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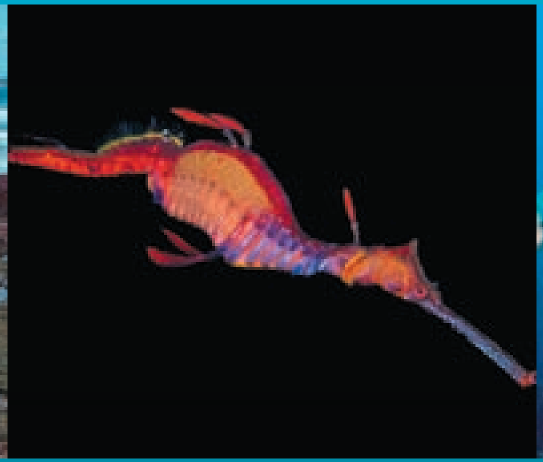

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Victorian Subtidal Reef Monitoring Program

The Reef Biota at Port Phillip Heads Marine National Park

Authors: Malcom Lindsay, Matt Edmunds, Patrick Gilmour, Claire Bryant and Joel Williams

February 2006

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Victorian Subtidal Reef Monitoring Program:

The Reef Biota at Port Phillip Heads Marine National Park

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Australian Marine Ecology Pty Ltd

February 2006

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. In order 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 monitoring program in, and around, the now Port Phillip Heads Marine National Park began in 1998. Since that time 15 sites have been surveyed during 11 census events. The monitoring involves standardised underwater visual census methods to a depth of between 2 and 7 m. This report aims to provide:

- a general description of the biological communities and species populations at each monitoring site; and
- an identification of any unusual biological phenomena, interesting communities, strong temporal trends and/or the presence of any introduced species.

The surveys were done 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 dominant kelp species.

To date over 300 different species have been observed during the monitoring program in, and around, Port Phillip Heads Marine National Park. Four algal assemblages were identified corresponding with four site groupings: well inside the Heads; Nepean Bay; Lonsdale Bay; and outside the Heads. The algal species richness at each site ranged from 20-40 species at most sites and species diversity was relatively variable through time. Six general invertebrate assemblages were apparent in the Port Phillip Heads region. The invertebrate species richness ranged from 5–15 species with relatively stable species diversity. The common fish species included scalyfin, marble fish, magpie perch, blue-throated wrasse and leatherjackets, however the abundance of these species was 4-10 times higher at Popes Eye. Species richness of fishes was quite variable between sites, and the species diversity appears to be similar for most sites.

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 datasets are accumulated (over multiple years to decades) the program will be able to more adequately reflect the average trends and ecological patterns occurring in the system.

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1.0 INTRODUCTION

1.1 Subtidal Reef Ecosystems of Victoria

Shallow reef habitats cover extensive areas along the Victorian coast. Prominent biological components of Victorian shallow reefs are kelp and other seaweeds (Figure 1.1). Large species, such as the common kelp *Ecklonia radiata* and crayweed *Phyllospora comosa*, are usually present along the open coast in dense stands. The production rates of dense seaweed beds are equivalent to the most productive habitats in the world, including grasslands and seagrass beds, with approximately 2 kg of plant material produced per square metre per year. These stands typically have 10-30 kg of plant material per square metre. The biomass of seaweeds is substantially greater where giant species such as string kelp *Macrocystis angustifolia* and bull kelp *Durvillaea potatorum* occur.

Seaweeds provide important habitat structure for other organisms on the reef. This habitat structure varies considerably, depending on the type of seaweed species present. Tall vertical structures in the water column are formed by *Macrocystis angustifolia*, which sometimes form a dense layer of fronds floating on the water surface. Other species with large, stalk-like stipes, such as *Ecklonia radiata*, *Phyllospora comosa* and *Durvillaea potatorum*, form a canopy 0.5-2 m above the rocky substratum. Lower layers of structure are formed by: foliose macroalgae typically 10-30 cm high, such as the green *Caulerpa* and red *Plocamium* species; turfs (to 10 cm high) of red algae species, such as *Pterocladia capillacea*; and hard encrusting layers of pink coralline algae. The nature and composition of these structural layers varies considerably within and between reefs, depending on the biogeographical region, depth, exposure to swell and waves, currents, temperature range, water clarity and presence of sand.

Grazing and predatory mobile invertebrates are prominent animal inhabitants of the reef (Figure 1.2). Common grazers include blacklip and greenlip abalone *Haliotis rubra* and *H. laevigata*, the warrener *Turbo undulatus* and sea urchins *Heliocidaris erythrogramma*, *Holopneustes* species and *Amblypneustes* species. These species can influence the growth and survival of habitat forming species. For example, sponges and foliose seaweeds are often prevented from growing on encrusting coralline algae surfaces through the grazing actions of abalone and sea urchins. Predatory invertebrates include dogwhelks *Dicathais orbita*, southern rock lobster *Jasus edwardsii*, octopus *Octopus maorum* and a wide variety of seastar species. Other large reef invertebrates include mobile filter feeding animals such as feather stars *Cenolia trichoptera* and sessile (attached) species such as sponges, corals, bryozoans, hydroids and ascidians.

Fishes are also a dominant component of reef ecosystems, in terms of both biomass and ecological function (Figure 1.3). Reef fish assemblages include roaming predators such as blue-throated wrasse *Notolabrus tetricus*, herbivores such as herring cale *Odax cyanomelas*, planktivores such as sea sweep *Scorpis aequipinnis* and picker-feeders such as the six-spined leatherjacket *Meuschenia freycineti*. The type and abundance of each fish species varies considerably, depending on exposure to swell and waves, depth, currents, reef structure, seaweed habitat structure and many other ecological variables. Many fish species play a substantial ecological role in the functioning and shaping of the ecosystem. For example, the feeding activities of fishes such as scalyfin *Parma victoriae* and magpie morwong *Cheilodactylus nigripes* promote the formation of open algal turf areas, free of larger canopy-forming seaweeds.

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, variously grazers, predators and scavengers. At the microscopic level, films of microalgae 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 also 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 wrasses, morwong, rock lobster, abalone and sea urchins, as well as recreational fishing, diving and other tourism activities.

1.2 Subtidal Reef Monitoring Program

1.2.1 Objectives

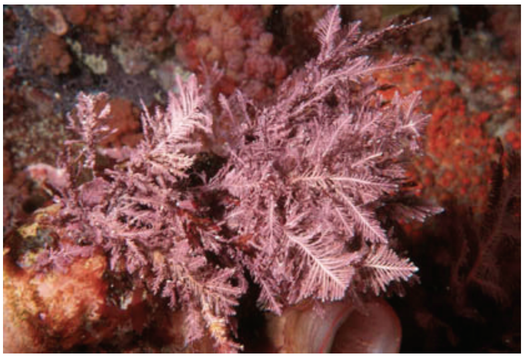
An important aspect in the management and conservation of Victorian marine natural resources and assets is assessing the condition of the ecosystem and how this changes over time. Combined with an understanding of ecosystem processes, this information can be used to manage any threats or pressures on the environment to ensure ecosystem sustainability.

Consequently, the Victorian Government has established a 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.

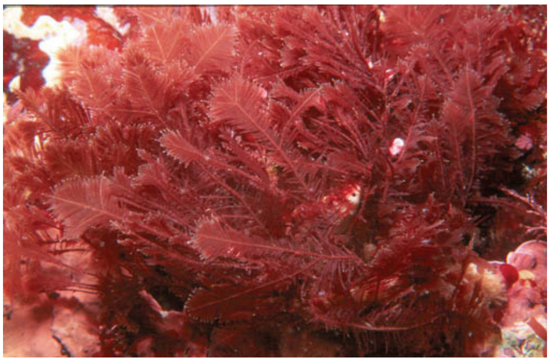
Green algae *Caulerpa flexilis*

Encrusting coralline algae at the base of crayweed *Phyllospora comosa* holdfast

Figure 1.1 Examples of species of macroalgae found on Victorian subtidal reefs



Red coralline algae *Haliptilon roseum*

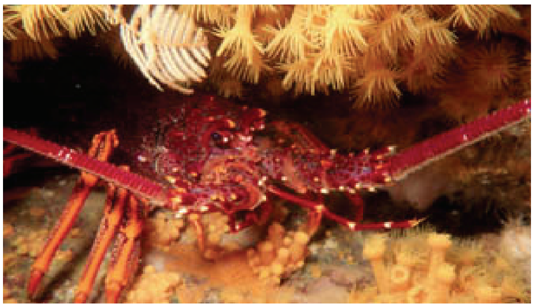


Thallose red algae *Ballia callitricha*

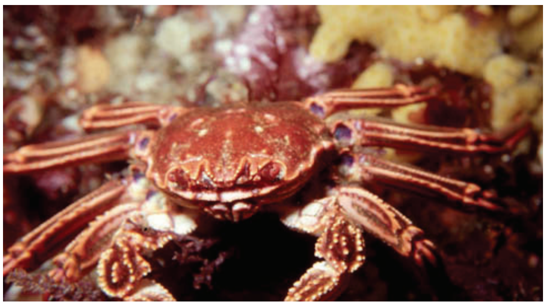
Crayweed *Phyllospora comosa* canopy

Common kelp *Ecklonia radiata* canopy

Figure 1.1 Cont. Examples of species of macroalgae found on Victorian subtidal reefs



Southern rock-lobster *Jasus edwardsii*

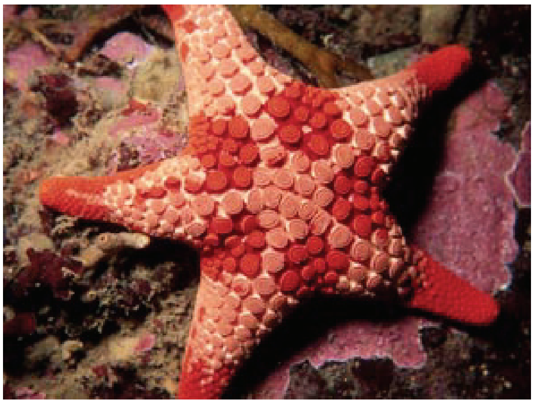


Red bait crab *Plagusia chabrus*

Figure 1.2 Examples of species of invertebrates and cryptic fish found on Victorian subtidal reefs

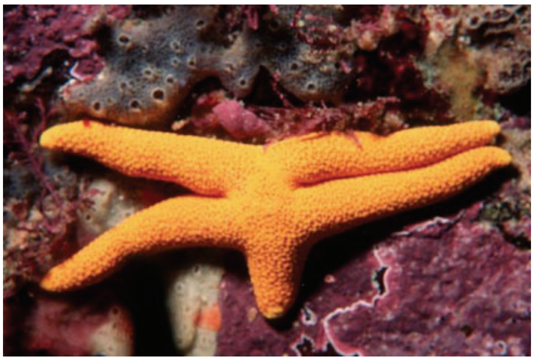
Blacklip abalone *Haliotis rubra*

Feather star *Cenolia trichoptera*



Nectria ocellata

Common sea urchin *Heliocidaris erythrogramma*



Fromia polypora

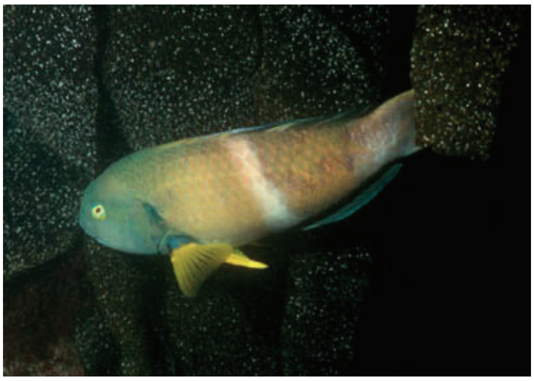
Red velvet fish *Gnathanocanthus goetzeei*

Figure 1.2 Cont. Examples of species of invertebrates and cryptic fish found on Victorian subtidal reefs

Sea sweep Scorpis aequipinnis, and

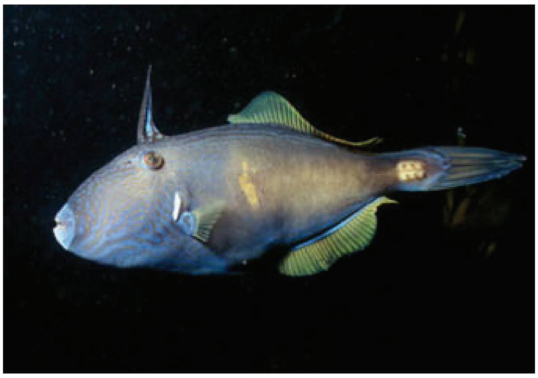
butterfly perch Caesioperca lepidoptera

Scalyfin Parma victoriae



Blue-throated wrasse *Notolabrus tetricus*

(male)



Six-spined leatherjacket *Meuscheni freycineti*

(male)

Magpie morwong Cheilodactylus nigripes

Old-wife Enoplosus armatus

Figure 1.3. Examples of fish species found on Victorian subtidal reef

Information from the SRMP will allow 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 are 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, Roob and Ferns 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.* 2000).

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. Graphs 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 1.4). 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.

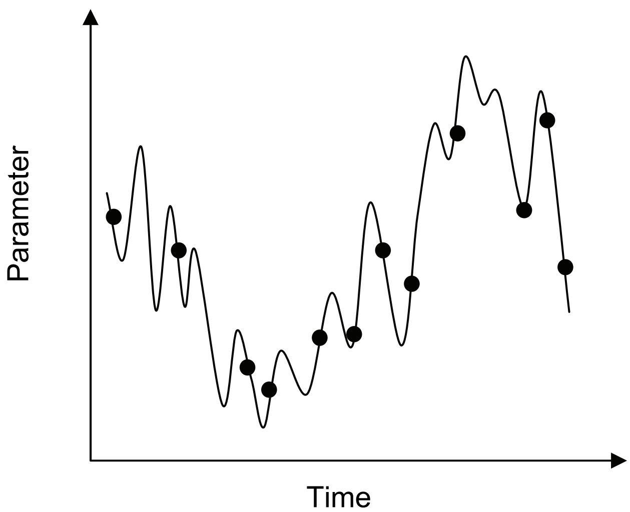


Figure 1.4 An example plot depicting change in an environmental, population or community variable over time (days, months or years). The black circles denote examples of monitoring times. Note how data from these times may not necessarily reflect patterns over shorter time periods, or true maxima or 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 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 with 15 sites established on subtidal reef habitats 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 (12 sites), Phillip Island (6 sites), and Wilsons Promontory Marine National Park (20 sites).

In 2003, the Subtidal Reef Monitoring Program was expanded to include a further seven Marine National Parks and Marine Sanctuaries: Point Cooke, Jawbone, Ricketts Point, Merri, Marengo Reef and Eagle Rock Marine Sanctuaries and Point Addis Marine National Park.

1.3 Marine Protected Areas at Port Phillip Heads

1.3.1 Previous marine protected areas

The Harold Holt Marine Reserves in the Port Phillip Heads region were declared under section 79A of the Fisheries Act 1968, on 7 February 1979. The reserves included a variety of marine habitats at Swan Bay, Mud Islands, Point Lonsdale, Point Nepean and The Annulus (Popes Eye). The Swan Bay and Mud Islands reserves were predominantly mudflats, seagrass meadows and sandbanks. The Swan Bay and Mud Island areas were not investigated as part of this study.

Line fishing (only) was permitted in the Point Nepean and Point Lonsdale reserves. The Annulus had sanctuary status: all forms of commercial and amateur fishing, and removal of any living or non-living material was prohibited.

1.3.2 Proposed ECC Marine Protected Areas

In 1998, the Environment Conservation Council provided recommendations on the location of marine protected areas for the Port Phillip Heads Region (ECC 1998). This proposal was based on the existing Harold Holt Marine Reserves, with a larger protected area in Lonsdale Bay and higher levels of protection in all areas. The baseline monitoring program at Port Phillip Heads was designed on the basis of this proposal and the distribution of shallow reefs.

The ECC final proposal (ECC 2000) was subsequently adapted to form the Port Phillip Heads Marine National Park in 2002.

1.3.3 Port Phillip Heads Marine National Park

The Port Phillip Heads Marine National Park was declared under the *National Parks (Amendment) Act 2002*, on 16 November 2002. The new Marine National Park incorporates the five locations previously protected as the Harold Holt Marine Reserves – Point Lonsdale, Point Nepean, The Annulus (Popes Eye), Mud Islands, Swan Bay and also includes a new location – Portsea Hole (Figure 2.1).

All recreational and commercial collection and fishing activities are prohibited within the Port Phillip Heads Marine National Park.

1.3.3.1 Point Lonsdale

The Point Lonsdale component is on the western side of the entrance to Port Phillip Bay and includes intertidal rocky platform and subtidal rocky reefs exposed to the open ocean and strong tidal currents as well as a more protected section in Lonsdale Bay. Over one hundred and fifty species of opisthobranch molluscs (colourful seaslugs) have been observed within this reserve and this area is a type locality for many marine species (Ivanovici 1984).

1.3.3.2 Point Nepean

The Point Nepean component is on the eastern side of the entrance to Port Phillip Bay, and includes intertidal rocky platforms and subtidal rocky reefs. This area includes reefs exposed to the open ocean and strong tidal currents as well more protected areas inside Nepean Bay. This area provides habitat for some rare species of algae and molluscs.

1.3.3.3 The Annulus (Popes Eye)

The Annulus is an artificial reef, originally constructed as a breakwater for a semi-submerged ship-fortress, to protect the entrance of Port Phillip Bay. The artificial reef consists of a semi-circular ring of large basalt blocks, near the Popes Eye Beacon. The reef is approximately 200 m long by 15 m wide, dropping steeply to sand (approximately 8 m depth on the southern side).

1.4 Monitoring at Port Phillip Heads

The monitoring program uses standardised underwater visual census methods originally developed and applied in Tasmania (described in Edgar and Barrett 1997). The study concentrates on species associated with reefs because this habitat type is of particular interest to natural resource managers. In addition, many reef-associated species are site attached and therefore provide a good indication of the performance of management strategies. By contrast, most open water and soft-bottom fishes are highly mobile, and generally pass through relatively small areas before management processes can have an effect.

This report provides a description of the monitoring program, and its status, at Port Phillip Heads. Summaries of the data are provided, building on the results from previous reports (Edmunds *et al.* 1999; Edmunds *et al.* 2000; Edmunds, Roob and Ling 2001; Edmunds, Roob and Callan 2001; Edmunds *et al.* 2002). Objectives of this report were to:

1. Describe the general progress of the monitoring program;
2. Provide general descriptions of the biological communities and species populations at each monitoring site; and
3. Identify any unusual biological phenomena, such as interesting communities; strong temporal trends and the presence of introduced species.

2.0 METHODS

2.1 Site Selection and Survey Times

Fifteen sites were established in the Port Phillip Heads region in May 1998 (Table 2.1; Figure 2.1). The sites were established in four general regions that corresponded with the Harold Holt Marine Reserves that existed at that time, in addition to potential new marine protected areas proposed at that time (Environment Conservation Council 1998). The sites were generally selected so they had matching habitat types inside and outside the existing and proposed protected areas. This was not always possible given habitat availability. The amount of reef suitable for surveying was limited in extent, which also restricted the ability to match site characteristics.

The Port Phillip Heads Marine National Park was declared in 2002 and incorporates areas previously protected as the Harold Holt Marine Reserves. Changes were made to the boundaries of the Marine National Park as originally proposed by the Environment Conservation Council (ECC) in 1998 and 2000 (ECC 1998, 2000). Some sites that were located on the basis of the proposed marine national park boundaries in 1998 are no longer situated in accordance with the initial monitoring strategy. However, monitoring is continuing at all sites in their original locations to ensure continuity of the long-term data set (the longest marine ecological dataset in Victoria).

Survey sites are in four general regions at Port Phillip Heads: sheltered habitats well inside the Heads, from Shortland Bluff to South Channel Fort; the inside shore of Point Nepean, on the eastern side of the Heads; Lonsdale Bay on the western side of the Heads; and outside the Heads, from Point Lonsdale to Lonsdale Back-beach. These regions vary in exposure to wave action, ranging from sheltered conditions well inside the Heads, to moderately exposed conditions in Nepean and Lonsdale Bays through to sub-maximally exposed conditions on the open coast.

No sites were established on the exposed coast of Point Nepean, where the boundary of the proposed park was originally to the 2 m depth contour. The waves are usually too large to work in this region, particularly at depths less than 2 m, and there is virtually no reef deeper than 2-3 m. Three monitoring sites were established on the inner side of Point Nepean, in Nepean Bay. There is a limited amount of patchy reef in this bay, mostly at 2-3 m depth but extending to 5 m depth in places. With the exception of a limited area of reef at Point Franklin, there are few suitable reference areas for the Nepean Bay reefs. Two sites were established on reefs within the original Harold-Holt marine reserve (Sites 3 & 8), with these being matched by sites at Nepean Bay (Site 2) and Point Franklin (Site 1).

A monitoring site was established on the southern side of the reef at Popes Eye (The Annulus, Site 12). This site is matched by a site at South Channel Fort (Site 4). While there is a moderate amount of reef available for survey at Portsea Hole and on the Lonsdale Wall, these sites are below safe depths for detailed quantitative surveys.

Within the Lonsdale Bay region (inside Point Lonsdale), there are small patches of reef outcrops in 5-7 m of water. Five sites were established in Lonsdale Bay (Sites 6, 7, 9, 10 and 11) and one site was established at Shortland Bluff. Three sites were established on the open coast, south and to the west of Point Lonsdale (Site 13, 14 and 15).

The monitoring program at Port Phillip Heads began in May 1998, with biannual surveys occurring during the spring and autumn seasons until 2001, with annual surveys thereafter. There have been ten surveys since the program began, with the latest in summer 2004 (Table 2.2). Persistent bad weather during autumn and winter of 2000 meant the fifth survey had to be completed over a period of several months. The sixth survey was scheduled for spring 2000 but was delayed until December and January, while the seventh survey was in June 2001.

The eighth and ninth surveys at Port Phillip Heads were completed in the mid-summer period (January 2002 and 2003) to enable the assessment of any invasion of introduced Japanese kelp *Undaria pinnatifida* (often termed 'blackberries of the sea'). This marine pest is established in the north of Port Phillip Bay and is gradually colonising subtidal habitats southwards along the eastern side of the Bay. This species is an annual with biomass highest in spring/early summer and lowest in autumn/early winter. No *Undaria pinnatifolia* plants were observed at the Port Phillip Heads over these two surveys.

The tenth survey was during winter 2004 to attain some seasonal variation between the different survey periods. The eleventh survey was in summer 2004 providing another 6 month (summer/winter) comparison period.

2.2 Census method

2.2.1 Transect Layout

The visual census methods of Edgar-Barrett (Edgar and Barrett 1997, 1999; Edgar *et al.* 1997) are used for this monitoring program, as they 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 and Western Australia, and 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 standardised operational procedure (Edmunds and Hart 2003), to ensure long-term integrity and quality of the data.

Table 2.1. Site details for Port Phillip Heads.

Region	*No.*	*Description*	*Depth*
Inside Heads	12	Annulus (Popes Eye)	5
	4	South Channel Fort	2
	1	Point Franklin	2
	5	Shortland Bluff	5
Point Nepean	2	Nepean Offshore	2
	3	Nepean Inner West	2
	8	Nepean Inner East	2
Lonsdale Bay	6	Victory Shoal	5
	7	Merlan Inner	5
	10	Merlan Outer	5
	9	Lonsdale Kelp Outer	7
	11	Lonsdale Kelp Inner	7
Outside Heads	13	Lonsdale Point	7
	14	Lonsdale Back Beach	5
	15	Lonsdale Pt SW	7

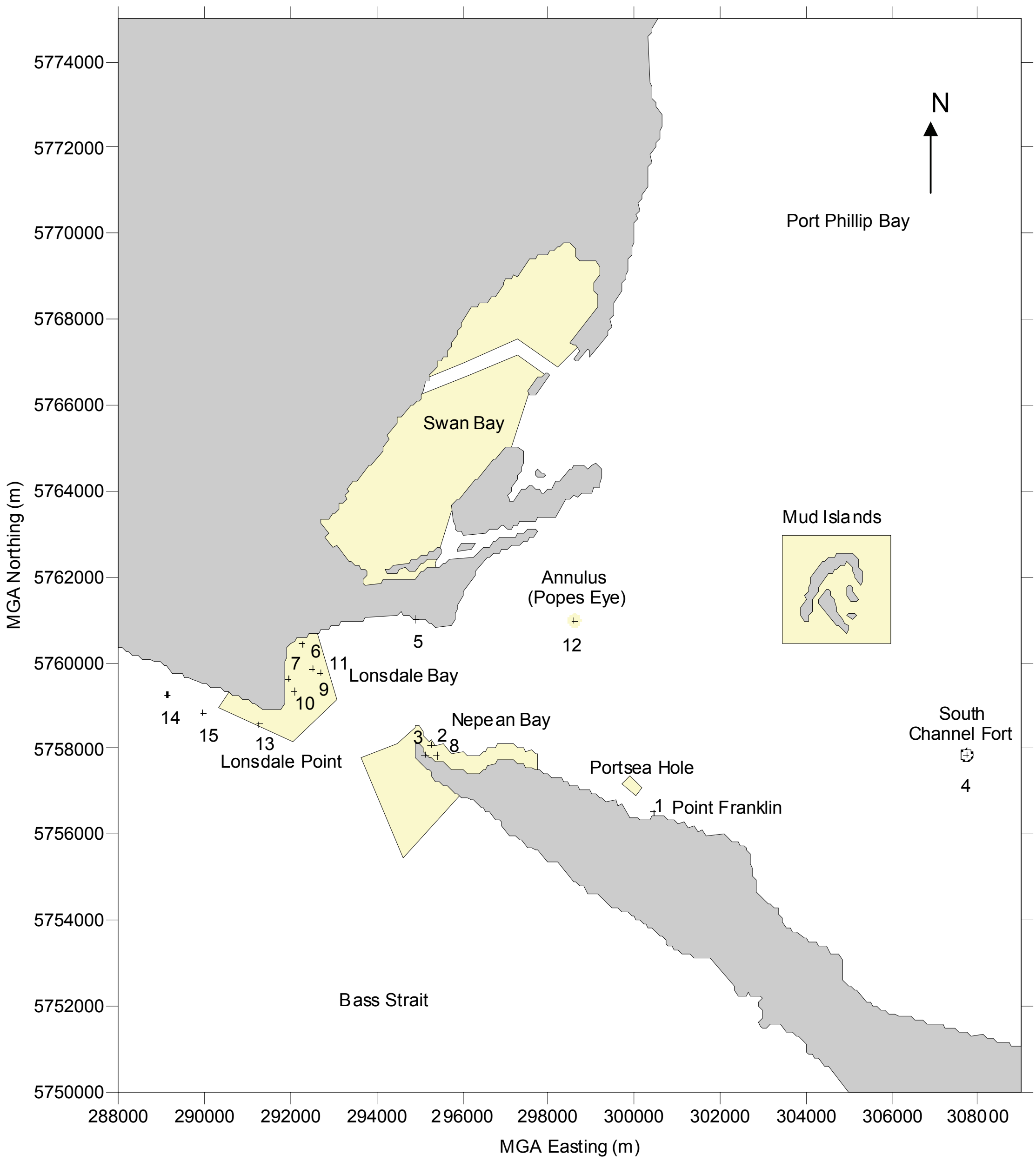


Figure 2.1. Port Phillip Heads Marine National Park (in yellow). The positions of long-term monitoring sites are shown.

