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Victorian Subtidal Reef Monitoring Program: The reef biota at Port Phillip Heads Marine National Park Volume 4

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Victorian Marine Park Subtidal Reef Monitoring Program:

The Reef Biota at Port Phillip Heads Marine National Park

Volume 4

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EXECUTIVE SUMMARY

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

The subtidal reef monitoring program is established throughout Victoria for all relevant marine protected areas. This report describes the thirteenth (2009) survey of the Port Phillip Heads sites associated with the Port Phillip Heads Marine National Park.

The subtidal reef monitoring program used standardised underwater visual census methods to survey algae, macroinvertebrates, and fish. This report aims to:

- Provide general descriptions of the biological communities and species populations at each monitoring site in May-June 2009.
- Identify any unusual biological phenomena such as interesting communities and species.
- Ecologically significant temporal changes in comparison with reference areas.
- Identify any introduced species at the monitoring locations.

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

1. Abundance and size structure of large fishes.
2. Abundance of cryptic fishes and benthic invertebrates.
3. Percentage cover of macroalgae.
4. Density of string kelp species.

There have been thirteen surveys in the Port Phillip Heads Marine National Park over the past seven years: May 1998; October-September 1998; May-June 1999; October-November 1999; May-August 2000; November 2000- January 2001; June-July 2001; January 2002; January 2003; July-August 2004; November-December 2004; May-June 2006; and May-June 2009.

Port Phillip Heads Marine National Park

Four general groups of macroalgal and invertebrate assemblages were observed: well inside the Heads; Nepean Bay; Lonsdale Bight; and outside the Heads, This corresponds with regional differences in currents, wave exposure and depth. There was less distinct grouping of fish assemblages.

Port Phillip Heads

Key observations made at Port Phillip Heads during the monitoring program are:

- The mean algal species richness of sites within the Marine National Park increased between 1998 and 2002, and has remained relatively stable since, while species richness of reference sites at Port Phillip Heads has been relatively stable since monitoring began.

- In 2009, substantial dieback of Kelp *Ecklonia radiata* was observed at Point Franklin, and small patches in the marine national park in Lonsdale Bight. This appeared to be a disease that caused necrosis of the blade and laterals fronds back to the stipe.
- String Kelp *Macrocystis angustifolia* abundance has declined dramatically in Port Phillip Heads, with few plants observed since 2005. This is part of a more widespread decline threatening this species.
- The sea urchin *Heliocidaris erythrogramma* was highest in abundance at Point Franklin and moderately high at Shortland Bluff. Over time however, there appears to have been a declining trend in abundance at these sites.
- There was a large increase in the abundance of blue-throated wrasse *Notolabrus tetricus* at Nepean Inner West during the most recent survey.
- Large increases in the abundance of the horseshoe leatherjacket *Meuschenia hippocrepis* were apparent at Nepean Inner East and Lonsdale Point during the most recent survey.
- Point Franklin had seaweed and invertebrate communities that were more similar to Popes Eye than Port Phillip Heads.
- Point Franklin initially had very low fish species richness and low diversity. The number fish species observed per survey have increased steadily; from 5 species in 1998 to 27 species in 2009. In 2009 Point Franklin had the highest fish diversity of any site.

Marine National Park- Pope's Eye

Key observations made at Popes Eye and reference site South Channel Fort during the monitoring program are:

- Popes Eye and the reference site South Channel Fort had seaweed, invertebrate and fish communities that were distinctly different to the other monitoring regions.
- Popes Eye and South Channel Fort were dominated by the kelp *Ecklonia radiata* and had a high predominance of the green algae *Cladophora prolifera* and Caulerpa species.
- Invertebrate species diversity increased at both Popes Eye and South Channel Fort between 2006 and 2009 surveys.
- At Popes Eye, the feather star *Comanthus tricoptera* was the most abundant macroinvertebrate recorded. It was particularly abundant in 2006, when densities at both sites increased fivefold, before returning to earlier levels in 2009
- The urchin *Heliocidaris erythrogramma* was common, but has declined in abundance at South Channel Fort, from 241 per 2000 m2 in 1998 to 15 per 2000 m2 in 2006 before a slight increase in 2009.
- Popes Eye is characterised by higher species richness and much higher abundances of most fish species than anywhere else. Several species, including sea sweep *Scorpis aequipinnis* and rosy wrasse *Pseudolabrus psittaculus* were rarely observed at other sites.
- Barber perch *Caesioperca razor* and southern hula fish *Trachinops caudimaculatus* were common to both South Channel Fort and Popes Eye, but generally not elsewhere.
- There was an increasing trend in *Notolabrus tetricus* abundances over the monitoring period at Popes Eye.
- There was an apparent increase in *Notolabrus fucicola* at Popes Eye, until the two most recent surveys, when abundances declined sharply.

- The abundance of *Trachinops caudimaculatus* at Popes Eye has increased since 2000 and is approaching densities not recorded since the initial survey in 1998.

