SRMP 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 reef areas (*e.g.* Edgar and Barrett 1997, 1999);
- determine associations between species and between species and environmental parameters (*e.g.* depth, exposure, reef topography) and assess how these associations vary through space and time (*e.g.* Edgar *et al.* 1997; Dayton *et al.* 1998; Edmunds *et al*. 2000);
- provide benchmarks for assessing the effectiveness of management actions, in accordance with international best practice for quality environmental management systems (Holling 1978; Meredith 1997); and
- determine 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 (*e.g.* Ebeling *et al.* 1985; Edgar 1998; Roob *et al.* 2000; Sweatman *et al.* 2003).

A monitoring survey provides an estimate of population abundance and community structure at a small window in time. Patterns seen in data from periodic surveys are a function of: actual patterns in the environment; coincidences in timing of the survey periods and actual event cycles; and measurement variability (including natural day-to-day variability). Plots of changes over time may not necessarily match the changes in real populations because changes over shorter time periods and actual minima and maxima may not be adequately sampled (e.g. Figure 1.4). Sources of environmental variation can operate at the scale of months (*e.g.* seasonal variation, harvesting), years (*e.g.* el Niño), decades (*e.g.* pollution, extreme storm events) or even centuries (*e.g.* tsunamis, 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). The results of this monitoring need to be interpreted within the context of the monitoring frequency and duration.

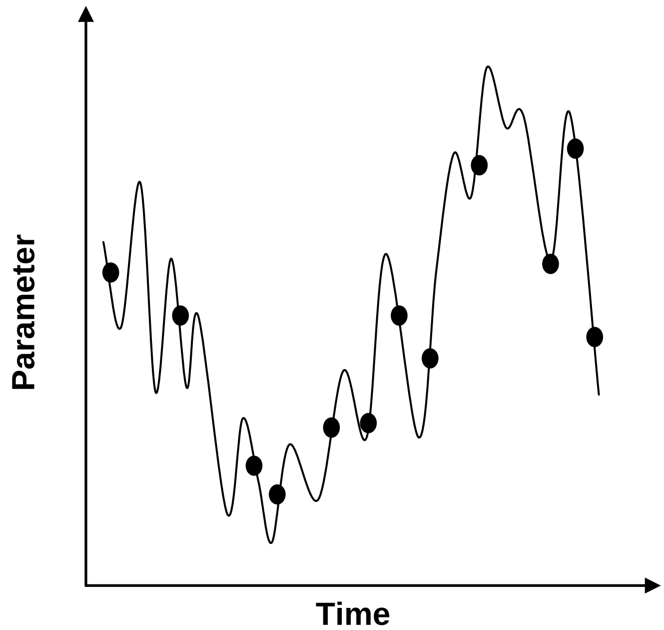


Figure 1.4. An example plot depicting change in an environmental, population or community variable over time (days, months or years) and potential patterns from isolated observations.

1.2.2 Monitoring Protocols and Locations

The SRMP uses standardised underwater visual census methods based on an approach developed and applied in Tasmania by Edgar and Barrett (1997). Details of standard operational procedures and quality control protocols for Victoria's SRMP are described in Edmunds and Hart (2003).

The SRMP was initiated in May 1998 in the vicinity of Port Phillip Heads Marine National Park. In 1999 the SRMP was expanded to reefs in the vicinity of the Bunurong Marine National Park, Phillip Island, and Wilsons Promontory Marine National Park.

In 2003 and 2004, the Subtidal Reef Monitoring Program was expanded to include Marine National Parks and Marine Sanctuaries throughout Victoria.

1.2.3 Monitoring in Port Phillip Bay Marine Sanctuaries

This report describes the Subtidal Reef Monitoring Program in northern Port Phillip Bay and the results of the four surveys, incorporating marine sanctuaries at Point Cooke, Jawbone and Ricketts Point. The objectives of this report were to:

1. provide an overview of the methods used for the SRMP;
2. provide general descriptions of the biological communities and species populations at each monitoring site in April 2009
3. describe changes and trends that have occurred over the monitoring period;
4. identify any unusual biological phenomena such as interesting or unique communities or species; and
5. identify any new introduced species, and any trends in existing introduced species populations, at the monitoring locations.

2 Methods

2.1 SITE SELECTION AND SURVEY TIMES

There are three Marine Sanctuaries in northern Port Phillip Bay: Point Cooke; Jawbone; and Ricketts Point. In March-April 2003 a pair of monitoring sites were established at each marine sanctuary, one site located within the marine sanctuary and one site located outside the marine sanctuary (Figure 2.1; Table 2.1).

Sanctuary monitoring sites were located on representative subtidal reef habitat within each marine sanctuary, with reference sites located on similar habitat nearby. A description of the monitoring sites is given in the following sections for each marine sanctuary.

Surveys on the northern Port Phillip Bay reefs were:

1. March-April 2003;
2. April 2004;
3. April 2005;
4. April 2009 (Table 2.2).

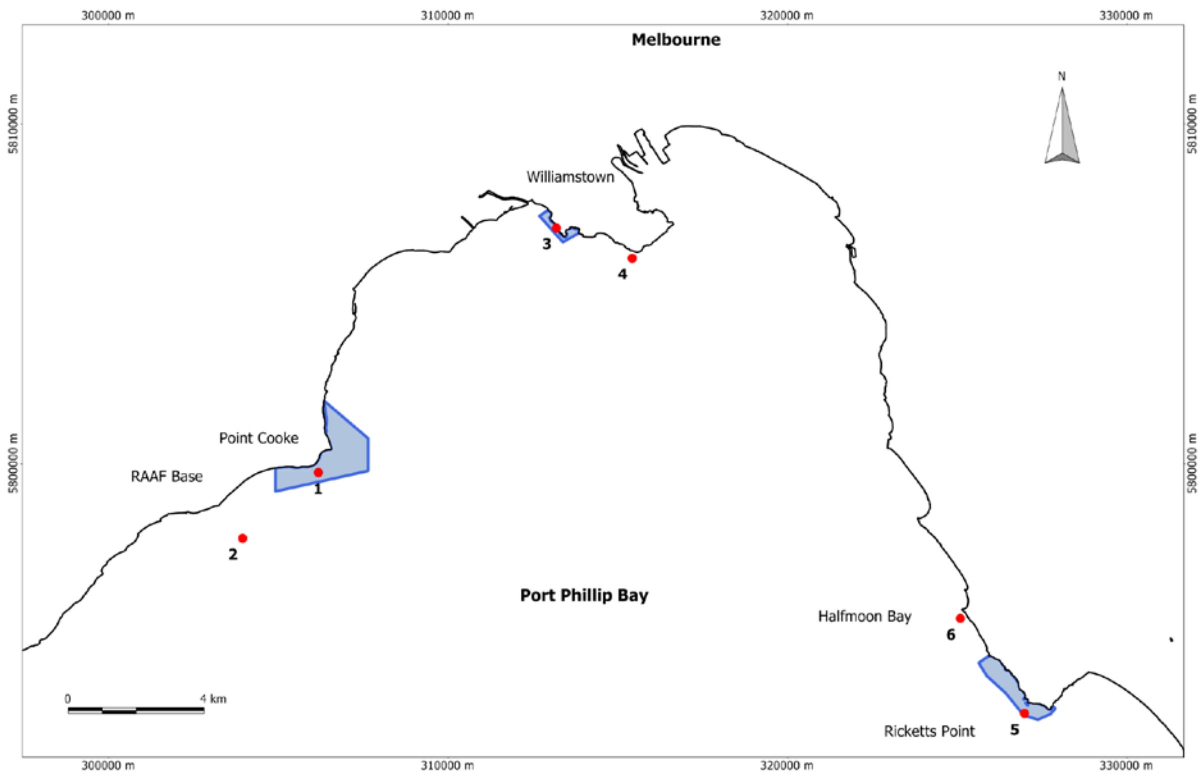


Figure 2.1. Location of monitoring sites in northern Port Phillip Bay. Marine Sanctuaries are indicated in blue.

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

Site No.	Site Name	Sanctuary/Reference	Depth (m)
Point Cooke Marine Sanctuary			
4101	Point Cooke	Sanctuary	3
4102	RAAF Base	Reference	4
Jawbone Marine Sanctuary			
4103	Jawbone	Sanctuary	3
4104	Point Gellibrand	Reference	2
Ricketts Point Marine Sanctuary			
4105	Ricketts Point	Sanctuary	3
4106	Halfmoon Bay	Reference	3

Table 2.2. Subtidal reef monitoring survey dates in northern Port Phillip Bay

Survey	Date	Sites
1	27 March 2003	4101, 4102, 4103, 4104
	01 April 2003	4105, 4106
2	27 April 2004	4105, 4106
	29 April 2004	4101, 4102
	30 April 2004	4103, 4104
3	21 April 2005	4104, 4105, 4106
	22 April 2005	4101, 4102, 4103
4	23 April 2009	4104, 4105, 4106
	24 April 2009	4101, 4102, 4103

2.2 CENSUS METHOD

2.2.1 Transect Layout

The visual census methods of Edgar and Barrett (Edgar and Barrett 1997, 1999; Edgar *et al.* 1997) are used for this monitoring program. These are non-destructive and provide quantitative data on a large number of species and the structure of the reef communities. The Edgar-Barrett method is also used in Tasmania, New South Wales, South Australia and Western Australia. The adoption of this method in Victoria provides a systematic and comparable approach to monitoring reefs in southern Australia. The surveys in Victoria are in accordance with a standard operational procedure to ensure long-term integrity and quality of the data (Edmunds and Hart 2003).

At most monitoring locations in Victoria, surveying along the 5 m depth contour is considered optimal because diving times are not limited by decompression schedules and these reefs are of interest to natural resource managers. However, the actual depth that can be surveyed varies with reef extent, geomorphology and exposure. Monitoring sites along the western coast of Victoria are between 3 and 8 m deep.

Each site is located using differential GPS and marked with a buoy or the boat anchor. A 100 m numbered and weighted transect line is run along the appropriate depth contour either side of the central marker. The resulting 200 m of line is divided into four contiguous 50 m sections (T1 to T4). The orientation of transect is the same for each survey, with T1 generally toward the north or east (*i.e.* anticlockwise along the coast).

For each transect, three different census methods were used to obtain adequate descriptive information on reef communities at different spatial scales. These involved the census of: (1) the abundance and size structure of large fishes; (2) the abundance of cryptic fishes and benthic invertebrates; and (3) the percent cover of macroalgae and sessile invertebrates. Where present, the density of string kelp *Macrocystis angustifolia* is also estimated. One hundred and fifty nine species were observed during the monitoring program in northern Port Phillip Bay (Tables 2.3-2.5). The depth, horizontal visibility, sea state and cloud cover are recorded for each site. Horizontal visibility is gauged by the distance along the transect line to detect a 100 mm long fish. All field observations are recorded on underwater paper.

2.2.2 Method 1 – Mobile Fishes and Cephalopods

The densities of mobile large fishes and cephalopods are estimated by a diver swimming up one side of a 50 m section of the transect and then back along the other. The diver records the number and estimated size-class of fish within 5 m of each side of the line (Figure 2.2). The size-classes for fish are 25, 50, 75, 100, 125, 150, 200, 250, 300, 350, 375, 400, 500, 625, 750, 875 and 1000+ mm. Each diver has size-marks on their underwater slate to enable calibration of their size estimates. A total of four 10 x 50 m sections of the 200 m transect are censused for mobile fish at each site. The data for easily sexed species are recorded separately for males and female/juveniles. Such species include the Blue-throated Wrasse *Notolabrus tetricus*, Herring Cale *Odax cyanomelas*, Barber Perch *Caesioperca rasor*, Rosy Wrasse *Pseudolabrus rubicundus* and some leatherjackets.

Table 2.3. Mobile fish surveyed in northern Port Phillip Bay using Method 1.

Method 1	Method 1	Method 1
Trygonorrhina fasciata	*Pempheris multiradiata*	*Heteroclinus perspicillatus*
Urolophus paucimaculatus	*Girella tricuspidata*	*Nesogobius* sp
Atherinason hepsetoides	*Girella zebra*	*Acanthaluteres vittiger*
Atherinid sp	*Scorpis aequipinnis*	*Brachaluteres jacksonianus*
Neosebastes scorpaenoides	*Tilodon sexfasciatus*	*Scobinichthys granulatus*
Platycephalus bassensis	*Enoplosus armatus*	*Meuschenia flavolineata*
Caesioperca rasor	*Parma victoriae*	*Meuschenia freycineti*
Trachinops caudimaculatus	*Cheilodactylus nigripes*	*Meuschenia hippocrepis*
Arripis trutta	*Dactylophora nigricans*	*Aracana ornata*
Acanthopagrus australis	*Notolabrus tetricus*	*Tetractenos glaber*
Pagrus auratus	*Neoodax balteatus*	*Diodon nichthemerus*
Upeneichthys vlaminghii	*Bovichtus angustifrons*	Unidentified Fish

2.2.3 Method 2 – Invertebrates and Cryptic Fishes

Cryptic fishes and mobile megafaunal invertebrates (*e.g.* large molluscs, echinoderms, crustaceans) are counted along the same transect lines used for the fish survey. A diver counts animals within 1 m of one side of the line (a total of four 1 x 50 m sections of the 200 m transect). A known arm span of the diver is used to standardise the 1 m distance. The maximum length of abalone is measured *in situ* using vernier callipers whenever possible. Selected specimens are photographed or collected for identification and preservation in a reference collection.

2.2.4 Method 3 – Macroalgae and Sessile Invertebrates

The area covered by macroalgal and sessile invertebrate species is quantified by placing a 0.25 m^2 quadrat at 10 m intervals along the transect line and determining the percent cover of the all plant species (Figure 2.3). The quadrat is divided into a grid of 7 x 7 perpendicular wires, giving 50 points (including one corner). Cover is estimated by counting the number of times each species occurs directly under the 50 positions on the quadrat (1.25 m^2 for each of the 50 m sections of the transect line). Selected specimens are photographed or collected for identification and preservation in a reference collection.

2.2.5 Method 4 – *Macrocystis*

Where present the density of *Macrocystis angustifolia* plants is estimated. While swimming along the 200 m transect line, a diver counts all observable plants within 5 m either side of the line, for each 10 m section of the transect (giving counts for 100 m^2 sections of the transect).

Table 2.4. Invertebrates and cryptic fish surveyed in northern Port Phillip Bay using Method 2.

(*****) introduced species.

Method 2	Method 2	Method 2
Mollusca	**Echinodermata**	**Polychaeta**
Plagusia chabrus	*Tosia australis*	*Sabella spallanzanii***
Haliotis rubra	*Tosia magnifica*	*Sabellastarte australiensis*
Diodora lineata	*Petricia vernicina*	
Dicathais orbita	*Plectaster decanus*	**Cryptic Fish**
Pterynotus triformis	*Meridiastra exigua*	*Urolophus paucimaculatus*
Pleuroploca australasia	*Meridiastra calcar*	*Urolophus gigas*
Cominella lineolata	*Meridiastra gunnii*	*Aetapcus maculatus*
Elysia sp	*Coscinasterias muricata*	*Vincentia conspersa*
Ceratosoma brevicaudatum	*Asterias amurensis***	*Pempheris multiradiata*
Ostrea angasi	*Uniophora granifera*	*Parma victoriae*
	Amblypneustes leucoglobus	*Bovichtus angustifrons*
	Amblypneustes spp.	*Parablennius tasmanianus*
Crustacea	*Heliocidaris erythrogramma*	*Trinorfolkia clarkei*
Strigopagurus strigimanus	*Stichopus mollis*	*Heteroclinus perspicillatus*
Pagurid unidentified		*Heteroclinus whiteleggei*
Austrodromidia octodentata		*Nesogobius* sp
Naxia aurita		*Brachaluteres jacksonianus*
Nectocarcinus tuberculosus		*Diodon nichthemerus*
Unidentified Crab		Unidentified Fish

Table 2.5. Macroalgae surveyed in northern Port Phillip Bay using Method 3.

(*) introduced species.