Figure 2.2. Biologist-diver with transect reel, Lonsdale Back Beach.

Table 2.2. Survey times for monitoring at Port Phillip Heads.

Survey	*Season*	*Survey Period*
1	Autumn 1998	May 1998
2	Spring 1998	September - October 1998
3	Autumn 1999	May - July 1999
4	Spring 1999	October - November 1999
5	Autumn/Winter 2000	May - August 2000
6	Summer 2000/2001	November 2000 - January 2001
7	Autumn 2001	June - July 2001
8	Summer 2001/2002	January 2002
9	Summer 2003	January 2003
10	Winter 2004	July 2004
11	Summer 2004	December 2004

At most monitoring locations in Victoria, 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, many of the reefs at Port Phillip Heads sites were only present in shallower or deeper water. Consequently, site depths vary between 2 and 7 m depth (Table 2.1).

Each site is located using differential GPS and marked with a buoy. 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 of transect (T1 to T4). The orientation of transect is the same for each survey, with T1 toward the north or east (*i.e.* anticlockwise along the open coast).

For each transect line, four 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; (3) the percent cover of macroalgae; and (4) the density of string-kelp *Macrocystis* plants. Over 300 species were observed during the monitoring program at Port Phillip Heads (Table 2.3, Table 2.4). 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 each of the 50 m sections 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. 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 an underwater slate to enable calibration of size estimates. 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 psittaculus* and some monacanthids. A total of four 10 x 50 m sections of the transect are censused for mobile fish at each site.

2.2.3 Method 2 – Invertebrates and Cryptic Fishes

Cryptic fishes and megafaunal invertebrates (non-sessile: *e.g.* large molluscs, echinoderms, crustaceans) are counted along the 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 transect). A pole carried by the diver is used to standardise the 1 m distance. The maximum length of abalone and the carapace length and sex of rock lobsters are measured *in situ* using vernier callipers whenever possible. Selected specimens are collected for identification and preservation in a reference collection.

2.2.4 Method 3 – Macroalgae

The area covered by macroalgal 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. 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 collected for identification and preservation in a reference collection.

2.1.5 Method 4 – *Macrocystis*

In addition to macroalgal cover, 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). This survey component commenced during spring 1999.

Table 2.3. Macroalgae (method 3) taxa censused at Port Phillip Heads.

Method 3			
***Chlorophyta* (green algae)**	***Phaeophyta (cont.)***	***Rhodophya* (cont.)**	***Rhodophya (cont.)***
Ulva spp	*Zonaria turneriana*	*Pterocladia capillacea*	*Plocamium patagiatum*
Chaetomorpha sp	*Lobophora variegata*	*Asparagopsis armata*	*Plocamium mertensii*
Abjohnia laetevirens	*Scytosiphon lomentaria*	*Delisea pulchra*	*Plocamium dilatatum*
Cladophora rhizoclonioidea	*Colpomenia sinuosa*	*Delisea* spp	*Plocamium preissianum*
Cladophora prolifera	*Colpomenia peregrina*	*Ptilonia australasica*	*Plocamium cartilagineum*
Cladophora spp	*Carpomitra costata*	*Asparagopsis spp.*	*Plocamium leptophyllum*
Caulerpa remotifolia	*Sporochnus* sp	*Amphiroa anceps*	*Champia viridis*
Caulerpa scalpelliformis	*Perithalia cordata*	*Corallina officinalis*	*Champia zostericola*
Caulerpa longifolia	*Bellotia eriophorum*	*Haliptilon roseum*	*Champia* sp
Caulerpa trifaria	*Ecklonia radiata*	*Cheilosporum sagittatum*	*Botryocladia obovata*
Caulerpa brownii	*Macrocystis angustifolia*	*Metagoniolithon radiatum*	*Gloiosaccion brownii*
Caulerpa obscura	*Durvillaea potatorum*	*Geniculate corralines*	*Erythrymenia minuta*
Caulerpa flexilis	*Xiphophora chondrophylla*	*Encrusting corallines*	*Rhodymenia leptophylla*
Caulerpa flexilis var. *muelleri*	*Phyllospora comosa*	*Corallines unidentified*	*Rhodymenia australis*
Caulerpa geminata	*Seirococcus axillaris*	*Solieria robusta*	*Rhodymenia obtusa*
Caulerpa annulata	*Caulocystis cephalornithos*	*Rhodoglossum gigartinoides*	*Rhodymenia spp*
Caulerpa cactoides	*Acrocarpia paniculata*	*Gigartina sonderi*	*Cordylecladia furcellata*
Caulerpa vesiculifera	*Cystophora platylobium*	*Gigartina crassicaulis*	*Griffithsia teges*
Caulerpa simpliciuscula	*Cystophora moniliformis*	*Gigartina* sp.	*Ballia callitricha*
Codium lucasi	*Cystophora xiphocarpa*	*Hypnea ramentacea*	*Ballia scoparia*
Codium pomoides	*Cystophora pectinata*	*Callophyllis lambertii*	*Euptilota articulata*
Codium galeatum	*Cystophora monilifera*	*Callophyllis rangiferinus*	*Martensia australis*
Codium duthieae	*Cystophora expansa*	*Nizymenia australis*	*Hemineura frondosa*
Codium harveyi	*Cystophora retorta*	*Sonderopelta coriacea*	*Dictymenia harveyana*
Codium spp	*Cystophora siliquosa*	*Sonderopelta/ Peyssonelia*	*Dictymenia tridens*
Chlorodesmis baculifera	*Cystophora retroflexa*	*Phacelocarpus alatus*	*Jeannerettia lobata*
Ectocarpus spp	*Cystophora subfarcinata*	*Phacelocarpus complanatus*	*Jeannerettia pedicellata*
***Phaeophyta* (brown algae)**	*Cystophora* spp	*Phacelocarpus peperocarpus*	*Lenormandia marginata*
Halopteris spp	*Carpoglossum confluens*	*Stenogramme interrupta*	*Lenormandia muelleri*
Cladostephus spongiosus	*Sargassum heteromorphum*	*Callophycus laxus*	*Lenormandia smithiae*
Dictyota (fine)	*Sargassum decipiens*	*Callophycus* spp	*Laurencia clavate*
Dictyota dichotoma	*Sargassum sonderi*	*Erythroclonium sonderi*	*Laurencia elata*
Dilophus marginatus	*Sargassum varians*	*Erythroclonium* spp	*Laurencia filiformis*
Dilophus fastigiatus	*Sargassum verruculosum*	*Areschougia congesta*	*Laurencia* spp
Pachydictyon paniculatum	*Sargassum fallax*	*Areschougia* spp	*Echinothamnion sp*
Pachydictyon spp.	*Sargassum vestitum*	*Acrotylus australis*	*Echinothamnion hystrix*
Lobospira bicuspidata	*Sargassum linearifolium*	*Gracilaria secundata*	*Dasya sp*
Dictyopteris acrostichoides	*Sargassum spinuligerum*	*Curdiea angustata*	*Thuretia quercifolia*
Dictyopteris muelleri	*Sargassum* spp	*Melanthalia obtusata*	*Chondria viridis*
Chlanidophora microphylla	Filamentous browns	*Melanthalia abscissa*	*Filamentous red algae*
Distromium spp	Brown algae unidentified	*Melanthalia concinna*	*Other thallose red alga*
Homeostrichus sinclairii	***Rhodophya* (red algae)**	*Polyopes constrictus*	***Magnoliophyta***
Homeostrichus olsenii	*Gelidium asperum*	*Grateloupia filicina*	*Halophila ovalis*
Zonaria angustata	*Gelidium australe*	*Thamnoclonium dichotomum*	*Amphibolis antarctica*
Zonaria crenata	*Gelidium* spp	*Plocamium angustum*	*Zostera tasmanica*
Zonaria spiralis	*Pterocladia lucida*	*Plocamium costatum*	

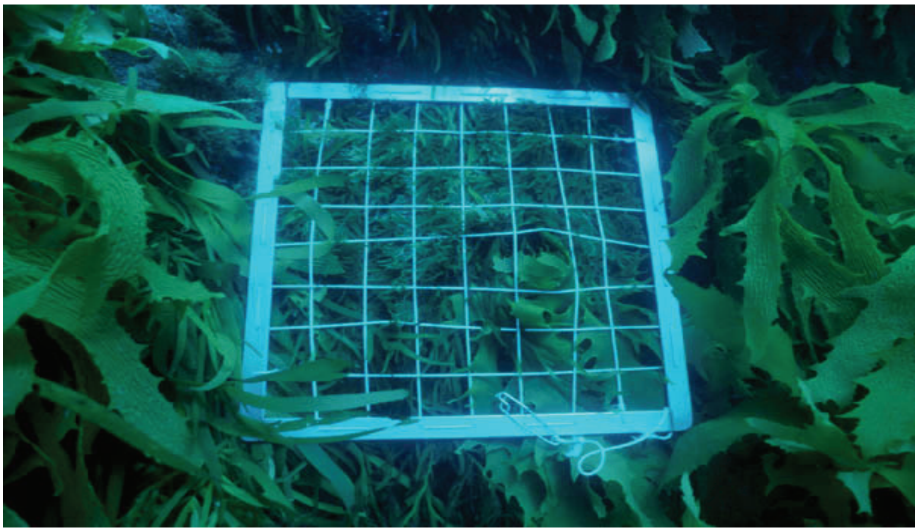


Figure 2.3. The cover of macrophytes is measured by the number of points intersecting each species on the quadrat grid.

Table 2.4. Invertebrate, cryptic fish (Method 2) and mobile fish (Method 1) taxa censused at Port Phillip Heads.

Method 2		***Method 1***	
Cnidaria	***Mollusca* (cont.)**	**Mobile Fauna**	**Mobile Bony Fishes (Cont.)**
Phlyctenactis tuberculosa	*Chlamys asperimus*	***Cephalopoda* (squids)**	*Aplodactylus arctidens*
Polychaeta (worms)	*Pecten fumatus*	*Sepia apama*	*Cheilodactylus nigripes*
Sabella spallanzani	***Cephalopoda* (squids)**	*Sepioteuthis australis*	*Cheilodactylus spectabilis*
Crustacea	*Octopus maorum*	**Mobile Sharks and Rays**	*Nemadactylus valenciennesi*
Jasus edwardsii	*Sepia apama*	*Heterodontus portusjacksoni*	*Dactylophora nigricans*
Paguristes frontalis	***Echinodermata***	*Parascyllium variolatum*	*Latridopsis forsteri*
Strizopagurus strigimanus	*Cenolia trichoptera*	*Trygonorrhina fasciata*	*Achoerodus gouldii*
Diogenid (purple leg)	*Cenolia tasmaniae*	*Dasyatis brevicaudata*	*Coris sandageri*
Pagurid unidentified	*Tosia australis*	*Myliobatis australis*	*Dotalabrus aurantiacus*
Nectocarcinus tuberculatus	*Tosia magnifica*	*Urolophus cruciatus*	*Notolabrus tetricus*
Plagusia chabrus	*Pentagonaster dubeni*	*Urolophus gigas*	*Notolabrus fucicola*
Petrocheles australiensis	*Nectria ocellata*	*Urolophus paucimaculatus*	*Pseudolabrus psittaculus*
Mollusca	*Nectria macrobranchia*	*Trygonoptera mucosa*	*Pictilabrus laticlavius*
Haliotis rubra	*Nectria multispina*	**Mobile Bony Fishes**	*Odax acroptilus*
Haliotis laevigata	*Petricia vernicina*	*Sardinops neopilchardus*	*Odax cyanomelas*
Haliotis scalaris	*Fromia polypora*	*Engraulis australis*	*Siphonognathus beddomei*
Scutus antipodes	*Plectaster decanus*	*Pseudophycis bachus*	*Neoodax balteatus*
Calliostoma armillata	*Echinaster arcystatus*	*Hyporhamphus melanochir*	*Haletta semifasciata*
Phasianotrochus eximius	*Nepanthia troughtoni*	*Trachichthys australis*	*Bovichtus angustifrons*
Phasianella australis	*Patiriella brevispina*	*Phyllopteryx taeniolatus*	*Parablennius tasmanianus*
Phasianella ventricosa	*Coscinasterias muricata*	*Neosebastes scorpaenoides*	*Plagiotremus tapeinosoma*
Turbo undulatus	*Uniophora granifera*	*Platycephalus speculator*	*Heteroclinus tristis*
Astralium squamiferum	*Amblypneustes spp.*	*Caesioperca rasor*	*Heteroclinus johnstoni*
Astralium tentoriformis	*Holopneustes porosissimus*	*Hypoplectrodes nigrorubrum*	*Acanthaluteres vittiger*
Charonia lampas rubicunda	*Holopneustes inflatus*	*Paraplesiops meleagris*	*Acanthaluteres spilomelanurus*
Cabestana tabulata	*Heliocidaris erythrogramma*	*Trachinops caudimaculatus*	*Brachaluteres jacksonianus*
Cabestana spengleri	*Stichopus mollis*	*Dinolestes lewini*	*Monacanthus chinensis*
Cymatium parthenopeum	**Cryptic Fishes**	*Sillaginodes punctata*	*Scobinichthys granulatus*
Ranella australasia	*Parascyllium variolatum*	*Arripis georgiana*	*Meuschenia australis*
Sassia subdistorta	*Orectolobus ornatus*	*Arripis* spp.	*Meuschenia flavolineata*
Dicathais orbita	*Trygonoptera testacea*	*Upeneichthys vlaminghii*	*Meuschenia freycineti*
Agnewia tritoniformis	*Phyllopteryx taeniolatus*	*Pempheris multiradiata*	*Meuschenia galii*
Pleuroploca australasia	*Neosebastes scorpaenoides*	*Girella tricuspidata*	*Meuschenia hippocrepis*
Penion mandarinus	*Glyptauchen panduratus*	*Girella elevata*	*Meuschenia scaber*
Penion maxima	*Aetapcus maculatus*	*Girella zebra*	*Eubalichthys gunnii*
Conus anemone	*Platycephalus bassensis*	*Scorpis aequipinnis*	*Aracana aurita*
Aplysia spp	*Paraplesiops meleagris*	*Scorpis lineolata*	*Contusus brevicaudus*
Aplysia dactylomela	*Pempheris multiradiata*	*Atypichthys strigatus*	*Tetractenos glaber*
Sagaminopteron ornatum	*Pempheris compressa*	*Tilodon sexfasciatus*	*Diodon nichthemerus*
Tambja verconis	*Neoodax balteatus*	*Enoplosus armatus*	Unidentified fish
Neodoris chrysoderma	*Bovichtus angustifrons*	*Pentaceropsis recurvirostris*	**Marine Mammals**
Ceratosoma brevicaudatum	*Parablennius tasmanianus*	*Parma victoriae*	*Arctocephalus pusillis*
Chromodoris tasmaniensis	*Heteroclinus tristis*	*Parma microlepis*	
Mytilus edulis	*Heteroclinus johnstoni*	*Chromis hypsilepis*	

2.3 Data Analysis

2.3.1 Community Structure

Community structure is a multivariate function of both the type of species present and the abundance of each species. The community structure between pairs of samples was compared using the Bray-Curtis dissimilarity coefficient. This index compares the abundance of each species between two samples to give a single value of the difference between the samples, expressed as a percentage (Faith *et al.* 1987; Clarke 1993).

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

The Bray-Curtis dissimilarity index was calculated for all possible combinations of sites and surveys. 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 (*i.e.* 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 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. These guidelines are simplistic and increasing stress is correlated with increasing numbers of samples. In this case, three-dimensional solutions were sought to ensure an adequate representation of the higher-dimensional patterns.

2.3.3 Trends in Community Structure

Trends in community structure were examined statistically for each site using the Bray-Curtis matrix of dissimilarities. This was done by calculating the correlation between dissimilarity in species composition (Bray-Curtis coefficient) and the difference in times using all pairs of samples between times at each site (following Philippi *et al.* 1998). The Mantel r_M statistic was used as a measure of this correlation (ranging from 0 to 1). The significance of the r_M statistic was tested using a matrix permutation test (one tailed) with 1000 permutations (Upton and Fingleton 1985; Legendre and Legendre 1998).

2.3.4 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 ($1/D_{Simpson}$ = 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.

2.3.5 Species Populations

The abundances of each species were summarised by calculating total counts of fish and invertebrates, and total percentage cover of macroalgae, for each site. The abundances of selected species were plotted to examine the nature of temporal variations. Trend lines were fitted to the data using linear regressions of log-transformed abundances and plotting back-transformed curves (following Sweatman *et al.* 2000 except linear not quadratic functions were fitted). Trend lines were also fitted for diversity and species richness values (using untransformed data).

The population size structure for blacklip abalone *Haliotis rubra* was assessed by calculating mean lengths. The size structure of common fishes, particularly blue-throated wrasse *Notolabrus tetricus* and herring cale *Odax cyanomelas*, was examined using mean lengths and frequency tables. The sex ratio of sexually dimorphic species was also compared between sites.

3.0 MACROALGAE

3.1 Community Structure

Four general groups of macroalgal assemblages were observed corresponding with four site groupings: well inside the Heads; Nepean Bay; Lonsdale Bay; and outside the Heads. These groupings corresponded with differences in wave exposure and depth between sites. The most sheltered sites at Point Franklin (Site 1), South Channel Fort (Site 4), Shortland Bluff (Site 5) and Popes Eye (Site 12) were dominated by the kelp *Ecklonia radiata* and, with the exception of Point Franklin, had a high predominance of the turfing green algae *Cladophora prolifera* and *Caulerpa* species. Red algal species were generally absent at the island sites, possibly because of high silt loading. *Macrocystis angustifolia* formed small stands at Popes Eye, while *Caulocystis cephalornithos* and *Sargassum* species were more prevalent at South Channel Fort. Patches of *Amphibolis antarctica* were present at the Shortland Bluff site. Point Franklin was characterised by a variety of *Cystophora* and *Sargassum* species, as well as a greater abundance of red algae than the island sites.

The Nepean Bay sites (Sites 2, 3 and 8) were reasonably shallow (2-4 m) and moderately exposed. These sites were dominated by patches of mixed brown algal species and monospecific stands of the seagrass *Amphibolis antarctica*. The brown algae included *Ecklonia radiata*, *Phyllospora comosa*, *Cystophora moniliformis*, *Cystophora monilifera* and *Cystophora retorta*. Other common species included *Caulerpa flexilis*, *Caulerpa simplisciuscula*, *Codium duthieae*, *Sargassum decipiens* and *Sargassum spinuligerum*.

The Lonsdale Bay sites (Sites 6, 7, 9, 10 and 11) were deeper than Nepean Bay (4-7 m) but had a similar, moderate level of exposure. The predominant cover at the inner Bay site (Site 6) was by *Ecklonia radiata*, with *Cladophora prolifera*, *Seirococcus axillaris* and *Cystophora moniliformis*. *Amphibolis antarctica* formed substantial patches at Lonsdale kelp inner (Site 11). The algal assemblages at the more southern sites in Lonsdale Bay (Sites 7, 9, 10 and 11) had a higher dominance of *Phyllospora*, with *Ecklonia* also contributing a considerable portion of the canopy. A relatively low cover of red algal species was present as an understorey. The understorey species included *Ballia callitricha*, *Areschougia congesta*, *Phacelocarpus peperocarpus* and *Plocamium* spp.

The three sub-maximally exposed sites outside the Heads (Sites 13, 14 and 15) had a relatively high cover of *Ecklonia*, with the eastern Sites 13 and 15 also having a high cover of *Phyllospora*. *Phyllospora* was absent from the western-most Site 14, where a larger variety of brown species was present, including *Carpoglossum confluens*, *Cystophora moniliformis, Cystophora platylobium* and *Cystophora retorta*. This difference in community structure between Site 14 and Sites 13 and 15 may be attributable to the lower profile reef at Site 14, which was prone to covering and scour by sand (wave surge characteristics may also be different). All three outer sites had a high cover of understorey species, such as *Haliptalon roseum*, *Phacelocarpus peperocarpus*, *Pterocladia lucida*, *Ballia callitricha* and *Areschougia congesta*.

The algal community structures were compared between the eleven times for each of the 15 sites (165 site-time combinations) using MDS analysis (Figure 3.1). In most cases, the variation between times was generally less than the differences between sites: differences in community structure between sites tended to be maintained over the survey period (Figure 3.1).

Tests for progressive changes (trends) in species composition over the five monitoring years detected significant ($p \leq 0.05$) trends in community structure at most sites (Table 3.1). The only exception was Site 1, where successive changes between times appeared to be random (Table 3.1).

Table 3.1. Tests of trends in macrophyte community changes over time at Port Phillip Heads. The Mantel rM statistic is a measure of the correlation between dissimilarity in species composition (Bray-Curtis coefficient) and difference in times. The significance of the rM value was tested using a permutation test with 1000 permutations.

Site	***Mantel r_M***	***Probability***	***% B-C Dissimilarity (first to last)***
1	0.16	0.20	47
2	0.33	0.05	56
3	0.39	0.02	55
4	0.40	< 0.00	49
5	0.52	< 0.00	63
6	0.45	0.01	57
7	0.47	< 0.00	49
8	0.46	< 0.00	45
9	0.56	< 0.00	53
10	0.52	< 0.00	51
11	0.29	0.05	51
12	0.32	0.04	48
13	0.62	< 0.00	49
14	0.56	< 0.00	47
15	0.31	0.05	42

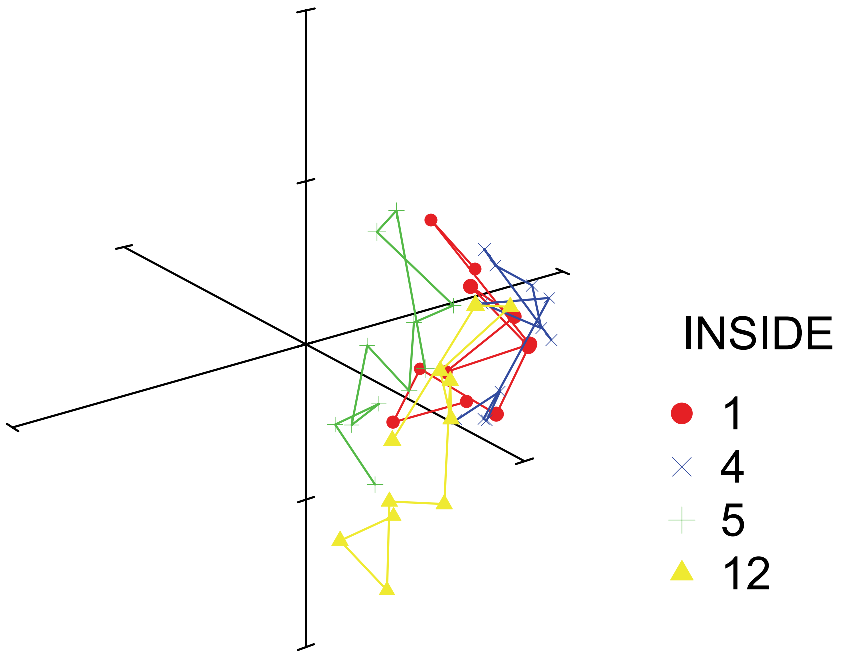


Figure 3.1a Three-dimensional MDS plot of algal assemblage structure for inner Heads. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17.

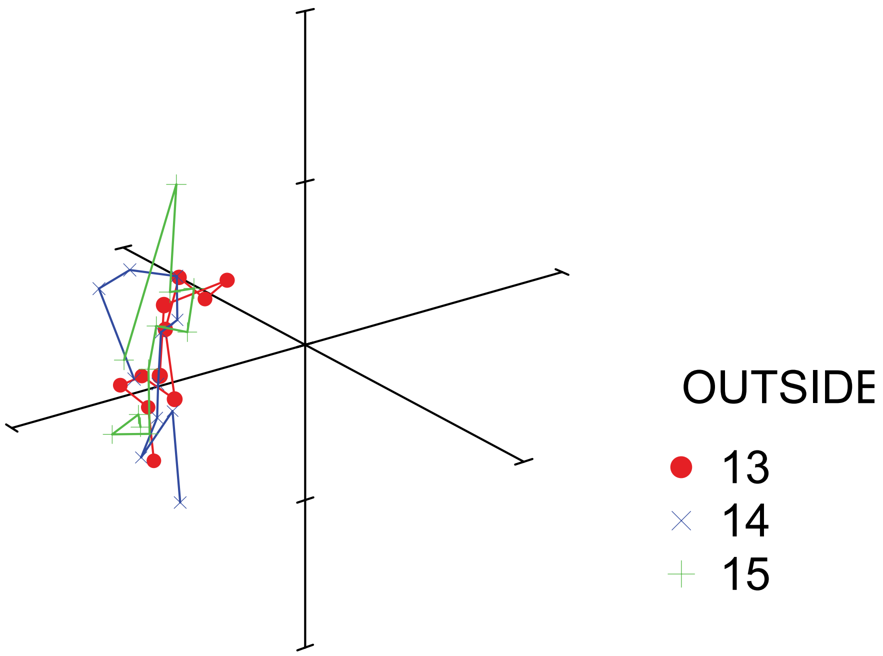


Figure 3.1b Three-dimensional MDS plot of algal assemblage structure for outside the Heads. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17.