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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 *Comanthus trichoptera* and sessile (attached) species such as sponges, corals, bryozoans, hydroids and ascidians.

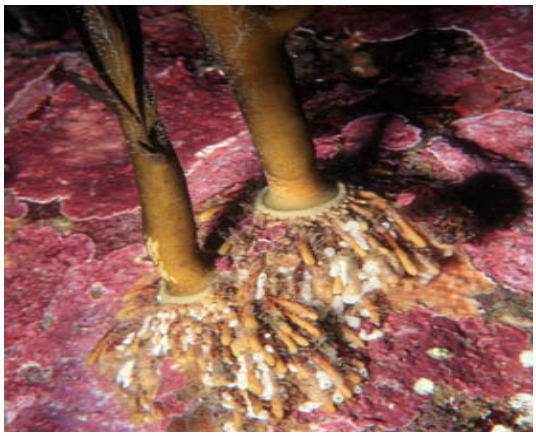
Fishes are also a dominant component of reef ecosystems, in terms of both biomass and ecological function (Figure 1.3). Reef fish assemblages include roaming predators such as blue-throated wrasse *Notolabrus tetricus*, herbivores such as herring cale *Odax cyanomelas*, planktivores such as sea sweep *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 (mesoinvertebrates), occupying various niches as

grazers, predators and detritivores. At the microscopic level, films of microalgae, fungi and bacteria on the reef surface are also important.

Victoria's shallow reefs are a very important component of the marine environment because of their high biological complexity, species diversity and productivity. Subtidal reef habitats have important social and cultural values, which incorporate aesthetic, recreational, commercial and historical aspects. Shallow subtidal reefs also have significant economic value, through commercial fishing of reef species such as abalone and sea urchins, as well as recreational fishing, diving and other tourism activities.

a. Green algae *Caulerpa flexilis.*



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

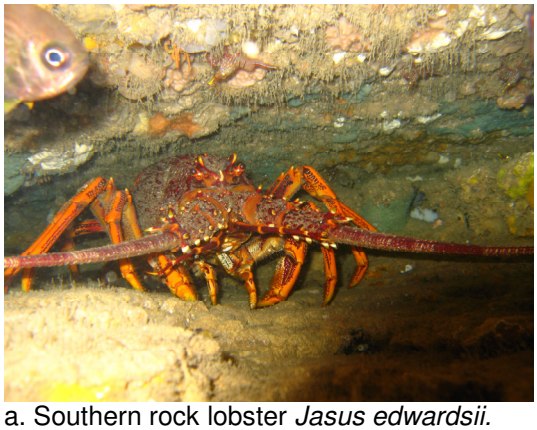
c. Red coralline algae *Haliptilon roseum.*

d. Thallose red algae *Ballia callitricha.*

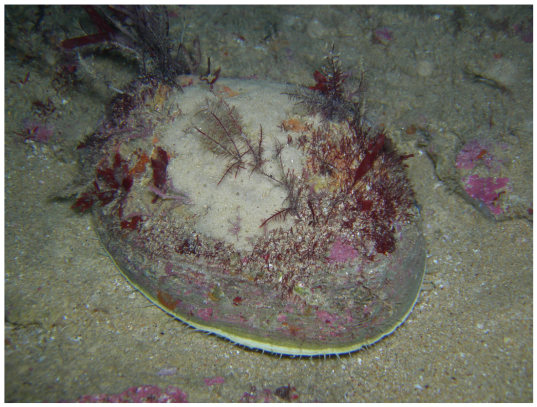
e. Crayweed *Phyllospora comosa* canopy.

f. Common kelp *Ecklonia radiata* canopy.

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



a. Southern rock lobster *Jasus edwardsii.*



b. Green lip abalone *Haliotis laevigata*.

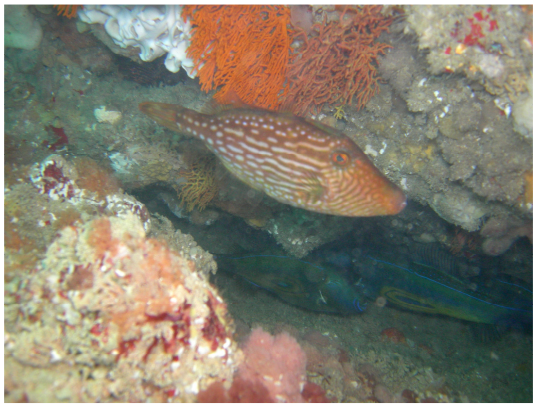
c. Seastar *Uniophora granifera*.

d. Seastar *Pseudonepanthia troughtoni*.

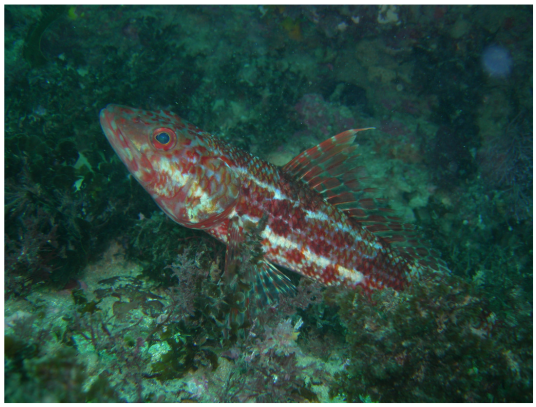
e. Nudibranch *Ceratosoma brevicaudatum*.

f. Feather star *Comanthus trichoptera*.