Method 3	Method 3	Method 3
Chlorophyta (green)	**Phaeophyta (brown)**	**Rhodophyta (red algae)**
Ulva spp	*Leathesia difformis*	*Encrusting corallines*
Cladophora prolifera	*Splachnidium rugosum*	*Solieria robusta*
Cladophora sp	*Dictyota dichotoma*	*Gigartina* sp
Caulerpa remotifolia	*Dilophus marginatus*	*Hypnea ramentacea*
Caulerpa longifolia	*Lobospira bicuspidata*	*Gracilaria cliftoni*
Caulerpa trifaria	*Padina* sp	*Plocamium angustum*
Caulerpa brownii	*Distromium flabellatum*	*Dictymenia harveyana*
Caulerpa flexilis	*Zonaria turneriana*	*Champia* sp
Caulerpa flexilis var. muelleri	*Colpomenia sinuosa*	*Ceramium* sp
Caulerpa geminata	*Colpomenia* sp	*Laurencia botryoides*
Caulerpa annulata	*Colpomenia peregrina*	*Laurencia filiformis*
Caulerpa simpliciuscula	*Ecklonia radiata*	*Laurencia tumida*
Codium lucasi	*Caulocystis cephalornithos*	*Laurencia* sp
Codium duthieae	*Acrocarpia paniculata*	*Echinothamnion hystrix*
Codium harveyi	*Cystophora moniliformis*	Other filamentous red algae
Codium spp	*Cystophora monilifera*	Other thallose red algae
	Cystophora retroflexa	
	Cystophora siliquosa	
	Cystophora subfarcinata	
	Sargassum decipiens	
	Sargassum fallax	
	Sargassum verruculosum	
	Sargassum linearifolium	
	Sargassum spinuligerum	
	Sargassum spp	
	*Undaria pinnatifida**	**Sessile Invertebrates**
Other	Filamentous browns	*Plesiastrea versipora*
Sand	Unidentified Brown algae	*Erythropodium hicksoni*

Figure 2.2. Biologist-diver recording field observations, Site 2, RAAF Base, 24 April 2009.

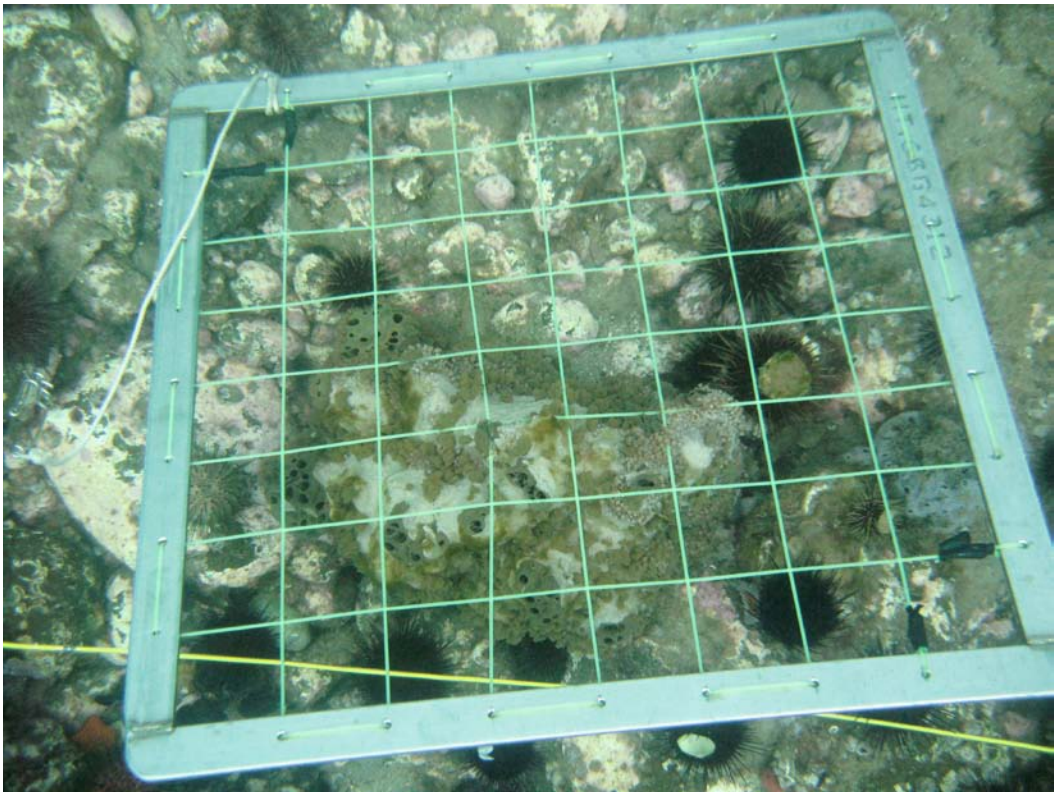


Figure 2.3. The cover of macrophytes is measured by the number of points intersecting each species on the quadrat grid.

2.3 DATA ANALYSIS

2.3.1 Community Structure

Community structure is a function of both the species present and the abundance of each species. The difference in community structure between pairs of samples was described 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 weight down the influence of highly abundant species in describing community structure, giving a more even weighting between abundant and rarer species (following count and points abundance transformations by Sweatman *et al.* 2000).

The Bray-Curtis Dissimilarity Index was calculated for all possible combinations of sites. This resulted in a matrix of pair-wise comparisons known as a dissimilarity matrix. The dissimilarity matrix is also termed a distance matrix as it effectively represents distances between samples in hyper-dimensional space. The dissimilarity matrix was used for all analyses of community structure in this study.

2.3.2 Depiction of Community Differences

The hyper-dimensional 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 the hyper-dimensional data (reduces the number of dimensions while depicting the salient relationships between the samples). 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 Kruskall 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. These guidelines are simplistic and increasing stress is correlated with increasing numbers of samples. Where high stress was encountered with a two-dimensional data set, three-dimensional solutions were sought to ensure an adequate representation of the higher-dimensional patterns.

2.3.3 Species Diversity

Species diversity involves the consideration of two components: species richness and heterogeneity. Species richness is the number of species present in the community while heterogeneity related to the distribution of abundances between species. 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 value describes species diversity as a combination of species richness (*i.e.* the number of species) and species evenness (*i.e*. the equitability of the abundances of the species). The value varies between 1 and *s* (*i.e.* the total number of species in the sample) with higher values indicating higher diversity. In general, Hills N_2 gives an indication of the number of dominant species within a community. Hills N_2 provides more weighting for common species, in contrast to indices such as the Shannon-Weiner Index (Krebs 1999), which weights the rarer species. The weighting of common species was considered more appropriate for this study because the sampling regime is designed to target the more common species.

2.3.5 Species Populations

The abundance of each species was summarised by calculating total counts of fish and invertebrates and total percentage cover of macroalgae, for each site. The population size structure for blacklip abalone *Haliotis rubra* was assessed by calculating median lengths and the inter-quartile range for each site and time.

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.

The reef habitats in the northern half of the bay are quite sheltered from the prevailing northwesterly to southwesterly weather and are not subject to large waves, strong currents or swell. With the prolonged period of drought, the waters of Port Phillip Bay have become hyper-saline. However, the northern reefs are in estuarine conditions and are subject to episodes of lower salinities from coastal runoff, rivers and drains (35-31 PSU). These reefs also experience considerable temperature ranges (as low as 8° C in winter and as high as 23° C in summer), as well as frequently turbid conditions from phytoplankton blooms, coastal discharges and disturbance of nearby fine sediments.

Reefs on the northeastern side of the bay, particularly between Halfmoon Bay and Ricketts Point, are exposed to the prevailing westerly weather across a relatively long fetch of water. Consequently, these reefs are occasionally subject to turbulent wind-driven waves. These northeastern reefs are also influenced, to some extent, by the Yarra River plume and east-coast drainages.

These environmental differences are reflected in the floral and faunal assemblages, with the subtidal reef biota of northern Port Phillip Bay being quite different to those of the coastal Central Victoria Bioregion Reefs (Edmunds *et al.* 2003a and 2003b). Analyses of the Parks Victoria monitoring data indicated the principal differences between these bioregions were:

- A lack of kelps and other large seaweeds on the northern reefs, having a higher predominance of smaller algae such as *Caulerpa* species, *Dictyota dichotoma* and *Ulva* sp;

- Higher abundances in the north of the sea urchin *Heliocidaris erythrogramma*, seastars *Meridiastra gunnii*, *M. calcar* and *Coscinasterias muricata* and the featherworm *Sabella spallanzanii* – the Heads region having higher abundances of the crinoid *Comanthus trichoptera*, warrener (periwinkle) *Turbo undulatus*, greenlip abalone *Haliotis laevigata* and seastars of the *Nectria* genus; and

- Higher abundances of Hulafish *Trachinops caudimaculatus*, Moonlighter *Tilodon sexfasciatus* and salmon *Arripis* sp in the north with a predominance of labrids (wrasses), *Odax* spp (cales) and monacanthids (leatherjackets) in the Heads region (Edmunds *et al.* 2003a and 2003b).

3.2 MACROALGAE

During the first three surveys the macroalgal community was distinct for each of the six sites and the interannual variability was generally smaller than the between-site variability (Figure 3.1). The largest changes in community structure occurred at all sites between 2005 and 2009. In particular, there was a marked change at the RAAF Base (Site 2), with a complete loss of thallose algal coverage. Changes at Point Gellibrand (Site 4) and Ricketts Point (Site 5) were also large compared with variations between previous surveys (Figure 3.1). The species abundances contributing to these changes are reported in the following sections.

Macroalgal species richness was relatively constant over time within the marine sanctuaries (Sites 1, 3, 5; Figure 3.2). Of these, Ricketts Point had double the species richness of Point Cooke and Jawbone. The reference sites had greater variability in species richness, with a sharp drop at RAAF Base (Site 2) to 2009 and a generally linear increasing trend at Halfmoon Bay (Site 6; Figure 3.2).

The western and northern sites generally had lower algal density than the eastern Halfmoon Bay and Ricketts Point sites (Sites 5 and 6; Figure 3.3). There was higher inter-survey variability at RAAF Base (Site 2) and diversity in 2009 was lowest recorded for all sites and times.

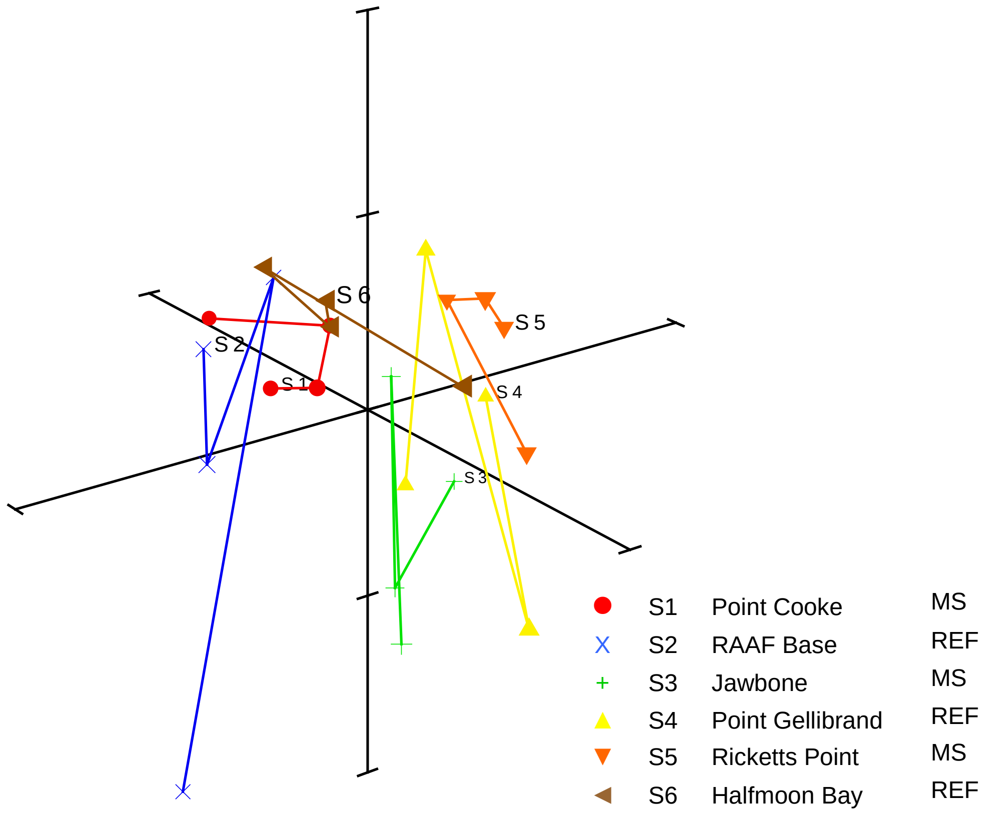


Figure 3.1. MDS plot of algal assemblage structure in northern Port Phillip Bay. Sites labels indicate the first survey time. Stress = 0.10.

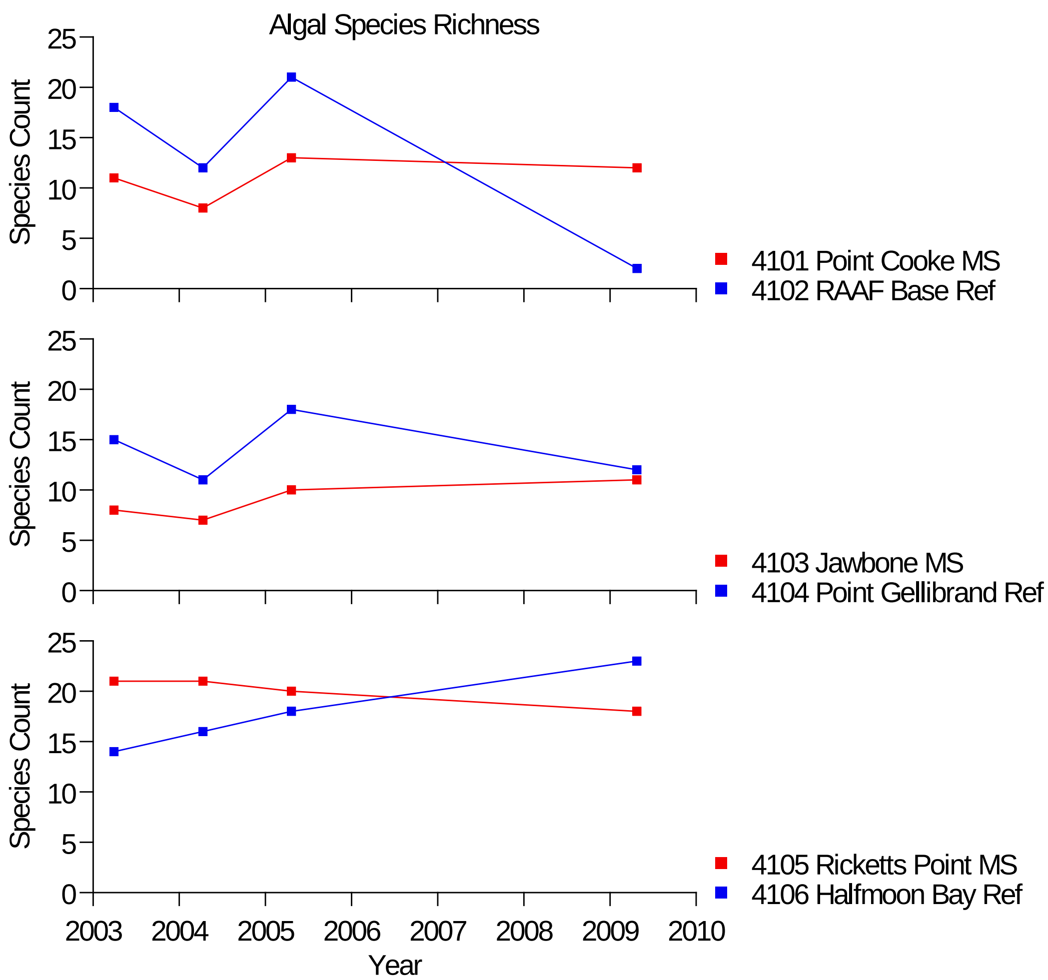


Figure 3.2. Time series of algal species richness (species count per site).