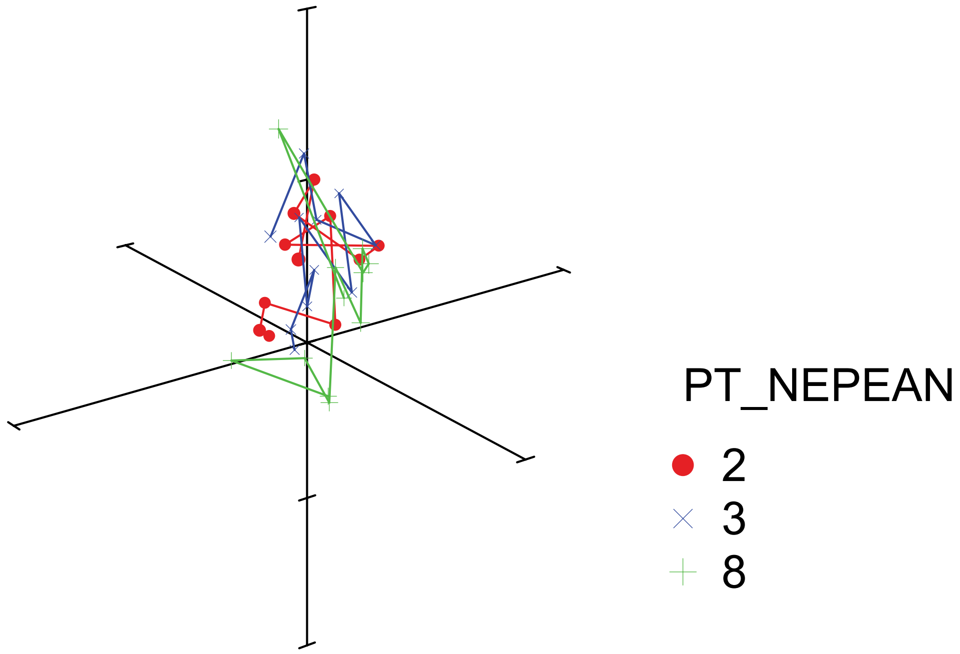


Figure 3.1c Three-dimensional MDS plot of algal assemblage structure for Nepean Bay. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17.

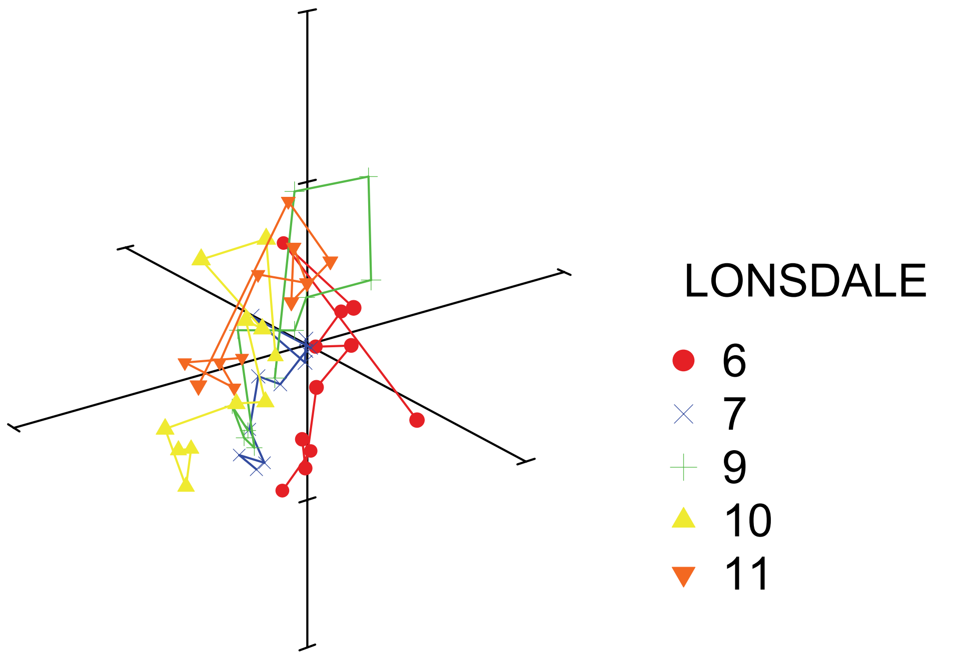


Figure 3.1d Three-dimensional MDS plot of algal assemblage structure Lonsdale Bay. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17.

3.2 Diversity

The macroalgal species richness at each site generally ranged between 30-40 species. Exceptions were at Point Nepean (Sites 3) and inside the Heads (Sites 1, 4 and 12), which ranged between 20-30 species (Figure 3.2). Over time, species richness has increased for most sites, particularly at Victory Shoal (Site 6), Merlin Inner (Site 7) and the three sites outside the heads (Sites 13, 14 and 15). Species diversity (Figure 3.3) was relatively variable through time at Shortland Bluff (Sites 5), Victory Shoal (Site 6) and Lonsdale Kelp Inner (Site 9). Most other sites had a slight increase in diversity of Hill's $N_2 \approx 5$ (Figure 3.3) over the eleven surveys. Lonsdale Backbeach (Site 14) had a much higher diversity of Hill's $N_2 \approx 15$ and, along with South Channel Fort (Site 4), showed a large increase in diversity through time (Figure 3.3).

3.3 Population Abundances

Examples of time trends in abundances of selected species are given for each site in Figures 3.4 to 3.13.

The green alga *Cladophora prolifera* was consistently present at the Inner Heads sites, as well as some Nepean Bay and Lonsdale Bay sites (Sites 4, 5, 6, 9 and 12; Figure 3.4). Abundances were highest at Popes Eye, Shortland Bluff and South Channel Fort (Sites 4, 5, and 12), but were quite variable through time at these sites (Figure 3.4).

The common kelp *Ecklonia radiata* was abundant at most sites, with highest abundances at the inner sites of Point Franklin and Popes Eye (Sites 1 and 12; Figure 3.5). Increasing trends in abundance were apparent for Victory Shoal, Nepean Inner East and Merlan Reef Outer (Sites 6, 8 and 10). Abundances appeared to be seasonally variable through time at the two island sites (Sites 4 and 12) and at Kelp Outer (Site 9), with higher coverage in spring/summer months. Increases and then a slight decline in abundance over time were apparent for Point Franklin and Merlan Outer (Sites 1 and 10).

The crayweed *Phyllospora comosa* was abundant at the more exposed sites, particularly Nepean Bay east (Site 8), Merlan Reef (Sites 7 and 10) and Point Lonsdale (Sites 13 and 15; Figure 3.6). A strong decreasing trend in abundance was apparent at Nepean Bay East (Site 8) and Outer Merlan Reef (Site 10). *Phyllospora comosa* was notably absent from Lonsdale Back Beach (Site 14). This was probably because this reef has a low profile and is subject to sand inundation.

Red algae (Rhodophyta) were relatively low in abundance compared to the larger green *Caulerpa* species and brown algae, and had considerably greater temporal variation. The most commonly encountered species were *Plocamium angustum*, *Melanthalia obtusata*, *Ballia callitricha*, *Phacelocarpus peperocarpus* and *Pterocladia lucida*. These species tended to be more persistent at sites outside the Heads (Figures 3.8 to 3.12).

The seagrass *Amphibolis antarctica* was prevalent on the transects in Nepean Bay (Sites 2 and 3) and Lonsdale Kelp Inner (Site 11; Figure 3.13). This species is also abundant at Victory Shoal (Site 6), but not along the transect location.

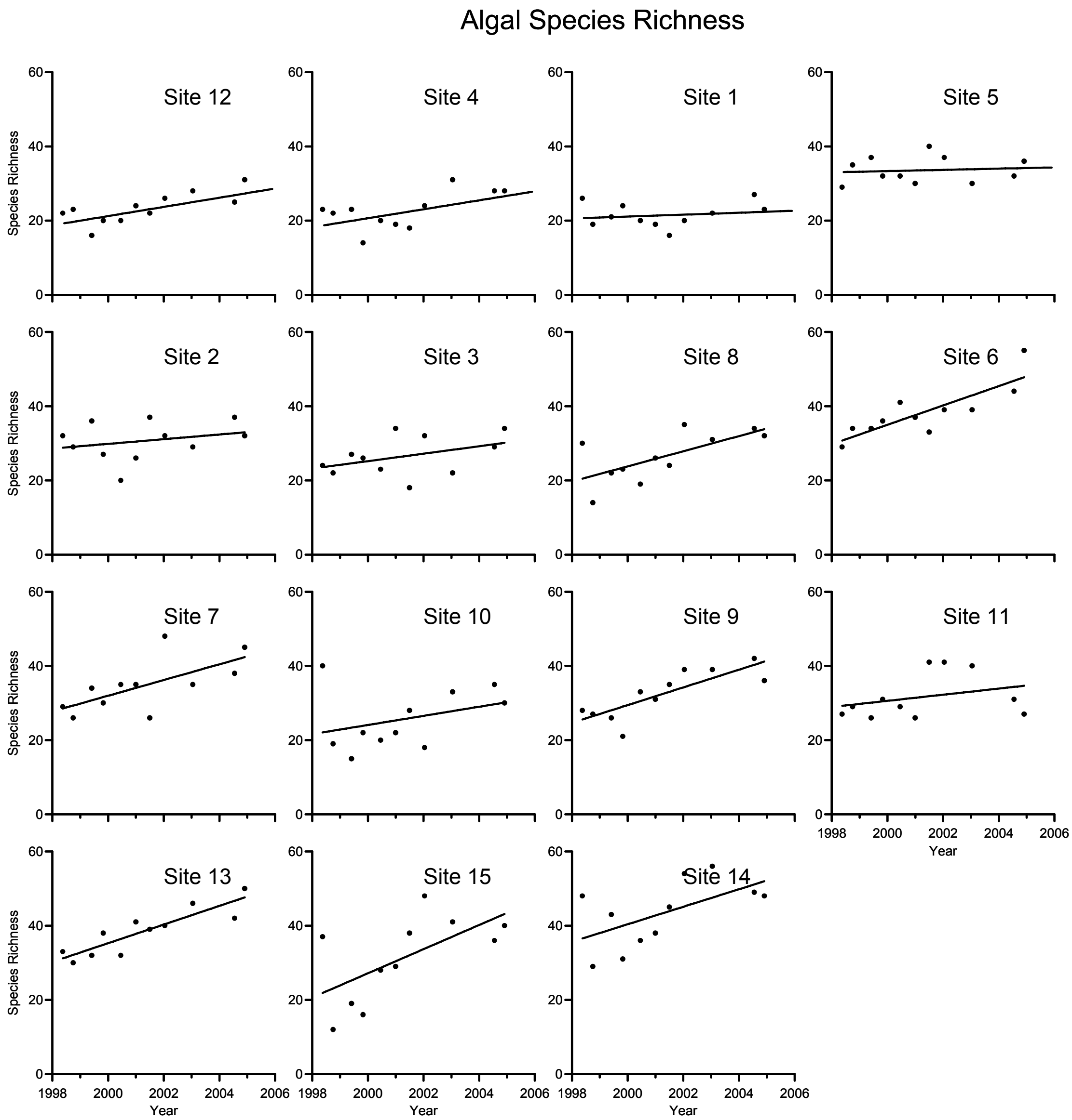


Figure 3.2 Trends in species richness of macrophytes at Port Phillip Heads.

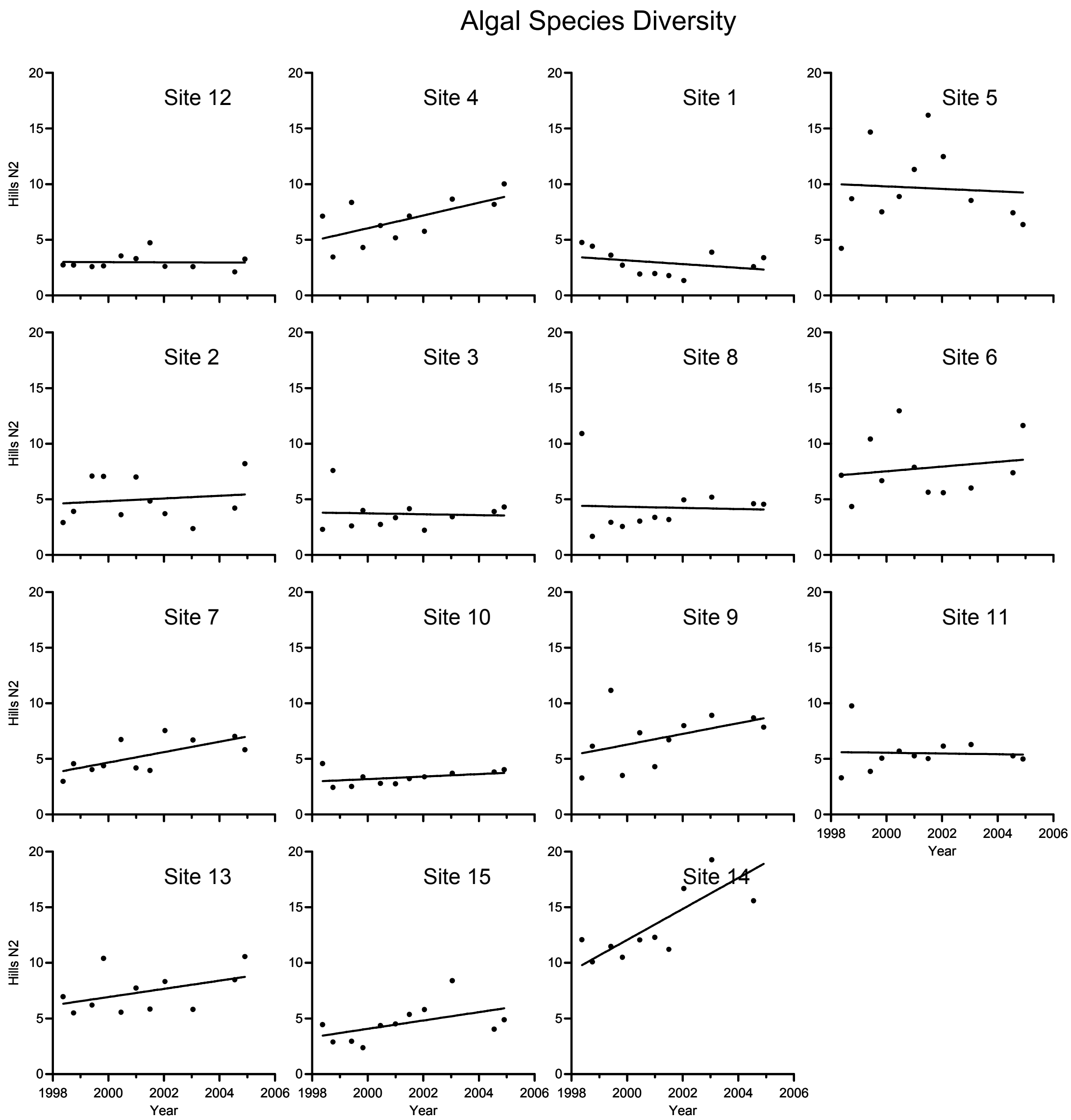


Figure 3.3 Trends in species diversity of macrophytes at Port Phillip Heads.

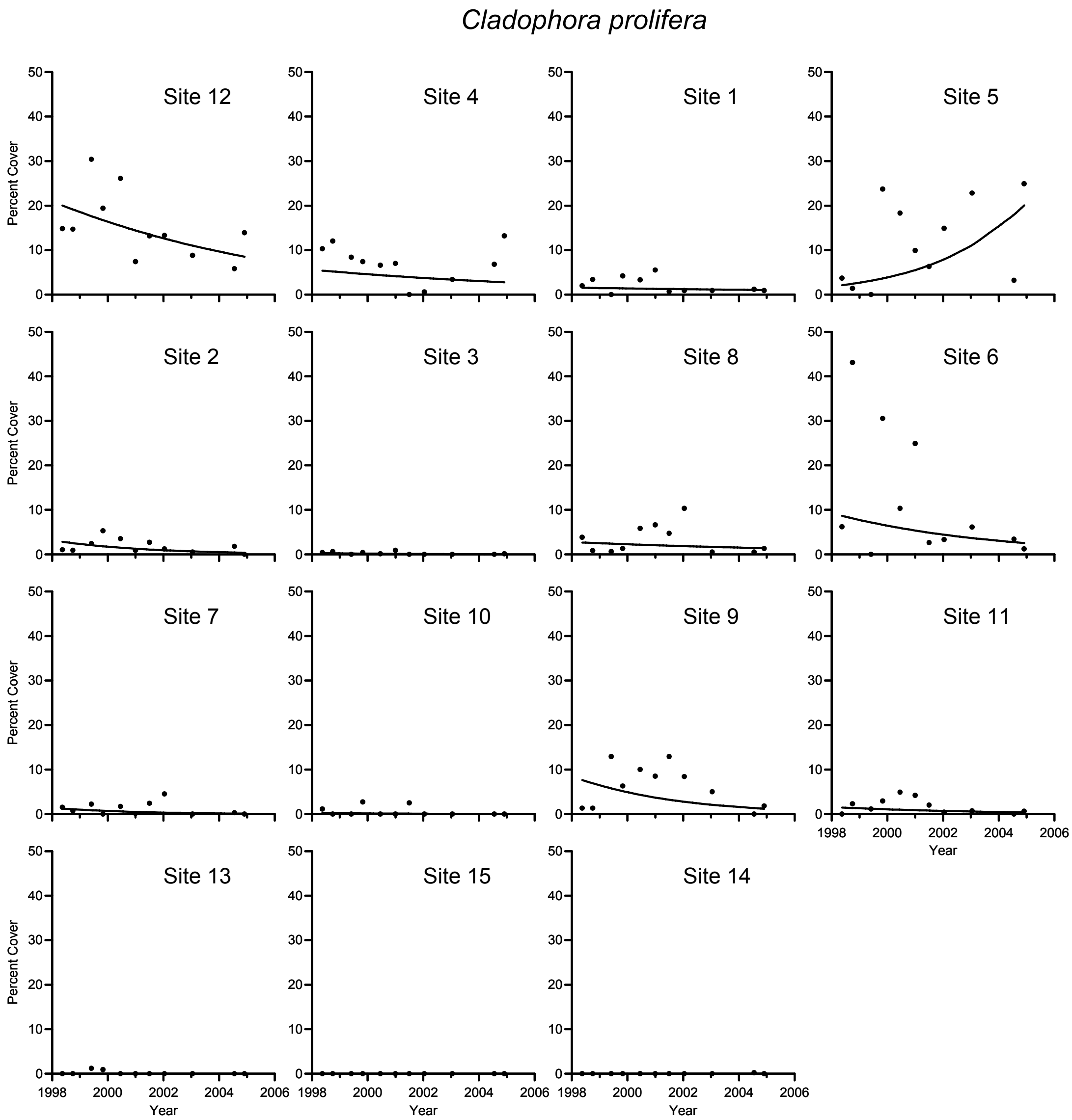


Figure 3.4 Trends in abundance of the filamentous green alga *Cladophora prolifera* at Port Phillip Heads.

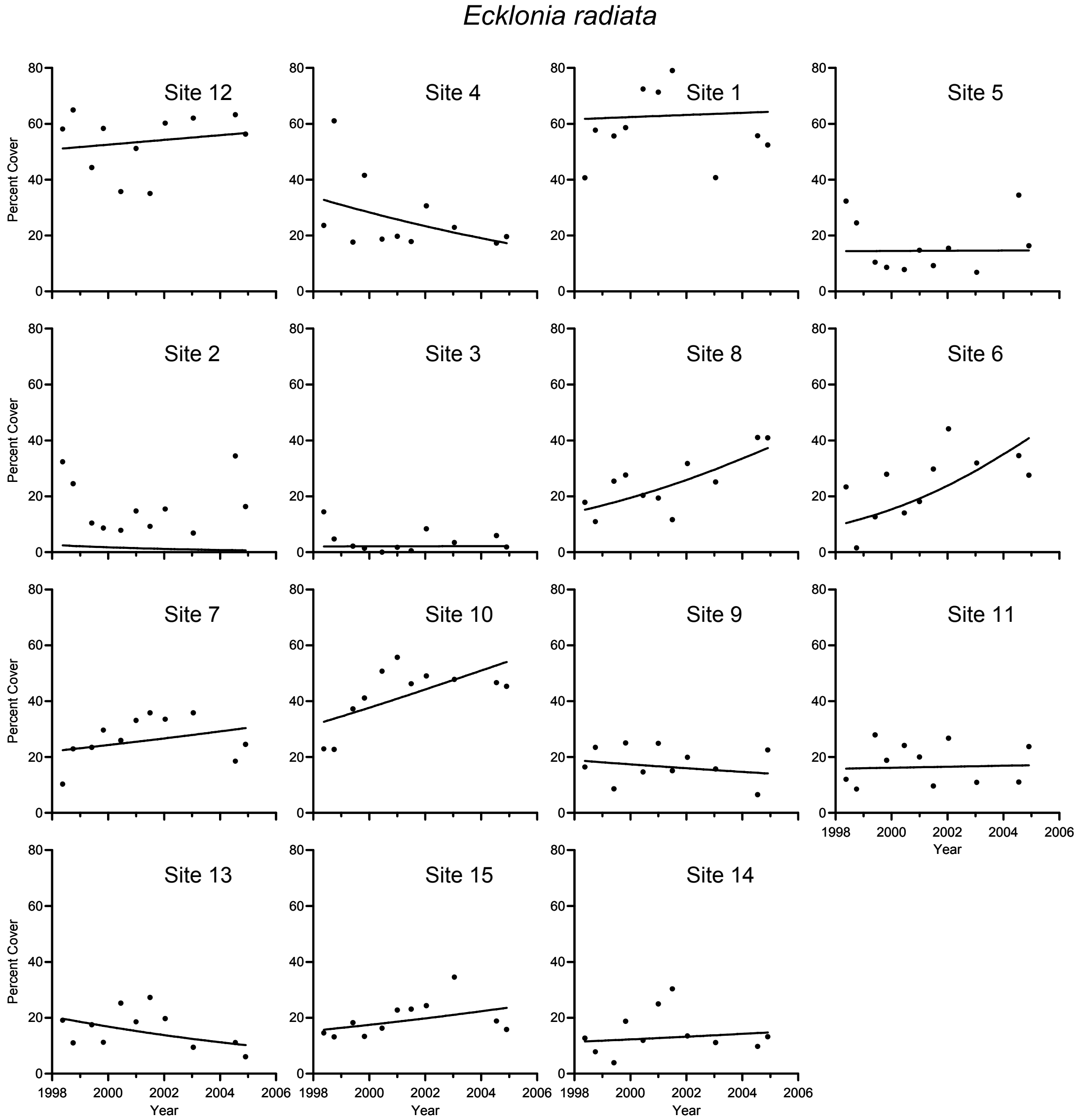


Figure 3.5 Trends in abundance of the common kelp *Ecklonia radiata* at Port Phillip Heads.

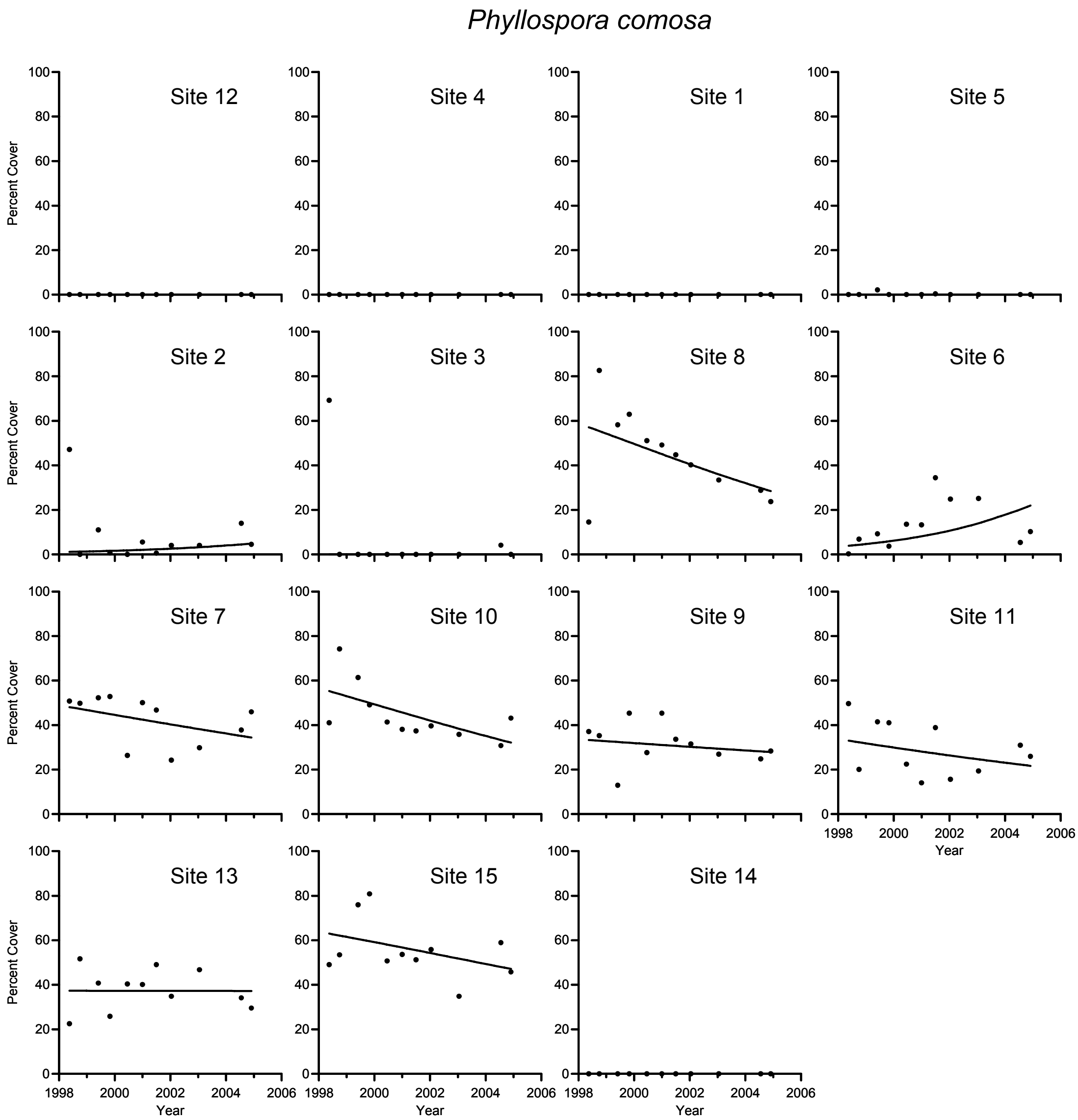


Figure 3.6 Trends in abundance of crayweed *Phyllospora comosa* at Port Phillip Heads.