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



a. Blue-lined leatherjacket *Meuschenia galii.*



b. Sergeant baker *Aulopus purpurissatus.*

c. Old wife *Enoplosus armatus*

d. Magpie perch *Cheilodactylus nigripes*.

e. Male Six-spined leatherjacket *Meauchenia freycineti* .

f. Purple wrasse *Notolabrus fucicola*.

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

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

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

Information from the SRMP allows managers to better understand and interpret long-term changes in the population and community dynamics of Victoria's reef flora and fauna. As a longer time series of data 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 *et al.* 2000).
- Provide benchmarks for assessing the effectiveness of management actions, in accordance with international best practice for quality environmental management systems (Holling 1978; Meredith 1997).
- 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 provides an estimate of population abundance and community structure at a small window in time. Patterns seen in data from periodic surveys are a function of: actual patterns in the environment; coincidences in timing of the survey periods and actual cycle events; and measure of variability (including natural day-to-day variability). Plots of changes over time may not necessarily match the changes in real populations because changes over shorter time periods and actual minima and maxima may not be adequately sampled (*e.g.* Figure 1.4) Sources of environmental variation can operate at the scale of months (*e.g.* seasonal variation, harvesting), years (*e.g.* el Niño), decades (*e.g.* pollution, extreme storm events) or even centuries (*e.g.* tsunamis, global warming). Other studies indicate this monitoring program will begin to adequately reflect average trends and patterns as the surveys continue over longer periods (multiple years to decades). The results of this monitoring need to be interpreted within the context of the monitoring frequency and duration.

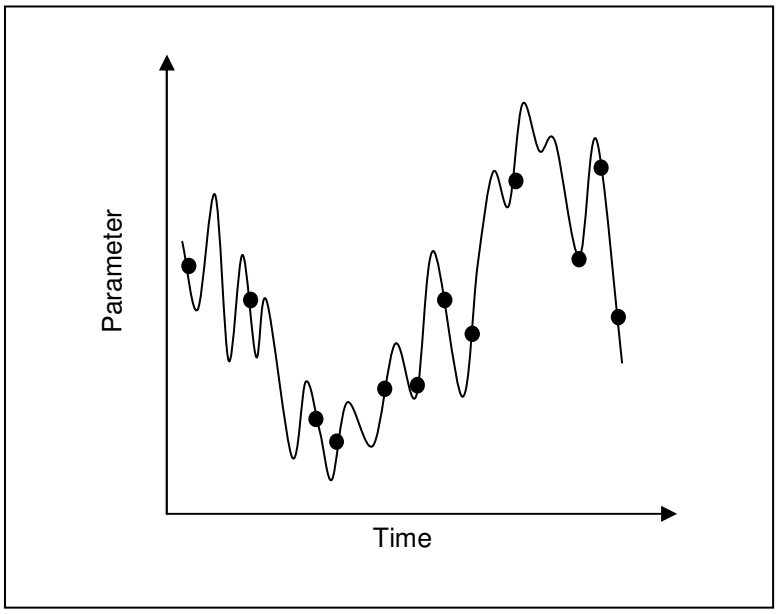


Figure 1.4. An example plot depicting change in an environmental, population or community variable over time (days, months or years) and potential patterns from isolated observations.

1.2.2 Monitoring Protocols and Locations

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

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

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

1.3 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 (ECC) 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 Bight 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 1.5).

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

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 Bight. 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).

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 as more protected areas inside Nepean Bay. This area provides habitat for some rare species of algae and molluscs.

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 10 m depth on the southern side).

1.4 Monitoring at Port Phillip Heads

This report describes the subtidal reef monitoring program in Port Phillip Heads and the results of the thirteen surveys, incorporating Port Phillip Heads Marine National Park. The objectives of this report were to:

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

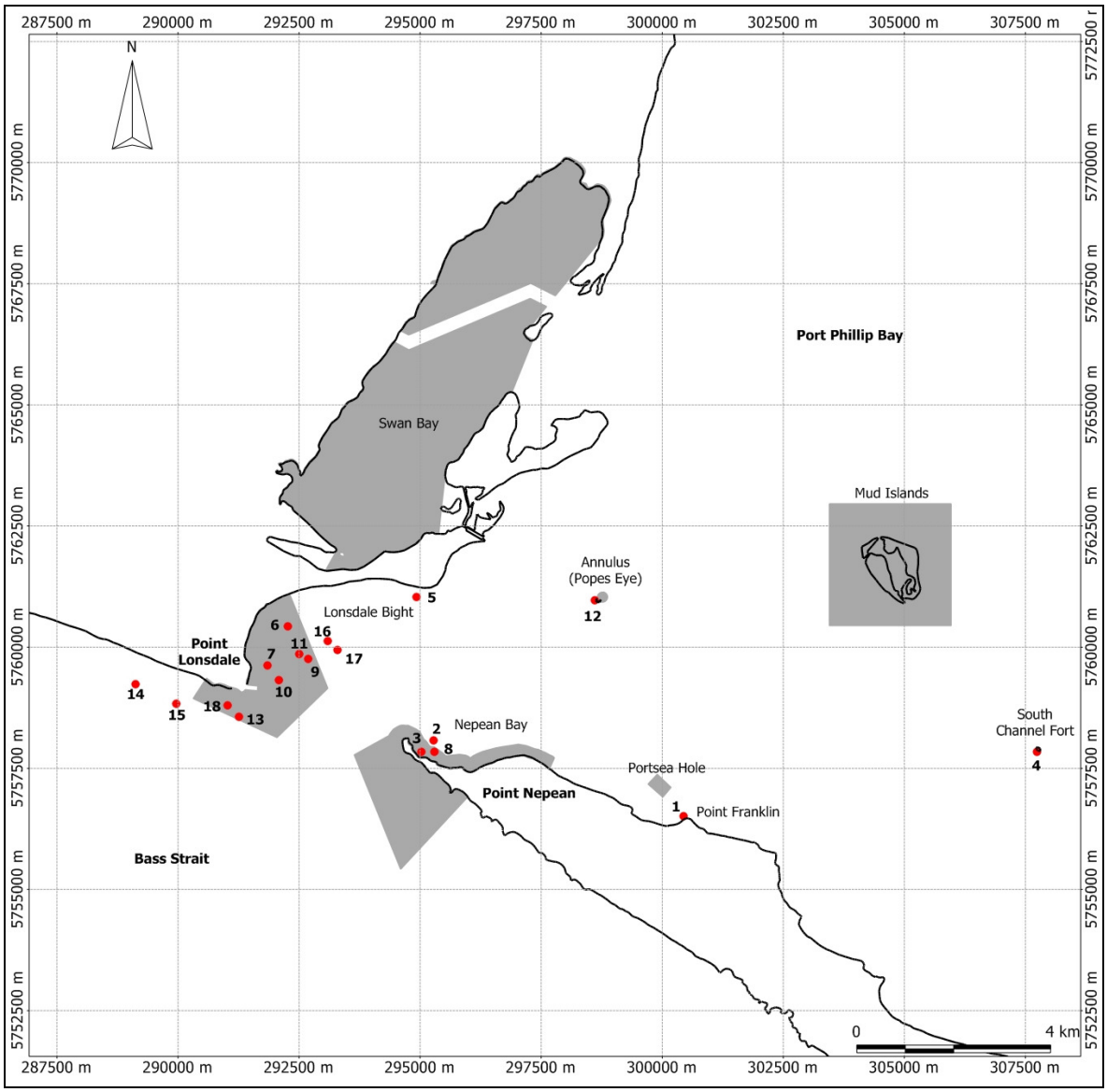


Figure 1.5. Port Phillip Heads Marine National Park (shaded areas) and the positions of long-term monitoring sites (red dots). Site numbers are also indicated.

2 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 1.5). 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 (ECC 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. An independent review of the Subtidal Reef Monitoring Program in 2005 recommended establishing three new sites to balance the number of sites surveyed inside and outside of the park (Boxshall *pers. comm.*). This rectified problems associated with the changes to the park boundaries since the monitoring program's inception. Monitoring is continuing at all but two of the original sites 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, at Popes Eye and South Channel Fort; the inside shore of Point Nepean, on the eastern side of the Heads; Lonsdale Bight 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 Bay and Lonsdale Bight, 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 Bight region (inside Point Lonsdale), there are small patches of reef outcrops in 5-8 m of water. Five sites were originally established in Lonsdale Bight (Sites 6, 7, 9, 10 and 11) and one site was established at Shortland Bluff (Site 5). Three sites were established on the open coast, south and to the west of Point Lonsdale (Site 13, 14 and 15).

During Survey 12 in autumn/winter 2006 three new sites were established: two in Lonsdale Bight, outside the Park (Sites 16 and 17) and one on the open coast of Point Lonsdale, inside the park (Site 18). Monitoring at two existing sites in Lonsdale Bight, inside the Park (Sites 7 and 9) was not considered essential and was discontinued during this survey.

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 thirteen surveys since the program began, with the latest in autumn/winter 2009 (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*. 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 pinnatifida* 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. The twelfth survey was in autumn/winter 2006 and thirteenth in autumn/winter 2009.

Table 2.1. Subtidal reef monitoring sites in Port Phillip Heads.