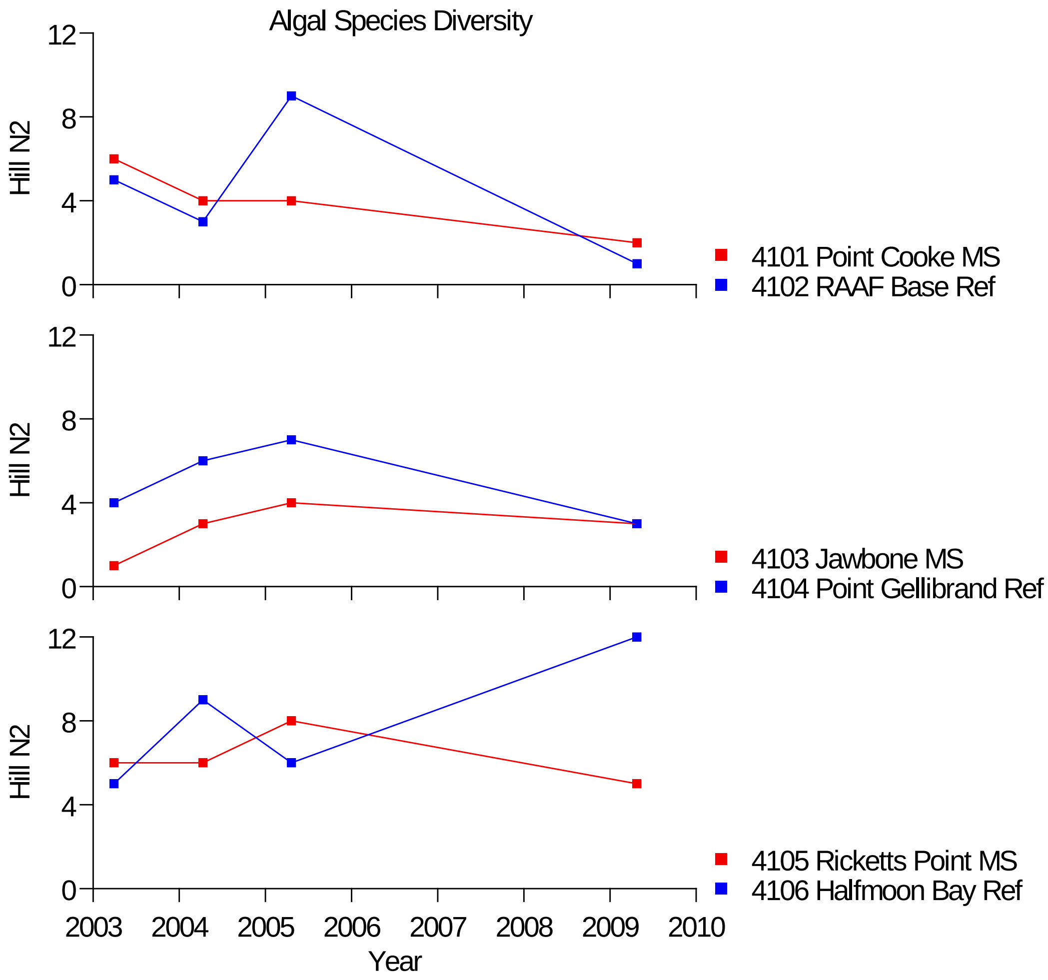


Figure 3.3. Time series of algal species diversity (Hill's N_2).

3.3 INVERTEBRATES

Within the north of the bay, the invertebrate assemblages were different between the northwest (Point Cooke), northern (Jawbone) and northeastern (Ricketts Point) regions of the Bay (Figure 3.4). The main differences between these regions were largely because of variations in the abundance of blacklip abalone *Haliotis rubra*, common sea urchin *Heliocidaris erythrogramma* and seastars *Meridiastra calcar* and *M. gunnii*.

The invertebrate assemblage structures were generally clustered into two types: those of the north and western sites (Sites 1 to 4) and those of the eastern shore (Sites 5 and 6; Figure 3.4). The pattern of differences between sites was generally maintained over time (Figure 3.4).

The species richness of the invertebrate assemblages was similar between sites and regions in northern Port Phillip Bay, although a higher species richness was observed at Point Cooke (Site 1) during the first survey (Figure 3.5). The diversity at most sites was relatively low because of a dominance of only two species: *Heliocidaris erythrogramma* and *Haliotis rubra* (Figure 3.6). The invertebrate species diversity was slightly higher at Point Cooke (Site 1) and initially at Jawbone (Site 3), however the diversity at Jawbone during the latest survey was considerably lower (Figure 3.6).

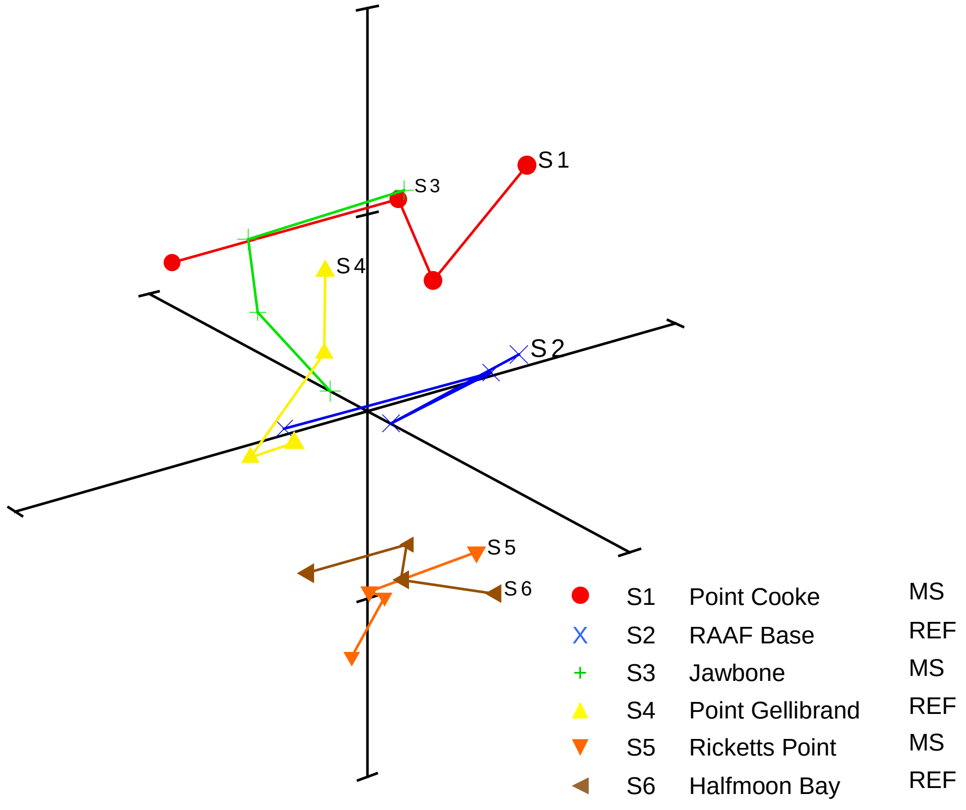


Figure 3.4. MDS plot of invertebrate assemblage structure in northern Port Phillip Bay. Sites labels indicate the first survey time. Stress = 0.09.

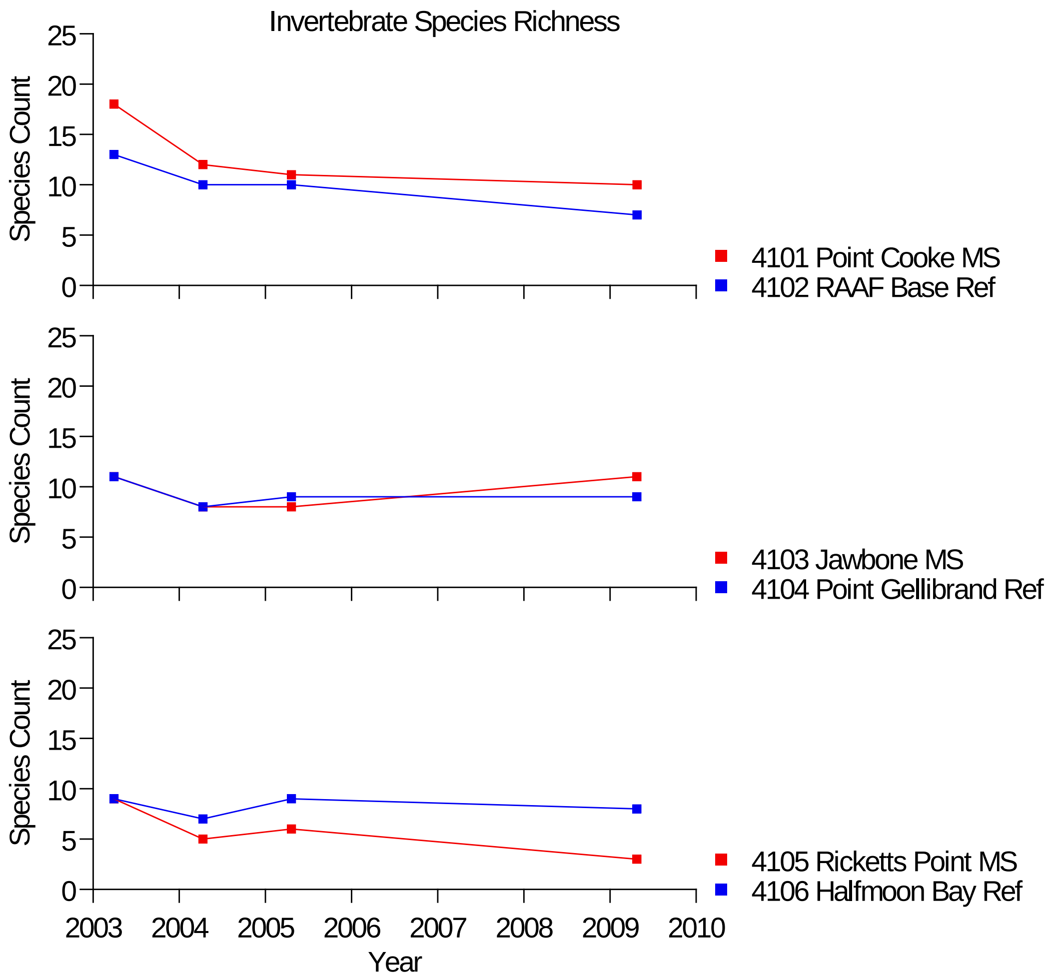


Figure 3.5. Time series of invertebrate species richness (species count per site).

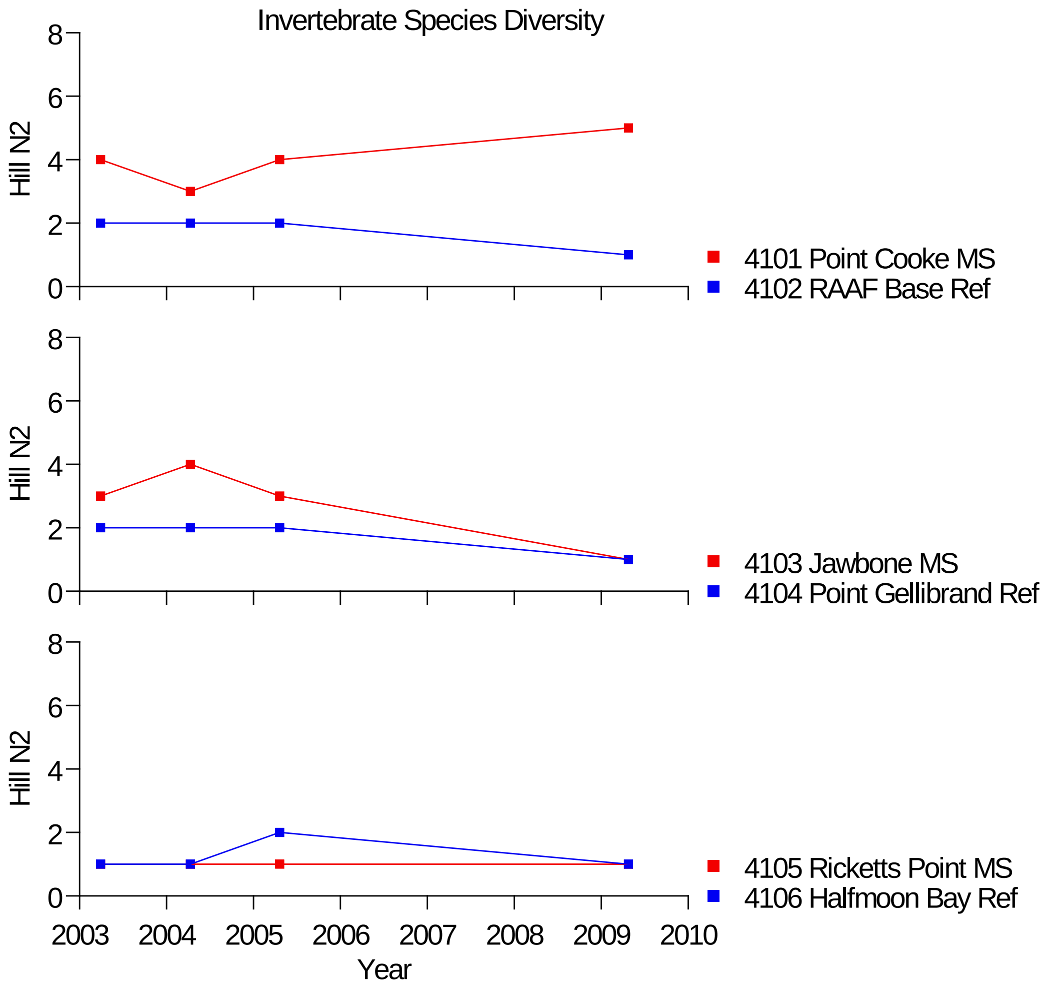


Figure 3.6. Time series of invertebrate species diversity (Hill's N_2).

3.4 FISHES

Most fish species were very low in density, apart from one or two species in high abundances that dominated the community structure: Little Rock Whiting *Neoodax balteatus* and Southern Hulafish *Trachinops caudimaculatus*. The Southern Hulafish *Trachinops caudimaculatus* was the most abundant species, but was highly variable in abundances between times within sites, making it difficult to make regional comparisons in assemblage structure. The high variability in the two dominant species contributed to the high relative variation assemblage structure between times (Figure 3.7). Nevertheless, there were distinctive assemblages maintained through time, these being for: Ricketts Point and Halfmoon Bay (Sites 5 and 6); RAAF Base (Site 2); and Point Cooke and Jawbone (Sites 1 and 3; Figure 3.7).

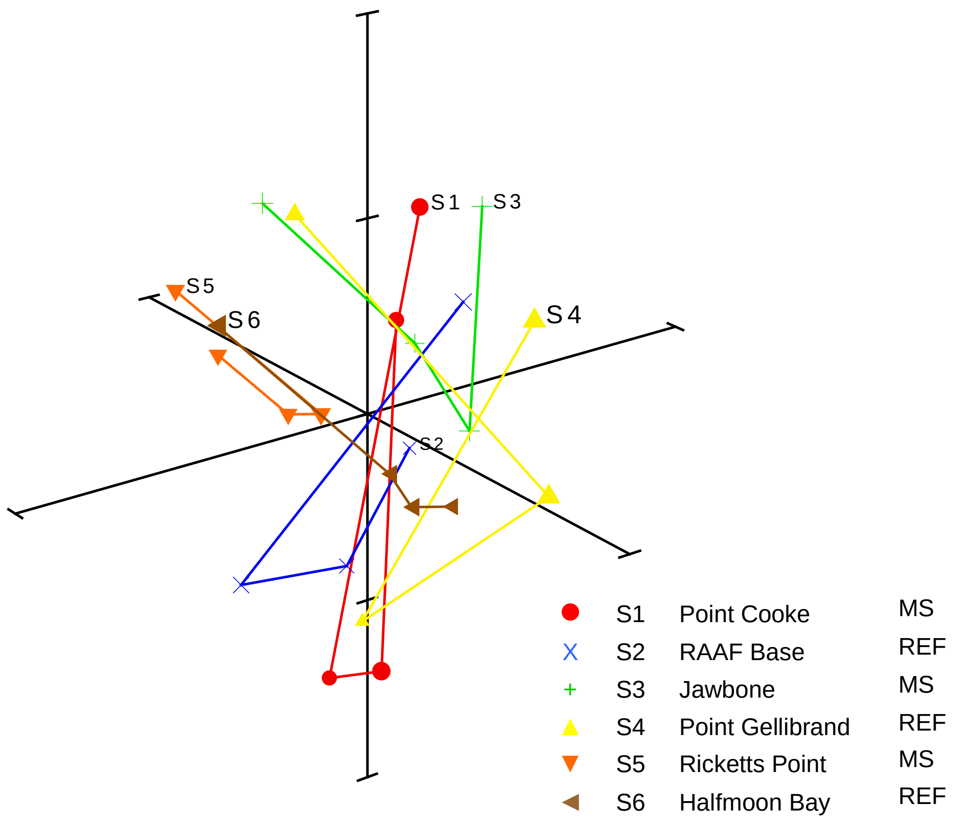


Figure 3.7. MDS plot of fishes assemblage structure in northern Port Phillip Bay. Sites labels indicate the first survey time. Stress = 0.12.

The species richness was relatively similar between sites for much of the time, however there was initially much higher richness observed during the first survey at Ricketts Point and Halfmoon Bay (Sites 5 and 6; Figure 3.8). The high dominance in abundance of *Trachinops caudimaculatus* was reflected in the diversity statistics, with all sites having low fish species diversity (Figure 3.9). There was little temporal variation in fish diversity for most sites except

RAAF Base (Site 2). At this site, there was considerable variation between surveys with the lowest recorded diversity during the latest survey (Figure 3.9).