Cystophora moniliformis

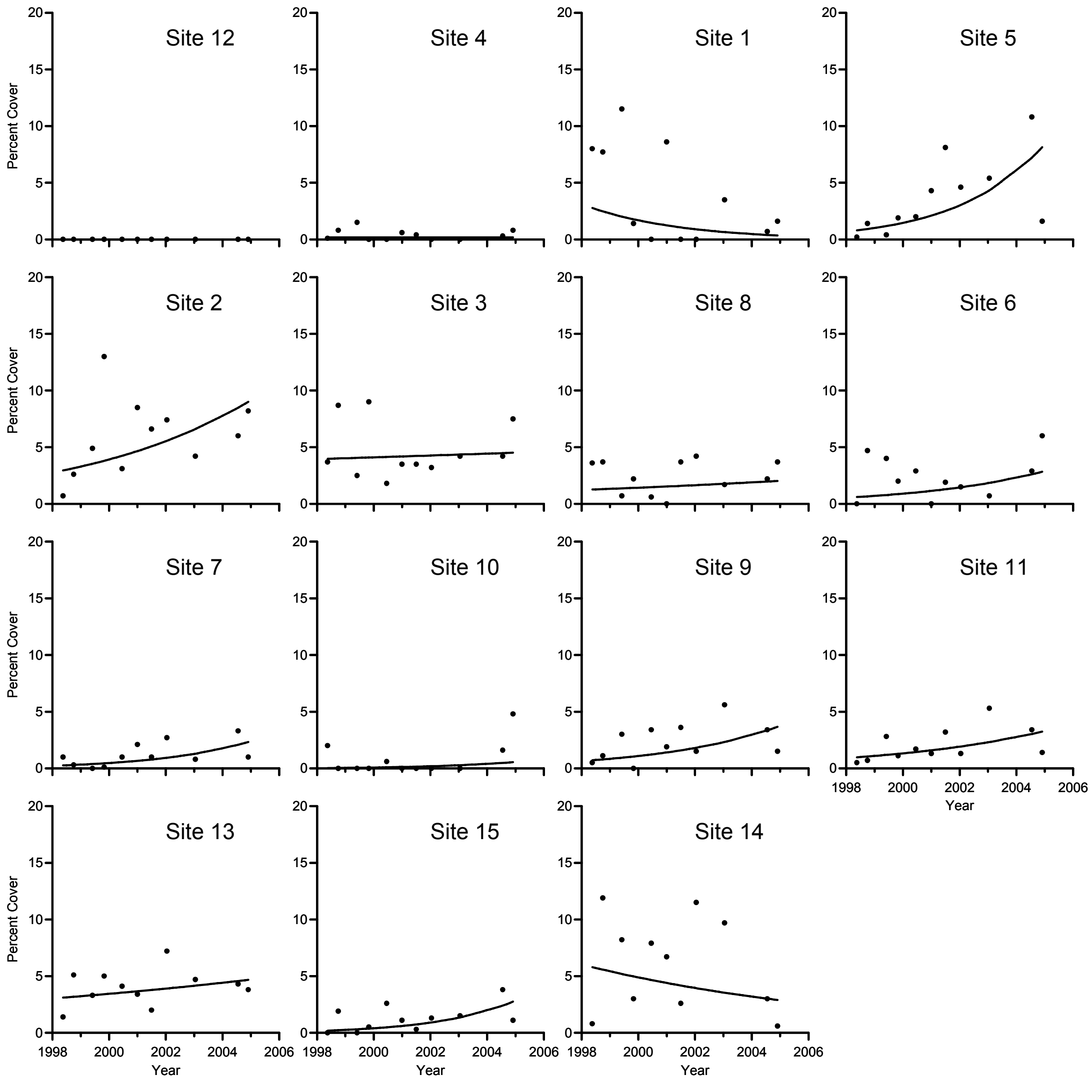


Figure 3.7 Trends in abundance of the brown alga *Cystophora moniliformis* at Port Phillip Heads.

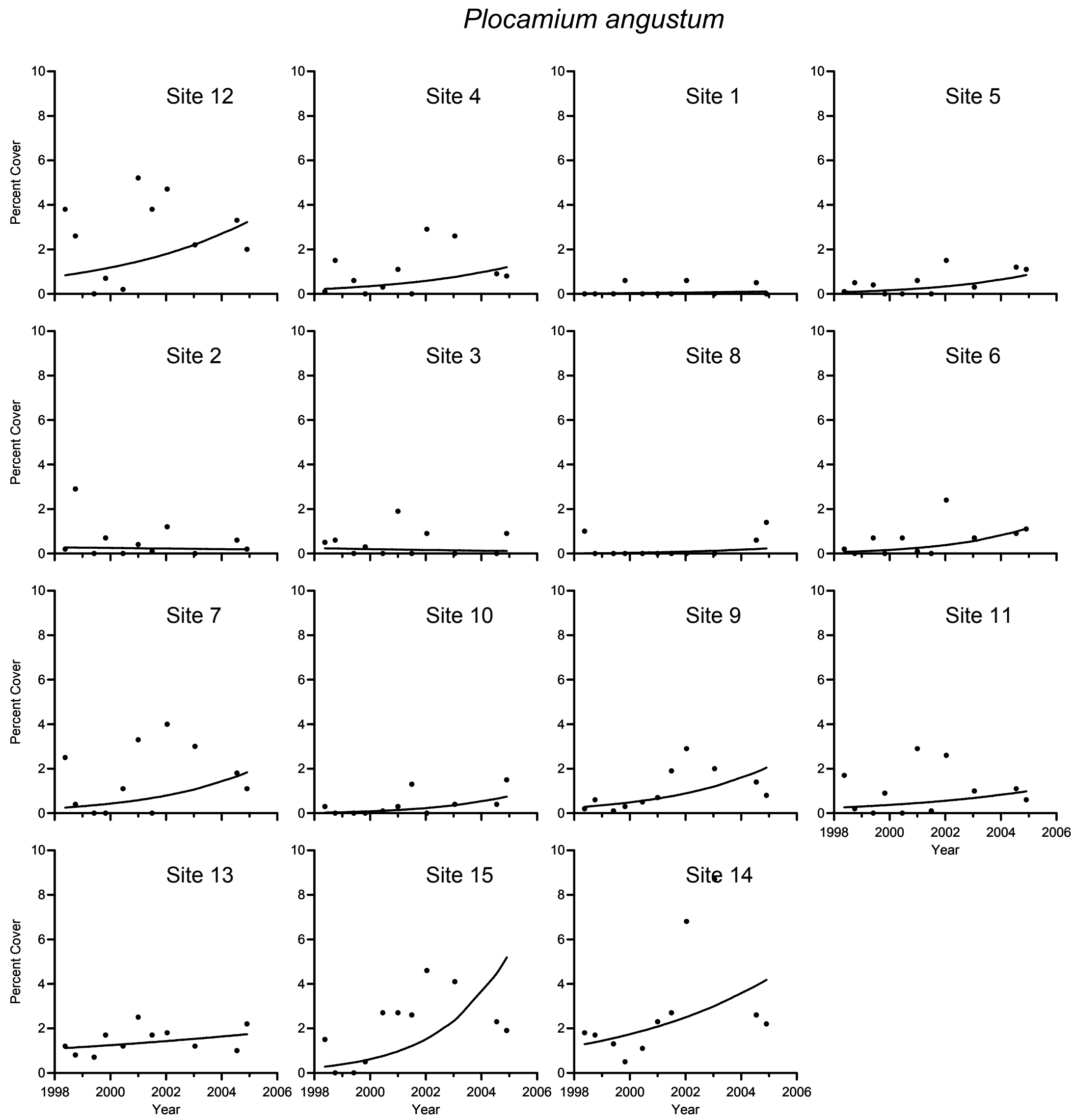


Figure 3.8 Trends in abundance of the red alga *Plocamium angustum* at Port Phillip Heads.

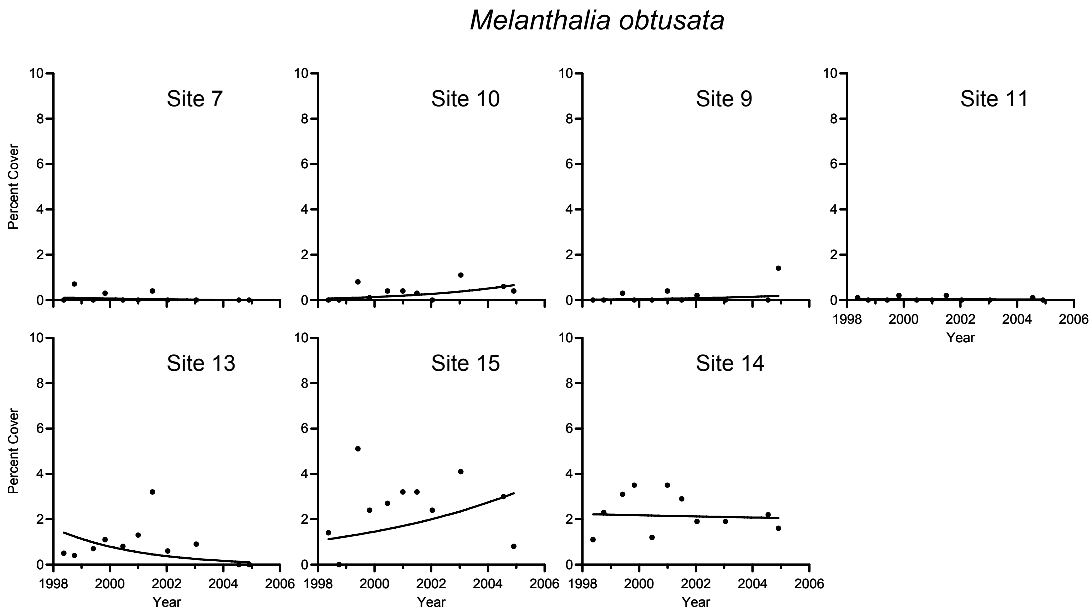


Figure 3.9 Trends in abundance of the red alga *Melanthalia obtusata* at Port Phillip Heads.

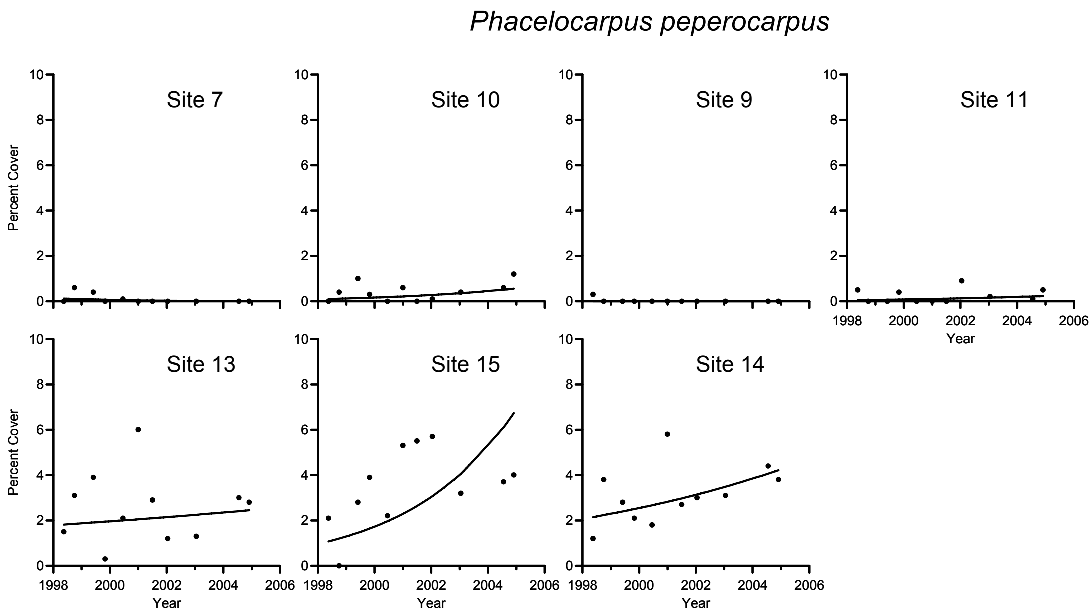


Figure 3.10 Trends in abundance of the red alga *Phacelocarpus peperocarpus* at Port Phillip Heads.

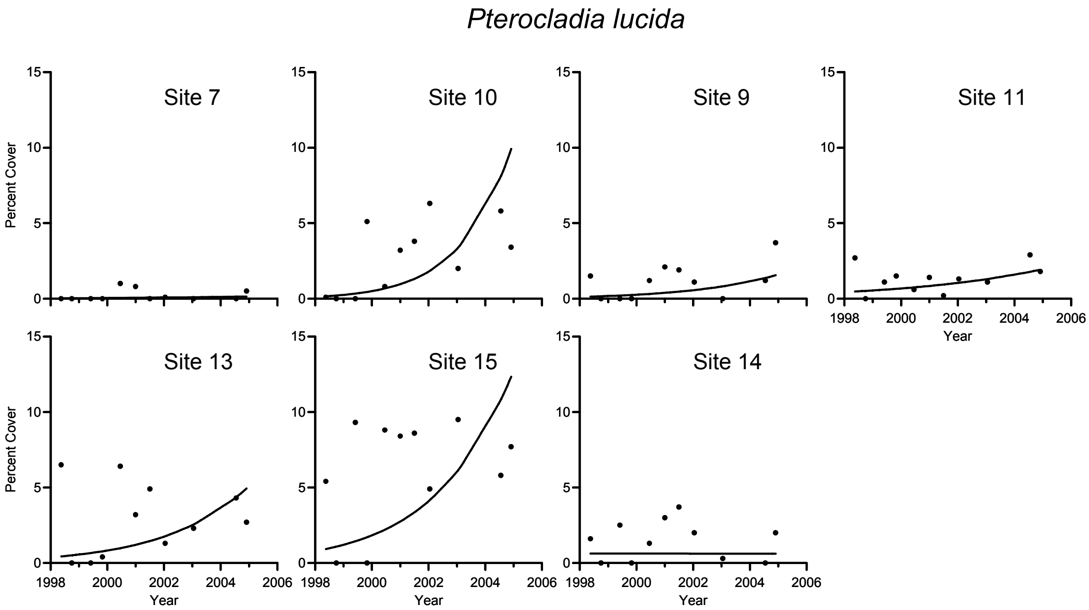


Figure 3.11 Trends in abundance of the red alga *Pterocladia lucida* at Port Phillip Heads.

Ballia callitricha

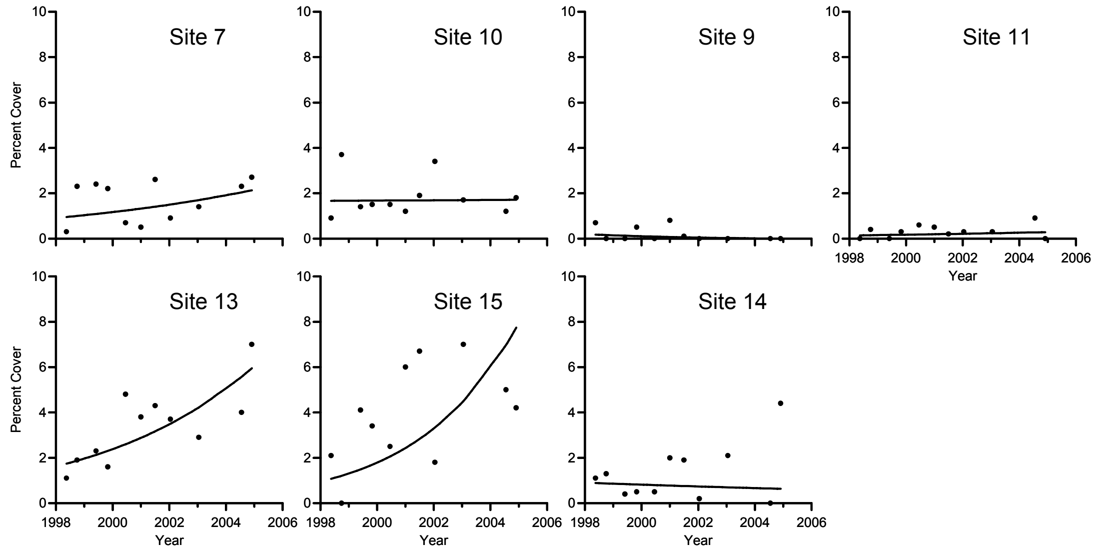


Figure 3.12 Trends in abundance of the red alga *Ballia callitricha* at Port Phillip Heads.

Amphibolis antarctica

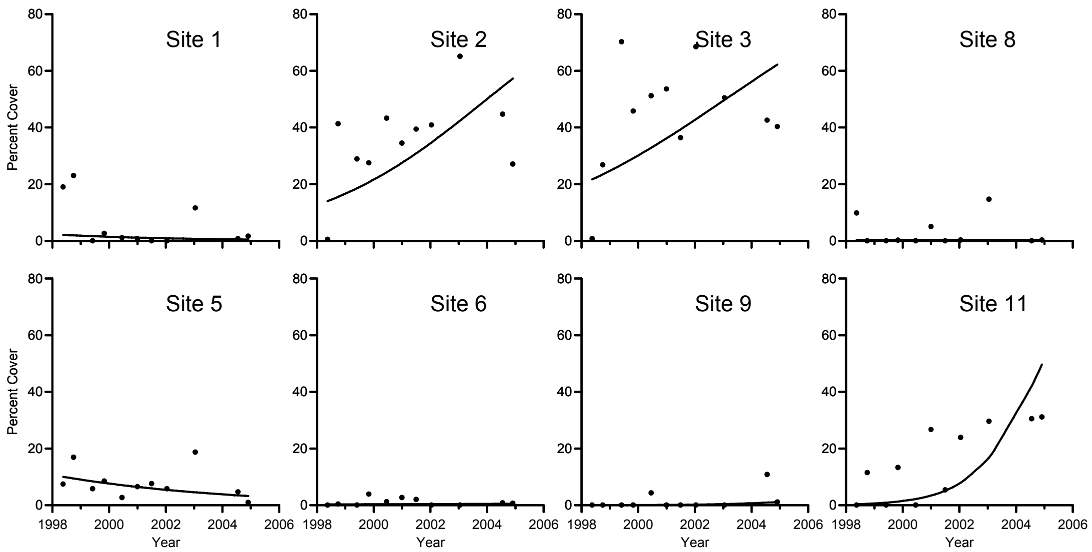


Figure 3.13 Trends in abundance of the reef inhabiting seagrass *Amphibolis antarctica* at Port Phillip Heads.

3.4 String Kelp *Macrocystis angustifolia*

The string kelp *Macrocystis angustifolia* can grow up to 10 m in height and form dense forests with a thick canopy floating on the surface. Consequently, *M. angustifolia* is a significant habitat forming species. *Macrocystis angustifolia* was once present in relatively high abundance in the Port Phillip Heads region, particularly off Lonsdale Point and in Lonsdale Bay, where it covered most of Kelp Reef (Sites 9 and 11). Abundances of *M. angustifolia* have been reduced considerably for much of this decade. Possible causes of this decline include a rapid succession of El Niño events in the late 1980s and early 1990s (affecting water temperature and nutrient levels), a long-term increase in average sea temperature (1º C over the last 40 years) and changes to nutrient inputs in Port Phillip Bay.

From casual observations, there appeared to be a slight increase in *M. angustifolia* density during the first four surveys at Port Phillip Heads. The quadrat-cover method is generally insensitive in detecting small changes in abundances of sparsely distributed individuals such as this species. Therefore, given the importance of this species, a new census technique was introduced to monitor abundance (Method 4; Section 2.2.5). This method was introduced in the spring 1999 survey at Popes Eye (Site 12) and is now used at all sites in the Subtidal Reef Monitoring Program.

Macrocystis angustifolia was reasonably abundant at Popes Eye during the spring 1999 survey (survey 4). The total density was 67 plants per 2000 m^2, with a surface canopy occurring at eastern, central and western parts of the reef (Table 3.2). By winter 2000, the total density was reduced to 23 plants per 2000 m^2. These plants were also much smaller, with most plants barely higher than the *Ecklonia* canopy. Although a few tall plants were still present in the far eastern and far western clumps (Table 3.2), this change represents a considerable alteration to the biogenic habitat structure at Popes Eye. By summer 2000/01, the only large plants present were on the northwest corner of the island, immediately adjacent to the seal haul-out and gannet colony. Nutrients from the seals and gannets were probably enabling this small patch to persist. No plants were observed along the transect at Popes Eye during the seventh and eighth surveys. A small number of plants were observed in the far west transect (T4) during the ninth survey, summer 2003, the tenth survey, winter of 2004, and the eleventh survey, summer of 2004.

While *Macrocystis angustifolia* declined during the period of 2000-2002 in abundance at Popes Eye, abundances increased at Nepean Bay Outer (Site 2; Table 3.3). These plants were generally 1-2 m high, and did not reach the surface. In contrast, there was a reduction in the number of plants observed during the ninth survey which continued into the tenth. On the tenth survey the density observed was only 5 plants per 2000 m^2, representing a decrease of 72 plants per 2000 m^2 over three years. During the eleventh survey, a large increase in individual plants was observed along the eastern transects. A total of 34 plants was observed, representing a reversal of the trend seen in previous years.

Table 3.2 Density and distribution of string kelp *Macrocystis angustifolia* plants at Popes Eye (Site 12), during the last seven surveys at Port Phillip Heads.

Survey/Year	***Distance (m)***																			
	95	85	75	65	55	45	35	25	15	5	-5	-15	-25	-35	-45	-55	-65	-75	-85	-95
2000	1	4	3	0	0	0	0	0	0	0	2	8	2	0	0	0	0	0	0	3
2000/2001	4	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	8	25
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001/2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
2004	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
2004/2005	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.3 Density and distribution of string kelp *Macrocystis angustifolia* plants at Nepean Bay Offshore (Site 2), during the last seven surveys at Port Phillip Heads.

Survey/Year	***Distance (m)***																			
	95	85	75	65	55	45	35	25	15	5	-5	-15	-25	-35	-45	-55	-65	-75	-85	-95
2000	0	1	1	0	0	0	2	1	5	5	3	1	1	1	0	0	0	1	6	5
2000/2001	2	4	5	4	2	6	6	3	5	6	2	0	3	2	0	1	3	0	2	2
2001	3	5	2	2	3	7	5	18	5	1	3	1	6	5	1	6	4	0	0	0
2001/2002	0	0	2	2	1	0	4	0	2	0	0	9	6	4	4	0	2	2	0	3
2003	0	6	6	3	13	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
2004	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	2	0	0
2004/2005	0	0	0	0	0	0	0	0	0	2	2	1	4	2	2	1	9	9	0	2

4.0 INVERTEBRATES

4.1 Community Structure

The six general invertebrate assemblage types were apparent in the Port Phillip Heads region. These assemblage groupings consisted of: Point Franklin and South Channel (Sites 1 and 4); Popes Eye (Site 12); Nepean Bay (Sites 2, 3 and 8); Shortland Bluff (Site 5); Lonsdale Bay (Sites 6, 7, 9, 10 and 11); and outside the Heads (Sites 13, 14 and 15).

The Point Franklin and South Channel Fort sites were characterised by high abundances of the sea urchin *Heliocidaris erythrogramma*, intermediate abundances of the feather star *Cenolia trichoptera* and very low abundances of abalone *Haliotis* spp. In contrast, Popes Eye (Site 12) had low abundances of *Heliocidaris erythrogramma* and high abundances of *Cenolia trichoptera*. Popes Eye had similarly low abundances of *Haliotis* spp, differentiating Sites 1, 4 and 12 from all other sites, where *Haliotis* spp were more abundant.

The Nepean Bay sites were characterised by having relatively high abundances of both blacklip abalone *Haliotis rubra* and greenlip abalone *Haliotis laevigata*. The snails *Turbo undulatus* and *Dicathais orbita* tended to be more abundant in Nepean Bay, along with moderate abundances of *Heliocidaris erythrogramma* and *Cenolia trichoptera*.

Shortland Bluff (Site 5) was distinguished by high abundances of the seastar *Patiriella brevispina* and *Heliocidaris erythrogramma*. *Cenolia trichoptera* and *Haliotis* spp were in moderate abundances, however the gastropods *Turbo undulatus* and *Dicathais orbita* were usually absent.

The remaining sites in Lonsdale Bay and outside the heads were characterised by having moderate to high abundances of *Haliotis rubra* and low to moderate abundances of *Heliocidaris erythrogramma* and *Cenolia trichoptera*. *Haliotis laevigata*, *Turbo undulatus* and the seastar *Nectria ocellata* were common at these sites. The seastar *Tosia australis* was the most abundant seastar at all sites.

In many cases, the variation between times was generally less than the variation between sites. Differences in community structure between sites tended to be maintained over the survey period (Figure 4.1). The largest variations were observed at Sites 2 and 3 in Nepean Bay (Figure 4.1c), Site 5 at Shortland Bluff (Figure 4.1a) and Site 9 in Lonsdale Bay (Figure 4.1d). Of the four general regions, the sheltered sites inside the heads (Sites 12, 4, 1, and 5) were the most distinct from each other through time reflecting their greater geographic seperation than other regions. In contrast, the exposed sites from the general region outside the heads (Sites 13, 14 and 15) were consistently the most similar to each other throughout the surveys.

Tests for progressive changes (trends) in species composition over the five monitoring years detected significant ($p \leq 0.05$) trends in community structure at Sites 4 and 5 (Table 4.1).

Table 4.1 Tests of trends in invertebrate community changes over time at Port Phillip Heads. The Mantel r_M statistic is a measure of the correlation between dissimilarity in species composition (Bray-Curtis coefficient) and difference in times. The significance of the rM value was tested using a permutation test with 1000 permutations.