Region	No.	Description	Status	Depth (m)
Inside Heads	2812	Annulus (Popes Eye)	MPA	5
	2804	South Channel Fort	Reference	2
Point Nepean	2803	Nepean Inner West	MPA	2
	2808	Nepean Inner East	MPA	2
	2801	Point Franklin	Reference	2
	2802	Nepean Offshore	Reference	2
Lonsdale Bight	2806	Victory Shoal	MPA	5
	2807	Merlan Inner	MPA	5
	2810	Merlan Outer	MPA	5
	2809	Lonsdale Kelp Outer	MPA	7
	2811	Lonsdale Kelp Inner	MPA	7
	2805	Shortland Bluff	Reference	5
	2816	Kelp Bed Drift	Reference	5
	2817	Kelp Fields	Reference	8
Outside Heads	2813	Lonsdale Point	MPA	7
	2818	Lonsdale Surf Club	MPA	7
	2815	Lonsdale Pt SW	Reference	7
	2814	Lonsdale Back Beach	Reference	5

Table 2.2. Subtidal reef monitoring survey dates in Port Phillip Heads.

Survey	Date	Sites
1	May 1998	2801; 2802; 2803; 2804; 2805; 2806; 2807; 2808; 2809; 2810; 2811; 2812; 2813; 2814; 2815.
2	September - October 1998	2801; 2802; 2803; 2804; 2805; 2806; 2807; 2808; 2809; 2810; 2811; 2812; 2813; 2814; 2815.
3	May - July 1999	2801; 2802; 2803; 2804; 2805; 2806; 2807; 2808; 2809; 2810; 2811; 2812; 2813; 2814; 2815.
4	October - November 1999	2801; 2802; 2803; 2804; 2805; 2806; 2807; 2808; 2809; 2810; 2811; 2812; 2813; 2814; 2815.
5	May - August 2000	2801; 2802; 2803; 2804; 2805; 2806; 2807; 2808; 2809; 2810; 2811; 2812; 2813; 2814; 2815.
6	November 2000 - January 2001	2801; 2802; 2803; 2804; 2805; 2806; 2807; 2808; 2809; 2810; 2811; 2812; 2813; 2814; 2815.
7	June - July 2001	2801; 2802; 2803; 2804; 2805; 2806; 2807; 2808; 2809; 2810; 2811; 2812; 2813; 2814; 2815.
8	January 2002	2801; 2802; 2803; 2804; 2805; 2806; 2807; 2808; 2809; 2810; 2811; 2812; 2813; 2814; 2815.
9	January 2003	2801; 2802; 2803; 2804; 2805; 2806; 2807; 2808; 2809; 2810; 2811; 2812; 2813; 2814; 2815.
10	July 2004	2801; 2802; 2803; 2804; 2805; 2806; 2807; 2808; 2809; 2810; 2811; 2812; 2813; 2814; 2815.
11	December 2004	2801; 2802; 2803; 2804; 2805; 2806; 2807; 2808; 2809; 2810; 2811; 2812; 2813; 2814; 2815.
12	May - June 2006	2801; 2802; 2803; 2804; 2805; 2806; 2808; 2810; 2811; 2812; 2813; 2814; 2815; 2816; 2817; 2818.
13	May – June 2009	2801; 2802; 2803; 2804; 2805; 2806; 2808; 2810; 2811; 2812; 2813; 2814; 2815; 2816; 2817; 2818.

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

As most monitoring locations in Victoria, surveying along the 5 m depth contour is considered optimal because diving times are not limited by decompression schedules and these reefs are of interest to natural resource managers.

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

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

2.2.2 Method 1 – Mobile Fishes and Cephalopods

The densities of mobile large fishes and cephalopods are estimated by a diver swimming up one side of a 50 m section of the transect and then back along the other. The diver records the number and estimated size-class of fish within 5 m of each side of the line (Figure 2.1). The size-classes for fish are 25, 50, 75, 100, 125, 150, 200, 250, 300, 350, 375, 400, 500, 625, 750, 875 and 1000+ mm. Each diver has size-marks on their underwater slate to enable calibration of their size estimates. A total of four 10 x 50 m sections of the 200 m transect are censused for mobile fish at each site. The data for easily sexed species are recorded separately for males and female/juveniles. Such species include the blue-throated wrasse *Notolabrus tetricus*, herring cale *Odax cyanomelas*, barber perch *Caesioperca rasor*, rosy wrasse *Pseudolabrus rubicundus* and some leatherjackets.

2.2.3 Method 2 – Invertebrates and Cryptic Fishes

Cryptic fishes and mobile megafaunal invertebrates (*e.g.* large molluscs, echinoderms, crustaceans; Table 2.3) are counted along the same transect lines used for the fish survey. A diver counts animals within 1 m of one side of the line (a total of four 1 x 50 m sections of the 200 m transect). A known arm span of the diver is used to standardise the 1 m distance. The maximum length of abalone is measured *in situ* using vernier callipers whenever possible. Selected specimens are photographed or collected for identification and preservation in a reference collection.