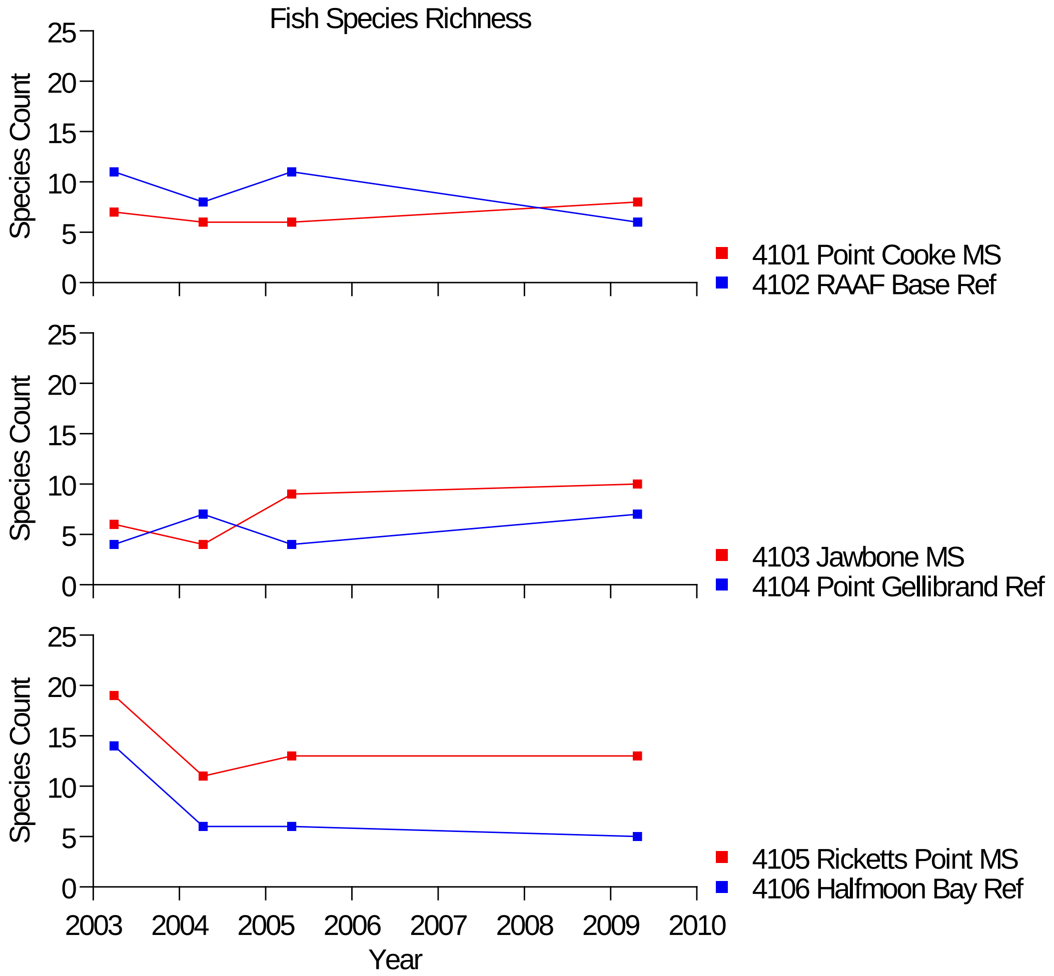


Figure 3.8. Time series of fish species richness (species count per site).

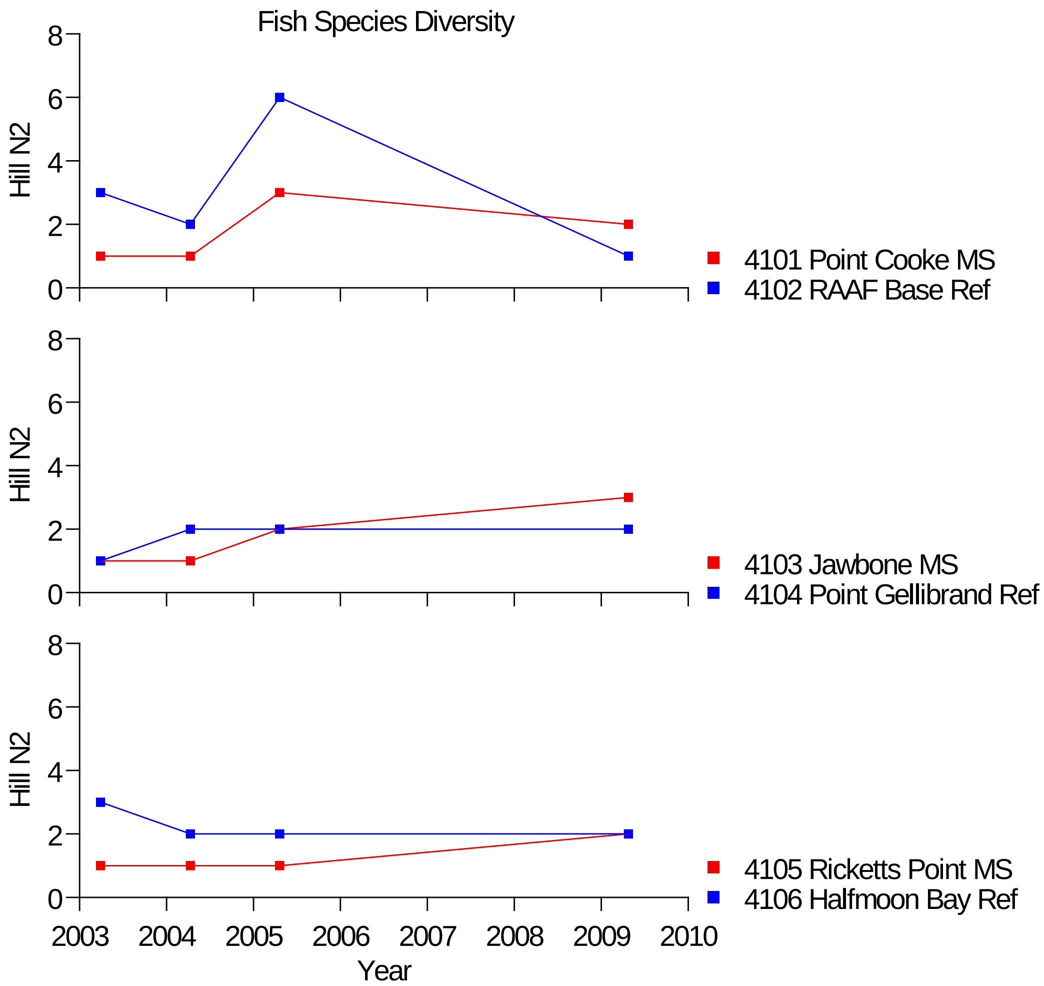


Figure 3.9. Time series of fish species diversity (Hill's N_2).

4 Point Cooke Marine Sanctuary

4.1 MONITORING SITES

Point Cooke Marine Sanctuary is close to Werribee on the northwestern shore of the bay. The subtidal reef at Point Cooke consists of low-relief, textured basalt reef interspersed with patches of sand and mud. The Point Cooke monitoring site (Site 1) was positioned along the 3-4 m isobath over the reef and patches of sand (Figure 4.1).

A reference monitoring site was located offshore from the RAAF Base at Laverton (RAAF Base; Site 4102), approximately 3 km southwest of Point Cooke Marine Sanctuary. The reef at RAAF Base is similar in structure to Point Cooke but differs substantially in the vegetation present (Figures 4.2 and 4.3). The RAAF Base monitoring site is at 3-4 m depth.

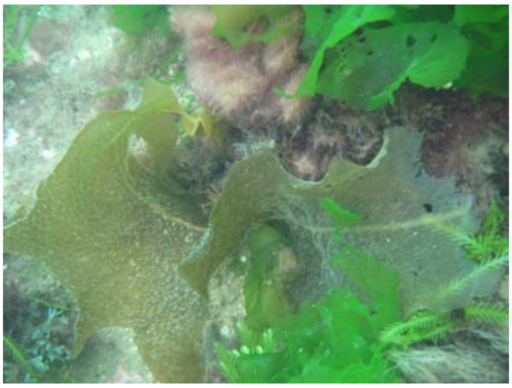
4.2 MACROALGAE

The reef at Point Cooke (Site 1) was patchy and interspersed with large areas of sediment. This was reflected in the patchy distribution and cover of algae at this site. The dominant species was initially common kelp *Ecklonia radiata*, with approximately 10 % cover for the first three surveys at Point Cooke. *Ecklonia radiata* was absent during the latest survey in 2009 (Figure 4.4a). The carpeting green alga *Caulerpa remotifolia* increased substantially in cover between each successive survey, from 2 % cover in 2003 to 48 % cover in 2009 (Figure 4.4c). There was a corresponding decline in cover of encrusting coralline algae. Other common species, but with cover generally less than 5 %, included sea lettuce *Ulva* sp., brown algae *Dilophus marginatus* and *Dictyota dichotoma* and thallose red algae such as *Gigartina* sp.

The introduced Japanese Wakame *Undaria pinnatifida* was formally observed for the first time at Point Cooke during the latest survey in April 2009. Most of the individuals observed were small juveniles 70-400 mm in length (Stages I and II). The coverage was only 1.6 %.

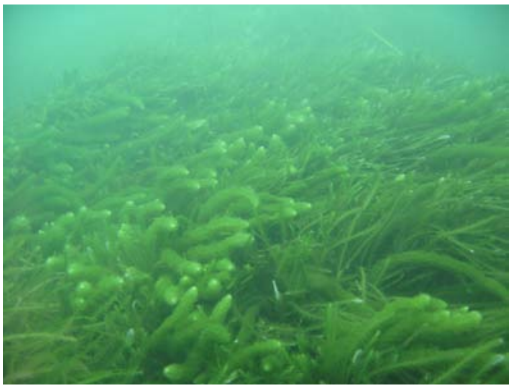
Undaria pinnatifida has infested reefs along the northern shore of Geelong Arm and on the piers and structures of Hobsons Bay for some time and colonisation of reefs in northern Port Phillip Bay was to be expected. This kelp has distinct alteration of generation life phases, with the macroscopic sporophyte stage occurring from late May/June through to early/mid summer, when senescence occurs. Few macroscopic plants are usually present from late summer to late spring, the population being present as microscopic gametophyte plants. The SRMP surveys have always been during autumn and therefore were not expected to provide information on the colonisation of *Undaria*. The observed early presence at Point Cooke indicates the establishment of populations of the microscopic gametophyte stage and considerable growth and canopy formation may occur in the latter half of 2009.

a. Southern Golfball Sponge *Tethya bergquistae.*

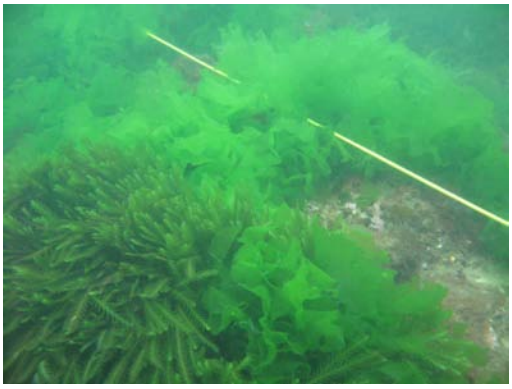


b. Japanese Kelp *Undaria pinnatifida*.

c. Orange Sponge.



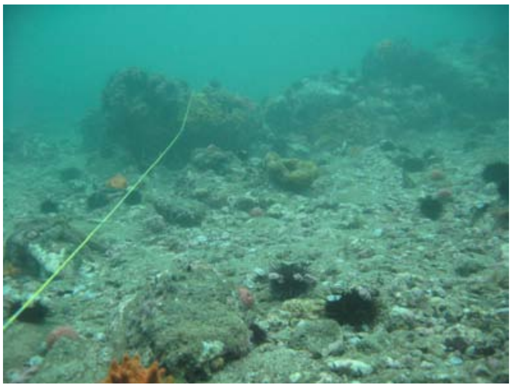
d. Green algae *Caulerpa longifolia* and *C. remotifolia*.



e. Green algae *Ulva sp* and *Caulerpa remotifolia*.

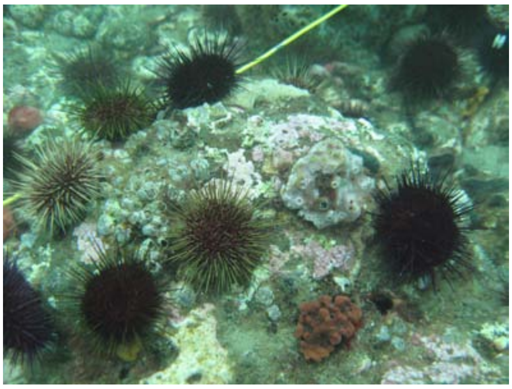
f. Globular Sponge and green algae *Caulerpa remotifolia*.

Figure 4.1. Site conditions and example photographs of typical flora and fauna observed at Site 1, Point Cooke, 23 April 2009.



a. Urchin barren, sea urchin *Heliocidaris erythrogramma*.

b. Encrusting Grey Zoanthid *Epizoanthus sabulosus* and Eleven-armed Seastar *Coscinasterias muricata*.



c. Urchin barren, sea urchin *Heliocidaris erythrogramma*.

d. Stony Coral *Plesiastrea versipora*.

e. Sponges *Aplysilla rosea* and *Tethya bergquistae*, sea urchin *Heliocidaris erythrogramma* and seastar *Petricia vernicina*.

f. Yellow Hyphae Sponge and Rose Sponge *Aplysilla rosea*.

Figure 4.2. Site conditions and example photographs of typical flora and fauna observed at RAAF Base, April 2009.

During the initial years of monitoring (2003-2005) at the RAAF Base (Site 2), there was initially an *Ecklonia radiata* and *Caulerpa* bed assemblage, dominated by *Caulerpa flexilis*, but also including *C. longifolia*, *C. brownii*, *C. remotifolia* and *C. simpliciuscula.* The total seaweed cover ranged from 60 to 69 % cover, including 1-7 % cover of encrusting coralline algae. By the latest survey in 2009, the community structure had changed markedly to sea urchin barren habitat. The only algae present was 18 % cover of encrusting corallines and a few small plants of *Caulerpa remotifolia* (0.1 % cover; Figures 4.4b and 4.4c).

Figure 4.3. Yellow Hyphae Sponge and sea urchin *Heliocidaris erythrogramma* observed at RAAF base, 24 April 2009. Note the sponge growing over the top of sea urchins.

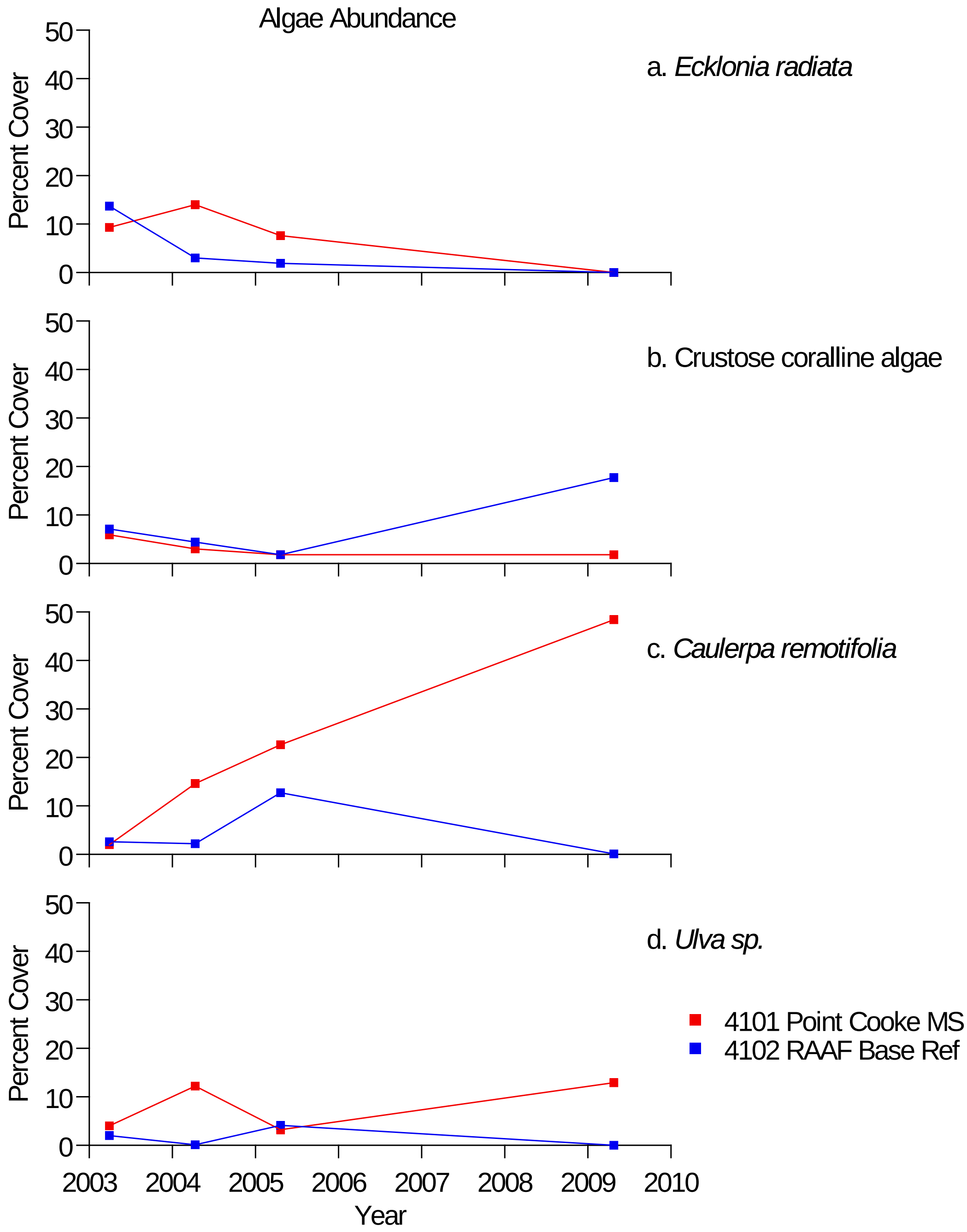


Figure 4.4. Abundances (percent cover) of selected macroalgal species in Point Cooke Marine Sanctuary and the reference site at the RAAF base.