Site	***Mantel r_M***	***Probability***	***% B-C Dissimilarity (first to last)***
1	0.11	0.21	46
2	-0.18	0.86	65
3	0.17	0.18	63
4	0.43	0.01	50
5	0.47	0.01	49
6	0.17	0.19	48
7	0.09	0.29	45
8	0.33	0.02	42
9	-0.03	0.54	38
10	0.02	0.43	30
11	0.28	0.06	40
12	-0.10	0.71	32
13	-0.31	0.98	37
14	-0.11	0.75	52
15	-0.02	0.55	35

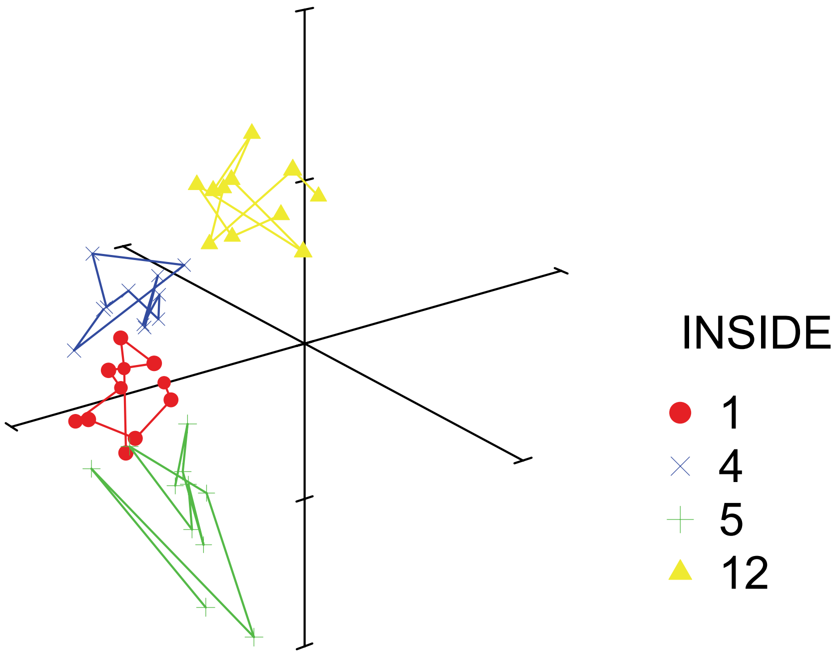


Figure 4.1a Three-dimensional MDS plot of invertebrate assemblage structure for inner Heads region. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17.

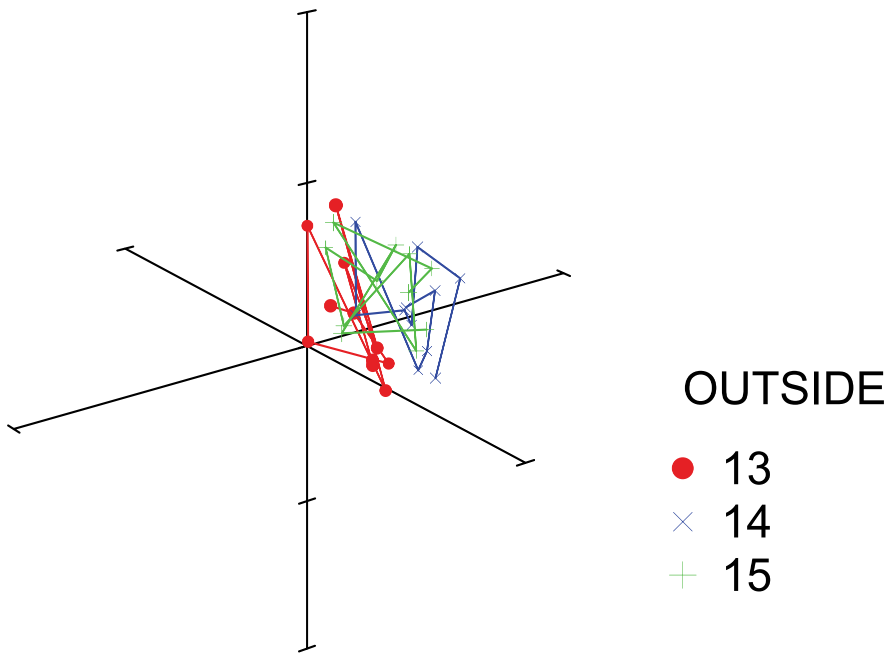


Figure 4.1b Three-dimensional MDS plot of invertebrate assemblage structure outer Heads region. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17

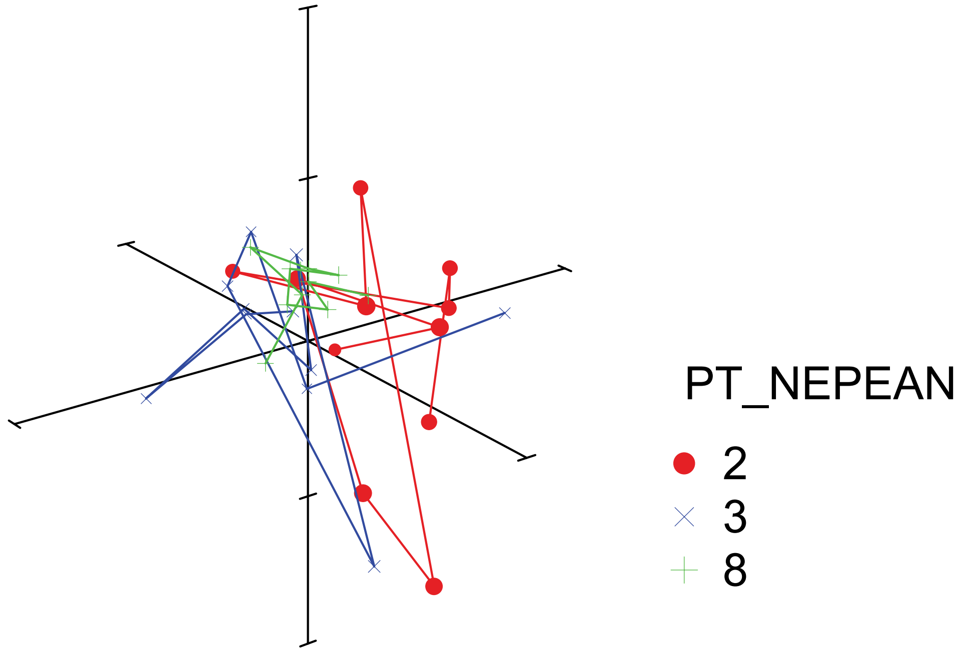


Figure 4.1c Three-dimensional MDS plot of invertebrate assemblage structure for Nepean Bay. Data labels are site number followed by survey number. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17.

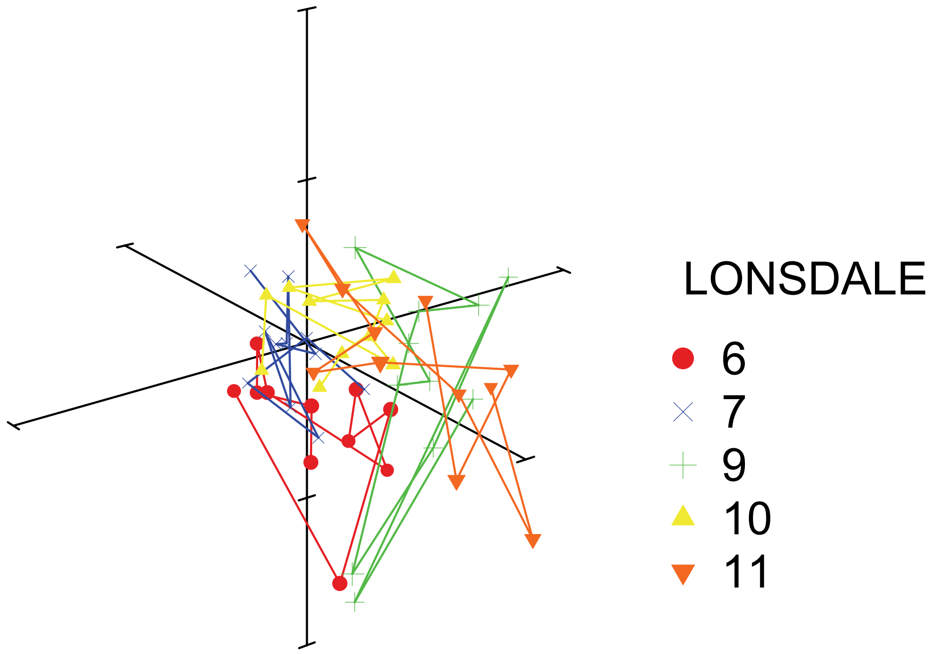


Figure 4.1d Three-dimensional MDS plot of invertebrate assemblage structure for Lonsdale Bay. Data labels are site number followed by survey number. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17.

4.2 Diversity

Invertebrate species richness was in the range of 5-15 species for most sites (Figure 4.2). Species richness was highly variable over the whole survey program, but the variation appeared to be highly temporally auto-correlated (i.e. changes from survey to survey tended to be in sequential steps). Species diversity was relatively stable through time at most sites, though there appeared to be a gradual increase in diversity at Nepean Offshore (Site 2). Diversity tended to be higher at Nepean Offshore (Site 2), Nepean Inner West (Site 3) and at the two Merlan Reef Sites (Sites 9 and 11; Figure 4.3).

4.3 Population Abundances and Sizes

Examples of time trends in abundances of selected species are given for each site in Figures 4.4 to 4.7. Most species show considerable differences between sites, with some sites having considerably more variation between times than others. There appears to have been a decline in the abundance of the sea urchin *Heliocidaris erythrogramma* in recent years at south Channel Fort (Site 4) and Shortland Bluff (Site 5).

The mean size of the blacklip abalone *Haliotis rubra* outside the Heads was generally below the legal catch size (110 mm) at Point Lonsdale (Site 13) and higher at sites further outside the Heads (111-119 mm; Sites 14 and 15; Figure 4.8). Mean sizes inside the Heads were generally above the Port Phillip Bay legal minimum length of 100 mm, with most sites generally above 103 mm (Figure 4.8).

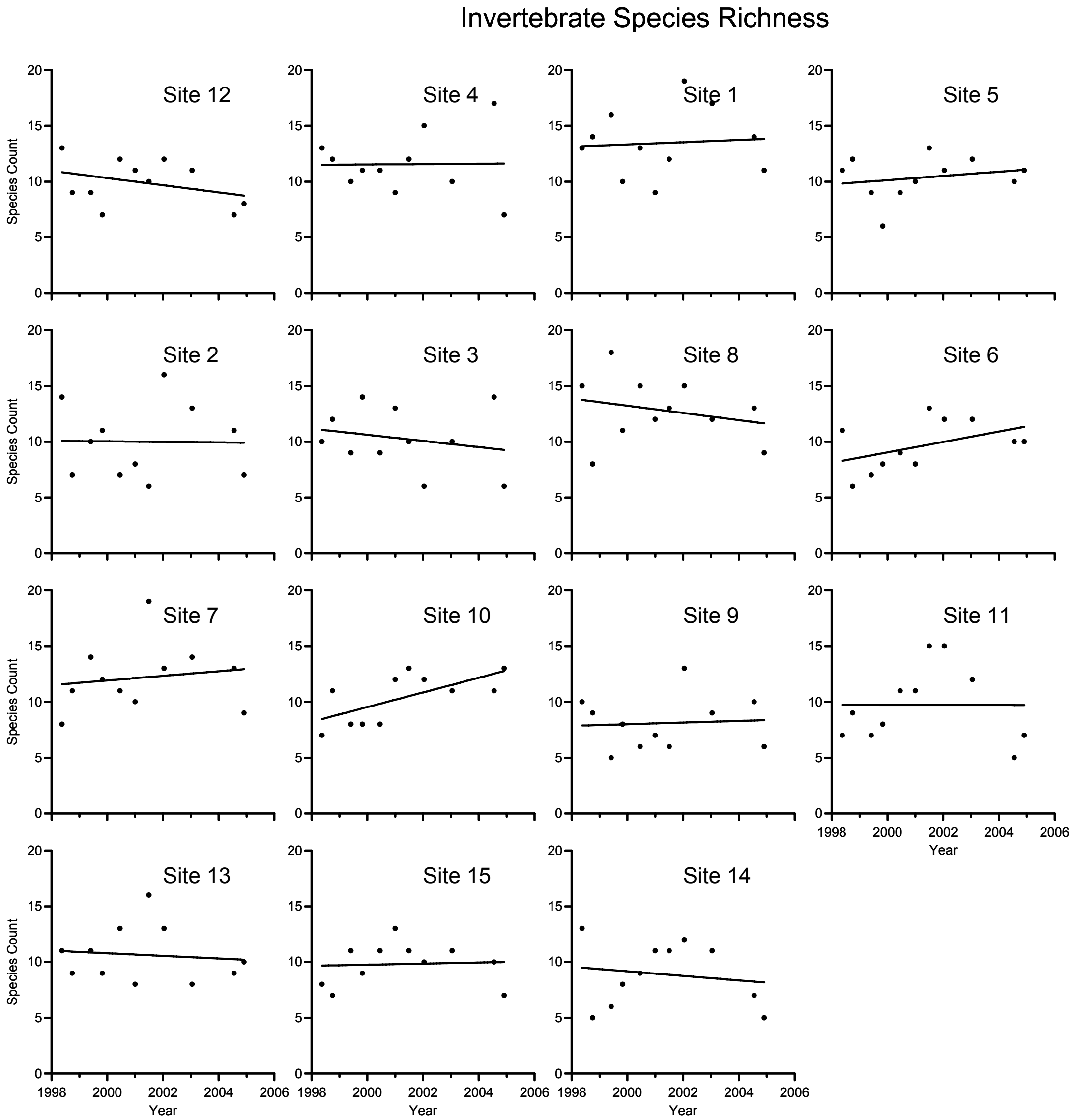


Figure 4.2 Trends in species richness of invertebrates at Port Phillip Heads.

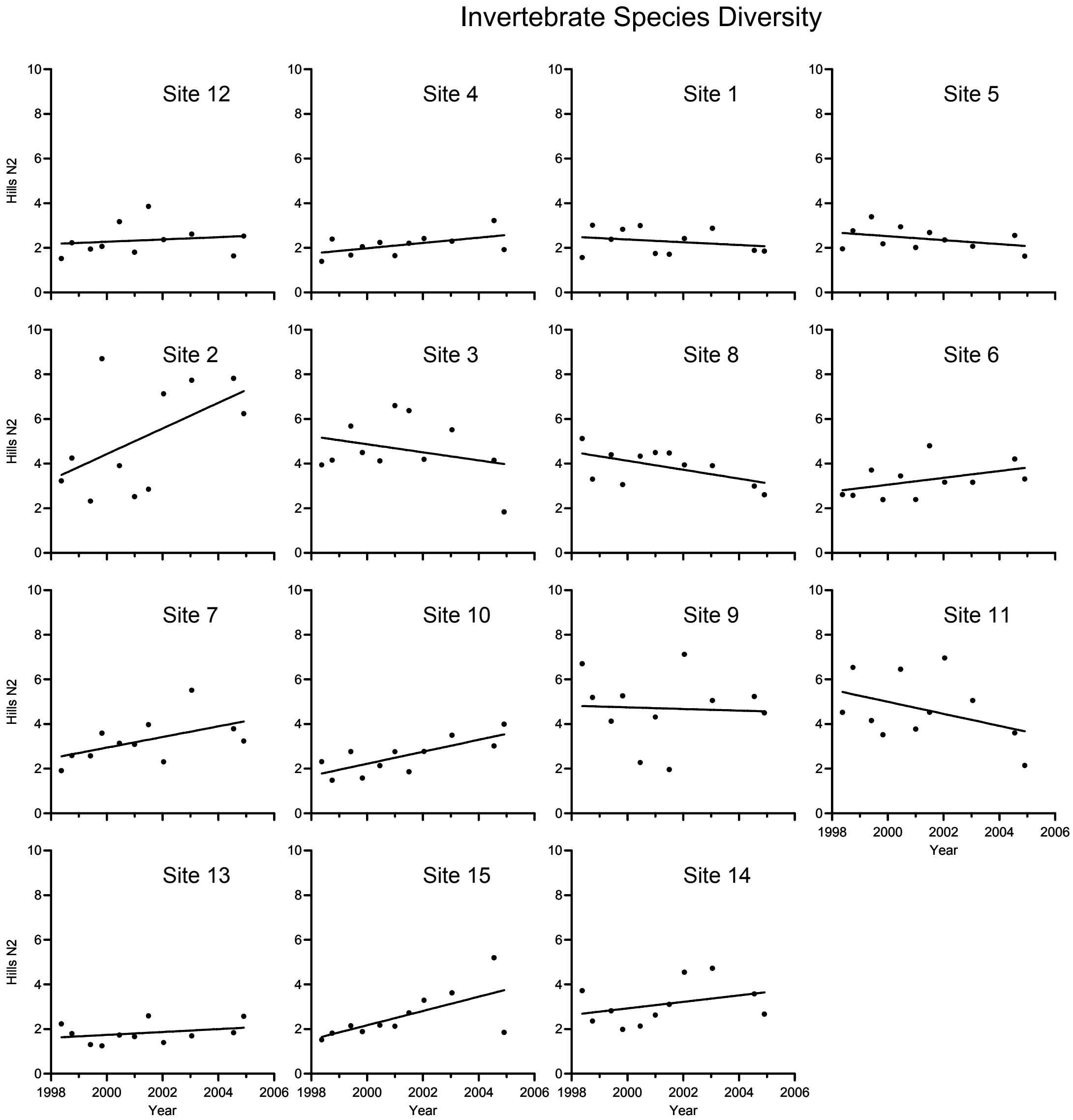


Figure 4.3 Trends in species diversity of invertebrates at Port Phillip Heads.

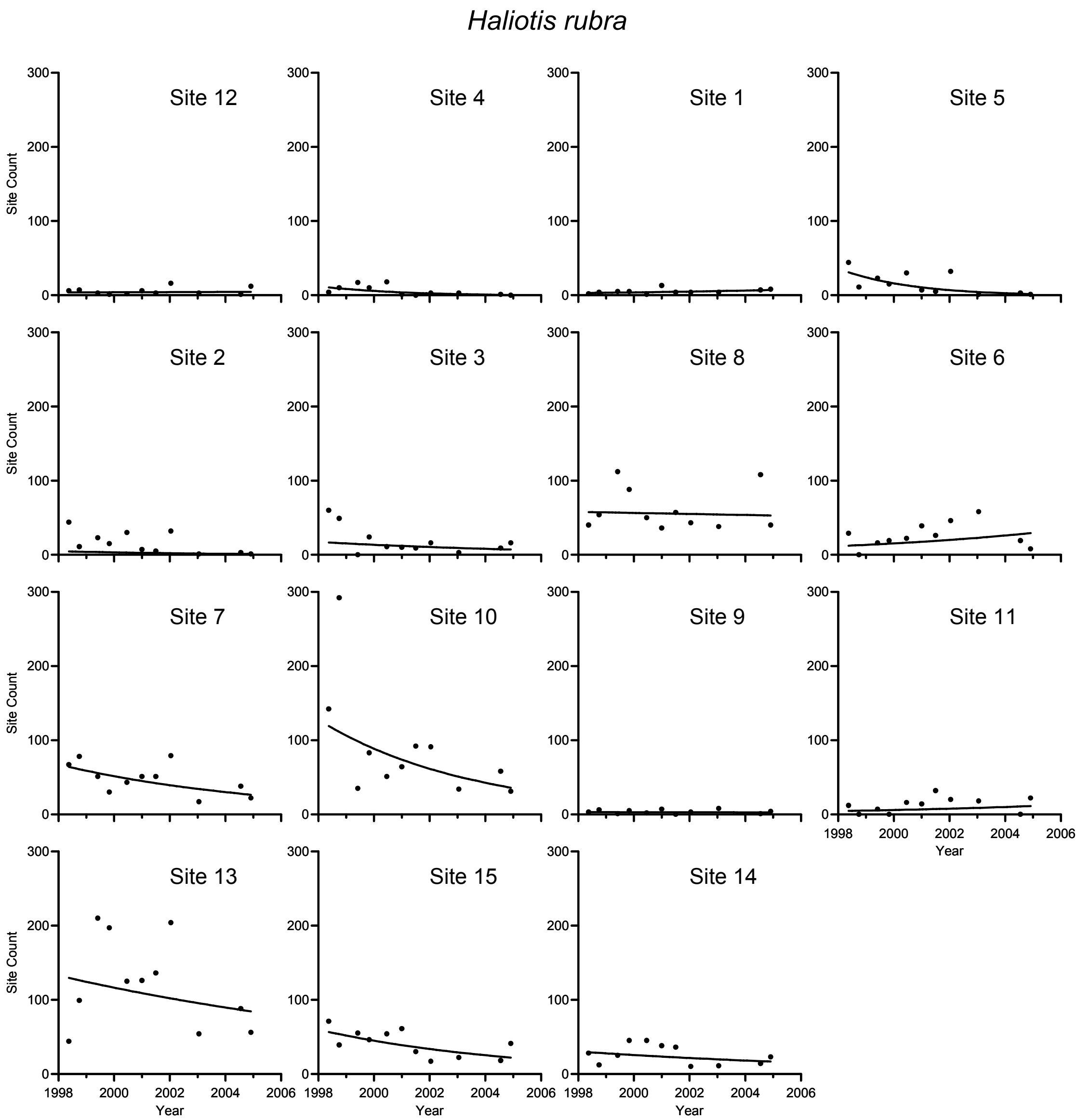


Figure 4.4 Trends in abundance of the blacklip abalone *Haliotis rubra* at Port Phillip Heads.

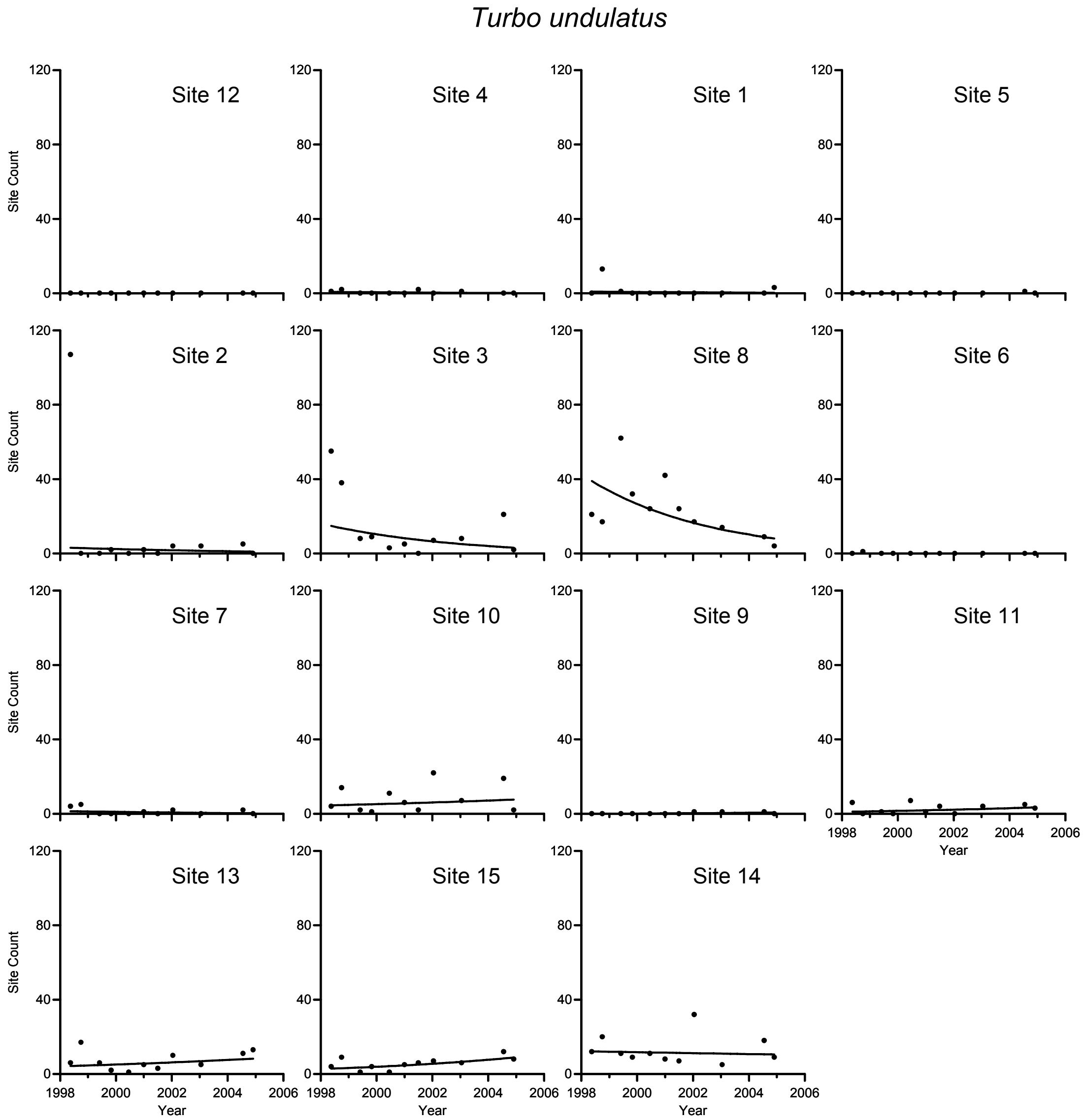


Figure 4.5 Trends in abundance of the periwinkle *Turbo undulatus* at Port Phillip Heads.