2.2.4 Method 3 – Macroalgae

The area covered by macroalgal and sessile invertebrate species is quantified by placing a 0.25 m^2 quadrat at 10 m intervals along the transect line and determining the percent cover of the all plant species (Figure 2.2). The quadrat is divided into a grid of 7 x 7 perpendicular wires, giving 50 points (including one corner). Cover is estimated by counting the number of times each species occurs directly under the 50 positions on the quadrat (1.25 m^2 for each of the 50 m sections of the transect line). Selected specimens are photographed or collected for identification and preservation in a reference collection.

2.2.5 Method 4 – Macrocystis angustifolia

The quadrat-cover method is generally insensitive in detecting small changes in abundances of sparsely distributed individuals such as this *Macrocystis angustifolia*. Therefore, given the importance of this species, a new census technique was introduced to monitor its abundance in the spring 1999 survey at Popes Eye (Site 12) and is now used at all sites in the Subtidal Reef Monitoring Program.

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

Table 2.3. Mobile fish (Method 1) taxa censused at Port Phillip Heads.

Method 1	**Method 1**	**Method 1**	**Method 1**
Cephalopoda	Mobile Bony Fishes	Mobile Bony Fishes	Mobile Bony Fishes
Sepia apama	*Paraplesiops meleagris*	*Ophthalmolepis lineolata*	*Meuschenia galii*
Sepioteuthis australis	*Trachinops caudimaculatus*	*Dotalabrus aurantiacus*	*Meuschenia hippocrepis*
	Dinolestes lewini	*Eupetrichthys angustipes*	*Meuschenia venusta*
Sharks and Rays	*Sillaginodes punctata*	*Notolabrus tetricus*	*Meuschenia scaber*
Heterodontus portusjacksoni	*Pseudocaranx georgianus*	*Notolabrus fucicola*	*Eubalichthys bucephalus*
Parascyllium variolatum	*Arripis georgianus*	*Pseudolabrus rubicundus*	*Eubalichthys gunnii*
Cephaloscyllium laticeps	Arripis spp.	*Pictilabrus laticlavius*	*Eubalichthys mosaicus*
Trygonorrhina fasciata	*Upeneichthys vlaminghii*	*Odax acroptilus*	*Aracana aurita*
Trygonorrhina guaneria	*Pempheris multiradiata*	*Odax cyanomelas*	*Aracana ornata*
Dasyatis brevicaudata	*Girella tricuspidata*	*Siphonognathus attenuatus*	*Contusus brevicaudus*
Myliobatis australis	*Girella elevata*	*Siphonognathus beddomei*	*Tetractenos glaber*
Urolophus cruciatus	*Girella zebra*	*Siphonognathus radiatus*	*Diodon nichthemerus*
Urolophus paucimaculatus	*Scorpis aequipinnis*	*Neoodax balteatus*	Unidentified fish
Urolophus gigas	*Scorpis lineolata*	*Haletta semifasciata*	
Trygonoptera mucosa	*Atypichthys strigatus*	*Bovichtus angustifrons*	Mammals
	Tilodon sexfasciatus	*Parablennius tasmanianus*	*Arctocephalus pusillus*
Mobile Bony Fishes	*Enoplosus armatus*	*Plagiotremus tapeinosoma*	
Sardinops neopilchardus	*Pentaceropsis recurvirostris*	*Heteroclinus tristis*	
Engraulis australis	*Parma victoriae*	*Heteroclinus johnstoni*	
Aulopus purpurissatus	*Parma microlepis*	Unidentified heteroclinid	
Pseudophycis bachus	*Chromis hypsilepis*	*Seriolella brama*	
Hyporhamphus melanochir	*Aplodactylus arctidens*	*Acanthaluteres spilomelanurus*	
Trachichthys australis	*Cheilodactylus nigripes*	*Acanthaluteres vittiger*	
Phyllopteryx taeniolatus	*Cheilodactylus spectabilis*	*Brachaluteres jacksonianus*	
Neosebastes scorpaenoides	*Nemadactylus valenciennesi*	*Monacanthus chinensis*	
Platycephalus speculator	*Dactylophora nigricans*	*Scobinichthys granulatus*	
Caesioperca lepidoptera	*Latridopsis forsteri*	*Meuschenia australis*	
Caesioperca rasor	*Achoerodus gouldii*	*Meuschenia flavolineata*	
Hypoplectrodes nigrorubrum	*Coris sandageri*	*Meuschenia freycineti*	