4.4 INVERTERBRATES

The invertebrate assemblages at Point Cooke and RAAF Base were dominated by echinoderms, with similar species present at both sites. Abundant species included black lip abalone *Haliotis rubra*, the common sea urchin *Heliocidaris erythrogramma* and the seastars *Meridiastra gunnii*, *Coscinasterias muricata, Uniophora granifera* and *Tosia australis*. *Heliocidaris erythrogramma*, *Tosia australis*, *Meridiastra gunnii* and *Coscinasterias muricata* were the predominant invertebrate assemblage components.

The abundance of abalone *Haliotis rubra* declined at both sites over the course of the surveys, ranging from 212-376 per 200 m^2 in 2003 to 13-33 per 200 m^2 in 2009 (Figure 4.5a). The median size of abalone *H. rubra* was relatively constant at both sites over the initial years of monitoring from 2003 to 2005. The median size was 84-89 mm at Point Cooke and 86-91 mm at RAAF Base. In 2009 the median size at RAAF Base had not changed (91 mm) while there was a substantial decrease at Point Cooke Marine Sanctuary to 63 mm (Figure 4.6).

During the initial survey years (2003-2005), the common sea urchin *Heliocidaris erythrogramma* was highly abundant, with generally 320 individuals per 200 m^2 at Point Cooke and 800-1000 per 200 m^2 at RAAF Base. At Point Cooke, there was a decline in abundance to 52 per 200 m^2 while at RAAF Base there was a population explosion to 3018 per 200 m^2 (Figure 4.5b). These high densities are associated with a structural change in habitat type at RAAF Base from seaweed to urchin barrens.

There was a notable increase in the abundance of seastars *Uniophora granifera* and *Coscinasterias muricata* at RAAF Base, corresponding with the increase in *H. erythrogramma* (Figures 4.5e and 4.5f). There was also a considerable increase in abundance of *C. muricata* at Point Cooke to 2009 (Figure 4.5e).

The seastar *Meridiastra calcar* was present in moderate abundances at Point Cooke (28-92 per 200 m^2), but was not observed at the RAAF Base site on the transect (but is present in low abundances). The introduced Northern Pacific Seastar *Asterias amurensis* was not observed at either site over the survey period.

The introduced Mediterranean Fanworm *Sabella spallanzanii* was observed sporadically at both sites, although in relatively low abundances at Point Cooke. *Sabella* are sessile invertebrates and there have been misunderstandings for some observers about whether this species was to be counted during the mobile invertebrate surveys. The data to date have been deemed unsuitable for reporting, however this species will be formally counted in future surveys.

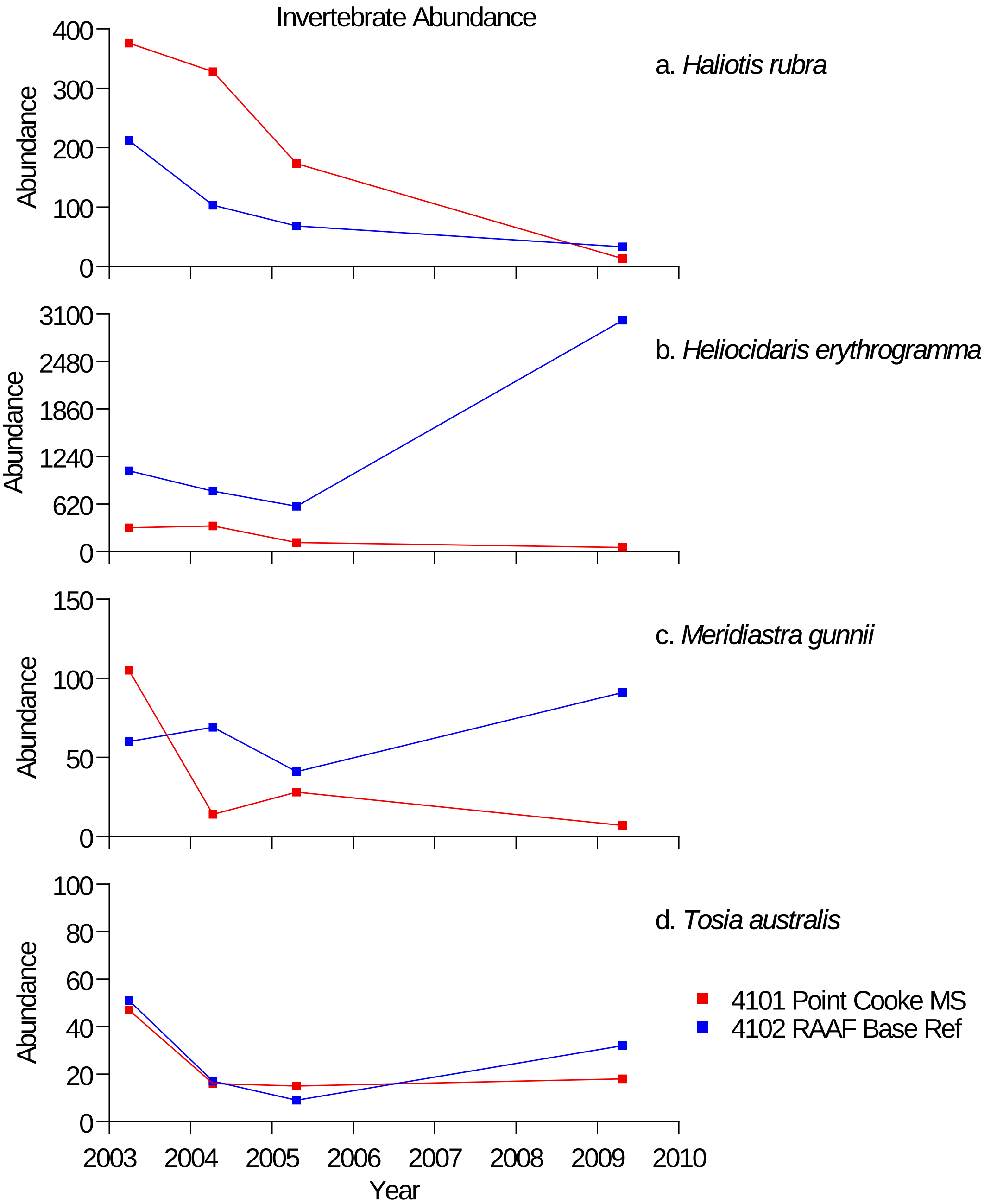


Figure 4.5. Densities (per 200 m^2) of selected invertebrates in Point Cooke Marine Sanctuary and the reference site at the RAAF base.

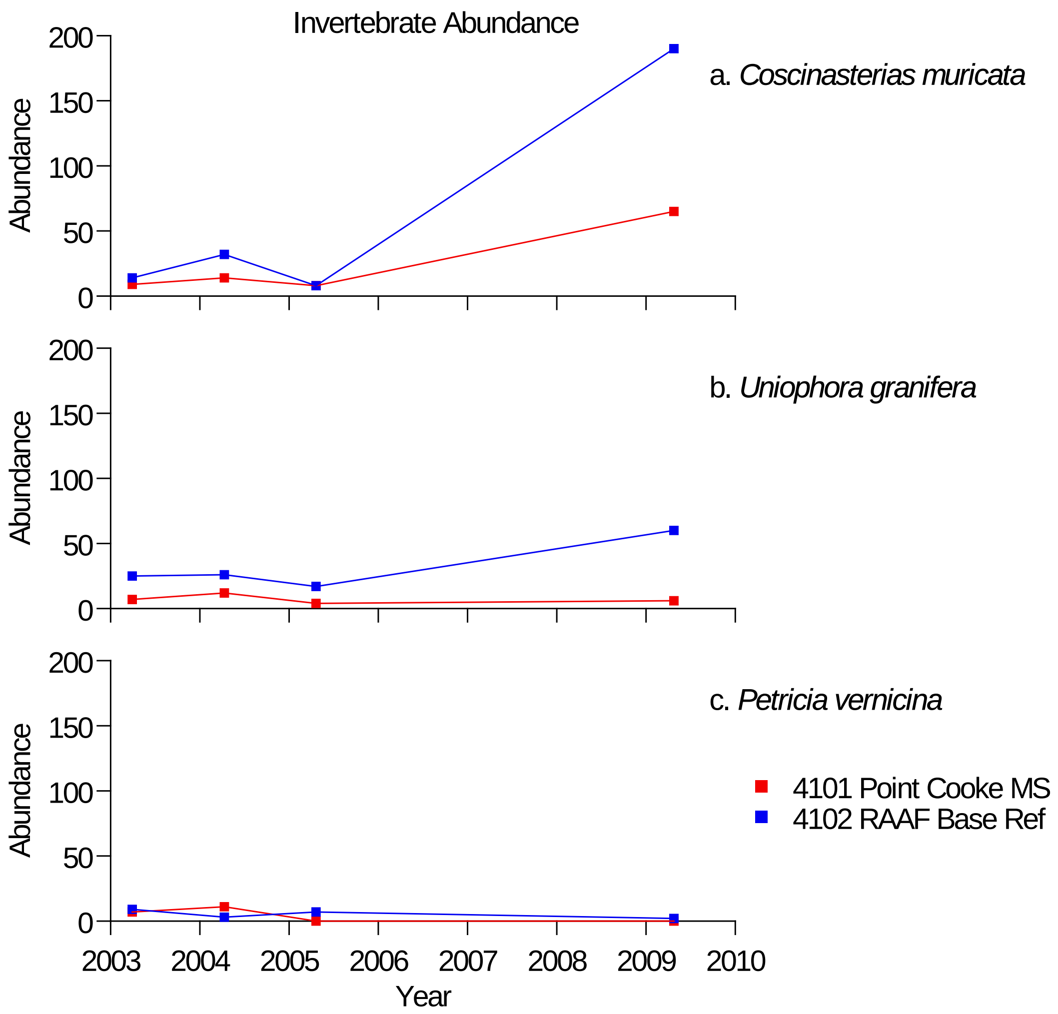


Figure 4.5 (continued). Densities (per 200 m^2) of selected invertebrate species in Point Cooke Marine Sanctuary and the reference site at the RAAF base.

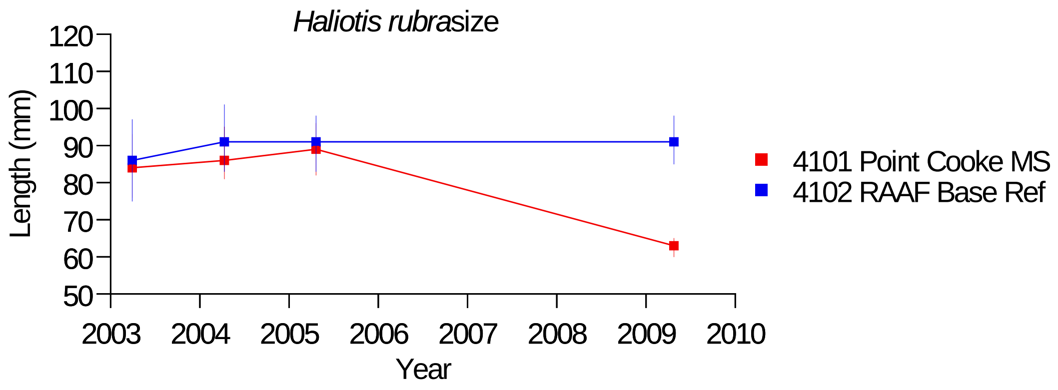


Figure 4.6. Median sizes (± 25 percentiles) of black lip abalone *Haliotis rubra* at Point Cooke Marine Sanctuary and RAAF Base reference site.

4.5 FISHES

The southern Hulafish *Trachinops caudimaculatus* was one of the most abundant fish species at Point Cooke and RAAF Base. Other typical species were Little Rock Whiting *Neoodax balteatus*, Southern Goatfish *Upeinichthys vlaminghii* and small unidentified fishes (probably post-larval stages). There were occasional sightings of Banjo Ray *Trygonorrhina fasciata*, Zebrafish *Girella zebra*, Moonlighter *Tilodon sexfasciatus*, Dusky Morwong *Dactylophora nigricans* and Globefish *Diodon nichthemerus*.

During the first survey large numbers of the Southern Hulafish, *Trachinops caudimaculatus*, were observed at both sites, however in the subsequent two surveys few individuals were seen (Figure 4.6a). In 2009, the abundances of *T. caudimaculatus* increased considerably and were very high at RAAF Base (Figure 4.6a). The abundances of Little Rock Whiting *Neoodax balteatus* followed a converse pattern, being low in abundance during the first and fourth surveys and higher abundances during Surveys 2 and 3 (Figure 4.6b).

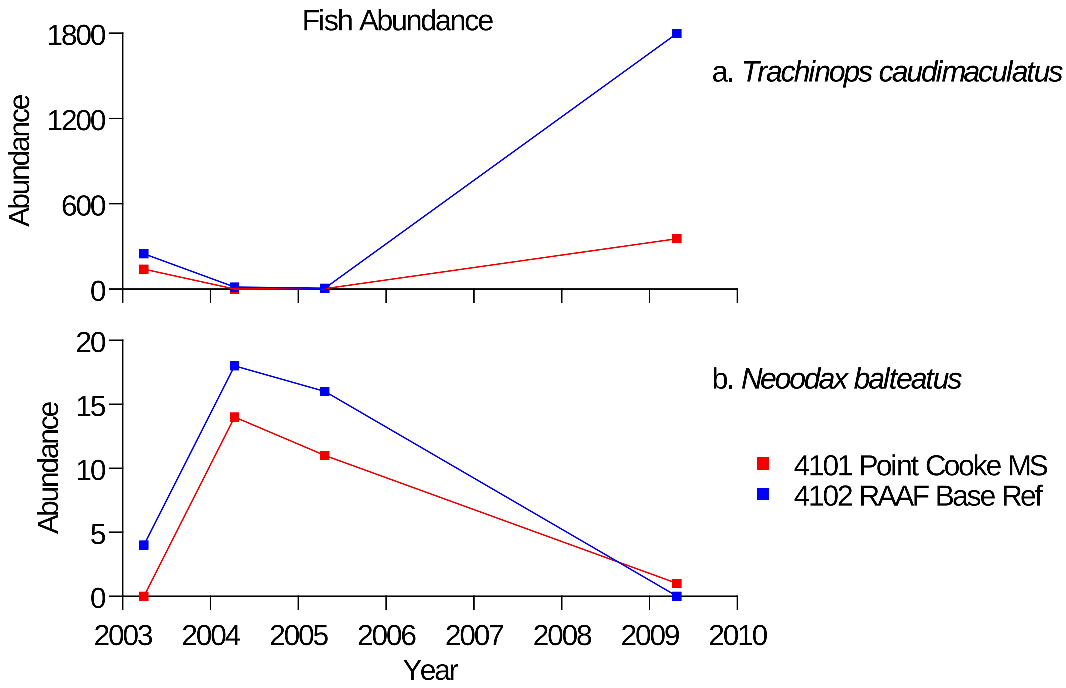


Figure 4.7. Densities (per 2000 m2) of Southern Hulafish *Trachinops caudimaculatus* and Little Rock Whiting *Neoodax balteatus* in Point Cooke Marine Sanctuary and the reference site at the RAAF base.