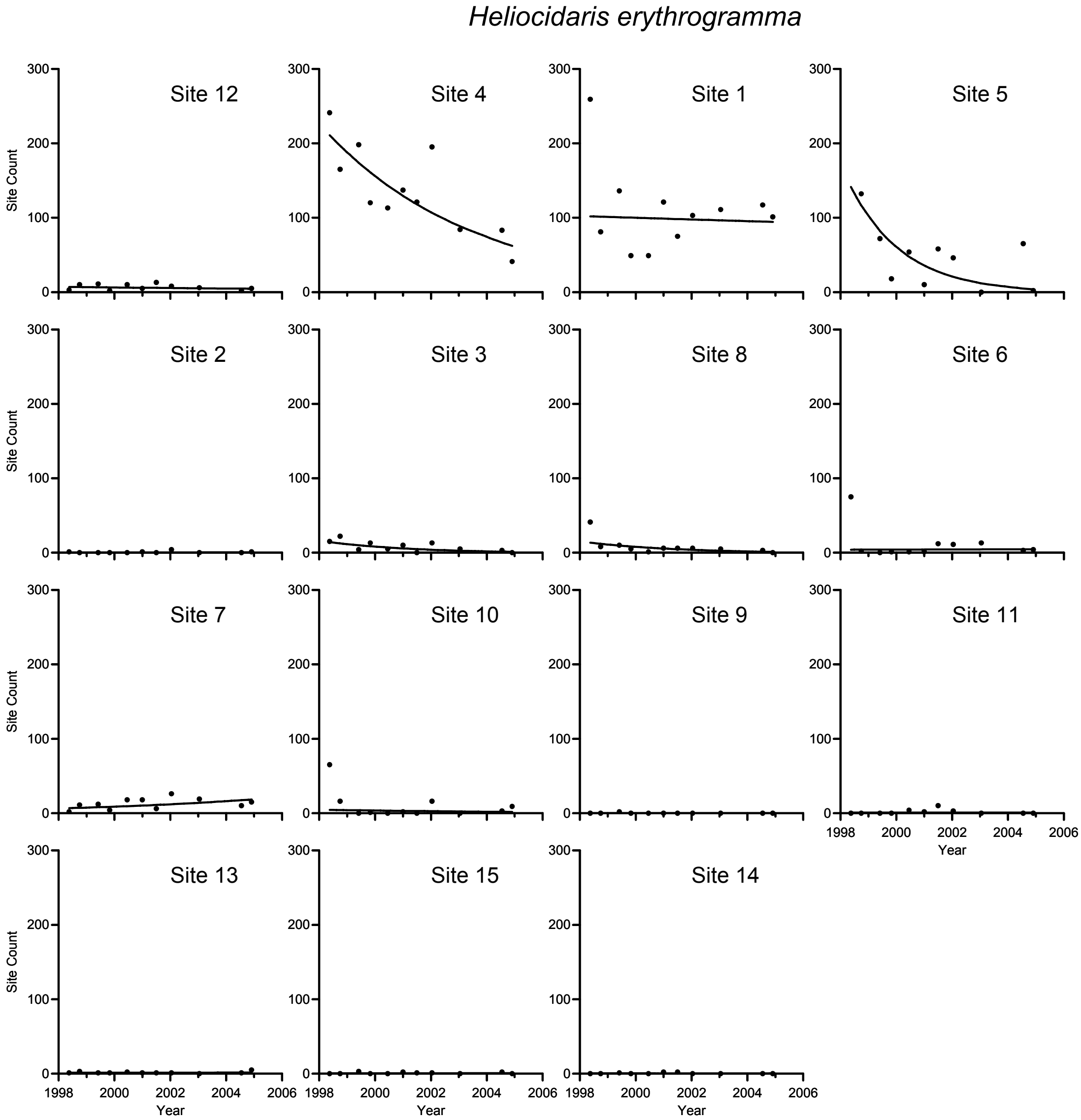


Figure 4.6 Trends in abundance of the sea urchin *Heliocidaris erythrogramma* at Port Phillip Heads.

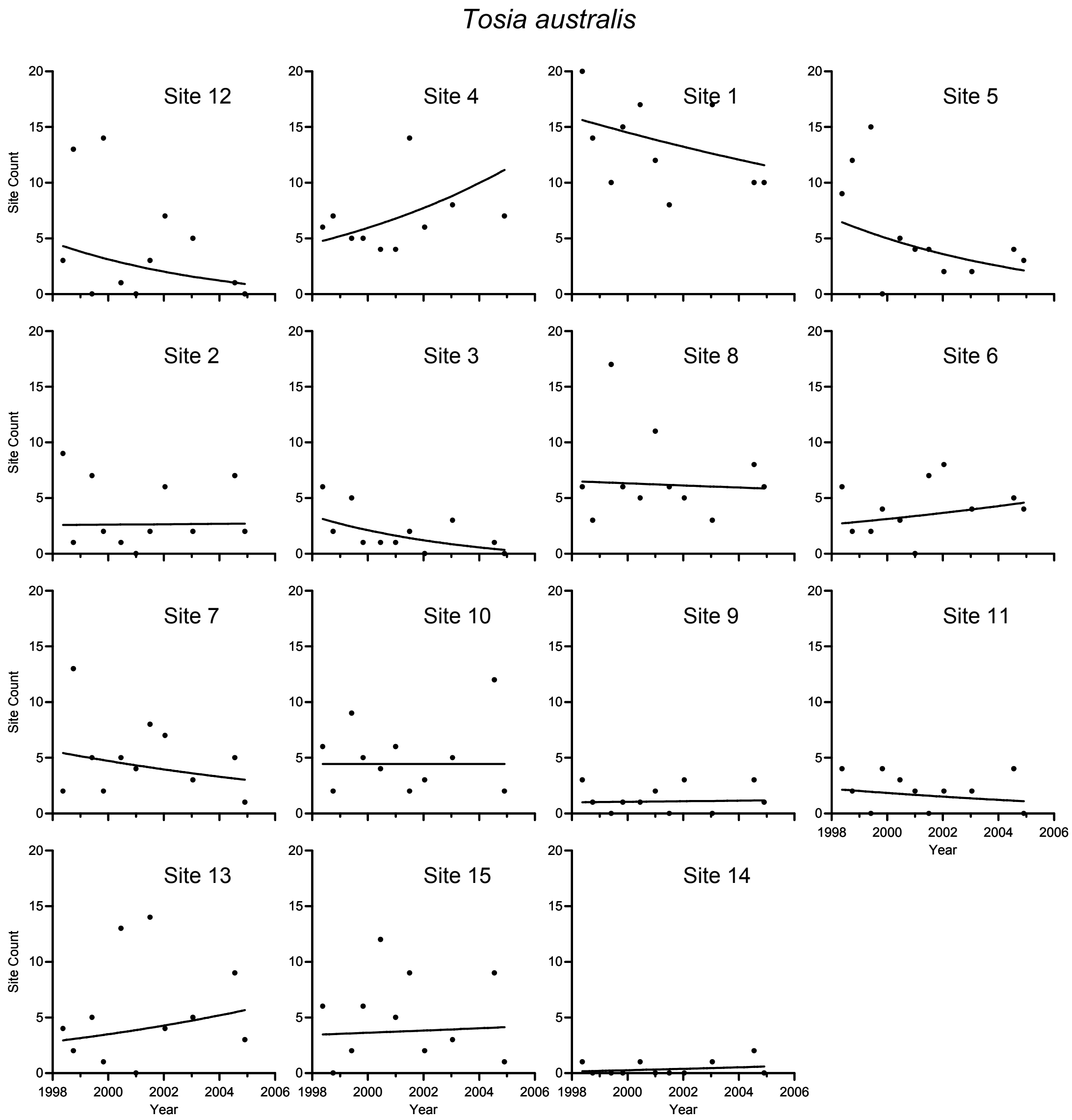


Figure 4.7 Trends in abundance of the common biscuit star *Tosia australis* at Port Phillip Heads.

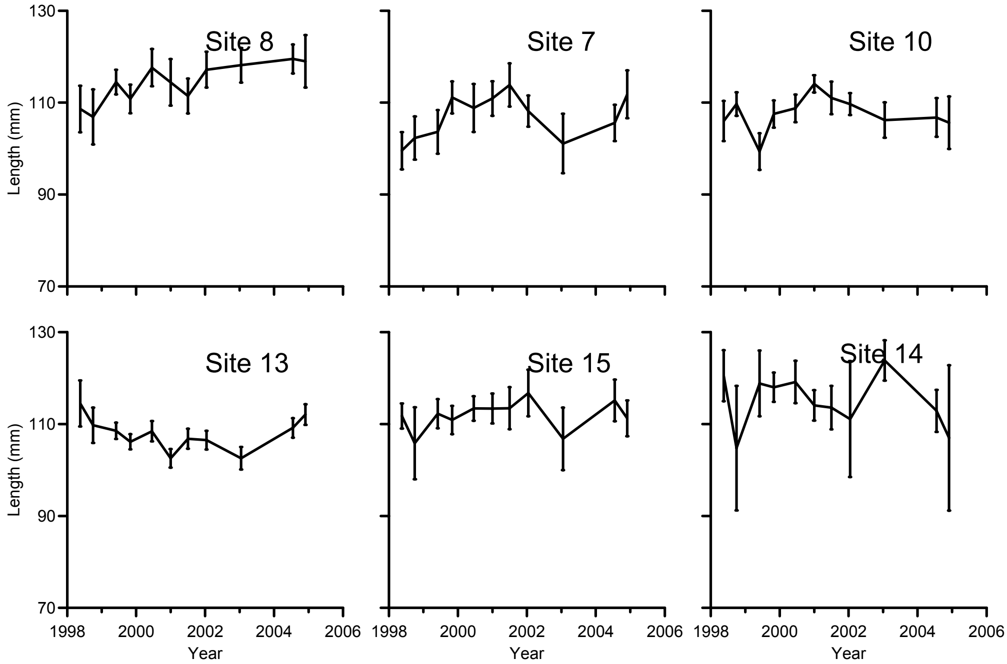


Figure 4.8 Trends in mean length (± 95% CI) of blacklip abalone *Haliotis rubra* at Port Phillip Heads. Sites 7 and 10 are in Lonsdale Bay, Site 8 is at Point Nepean, and 13, 14 and 15 are outside the Heads.

5.0 FISH

5.1 Community Structure

Prior to November 2002, Popes Eye (Site 12) was the only 'no-take' reserve in the region and is characterised by much higher abundances of most fish species than anywhere else. Species such as the scalyfin *Parma victoriae*, marble fish *Aplodactylus arctidens*, magpie perch *Cheilodactylus nigripes*, blue-throated wrasse *Notolabrus tetricus* and leatherjackets *Meuschenia flavolineata*, *M. freycineti* and *M. hippocrepis* were common at all sites, but were 4-10 times more abundant inside the Popes Eye reserve. The sea sweep *Scorpis aequipinnis* and rosy wrasse *Pseudolabrus psittaculus* were rarely observed at sites other than Popes Eye during the surveys. There was also a much higher abundance of larger fish at Popes Eye.

Popes Eye contrasted starkly with Point Franklin (Site 1) which had very low abundances of all species, including the typically abundant *Notolabrus tetricus*. In addition to *N. tetricus*, the only species observed in densities greater than 5 per 2000 m^2 were usually small, such as mado *Atypichthys strigatus* or juvenile toothbrush leatherjackets *Acanthaluteres vittiger*. This site is subject to exceptional line and spear fishing pressure, with casual observations indicating this site is likely to have the highest spear-fishing pressure in Victoria. This location being frequented by novice fishers and indiscriminate spearing may have resulted in the observed paucity of all fish species. In more recent surveys both the number of species and abundance of individuals at Point Franklin has increased. Fish were also scarce at Shortland Bluff (Site 5), the assemblage consisting of low numbers of *N. tetricus*, goat fish *Upeneichthys vlaminghii* and *Cheilodactylus nigripes*.

South Channel Fort (Site 4) had reasonably high abundances of the southern hula fish *Trachinops caudimaculatus*. This small species was also present at Popes Eye, but not elsewhere. Scalyfin *Parma victoriae*, purple wrasse *Notolabrus fucicola*, senator wrasse *Pictilabrus laticlavius*, globefish *Diodon nichthemerus* and various leatherjackets were also common at South Channel Fort.

The Nepean Bay fish assemblages generally consisted of herring cale *Odax cyanomelas*, *Notolabrus tetricus*, *Parma victoriae* and the horseshoe leatherjacket *Meuschenia hippocrepis*. The assemblages in Lonsdale Bay and outside the Heads were similar to Nepean Bay, except for increased abundances of zebra fish *Girella zebra* and *Cheilodactylus nigripes* inside Lonsdale Bay and increased abundances of *Parma victoriae* and *Pictilabrus laticlavius* outside the Heads.

The community structure at approximately half the sites was relatively consistent through time, particularly at Popes Eye (Site 12), South Channel Fort (Site 4) and Outside the Heads (Sites 13, 14 and 15 ; Figure 5.1). Temporally variable sites were Nepean Bay (Sites 2, 3 and 8), Shortland Bluff (Site 5), Victory Shoal (Site 6) and inner Merlan Reef (Site 7; Figure 5.1). As in the invertebrate communities, the sheltered sites inside the heads showed the greatest distinction from other sites over the eleven surveys, possibly reflecting an exposure gradient and/or the larger geographic separation of the sites. Tests for progressive changes (trends) in species composition over the five monitoring years detected significant ($p \leq 0.05$) trends in community structure only at Sites 8 and 11(Table 5.1).

Table 5.1 *Tests of trends in fish community changes over time at Port Phillip Heads. The Mantel* r_M statistic is a measure of the correlation between dissimilarity in species composition (Bray-Curtis coefficient) and difference in times. The significance of the rM value was tested using a permutation test with 1000 permutations.

Site	***Mantel*** r_M	***Probability***	***% B-C Dissimilarity (first to last)***
1	0.21	0.15	53
2	0.00	0.47	43
3	0.01	0.47	58
4	0.04	0.41	34
5	-0.07	0.60	70
6	0.24	0.07	59
7	0.20	0.12	61
8	0.29	0.04	50
9	0.24	0.14	29
10	0.03	0.39	54
11	0.43	0.02	52
12	0.06	0.33	19
13	0.21	0.08	42
14	0.04	0.35	18
15	0.10	0.27	35

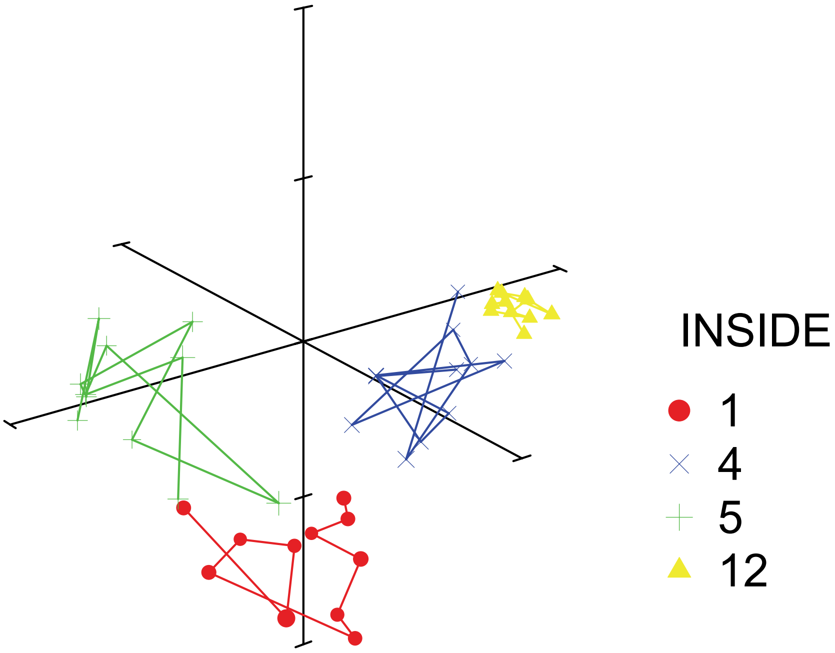


Figure 5.1a Three-dimensional MDS plot of fish assemblage structure for inner Heads. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17

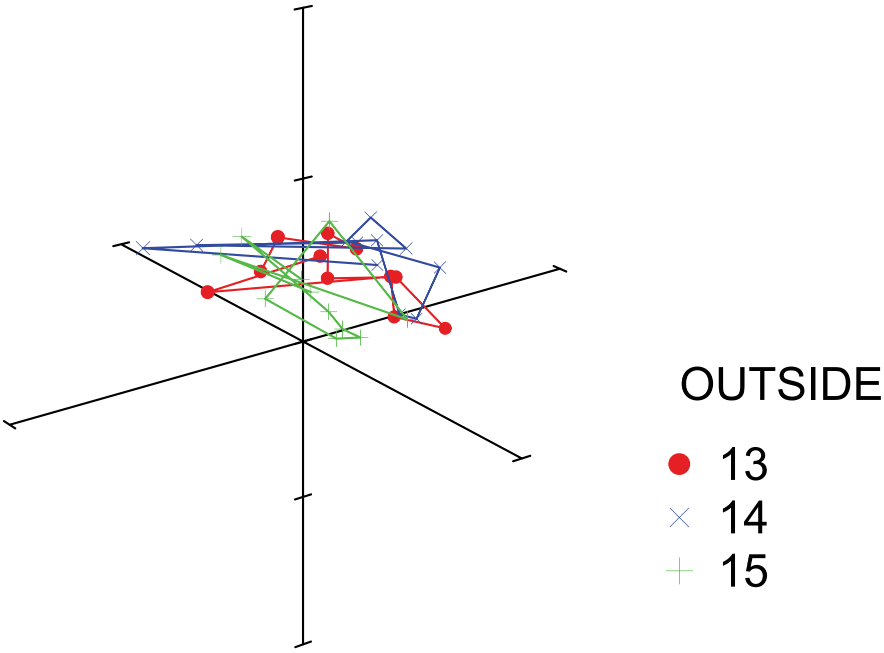


Figure 5.1b Three-dimensional MDS plot of fish assemblage structure for outside the Heads region. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17.

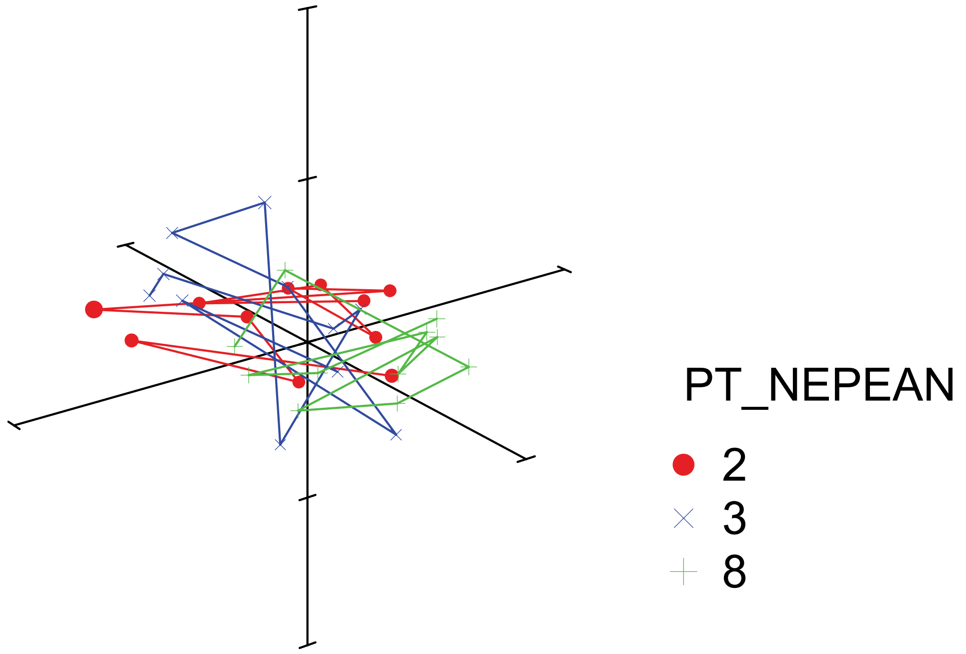


Figure 5.1c Three-dimensional MDS plot of fish assemblage structure for Nepean Bay. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17.

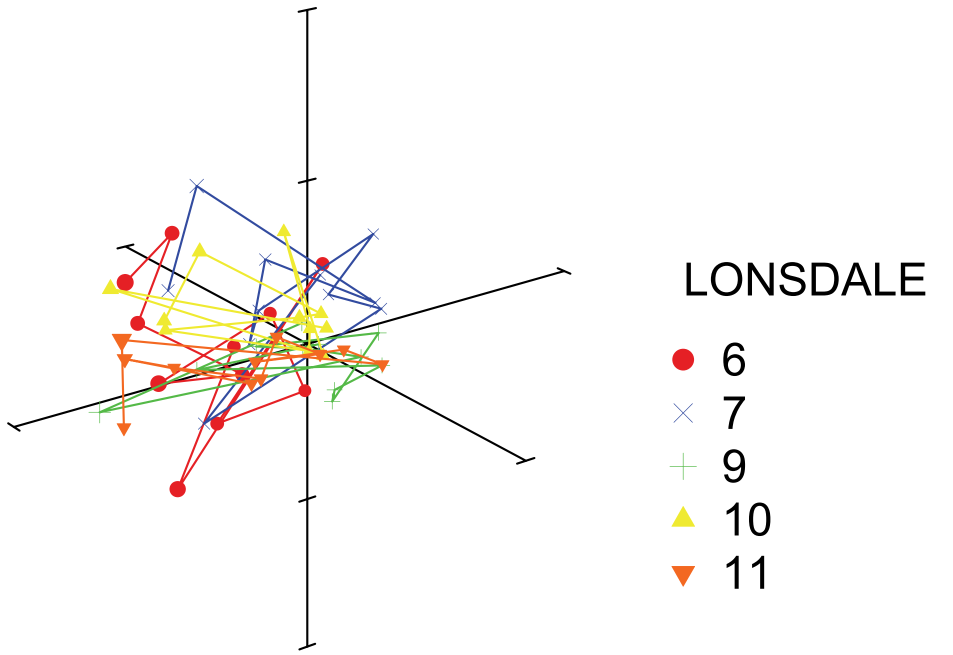


Figure 5.1d Three-dimensional MDS plot of fish assemblage structure for Lonsdale BayHeads. Site locations are given in Table 2.1 and times are in Table 2.2. Kruskal Stress value = 0.17.

5.2 Diversity

Species richness was consistently greater within the Popes Eye sanctuary (Site 12; Figure 5.2). South Channel Fort (Site 4) and west Nepean Bay (Site 8) also tended to have higher species richness. Shortland Bluff and Victory Shoal (Sites 5 and 6) had lower species richness than other sites (Figure 5.2).

Despite Popes Eye (Site 12) having high species richness, the diversity (homogeneity of individuals among species) was not markedly higher than other sites (Figure 5.3). This was because of a high dominance in abundance of some species, particularly *Trachinops caudimaculatus*, *Parma victoriae* and *Notolabrus tetricus*. Relatively large variations in Hill's N_2 was observed at most sites over time, however South Channel Fort (Site 4) and Shortland Bluff consistently had lower Hill's N_2 diversity than other sites (Figure 5.3).

5.3 Population Abundances and Sizes

Examples of time trends in abundances of selected species are given for each site in Figures 5.4 to 5.10. Most species displayed considerable variation between times at some sites.

There was an increasing trend in *Notolabrus tetricus* abundances over the monitoring period at Popes Eye, Nepean Bay and Merlan Inner (Sites 12, 2 and 7; Figure 5.4). There was an apparent increase in *N. fucicola* at Popes Eye (Site 12), except for the last survey (Survey 11), when abundances were the lowest recorded (Figure 5.5). Scalyfin, *Parma victoriae,* abundance was the highest ever recorded at Popes Eye during the eleventh survey (Figure 5.6). There were 154 individuals per 2000 m², over double that of most of the densities observed from 1998 to 2002 (Figure 5.6). This was largely attributed to a higher abundance of smaller individuals (Table 5.2).

The observed size structures of *Parma victoriae, Notolabrus tetricus*, *Notolabrus fucicola*, and *Odax cyanomelas* are given in Tables 5.2 to 5.5. There were no marked differences in mean sizes between sites except for a higher density of larger fish within the Popes Eye sanctuary.

The blue-throated wrasse *Notolabrus tetricus* is a protogynous hermaphrodite, with all juveniles and smaller adults being females. A few larger, dominant females change sex to males, and guard their harem of females against intrusion by other males. This sex change is accompanied by a thickening of the body, enlargement of the head, increased body length and change in colour (from mottled browns to blues and yellows). The higher abundance and larger size of *N. tetricus* at Popes Eye was accompanied by a high proportion of males in the population (20 %; Table 5.3). Sites in Lonsdale Bay and outside the Heads also had a reasonably high proportion of males (10-40 %), while the other sites had a very low proportion of males (0-6 %; Table 5.3).

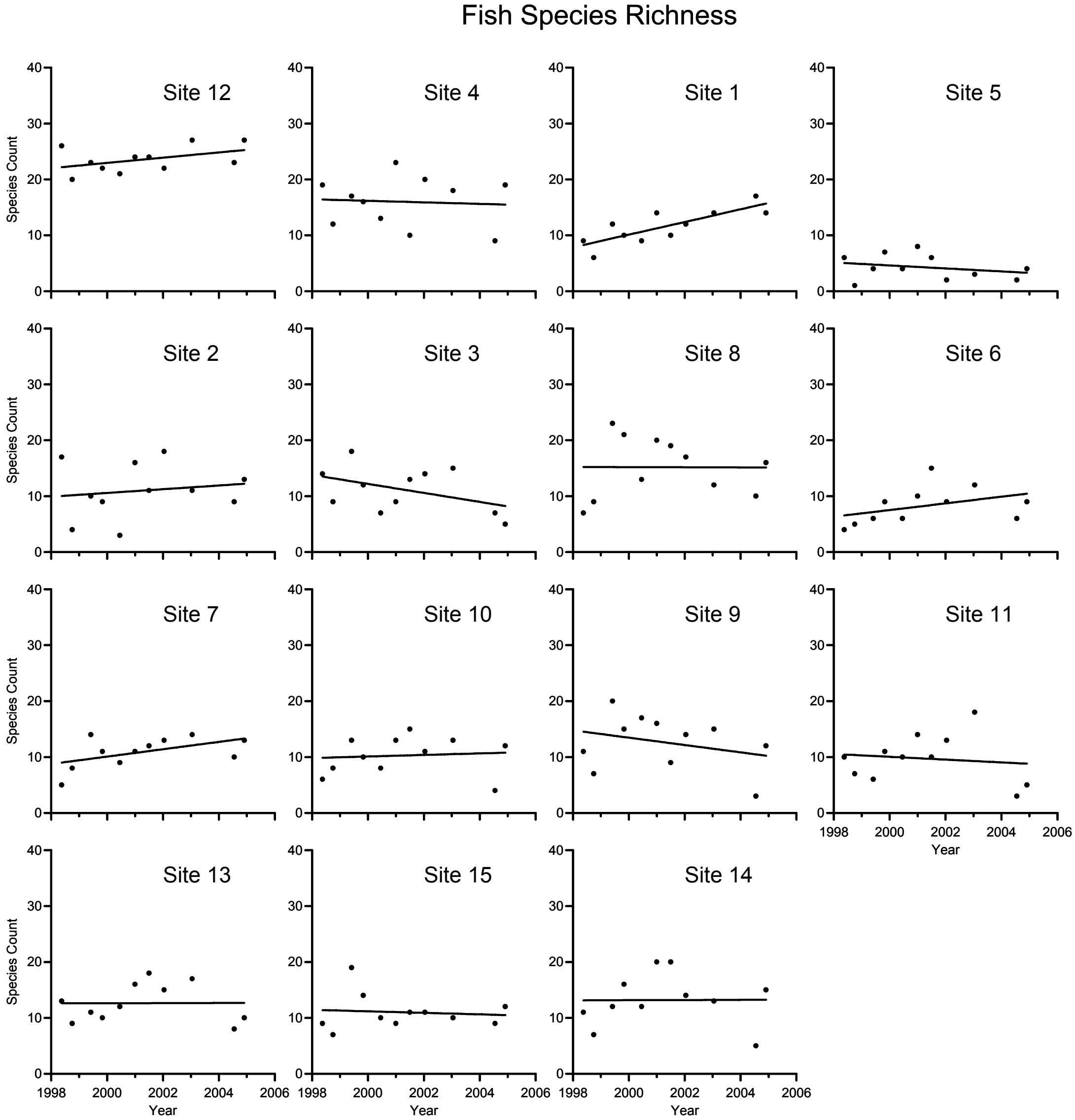


Figure 5.2 Trends in species richness of fishes at Port Phillip Heads.