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

Method 2	**Method 2**	**Method 2**
Cnidaria	Mollusca (continued)	Mollusca (continued)
Phlyctenactis tuberculosa	*Phasianotrochus eximius*	Unidentified nudibranch
	Phasianella australis	*Mytilus galloprovincialis*
Polychaeta (worms)	*Phasianella ventricosa*	*Chlamys asperimus*
Sabellastarte australiensis	*Turbo undulatus*	*Pecten fumatus*
Sabella spallanzani	*Astralium* sp.	
Unidentified platyhelminth	*Astralium aureum*	Cephalopoda (squids)
	Astralium squamiferum	*Octopus maorum*
Platyhelminthes	*Astralium tentoriformis*	*Sepia apama*
Unidentified platyhelminth	*Cypraea angustata*	
	Charonia lampas rubicunda	Echinodermata
Crustacea	*Cabestana tabulata*	*Comanthus trichoptera*
Jasus edwardsii	Cabestana spengleri	*Comanthus tasmaniae*
Paguristes frontalis	*Cymatium parthenopeum*	*Tosia australis*
Strigopagurus strigimanus	*Ranella australasia*	*Tosia magnifica*
Diogenid (purple leg)	*Sassia subdistorta*	*Pentagonaster dubeni*
Pagurid (grey)	*Dicathais orbita*	*Nectria ocellata*
Pagurid unidentified	*Agnewia tritoniformis*	*Nectria macrobranchia*
Nectocarcinus integrifrons	*Pterynotus triformis*	*Nectria* multispina
Nectocarcinus tuberculatus	*Pleuroploca australasia*	*Petricia vernicina*
Plagusia chabrus	*Penion mandarinus*	*Fromia polypora*
Petrocheles australiensis	*Penion maxima*	*Plectaster decanus*
	Conus anemone	*Echinaster arcystatus*
Mollusca	*Mitra glabra*	*Pseudonepanthia troughtoni*
Metacarcinus novaezelandiae	*Aplysia* sp.	*Meridiastra gunnii*
Unidentified chiton	*Aplysia dactylomela*	*Coscinasterias muricata*
Haliotis rubra	*Sagaminopteron ornatum*	*Uniophora granifera*
Haliotis laevigata	*Tambja verconis*	*Goniocidaris tubaria*
Haliotis scalaris	*Neodoris chrysoderma*	*Amblypneustes ovum*
Scutus antipodes	*Ceratosoma brevicaudatum*	*Amblypneustes* spp.
Calliostoma armillata	*Chromodoris tasmaniensis*	*Holopneustes porosissimus*

Table 2.4 (continued)

Method 2	**Method 2**	**Method 2**
Echinodermata	Cryptic Fish	Cryptic Fish
Holopneustes inflatus	*Parascyllium variolatum*	*Scorpis aequipinnis*
Holopneustes purpurascens	*Cephaloscyllium laticeps*	*Tilodon sexfasciatus*
Heliocidaris erythrogramma	*Orectolobus halei*	*Parma victoriae*
Stichopus mollis	*Trygonorrhina fasciata*	*Cheilodactylus nigripes*
	Dasyatis brevicaudata	*Notolabrus tetricus*
Ascidiacea	*Urolophus paucimaculatus*	*Notolabrus fucicola*
Cnemidocarpa radicosa	*Urolophus gigas*	*Pictilabrus laticlavius*
Herdmania momus	*Trygonoptera testacea*	*Neoodax balteatus*
	Paratrachichthys sp.	*Bovichtus angustifrons*
	Unidentified Pipefish	*Parablennius tasmanianus*
	Phyllopteryx taeniolatus	*Heteroclinus perspicillatus*
	Scorpaena papillosa	*Heteroclinus tristis*
	Glyptauchen panduratus	*Heteroclinus johnstoni*
	Neosebastes scorpaenoides	Unidentified heteroclinid
	Aetapcus maculatus	*Scobinichthys granulatus*
	Gnathanacanthus goetzii	*Meuschenia freycineti*
	Platycephalus bassensis	*Aracana aurita*
	Paraplesiops meleagris	*Aracana ornata*
	Upeneichthys vlaminghii	*Diodon nichthemerus*
	Pempheris multiradiata	Unidentified fish
	Pempheris compressa	

Table 2.5. Macroalgae (method 3) taxa censused at Port Phillip Heads.