5 Jawbone Marine Sanctuary

5.1 MONITORING SITES

Jawbone Marine Sanctuary is situated between Altona and Williamstown in the north of Port Phillip Bay. The subtidal reef at Jawbone Marine Sanctuary is in shallow water (< 4 m) and consists of large basalt boulders and bedrock sloping steeply to sand at the toe of the reef (Figure 5.1). The Jawbone monitoring site (Site 3) is very close to shore and is on the 2-3 m isobath.

A reference monitoring site was located approximately 2 km east of Jawbone Marine Sanctuary at Point Gellibrand (Site 4), Williamstown. The reef structure at this site was similar to the Jawbone Reef, consisting predominantly of large basalt boulders and bedrock, but was generally flatter with more sand among reef patches (Figure 5.2). The monitoring site at Point Gellibrand was at 2 m depth.

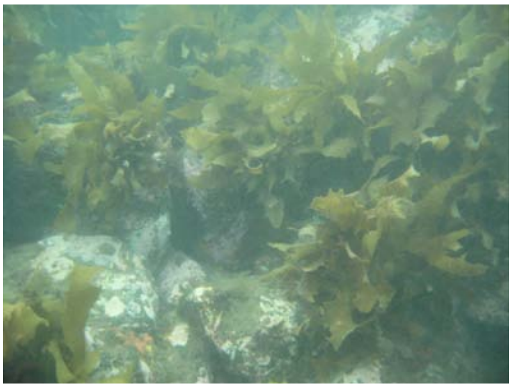
5.2 MACROALGAE

The algal assemblages at Jawbone Marine Sanctuary (Site 3) and Point Gellibrand (Site 4) were not diverse, with common components being low to moderate abundances of kelp *Ecklonia radiata*, filamentous brown algae (Ectocarpales), encrusting coralline algae and *Sargassum* spp (generally only as basal leaves). Other distinctive reef covering organisms were the coral *Plesiastra versipora* and sponges, these animals having less than 10 % cover.

The Point Gellibrand (Site 4) was also characterised by occasional plants of the green species *Ulva* sp, *Caulerpa geminata* and *Codium* sp, the medium-sized brown algae *Cystophora moniliformis*, *Cystophora retroflexa*, *Sargassum fallax* and *Sargassum spinuligerum* and small red algae such as *Laurencia* spp.

The assemblage structures at Jawbone and Point Gelibrand appear to reflect the stronger estuarine influence in this region. The lower abundances of larger brown algae and higher abundances of Ectocarpales are an indicator of higher nutrient concentrations and lower salinities.

The temporal changes at Jawbone (Site 1) consisted of an increase in *Ecklonia radiata* cover from 2003 to 2005, which persisted to 2009 (Figure 5.1a). There was a notable increase in encrusting coralline algal cover from 2005 to 2009 (Figure 5.3b). There was little to no coverage of filamentous browns (Ectocarpales) during 2009, changing from 20-40 % cover during the 2003-2005 period (Figure 5.3c).



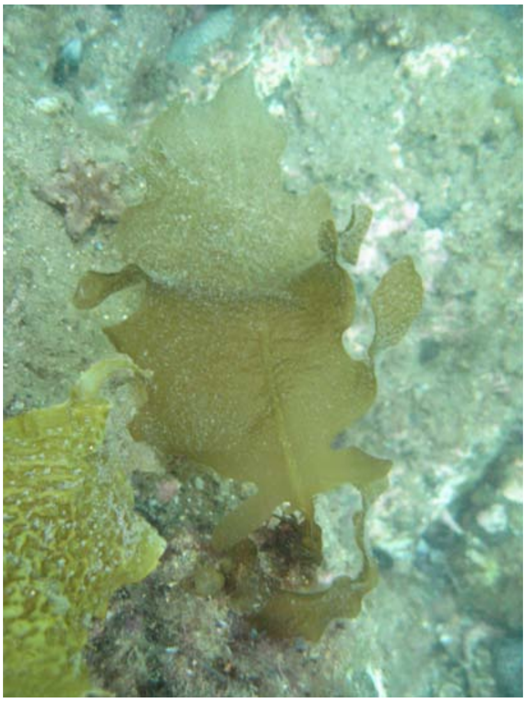
a. Common kelp *Ecklonia radiata.*

b. Sessile invertebrates on boulder reef.

c. Sponge and brown algae *Dictyota dichotoma.*

d. Southern Golf Ball Sponge *Tethya bergquistae.*

e. Green algae *Codium sp* and stony coral *Plesiastrea versipora.*



f. Japanese Kelp *Undaria pinnatifida.*

Figure 5.1. Site conditions and example photographs of typical flora and fauna observed at Jawbone MS, 24 April 2009.

a. Urchin barren, sea urchin *Heliocidaris erythrogramma.*

b. Red thallose algae and green bubble algae *Caulerpa geminata.*

c. Yellow Sponge.

d. Yellow Hyphae Sponge.

e. Smooth Grey Sponge.

f. Eleven-armed Seastar *Coscinasterias muricata.*

Figure 5.2. Site conditions and example photographs of typical flora and fauna observed at Pt Gellibrand, 23 April 2009.

There were few apparent temporal patterns and trends in the Point Gellibrand seaweed species, the exception being that filamentous browns (Ectocarpales) were only observed at the site during the first, 2003 survey (Figure 5.3c).

The Japanese Wakame Seaweed *Undaria pinnatifida* was observed by the SRMP surveys for the first time in 2009 at Jawbone. Juveniles 70-400 mm in length were sparsely distributed over the reef with a total cover of 0.3 %. As noted in for the RAAF Base site, sightings of this species are unusual for this time of year.

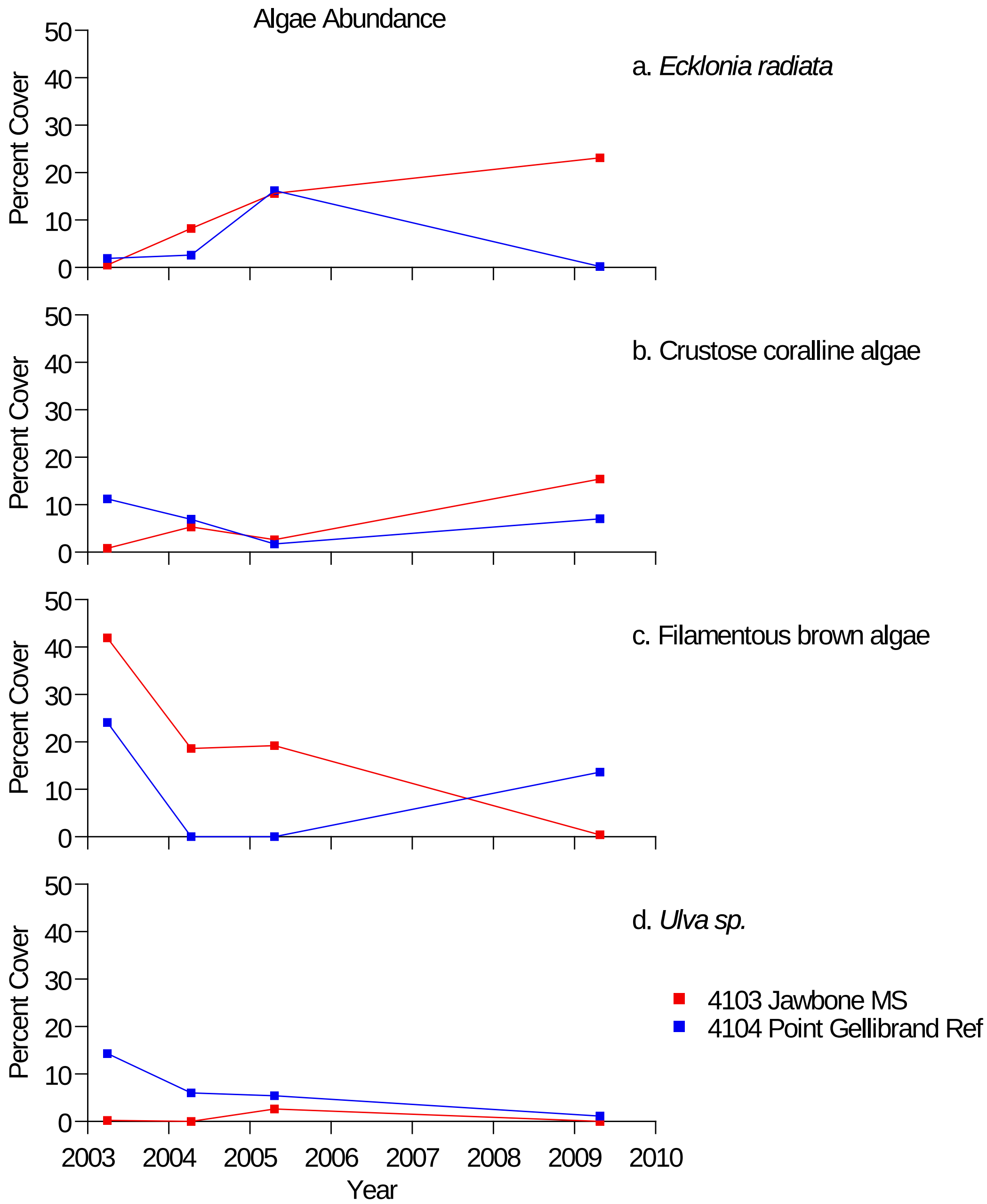


Figure 5.3. Abundances (percent cover) of selected macroalgal species in Jawbone Marine Sanctuary and the Point Gellibrand reference site.

5.3 INVERTEBRATES

The mobile invertebrate assemblages at Jawbone and Point Gellibrand were composed largely of the sea urchin *Heliocidaris erythrogramma*, the seastars *Meridiastra gunnii*, *Meridiastra calcar* and *Coscinasterias muricata* and the blacklip abalone *Haliotis rubra*. The abundance of *H. erythrogramma* was consistently higher at Point Gellibrand while the other species were of similar densities. Most species had very similar patterns of temporal change at the two sites.

Abundances of blacklip abalone *Haliotis rubra* were moderate to low at both sites with 10-40 per 200 m^2 between 2003 and 2009 (Figure 5.4a). There were no marked changes in median abalone size at the two sites, ranging from 72 to 89 mm over the survey period (Figure 5.5).

There was a very large increase in sea urchin *H. erythrogramma* density between 2005 and 2009 at both sites, increasing to densities of 653 and 1009 per 200 m^2 (Figure 5.4b). There were also corresponding increases in density of *Tosia australis* (Figure 5.4g).

The introduced Northern Pacific Seastar *Asterias amurensis* was observed at Jawbone during 2003 and 2004 (3 and 6 individuals per 100 m^2 respectively), but has not been observed at either site since.

The introduced Mediterranean Fanworm *Sabella spallanzanii* was observed sporadically at both sites: during 2003 at Jawbone; and 2003 and 2009 at Point Gellibrand. The densities were 13, 4 and 1 individual per 100 m^2 respectively.

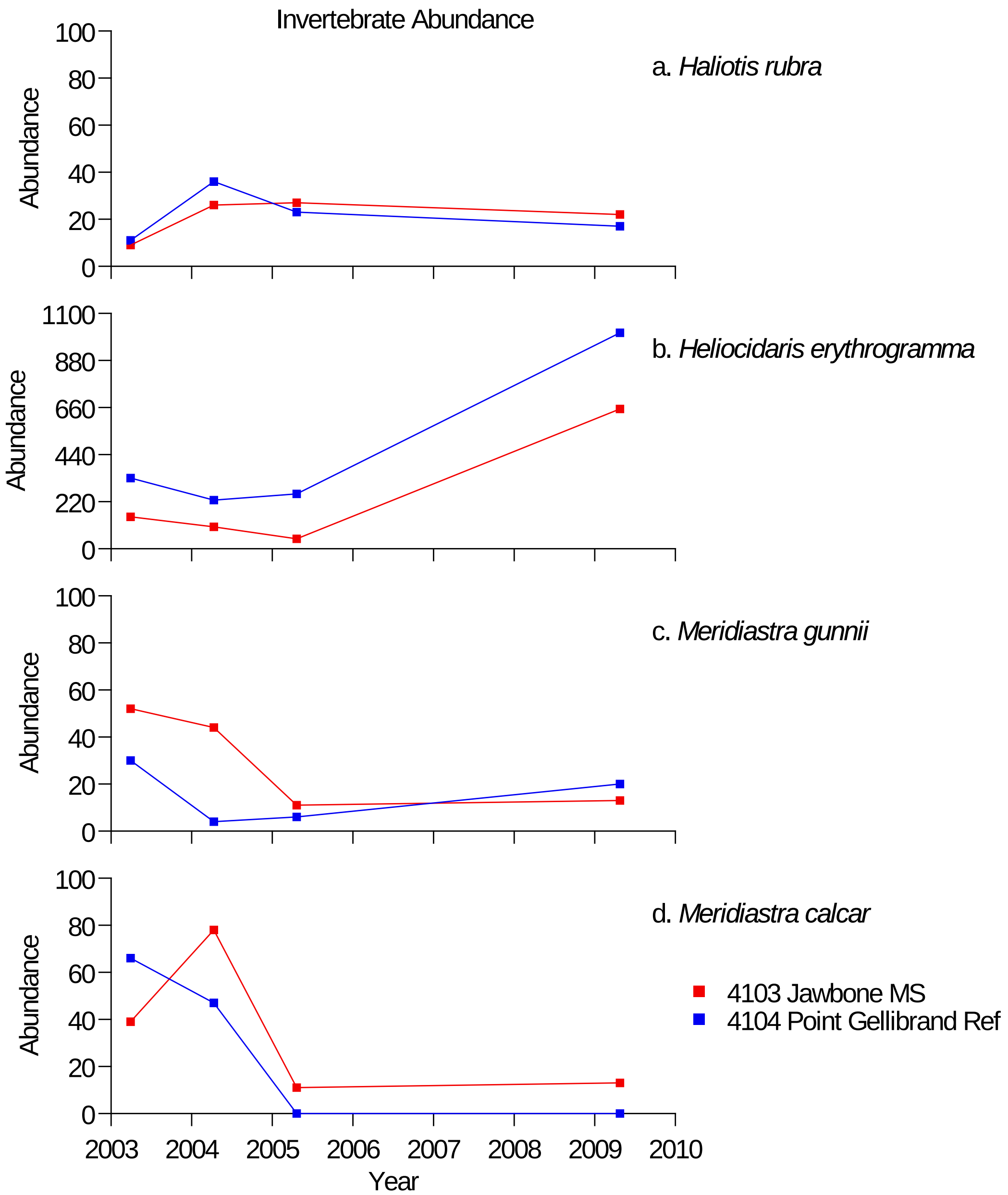


Figure 5.4. Densities (per 200 m^2) of selected invertebrate species in Jawbone Marine Sanctuary and the Point Gellibrand reference site.

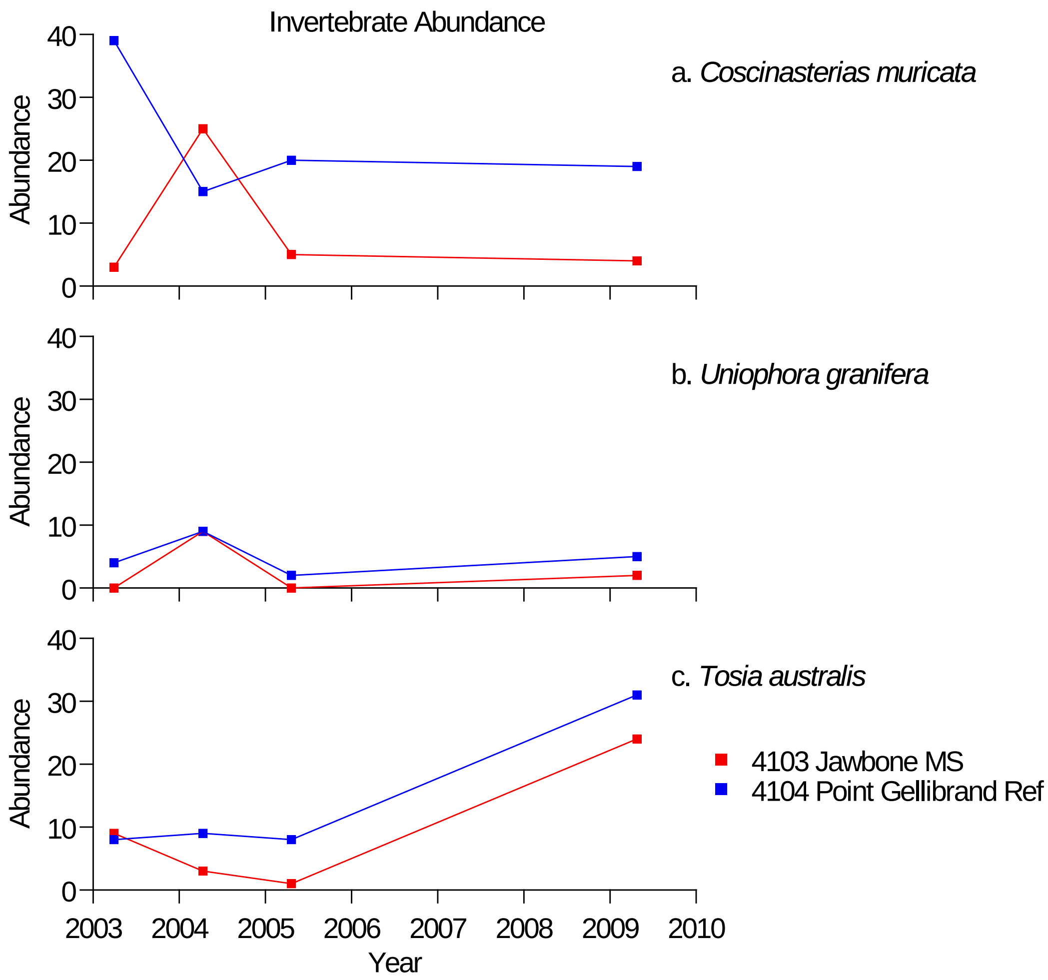


Figure 5.4. (continued). Densities (per 200 m²) of selected invertebrate species in Jawbone Marine Sanctuary and the Point Gellibrand reference site.