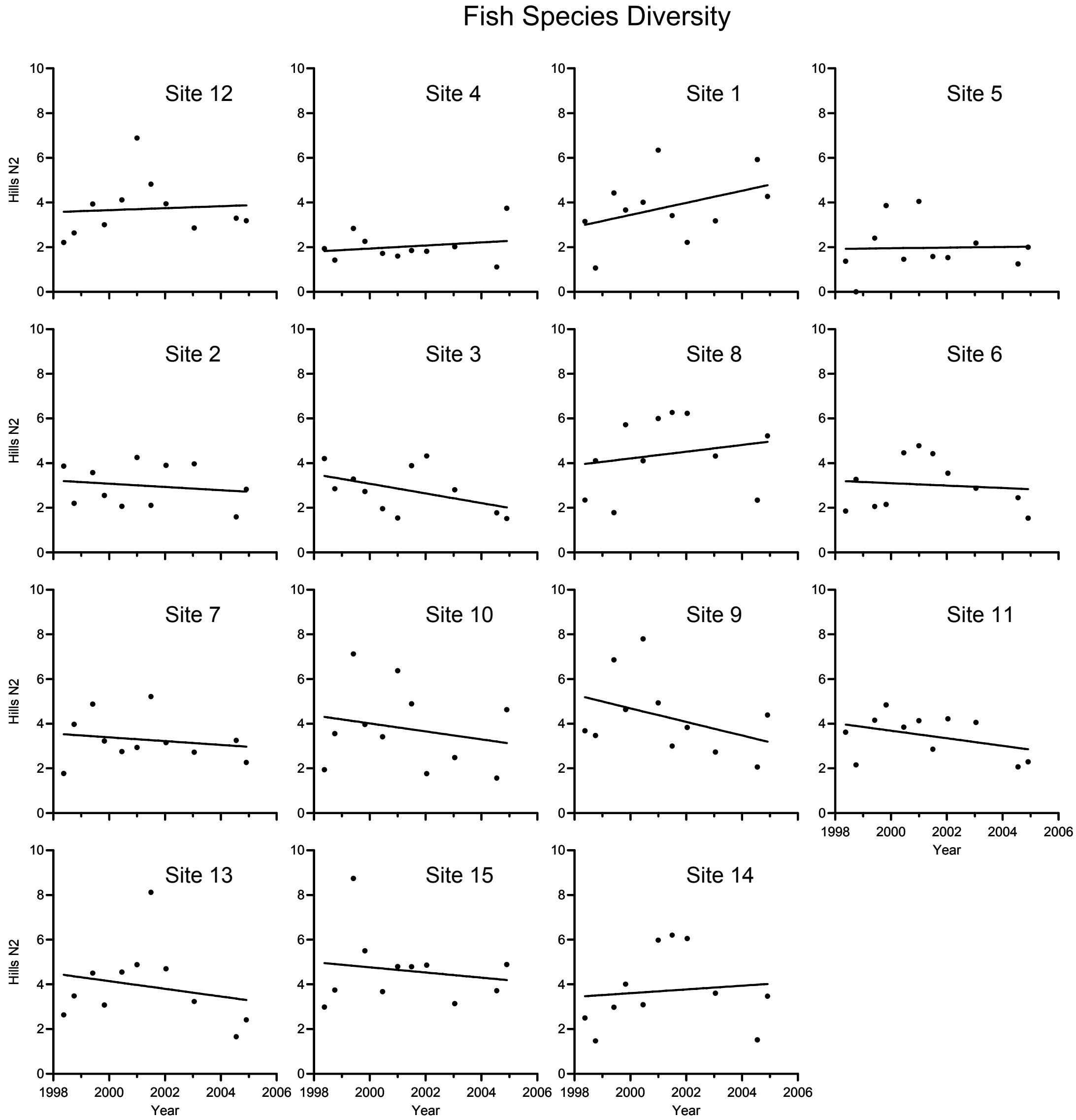


Figure 5.3 Trends in species diversity of fishes at Port Phillip Heads.

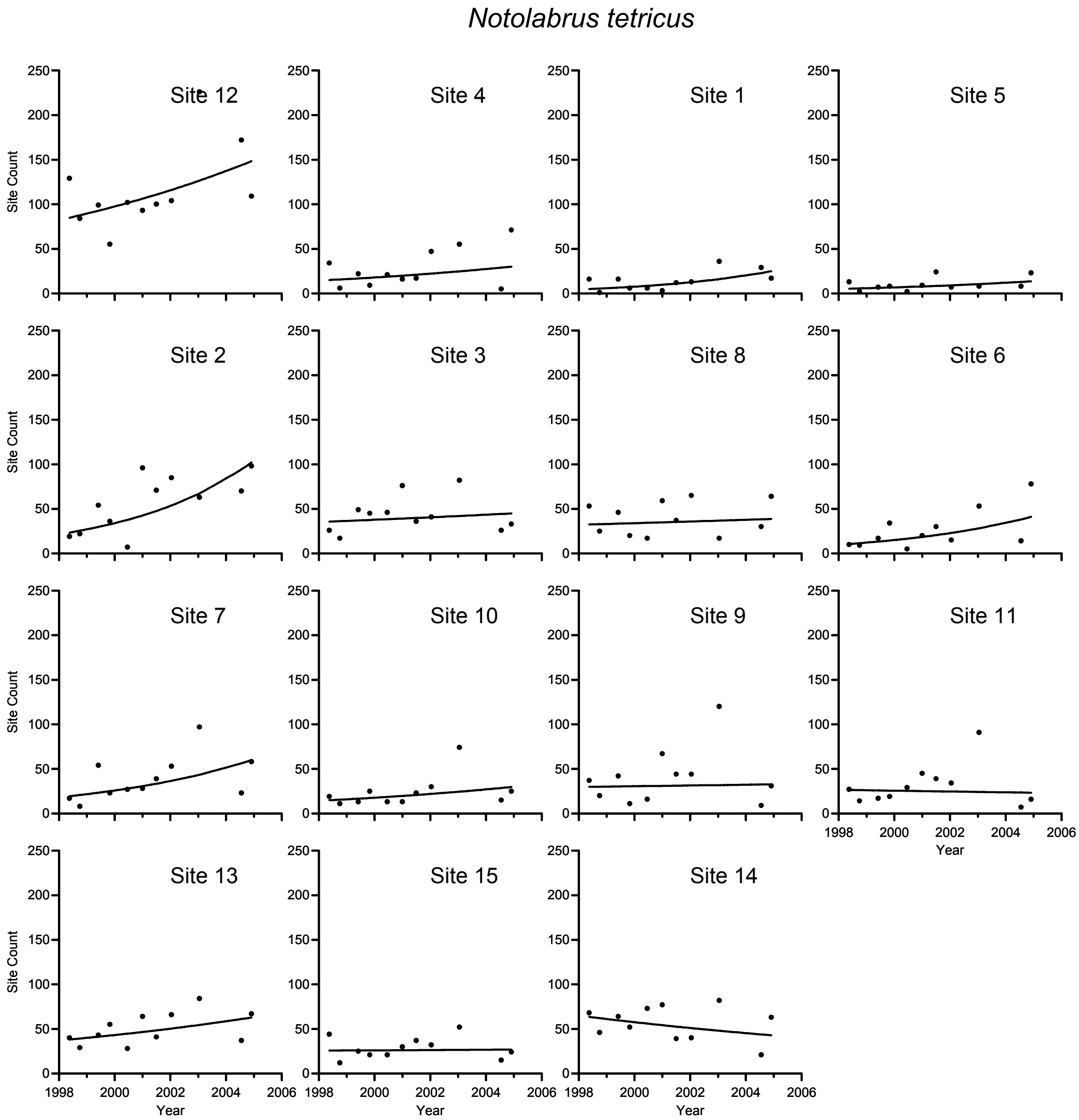


Figure 5.4 Trends in abundance of blue-throated wrasse *Notolabrus tetricus* at Port Phillip Heads.

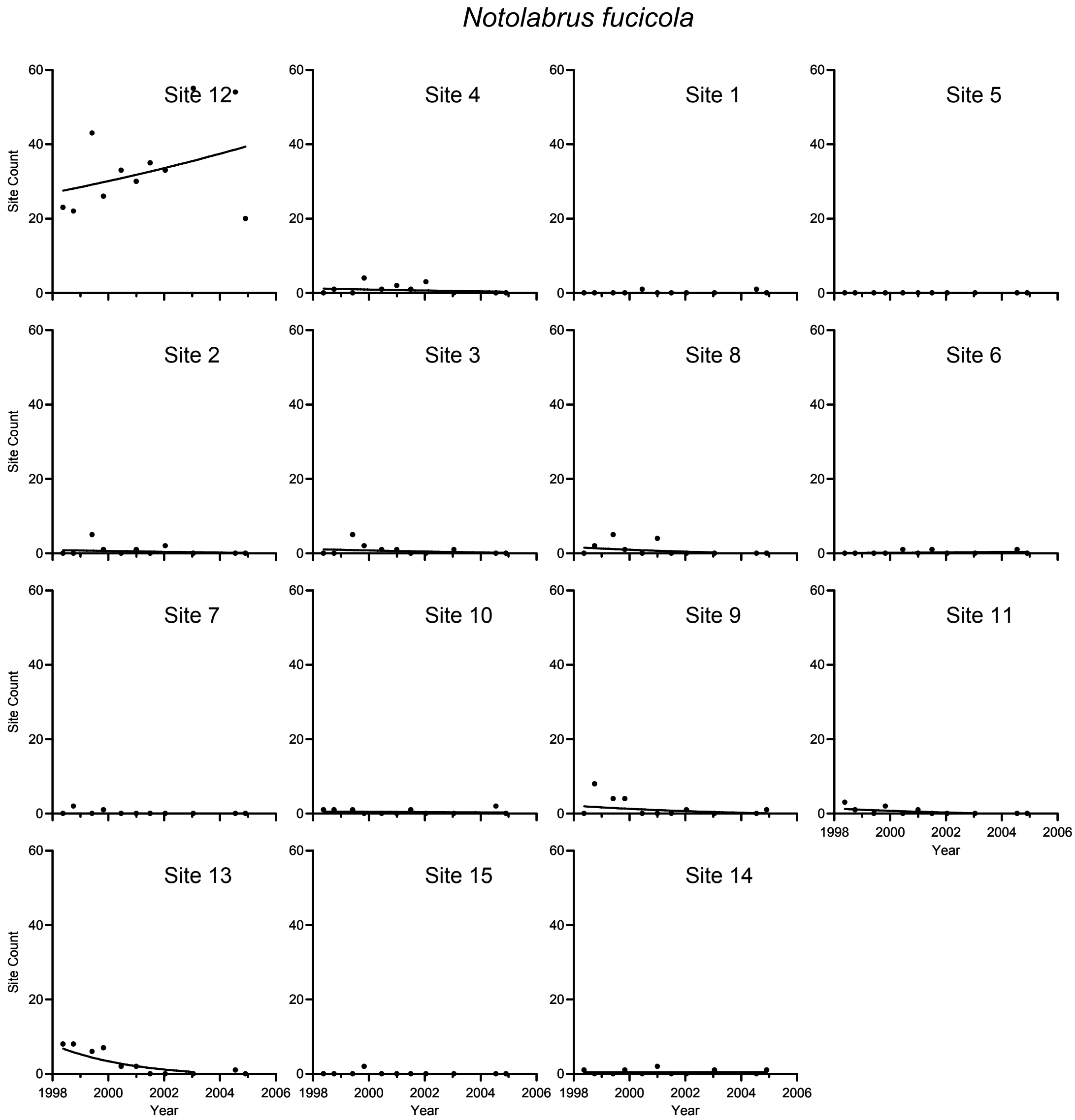


Figure 5.5 Trends in abundance of purple wrasse *Notolabrus fucicola* at Port Phillip Heads.

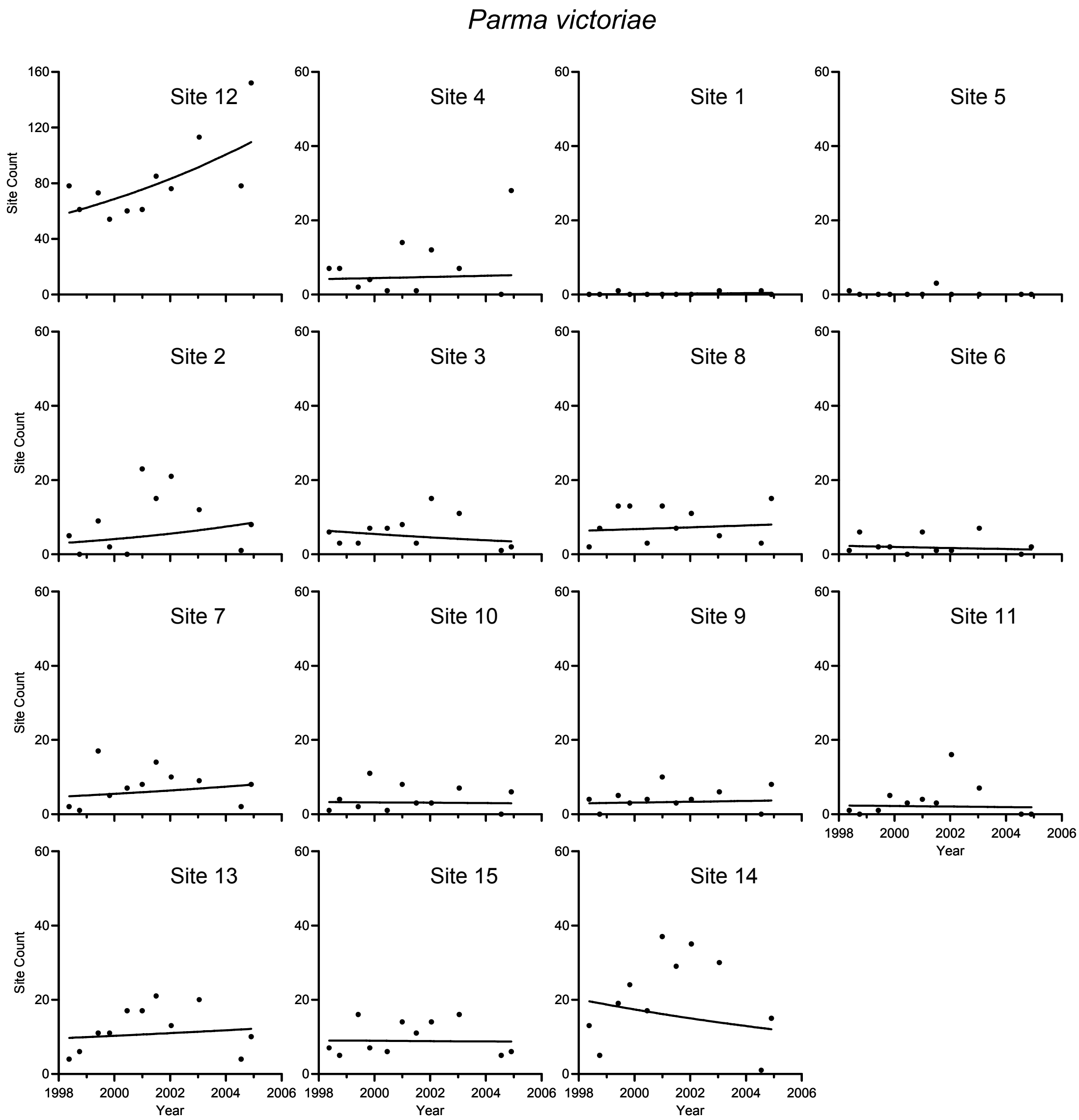


Figure 5.6 Trends in abundance of scalyfin *Parma victoriae* at Port Phillip Heads.

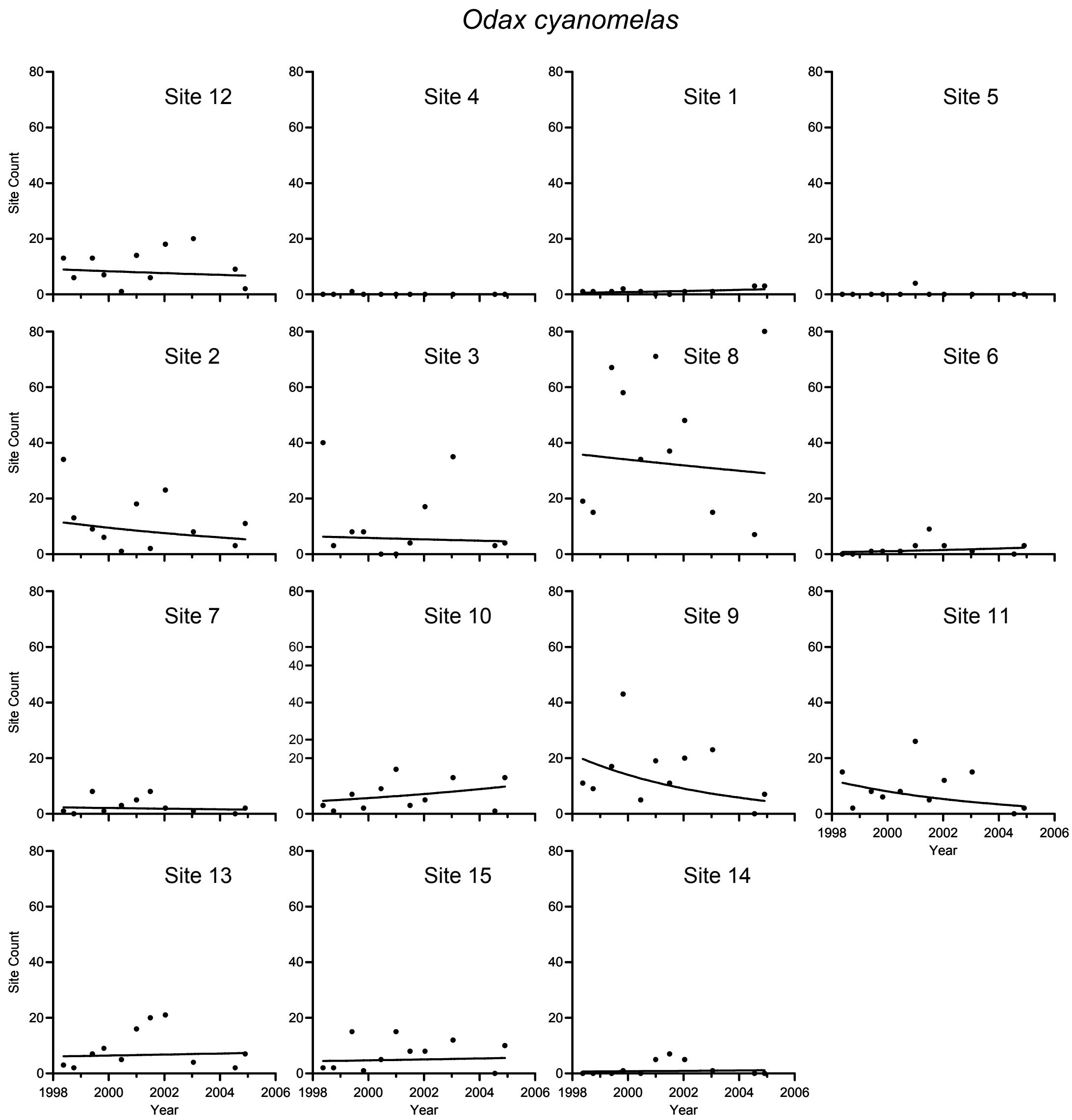


Figure 5.7 Trends in abundance of herring cale *Odax cyanomelas* at Port Phillip Heads.

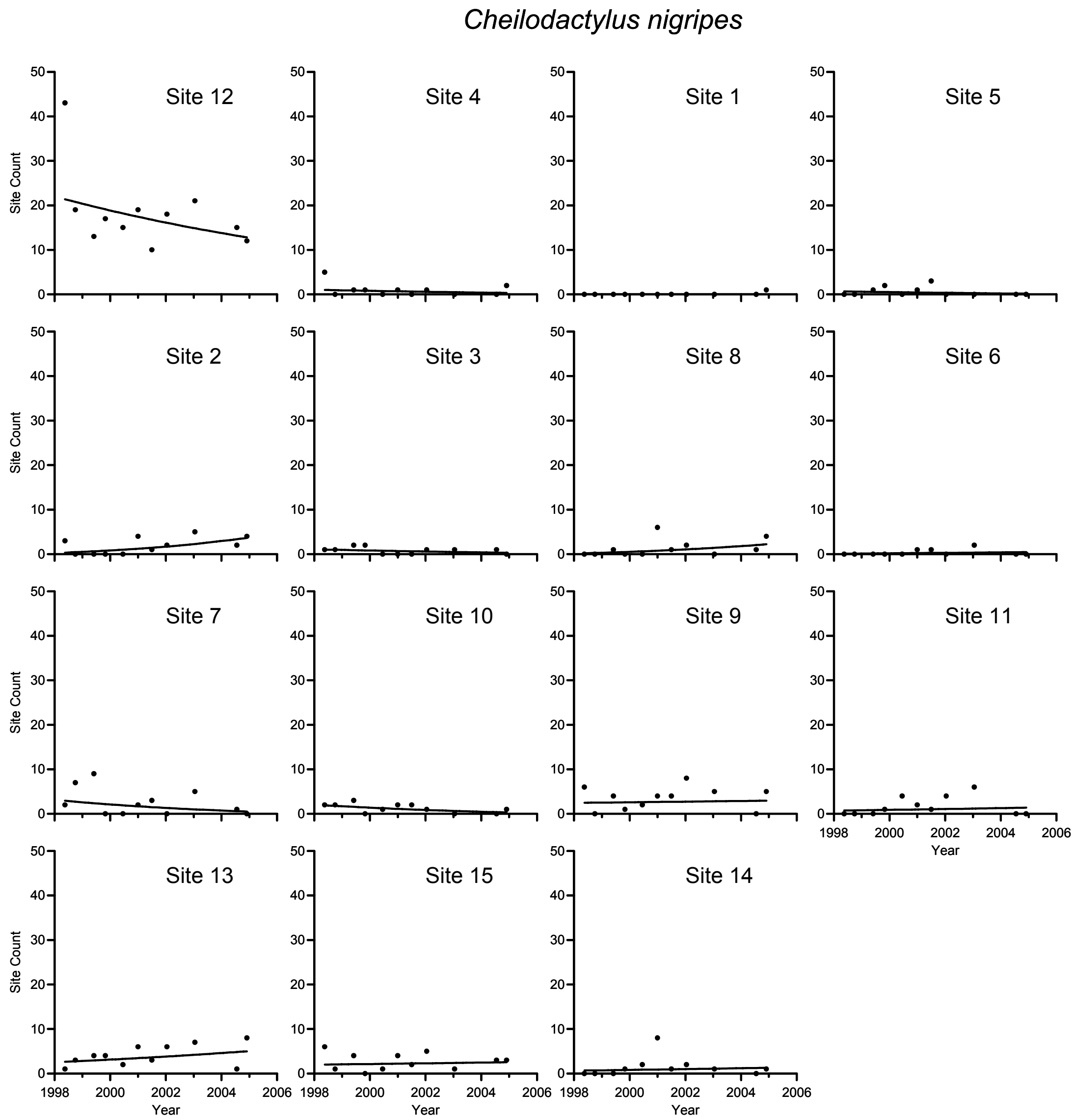


Figure 5.8 Trends in abundance of magpie morwong *Cheilodactylus nigripes* at Port Phillip Heads.