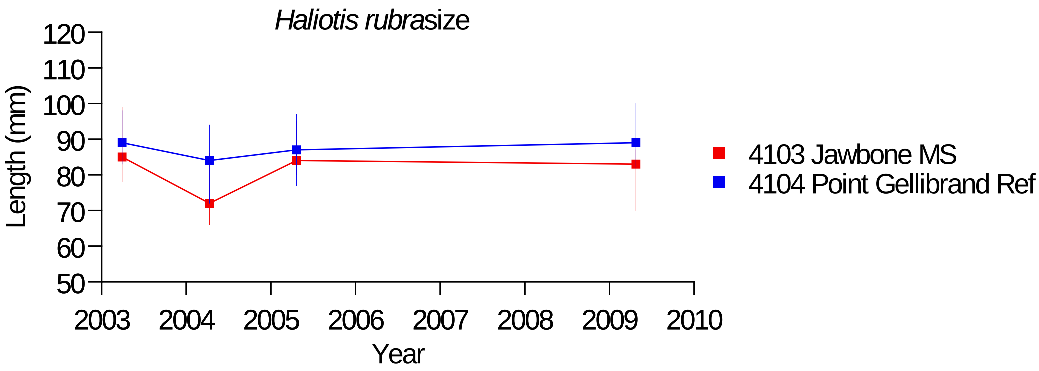


Figure 5.5. Median sizes (± 25 percentiles) of black lip abalone *Haliotis rubra* at Jawbone Marine Sanctuary and Point Gellibrand reference site.

5.4 FISHES

At Jawbone and Point Gellibrand, nearly all fish observed were Southern Hulafish *Trachinops caudimaculatus*. Other species, present in very low densities, were Zebrafish *Girella zebra*, Dusky Morwong *Dactylophora nigricans* and Little Rock Whiting *Neoodax balteatus*. During the first survey, the density of *T. caudimaculatus* at Jawbone was exceptionally high, 2200 per 2000 m^2, with much lower (more usual) densities observed in the subsequent surveys (Figure 5.6a). *Neoodax balteatus* not observed during the first survey but was present during all subsequent surveys (Figure 5.6b).

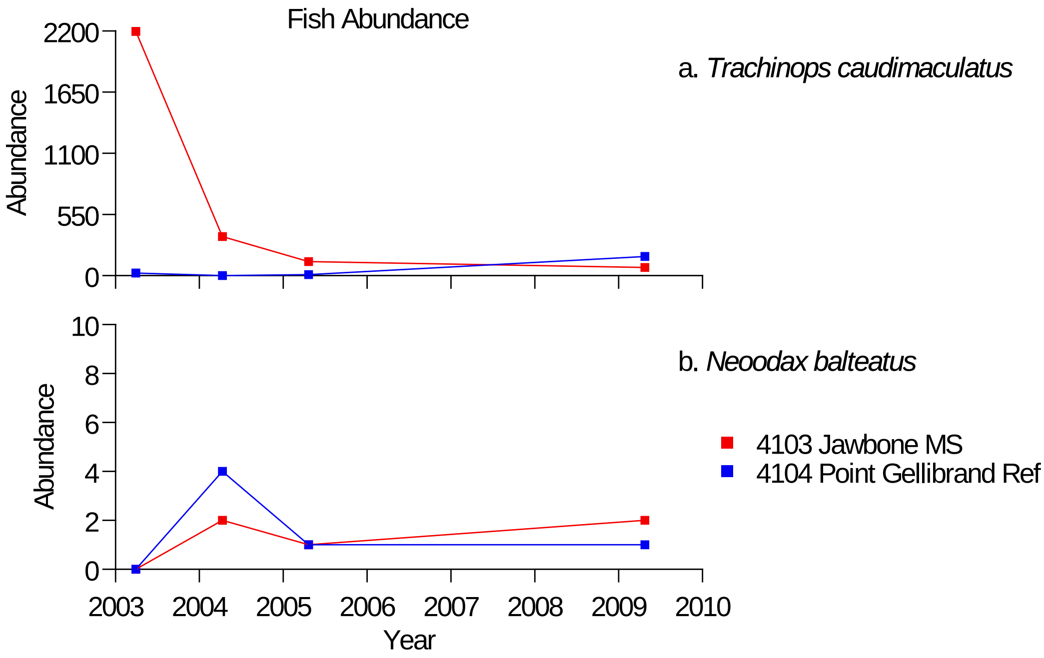


Figure 5.6. Densities (per 2000 m^2) of Southern Hulafish *Trachinops caudimaculatus* and Little Rock Whiting *Neoodax balteatus* in Jawbone Marine Sanctuary and the Point Gellibrand reference site.

6 Ricketts Point Marine Sanctuary

6.1 MONITORING SITES

Ricketts Point Marine Sanctuary is near Beaumaris on the north-eastern shore of the Port Phillip Bay. The reef at Ricketts Point is low relief sandstone reef with occasional steps and crevices, erosion holes and small rubble patches (Figure 6.1). The Ricketts Point monitoring site (Site 5) was at 3 m depth, near the reef/sand edge.

A reference monitoring site (Halfmoon Bay; Site 6) was located approximately 3 km north of Ricketts Point at Halfmoon Bay. The reef at Halfmoon Bay is low to medium relief (to 1 m) reef with occasional ledges and overhangs, but also having patches of flat, rubbly reef in places (Figure 6.2). This site was at 3 m depth. The reef is patchy with considerable areas of sand.

The reef habitats at Ricketts Point Marine Sanctuary and Halfmoon Bay have less estuarine influence than the other northern Port Phillip Bay Reefs and are also more exposed to waves during prevailing westerly and southwesterly weather. These reefs are also under the influence of the Yarra River Plume, which generally runs down the eastern shore.

6.2 MACROALGAE

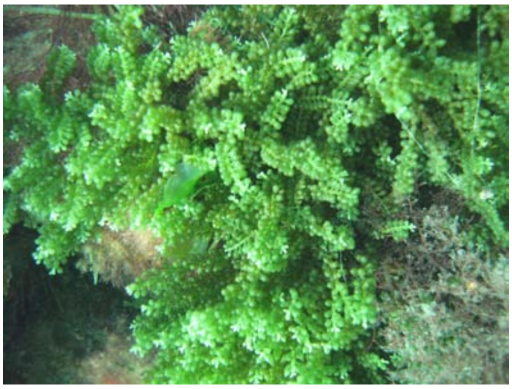
Ricketts Point (Site 5) and Halfmoon Bay (Site 6) were predominantly *Sargassum-Caulerpa* assemblages. At both sites, the dominant species have been the green mat forming species *Caulerpa geminata* and *C. remotifolia*, along with the kelp *Ecklonia radiata*, *Sargassum spinuligerum* and a mixture of smaller red and brown seaweeds. The habitats at both sites include sea urchin barrens, in which encrusting coralline algae and the stony coral *Plesiastrea versipora* are common. The sites differ in the presence of *Caulerpa brownii*, *Caulerpa longifolia* and *Cladophora prolifera* at Halfmoon Bay and higher abundances of *P. versipora* at Ricketts Point.

Caulerpa species can have a rate of expansion and contraction in coverage at seasonal and annual scales. This is reflected in *Caulerpa geminata* abundance at both sites, with little 10-25 % cover at both sites in 2003 and 2004, reducing to little to no coverage in 2005 and 2009. Abundances of *Caulerpa brownii* at Halfmoon Bay have oscillated over the four surveys: 21, 9, 19 and 0 % cover respectively. There were more gradual declines in coverage of *C. remotifolia* at both sites and *C. longifolia* at Halfmoon Bay over the monitoring period (*e.g.* Figure 6.1c). Because *Caulerpa* species are inherently variable, a longer time series of observations is required to understand the ecological significance and any persistence of these declines in abundance.

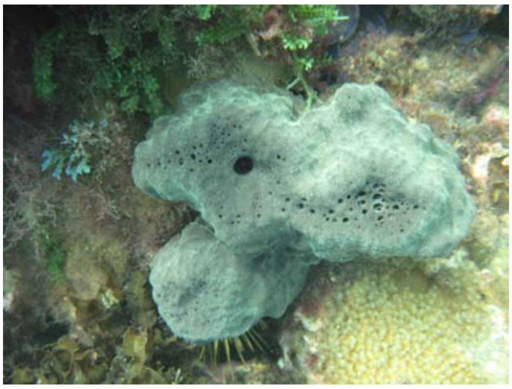
a. Zebra Fish *Girella zebra.*

b. Six-spine Leatherjacket *Meuschenia freycineti* and old wife *Enoplosus armatus.*

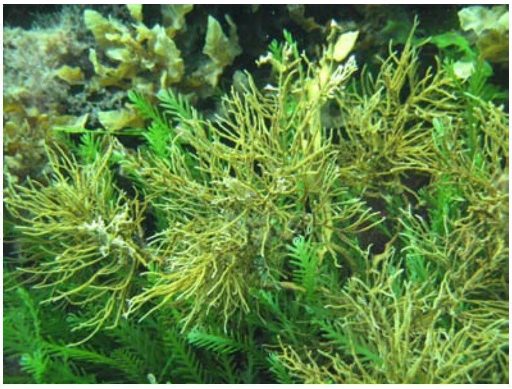
c. Old Wives *Enoplosus armatus.*



d. Green alga *Caulerpa geminata.*



e. Grey Sponge and Encrusting Grey Zoanthid *Epizoanthus sabulosus.*



f. Green alga *Caulerpa remotifolia* and brown algae *Cystophora retroflexa.*

Figure 6.1. Site conditions and example photographs of typical flora and fauna observed at Ricketts Point, 23 April 2009.

a. Sponge, red thallose algae and green algae *Ulva sp, Caulerpa brownii, Cladophora rugulosa.*

b. Green algae *Ulva sp* and *Caulerpa geminata.*

c. Eleven-armed Seastar *Coscinasterias muricata.*

d. Sea urchin *Heliocidaris erythrogramma*, Golf Ball Sponge *Tethya sp* and green alga *Caulerpa brownii.*

e. Green alga *Caulerpa longifolia.*

f. Green alga *Caulerpa trifaria.*

Figure 6.2. Site conditions and example photographs of typical flora and fauna observed at Halfmoon Bay, 23 April 2009.

The cover of kelp *E. radiata* oscillated between 10 % cover and less than 2 % cover at Ricketts Point, however this pattern was not evident at Halfmoon Bay (Figure 6.3a).

There was a notable increase in the coverage of *Sargassum spinuligerum* at Ricketts Point in 2009, with a coverage of 22 %. This species was previously observed there in 2004 with a coverage of 4 %. At Halfmoon Bay, cover as 1.1, 0.5, 0 and 4.2 % respectively.

The introduced pest Japanese Wakame *Undaria pinnatifida* was not observed during the surveys at these two sites.

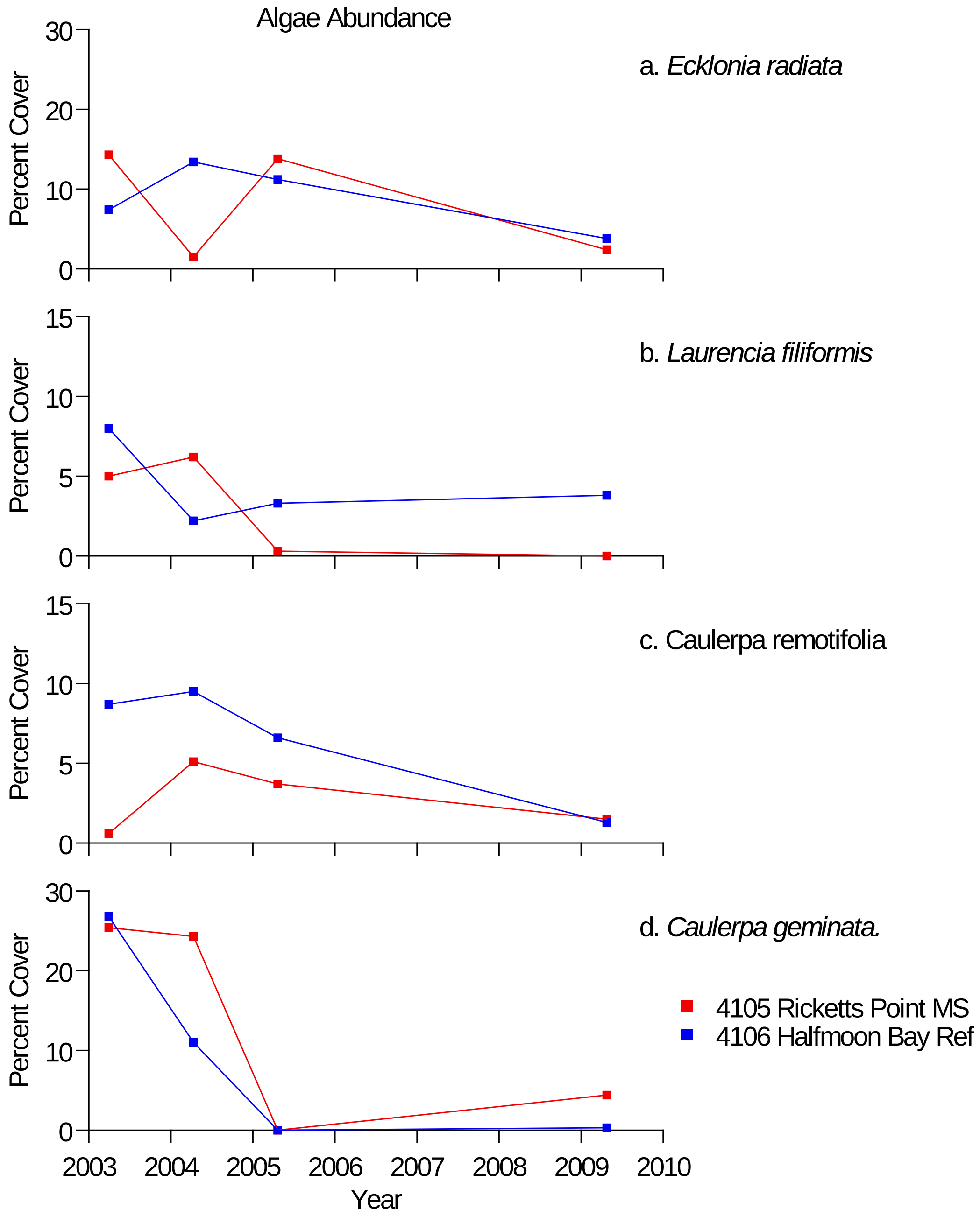


Figure 6.3. Abundances (percent cover) of selected macroalgal species in the vicinity of Ricketts Point Marine Sanctuary

6.3 INVERTEBRATES

There were relatively few invertebrate species at Ricketts Point and Halfmoon Bay, with the assemblage structure being similar at both sites. The assemblages were dominated by high abundances of the sea urchin *Heliocidaris erythrogramma*. Other common species were Blacklip Abalone *Haliotis rubra*, Biscuit Star *Tosia australis*, Eleven-armed Seastar *Coscinasterias muricata* and Velvet Star *Petricia vernicina*.

Blacklip abalone *Haliotis rubra* density was initially relatively high at Ricketts Point in 2003, with a rapid decline from 126 to 17 individuals per 200 m^2 between 2003 and 2004 (Figure 6.4a). The density increased slightly and remained stable in following survey years. The density at Halfmoon Bay was relatively similar during all years, with a slight decline from 2005 to 2009 (Figure 6.4a). The median abalone length declined by approximately 10 mm between 2005 and 2009 (Figure 6.5).