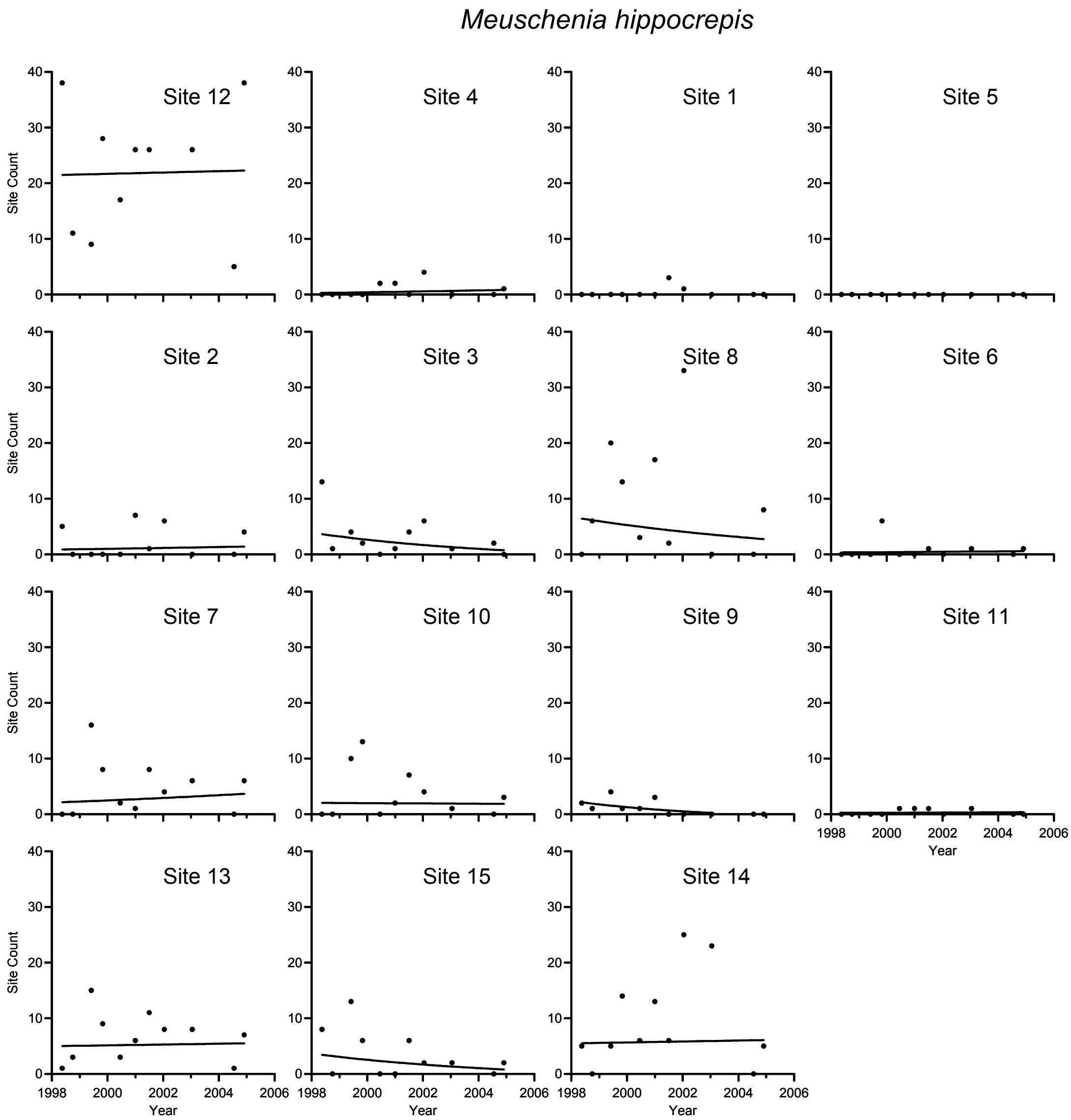


Figure 5.9 Trends in abundance of horseshoe leatherjacket *Meuschenia hippocrepis* at Port Phillip Heads.

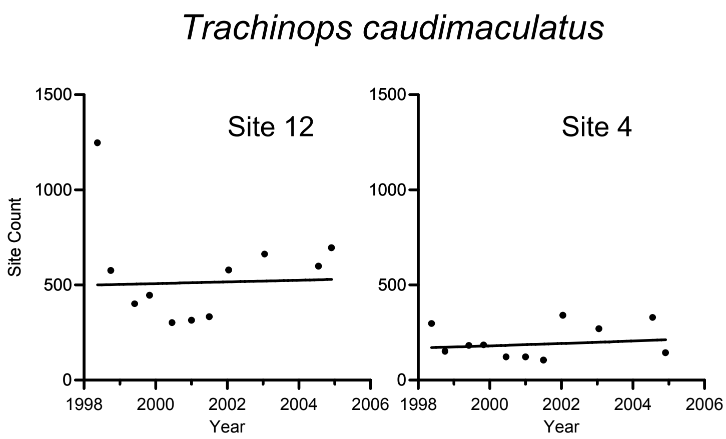


Figure 5.10 Trends in abundance of the southern hula fish *Trachinops caudimaculatus* at Popes Eye (Site 12) and South Channel Fort (Site 4).

Table 5.2 Population structure of scalyfin *Parma victoriae* at Port Phillip Heads.

Site		***Length (mm)***			***Length Class (mm)***										
		n	***mean***	***sd***	***25***	***50***	***75***	***100***	***125***	***150***	***200***	***250***	***300***	***350***	***375***
Survey 10, Winter 2004															
12		78	197	36		1		1	1	12	49	14			
1		1	100	0				1							
2		1	150	0						1					
3		1	200	0							1				
8		3	217	29							2	1			
7		2	225	35							1	1			
13		4	200	41						1	2	1			
14		1	200	0							1				
15		5	200	35						1	3	1			
Survey 11, Summer 2004															
12		152	172	36		1	2	3	20	45	78	3			
4		28	148	21					8	17	3				
2		8	159	38					1	6		1			
3		2	175	35						1	1				
8		15	157	18						13	2				
6		2	150	0						2					
7		8	188	23						2	6				
10		6	163	63		1			1		4				
9		8	191	27					1		7				
13		10	165	32					2	4	4				
14		15	170	30					2	6	7				
15		6	175	27						3	3				

Table 5.3 Population structure of purple wrasse *Notolabrus fucicola* at Port Phillip Heads.

Site		***Length (mm)***			***Length Class (mm)***										
		n	***mean***	***sd***	***75***	***100***	***125***	***150***	***200***	***250***	***300***	***350***	***375***	***400***	***500***
Survey 9, Summer 2003															
12		55	209	55		1		12	27	9	4	1		1	55
3		1	150	0				1							1
14		1	250	0						1					1
Survey 10, Winter 2004															
12		54	208	52			1	15	20	12	5	1			1
1		1	250	0						1					
6		1	200	0					1						
10		2	250	71					1		1				
Survey 11, Summer 2004															
12		20	181	48			1	11	4	3	1				
9		1	125	0			1								
14		1	250	0						1					

Table 5.4 Population structure of blue-throated wrasse *Notolabrus tetricus* at Port Phillip Heads.

Site	*% male*	*Length (mm)*			*Length Class (mm)*										
		n	*mean*	*sd*	*75*	*100*	*125*	*150*	*200*	*250*	*300*	*350*	*375*	*400*	*500*
Survey 10, Winter 2004															
12	20	172	231	96	3	6	16	37	34	21	19	12	14	8	2
4	0	5	210	65				2	1	1	1				
1	0	29	135	43	4	3	11	6	4	1					
5	0	8	119	32	2	1	2	3							
2	3	70	159	64	2	12	10	19	14	7	2			1	
3	0	26	162	58	1	3	7	6	6	1	2				
8	0	30	140	41	3	4	7	11	4	1					
6	0	14	150	52	1	2	3	5	1	2					
7	13	23	208	97		1	1	10	5	2	1	1		1	1
10	13	15	235	60				2	5	5	2		1		
9	33	9	222	75				3	3		2	1			
11	0	7	154	44			3	3		1					
13	3	37	160	62		8	7	11	6	4				1	
14	10	21	200	72			2	7	8	1	1	1		1	
15	0	15	173	64		1	4	4	4	1		1			
Survey 11, Summer 2004															
12	21	109	210	107	5	6	11	22	22	9	5	6	4	13	
4	1	71	143	43		16	24	17	12	1		1			
1	0	17	115	55		4	2	3	3						
5	0	23	143	26		1	10	9	3						
2	1	98	139	41	8	15	20	45	8		1	1			
3	0	33	146	58		5	6	11	5	2	1				
8	4	64	143	47		9	30	17	5	1		2			
6	5	78	169	67		10	17	24	17	6			1	3	
7	3	58	172	98	6	6	9	10	4	6	4	6		1	
10	20	25	237	102	1		1	8	3	4	2	1	1	4	
9	13	31	206	87		1	2	9	9	4	1	1		3	
11	6	16	183	78	1	2	2	2	6	2				1	
13	12	67	160	69	1	13	20	15	9	2	3	4			
14	3	63	152	53		6	27	17	8	3		1	1		
15	8	24	163	76		6	4	8	3	1			2		

Table 5.5 Population structure of herring cale *Odax cyanomelas* at Port Phillip Heads.

Site	***% male***	***Length (mm)***			***Length Class (mm)***										
		n	***mean***	***sd***	***75***	***100***	***125***	***150***	***200***	***250***	***300***	***350***	***375***	***400***	***500***
Survey 9, Summer 2003															
12	45	20	414	38									1	16	3
1	0	1	75	0	1										
2	0	8	363	44							2	2		4	
3	11	35	319	70				1	3	6	6	6	7	6	
8	53	15	363	42						1	1	4	4	5	
6	0	1	400	0										1	
7	0	1	350	0								1			
10	8	13	256	75				2	2	5	2		1	1	
9	0	23	365	32							3	6	8	6	
11	13	15	327	61					1	3	1	5	4	1	
13	0	4	331	90					1			1	1	1	
14	0	1	150	0				1							
15	8	12	279	72				1	2	3	1	5			
Survey 10, Winter 2004															
12	67	9	333	56						2	1	4		2	
1	33	3	250	50					1	1	1				
2	67	3	383	14									2	1	
3	0	3	150	0				3							
8	57	7	257	90			1		2	1	1	1	1		
10	0	1	200	0					1						
13	50	2	325	106						1				1	
Survey 11, Summer 2004															
12	50	2	388	18									1	1	
1	33	3	317	58						1		2			
2	64	11	275	72					3	4	1	1	1	1	
3	25	4	400	0										4	
8	31	80	194	30				19	51	10					
6	67	3	342	38							1	1	1		
7	0	2	213	124			1				1				
10	8	13	331	105				3				2	2	6	
9	71	7	364	75					1			1		5	
11	50	2	350	71							1			1	
13	29	7	211	91	1			2	1		3				
15	10	10	288	91				1	2	2	1	1	1	2	

6.0 INTRODUCED SPECIES

6.1 Macrophytes

The northern end of Port Phillip Bay is infested with the Japanese seaweed *Undaria pinnatifida*. This species has invaded and displaced native algal communities over large reef areas in Tasmania and is likely to have similar impacts on central Victorian reefs. *Undaria pinnatifida* has a distinct alternation of generations lifecycle, with a large, macroscopic sporophyte phase predominating in the winter-spring months (June to December) and a microscopic gametophyte phase predominating in the summer-autumn months (January to May). The large sporophyte phase forms a dense, monospecific canopy during spring and early winter, but degenerates over the summer months, leaving few visible traces of its presence until new sporophytes start growing in early winter. No *Undaria* sporophytes have been observed at the Subtidal Reef Monitoring Program sites to date. Because of the seasonal senescence of the sporophytes, the colonisation of *Undaria* is likely to be first observed during a future spring/early summer survey.

6.2 Invertebrates

The introduced Mediterranean fanworm *Sabella spallanzani* has colonised many subtidal habitats in Port Phillip Bay. This species can inhabit both reef and sediment habitats (particularly where *Pyura stolonifera* occurs). *Sabella spallanzani* tends to occur in clumps, growing up to 400 mm high with tubes 10 mm thick and filter-feeding tentacles approximately 120 mm across.

Sabella spallanzani was observed for the first time in the southern part of Port Phillip Bay during Survey 5, autumn 2000. One individual was found in the transect at South Channel Fort (Site 4) and another at Shortland Bluff (Site 5). Both specimens were juveniles, with tubes approximately 5 mm in diameter and 100 mm long. No *Sabella* were observed during Survey 6, summer 2000. Two *Sabella* individuals were observed at South Channel Fort (Site 4) during the seventh survey, autumn 2001. These individuals were not found within the survey transects. One *Sabella* individual was found within the transect at Nepean Bay Offshore (Site 2) during the eighth survey, Summer 2001.

During the tenth survey *Sabella* was observed at two sites. Four individuals were observed spaced along the transects at South Channel Fort (Site 4) as has been found in past surveys. One individual was observed outside the heads at Lonsdale Pt South West (Site 15). It is unusual to find *Sabella* at this site as it is an exposed sandy reef site and they generally prefer sheltered silty estuarine/bay habitats. This sighting is worrying as *Sabella* has not established in any of the other bay/inlets along the Victorian coast (Western Port, Anderson's Inlet and Anglesea Inlet) and, if introduced, could cause a major threat to these ecosystems. This individual could simply be a vagrant, or an extension of the range of *Sabella spallanzani* outside of Port Phillip Bay as has recently been observed in the introduced seastar *Asterias amulerensis*. No *Sabella* individuals were observed during the eleventh survey.

Also observed at South Cannel Fort during Survey 7 was the northern Pacific seastar *Asterias amurensis*. Two juveniles (70 mm) were sighted on the reef, but not within the survey transects. Many more individuals were observed under the jetty on the western end of the island. *Asterias amurensis* were particularly abundant on the mussel bed underneath the jetty. Soft-sediment habitats, the preferred habitats for *A. amurensis*, are not investigated for this monitoring program.

7.0 SOUTH CHANNEL FORT

South Channel Fort was built in the 1880's as part of a strategic set of fortifications (including the Annulus) to protect the entrance of Port Phillip Bay. The island has an extensive system of underground tunnels and weapon emplacements and is listed on the Victorian Heritage Register as an example of military technology. The Fort is part of the Mornington Peninsula National Park and is listed on the Register of the National Estate for its environmental values. These values include a significant breeding colony of white-faced storm petrels *Pelagodroma marima*, as well as little penguins *Eudyptula minor*, silver gulls *Larus novaehollandiae* and the short-tailed shearwater *Puffinus teniurostris*.

Access to South Channel Fort is by boat to a jetty on the western side. The jetty was previously utilised by a variety of recreational boaters and organised charter tours to the island. The jetty was closed on 24 December 1997 because of a deteriorated structural condition. Jetty reconstruction and rock revetment work was complete by summer 2000.

The jetty reconstruction involved complete removal of the previous structure, insertion of new piles and construction of frames and decking. A large barge was moored on the southern side of the jetty for this work, with mooring cables attached to shore and seaward anchors. Landing barges were also deployed. The jetty is located at the end of transect section T4 at South Channel Fort (Site 4). Survey 5 of South Channel Fort was during the jetty construction works and obvious disturbances to the habitat along T4 were observed. In particular, there were construction scars between 20 and 25 m, as well as between 37 and 50 m along T4 where all macrophytes were cleared from the boulder substratum.

The jetty construction does not appear to have affected the average abundance of most common plant and animal species along T4 (Figures 7.1 to 7.3). The abundances of most common species were within the range of values observed during the previous four surveys. Two exceptions were the globefish *Diodon nichthemerus* and the common kelp *Ecklonia radiata*, which had lower abundances than previously observed during and immediately after the construction period. However, their abundances have since increased (Figures 7.1 and 7.3).

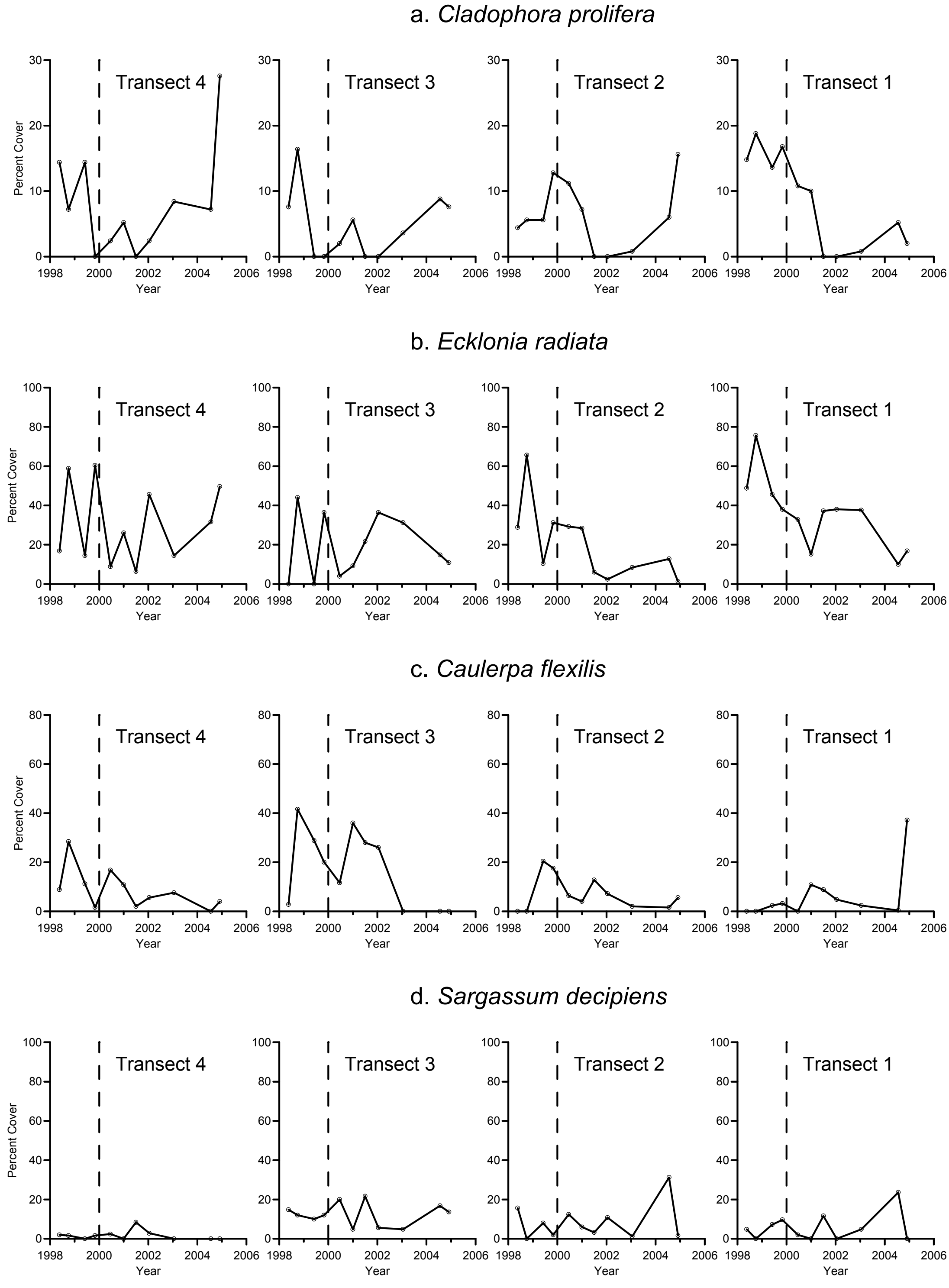


Figure 7.1 Trends in abundance of common macrophyte species for each section of the transect at South Channel Fort (Site 4): (a) filamentous green *Cladophora prolifera*; (b) common kelp *Ecklonia radiata*; (c) turfing green alga *Caulerpa flexilis*; and (d) brown alga *Sargassum decipiens*. The timing of the jetty reconstruction is indicated by the dashed line.

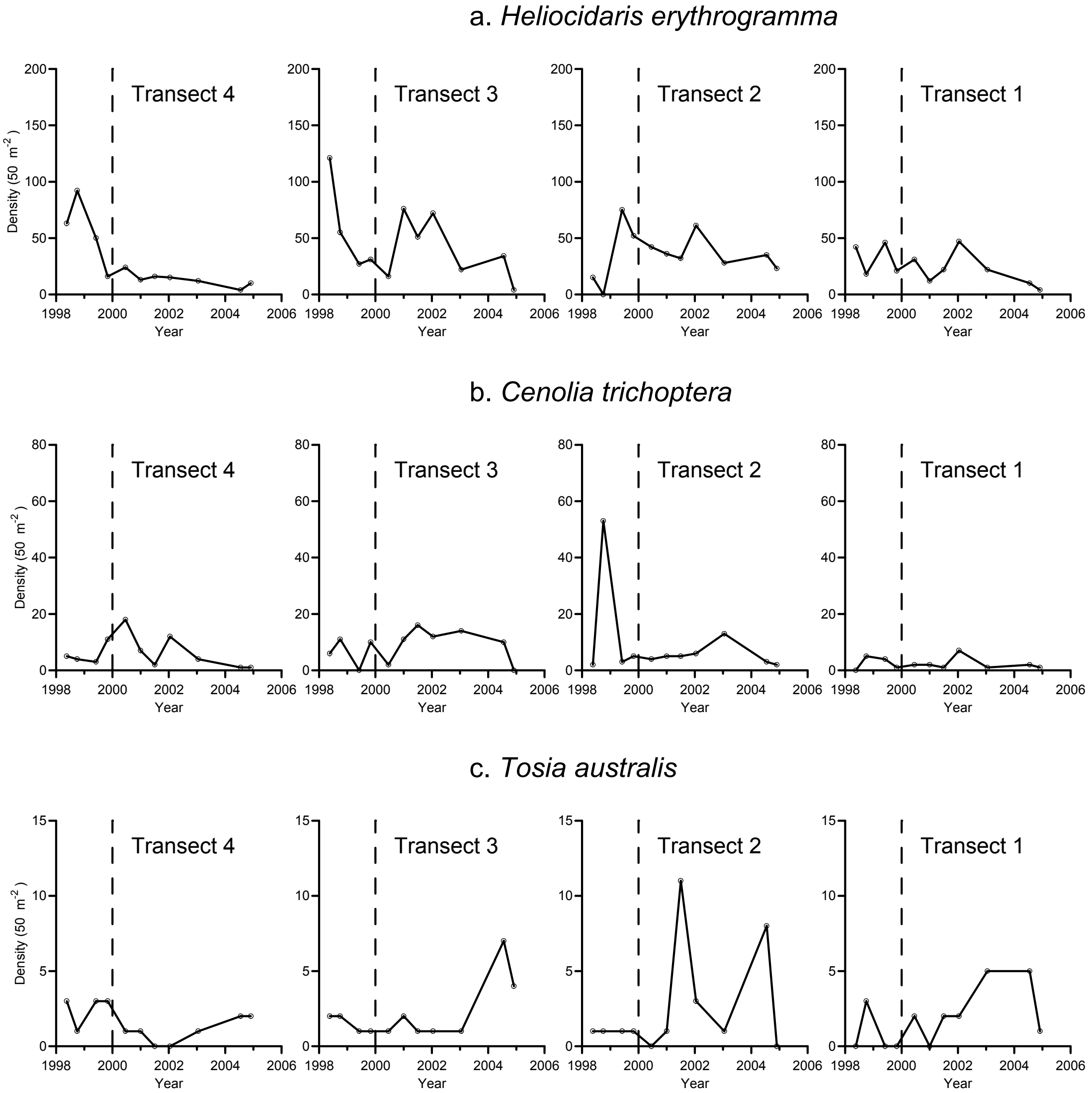


Figure 7.2 Trends in abundance of common invertebrate species for each section of the transect at South Channel Fort (Site 4): (a) sea urchin *Heliocidaris erythrogramma*; (b) feather star *Cenolia trichoptera*; and (c) common biscuit star *Tosia australis*. The timing of the jetty reconstruction is indicated by the dashed line.

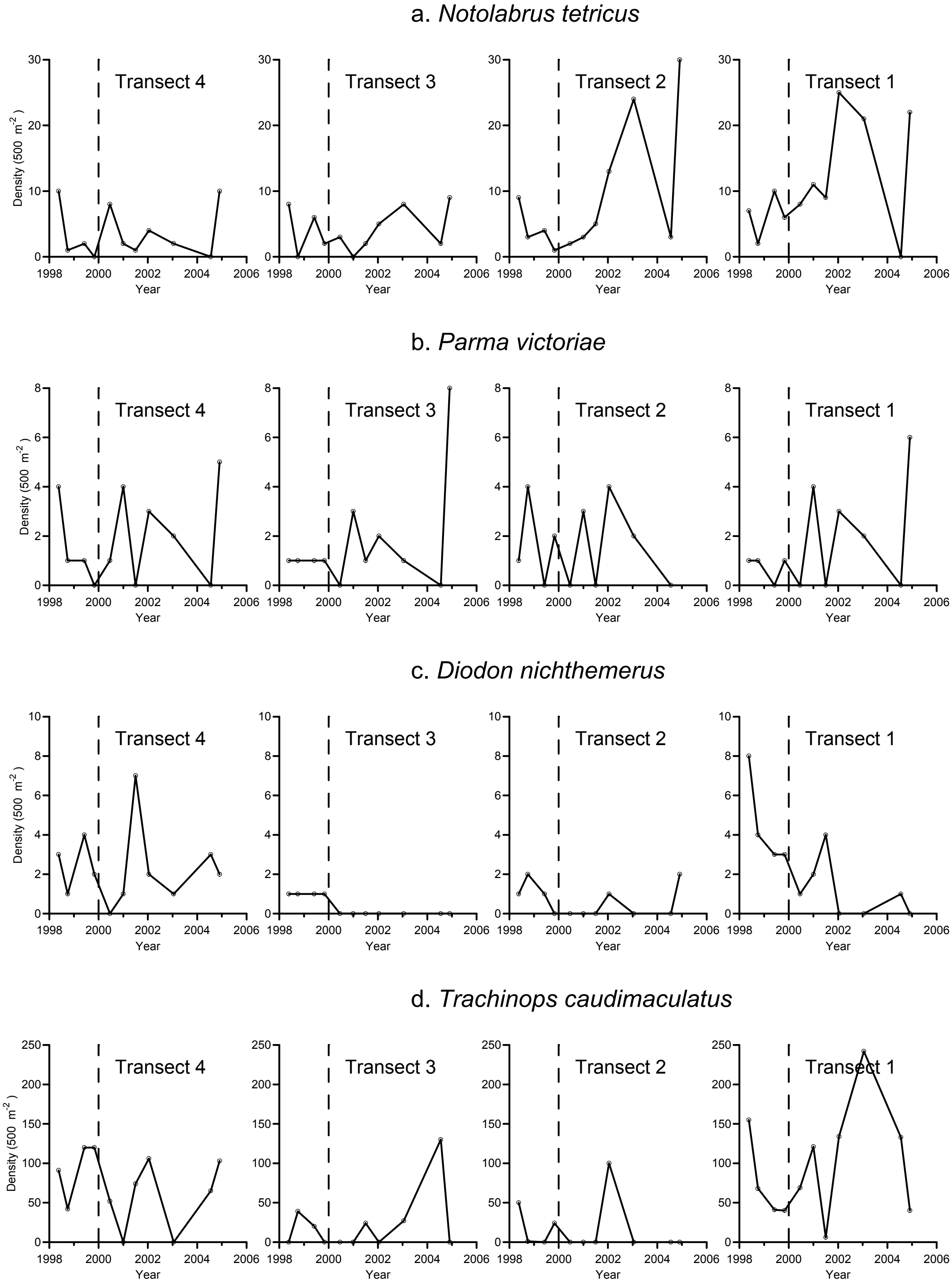


Figure 7.3 Trends in abundance of common fish species for each section of the transect at South Channel Fort (Site 4): (a) blue-throated wrasse *Notolabrus tetricus*; (b) scalyfin *Parma victoriae*; (c) spiny globefish *Diodon nichthemerus*; and (d) southern hula fish *Trachinops caudimaculatus*. The timing of the jetty reconstruction is indicated by the dashed line.

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