The patterns of temporal changes in sea urchin *H. erythrogramm*a density were remarkably similar at the two sites, with a range of 186 to 1067 individuals per 200 m^2 (Figure 6.4b). The density approximately halved between 2004 and 2005 and then more than doubled to 2009. The density at Halfmoon Bay in 2009 was much higher than previously observed at that site (Figure 6.4b).

Neither of the introduced pests Northern Pacific seastar *Asterias amurensis* or Mediterranean Fanworm *Sabella spallanzanii* were observed during surveys at these sites.

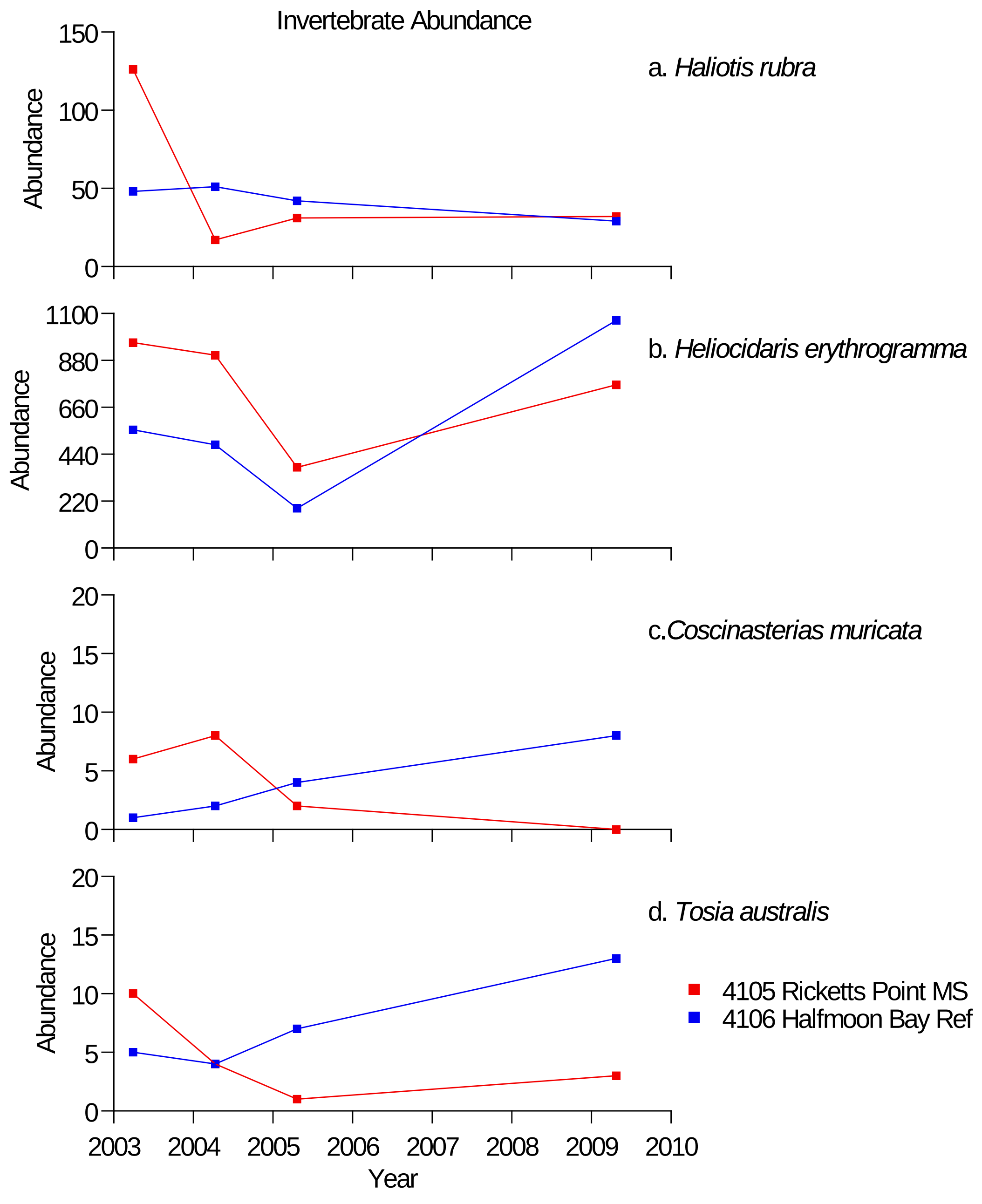


Figure 6.4. Densities (per 200 m^2) of selected invertebrate species in the vicinity of Ricketts Point Marine Sanctuary.

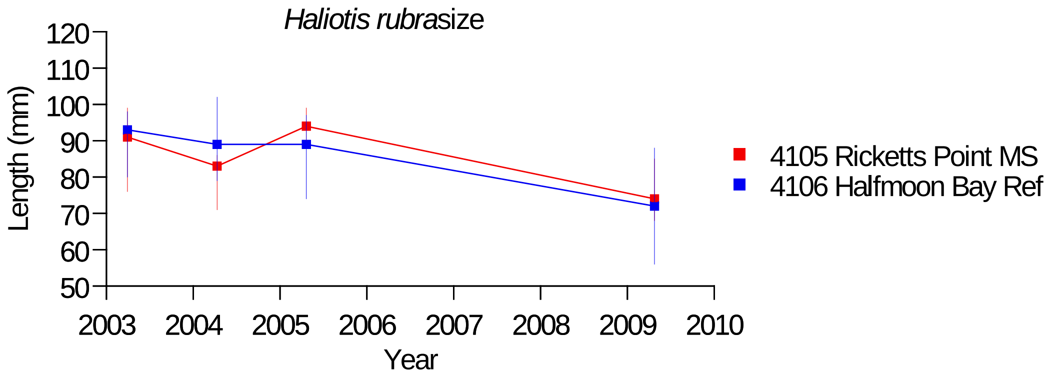


Figure 6.5. Median sizes (± 25 percentiles) of black lip abalone *Haliotis rubra* at Ricketts Point Marine Sanctuary and Halfmoon Bay reference site.

6.4 FISHES

Fish assemblages were slightly more diverse and larger species were more abundant at Ricketts Point and Halfmoon Bay, compared with other areas in northern Port Phillip Bay. At both sites, the fish assemblage was numerically dominated by the Southern Hulafish *Trachinops caudimaculatus* and to a lesser extent by Southern Goatfish *Upeneichthys vlaminghii* and Little Rock Whiting *Neoodax balteatus*.

During the first survey, transient species including a school of Australian Salmon *Arripis trutta* and several subadult male snapper *Chrysophrys auratus* were observed at Ricketts Point. Other prominent large species of fish included Zebra Fish *Girella zebra*, Horseshoe Leatherjacket *Meuschenia hippocrepis* and Moonlighter *Tilodon sexfasciatus*. Species of leatherjacket included Toothbrush Leatherjacket *Acanthaluteres vittiger*, Yellow-tailed Leatherjacket *Meuschenia flavolineata* and Six Spined Leatherjacket *Meuschenia freycineti*. There were lower abundances of fish at Halfmoon Bay than at Ricketts Point, although the assemblage was composed of the same species.

Both *Trachinops caudimaculatus* and *Neoodax balteatus* were variable in abundance between the four surveys. There was a notable increase in abundance of both species at both sites between 2005 and 2009 (Figure 6.6).

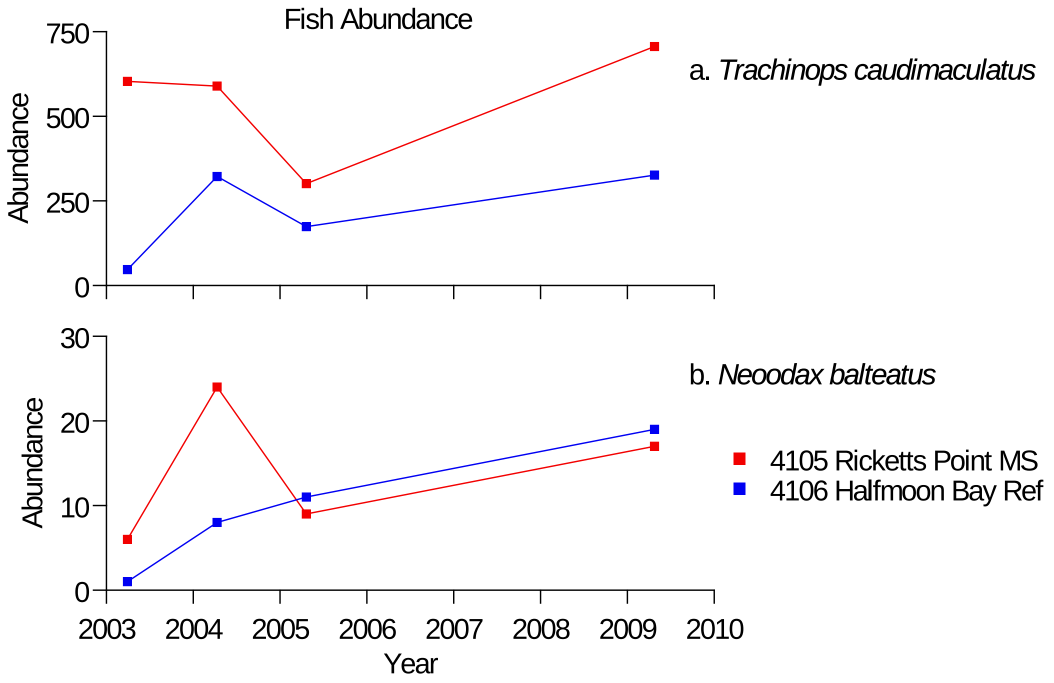


Figure 6.6. Densities (per 2000 m^2) of southern hulafish *Trachinops caudimaculatus* and little rock whiting *Neoodax balteatus* in the vicinity of Ricketts Point Marine Sanctuary.

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Appendix A – Site Details

Point Cook Pines – Site 4101

Site Description

Point Cooke Marine Sanctuary (Site1) is close to Werribee on the northwestern shore of Port Phillip Bay. The reef at Point Cooke consists of low-relief, textured basalt reef interspersed with patches of sand and mud. The reef is covered with dense red and green algae, particularly *Caulerpa remotifolia and Ulva* sp.

Transect Layout

The transects lie parallel to shore, T2 and T1 head northwest from the marker. T3 and T4 curve head to the southwest. The site is positioned along the 3-4 m isobath.

Latest Survey Notes

Latest survey: 24 April 2009. Marked increase in *Caulerpa remotifolia* coverage and absence of *Ecklonia radiata*. The introduced Japanese wakame *Undaria pinnatifida* was formally observed for the first time at Point Cooke. Abalone *Haliotis rubra* abundances decreased and the median size changed from 84-89 to 63 mm length. The abundance of eleven armed seastars *Coscinasterias muricata* increased.

Appendix A Figure 1. Site dive transects for Point Cook Pines (site 1) in northern Port Phillip Bay**.**

Appendix A Table 1. Site details for Point Cook Pines in northern Port Phillip Bay.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-37.92933255	144.7946535	55	306179	5799732	3	Y	MPA

RAAF Base – Site 4102

Site Description

The RAAF Base (Site 2) is a reference site for Point Cooke MS (Site1). The site is similar to Point Cooke MS consisting of mostly low relief reef. The substratum is predominantly flat rubble with small rocky outcrops and patches of sand and mud. The area is a sea urchin barren with seastars *Coscinasterias muricata, Meridiastra gunnii* and *Uniophora granifera* and golf ball sponge *Tethya bergquistae* abundant.

Transect Layout

T2 and T1 head in a straight line to the northwest from the marker, and T3 and T4 in a southwest direction.

Latest Survey Notes

Latest survey: 24 April 2009. Loss of all thallose seaweeds with development of sea urchin barrens. Increased coverage of encrusting coralline algae. Very high abundances of sea urchin *Heliocidaris erythrogramma*. Although not measured, there was an apparent increase in abundance of sponge colonies. Notable increases in abundance of seastars *Coscinasterias muricata* and *Uniophora granifera*. Very high abundances of southern hula fish *Trachinops caudimaculatus*.

Appendix A Figure 2. Site dive transect for RAAF Base (site 2) in northern Port Phillip Bay**.**

Appendix A Table 2. Site details for RAAF Base in northern Port Phillip Bay.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-37.94620838	144.7687272	55	303945	5797805	4	Y	Ref

Jawbone – Site 4103

Site Description

Jawbone Marine Sanctuary is situated between Altona and Williamstown in the north of Port Phillip Bay. The reef consists of large basalt boulders and bedrock sloping steeply to sand. There is generally only sparse macroalgae cover with some *Ecklonia radiata* present at the end of T4.

Transect Layout

The marker point lies on steep sloping bed rock. The transects follow the shoreline along a band of basalt boulder reef that slopes from the high water line to sand and rubble at approximately 5 m depth. T2 and T1 run in a straight line south-southeast from the marker keeping the shore to the left whilst reeling out. T3 and T4 head north-northwest, curving to the northwest as it follow the shoreline.

Latest Survey Notes

Latest survey: 24 April 2009. The introduced Japanese wakame *Undaria pinnatifida* was formally observed at Jawbone for the first time. Higher abundances of *Ecklonia radiata* maintained from previous survey and increased cover of encrusting coralline algae. Large increase in density of sea urchin *Heliocidaris erythrogramma*.

Appendix A Figure 3. Site dive transect for Jawbone (site 3) in northern Port Phillip Bay**.**

Appendix A Table 3. Site details for Jawbone in northern Port Phillip Bay.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-37.865919	144.875867	55	313167	5806945	3	Y	MPA

Point Gellibrand – Site 4104

Site Description

Point Gellibrand (site 4) is a reference site for Jawbone MS (site 3). The site is predominantly basalt boulder reef with some sand patches among the boulders. There is a high abundance of the urchin *Heliocidaris erythrogramma* and sparse algae coverage.

Transect Layout

The transects run parallel to the shore. T1 and T2 head straight east from the marker and T3 and T4 head west.

Latest Survey Notes

Latest survey: 23 April 2009. No obvious temporal changes were found within Point Gellibrand during the latest survey. It was noted filamentous browns (Ectocarpales) were not observed at the site after the initial 2003 survey. Large increase in density of sea urchin *Heliocidaris erythrogramma*.

Appendix A Figure 4. Site dive transect for Point Gelibrand (site 4) in northern Port Phillip Bay**.**

Appendix A Table 4. Site details for Point Gelibrand in northern Port Phillip Bay.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-37.87430626	144.9014429	55	315428	5806055	3	Y	Ref

Ricketts Point Tea House – Site 4105

Site Description

Ricketts Point Marine Sanctuary (site 5) is near Beaumaris on the north-eastern shore of the Port Phillip Bay. The substratum is low relief sandstone reef with occasional steps and crevices and some sand and rubble patches.

Transect Layout

The marker point lies north of a navigation pole. T1 and T2 initially head southeast from the marker but curve to the west, following the edge of the reef. T3 and T4 are straight towards the northwest.

Latest Survey Notes

Latest survey: 23 April 2009. Declines in the coverage of green algae *Caulerpa* species. Relatively large increase in cover of brown alga *Sargassum spinuligerum*, from 4 to 22 % cover. Decline in median abalone length of approximately 10 mm. Increases in sea urchin *Heliocidaris erythrogramma* density, but not above density observed during the first, 2003 survey.

Appendix A Figure 5. Site dive transect for Ricketts Point (site 5) in northern Port Phillip Bay**.**

Appendix A Table 5. Site details for Ricketts Point Tea House in northern Port Phillip Bay.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-37.99739345	145.0294783	55	326979	5792642	3	N	MPA

Halfmoon Bay – Site 4106

Site Description

The Halfmoon Bay site (site 6) is a reference site for Ricketts Point MS (site 5). The site is located approximately 300 m south of the southern point of Halfmoon Bay and 200 m from shore. The site is low to medium relief (to 1 m) reef with occasional ledges and overhangs, but also having patches of flat, rubble reef in places. The reef is patchy with considerable areas of sand.

Transect Layout

The transects run roughly parallel to shore. T1 and T2 head south from the marker and T3 and T4 head north.

Latest Survey Notes

Latest survey: 24 April 2009. Declines in the coverage of green algae *Caulerpa* species. Decline in median abalone length of approximately 10 mm. Large increase in sea urchin *Heliocidaris erythrogramma* density and moderate increases in seastars *Coscinasterias muricata* and *Tosia australis*.

Appendix A Figure 6. Site dive transect for Halfmoon Bay (site 6) in northern Port Phillip Bay**.**

Appendix A Table 6. Site details for Halfmoon Bay in northern Port Phillip Bay.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-37.97185734	145.0087825	55	325101	5795437	3	N	Ref

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

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

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

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