Method 3	**Method 3**	**Method 3**	**Method 3**
Phaeophyta (brown algae)	Phaeophyta (brown algae)	Phaeophyta (brown algae)	Rhodophya (red algae)
Halopteris spp.	*Ecklonia radiata*	*Sargassum linearifolium*	*Gelidium asperum*
Cladostephus spongiosus	*Macrocystis angustifolia*	*Sargassum spinuligerum*	*Gelidium australe*
Dictyota (fine)	*Durvillaea potatorum*	*Sargassum* spp.	Gelidium spp.
Dictyota dichotoma	*Xiphophora chondrophylla*	Filamentous browns	*Pterocladia lucida*
Dilophus marginatus	*Phyllospora comosa*	Brown algae unidentified	*Pterocladia capillacea*
Dilophus fastigiatus	*Seirococcus axillaris*	*Halophila ovalis*	*Pterocladiella capillacea*
Dilophus gunnianus	*Caulocystis cephalornithos*	*Halophila australis*	*Asparagopsis armata*
Pachydictyon paniculatum	*Acrocarpia paniculata*	*Amphibolis antarctica*	*Delisea hypneoides*
Pachydictyon spp.	*Cystophora platylobium*	*Heterozostera nigricaulis*	*Delisea pulchra*
Lobospira bicuspidata	*Cystophora moniliformis*		*Delisea* spp.
Dictyopteris acrostichoides	*Cystophora grevillei*		*Ptilonia australasica*
Dictyopteris muelleri	*Cystophora xiphocarpa*		*Asparagopsis* spp.
Chlanidophora microphylla	*Cystophora pectinata*		*Amphiroa anceps*
Distromium spp.	*Cystophora monilifera*		*Corallina officinalis*
Homeostrichus sinclairii	*Cystophora expansa*		*Arthrocardia wardii*
Homeostrichus olsenii	*Cystophora brownii*		*Haliptilon roseum*
Zonaria angustata	*Cystophora retorta*		*Cheilosporum sagittatum*
Zonaria crenata	*Cystophora siliquosa*		*Metagoniolithon radiatum*
Zonaria spiralis	*Cystophora retroflexa*		*Geniculate coralines*
Zonaria turneriana	*Cystophora subfarcinata*		Encrusting corallines
Zonaria spp.	Cystophora spp.		Corallines unidentified
Lobophora variegata	*Carpoglossum confluens*		Erect corallines
Scytosiphon lomentaria	*Sargassum heteromorphum*		*Solieria robusta*
Colpomenia sinuosa	*Sargassum decipiens*		*Rhodoglossum gigartinoides*
Colpomenia peregrina	*Sargassum sonderi*		*Gigartina sonderi*
Carpomitra costata	*Sargassum varians*		*Gigartina crassicaulis*
Sporochnus sp.	*Sargassum verruculosum*		*Gigartina* sp.

Table 2.5 (continued)

Method 3	Method 3	Method 3	Method 3
Rhodophya (red algae)	Rhodophya (red algae)	Rhodophya (red algae)	Chlorophyta (green algae)
Callophyllis rangiferina	*Plocamium mertensii*	*Jeannerettia pedicellata*	*Ulva* spp.
Nizymenia australis	*Plocamium dilatatum*	*Lenormandia marginata*	*Chaetomorpha* sp.
Sonderopelta coriacea	*Plocamium preissianum*	*Lenormandia muelleri*	*Abjohnia laetevirens*
Peyssonelia novaehollandiae	*Plocamium cartilagineum*	*Lenormandia smithiae*	*Cladophora rhizoclonioidea*
Sonderopelta/Peyssonelia	*Plocamium leptophyllum*	*Laurencia clavata*	*Cladophora prolifera*
Phacelocarpus alatus	*Champia viridis*	*Laurencia elata*	*Cladophora* spp.
Phacelocarpus complanatus	*Champia zostericola*	*Laurencia filiformis*	*Dictyosphaeria serica*
Phacelocarpus peperocarpos	Champia sp.	Laurencia spp.	*Bryopsis gemellipara*
Dasyphloea insignis	*Botryocladia sonderi*	Echinothamnion sp.	*Caulerpa remotifolia*
Stenogramme interrupta	*Botryocladia obovata*	*Echinothamnion hystrix*	*Caulerpa scalpelliformis*
Callophycus laxus	*Gloiosaccion brownii*	Dasya sp.	*Caulerpa longifolia*
Callophycus spp.	*Erythrymenia minuta*	*Heterosiphonia gunniana*	*Caulerpa trifaria*
Erythroclonium muelleri	*Hymenocladia chondricola*	*Thuretia quercifolia*	*Caulerpa brownii*
Erythroclonium sonderi	*Rhodymenia leptophylla*	*Chondria viridis*	*Caulerpa cf browni (v. fine ramuli)*
Erythroclonium spp.	*Rhodymenia australis*	Filamentous red algae	*Caulerpa obscura*
Areschougia congesta	*Rhodymenia obtusa*	Other thallose red algae	*Caulerpa flexilis*
Areschougia spp.	*Rhodymenia prolificans*	*Hymenena curdieana*	*Caulerpa flexilis var. muelleri*
Acrotylus australis	Rhodymenia spp.		*Caulerpa geminata*
Gracilaria secundata	*Cordylecladia furcellata*		*Caulerpa annulata*
Gracilara cliftoni	Ceramium spp.		*Caulerpa cactoides*
Curdiea angustata	*Griffithsia teges*		*Caulerpa vesiculifera*
Melanthalia obtusata	*Griffithsia monilis*		*Caulerpa simpliciuscula*
Melanthalia abscissa	*Ballia callitricha*		*Codium lucasi*
Melanthalia concinna	*Ballia scoparia*		*Codium spongiosum*
Polyopes constrictus	*Euptilota articulata*		*Codium pomoides*
Halymenia plana	*Martensia australis*		*Codium galeatum*
Grateloupia filicina	*Wrangelia nobilis*		*Codium duthieae*
Thamnoclonium dichotomum	*Hemineura frondosa*		*Codium harveyi*
Plocamium angustum	*Dictymenia harveyana*		*Codium* spp.
Plocamium costatum	*Dictymenia tridens*		*Chlorodesmis baculifera*
Plocamium patagiatum	*Jeannerettia lobata*		

Figure 2.1. Biologist-diver with transect line.

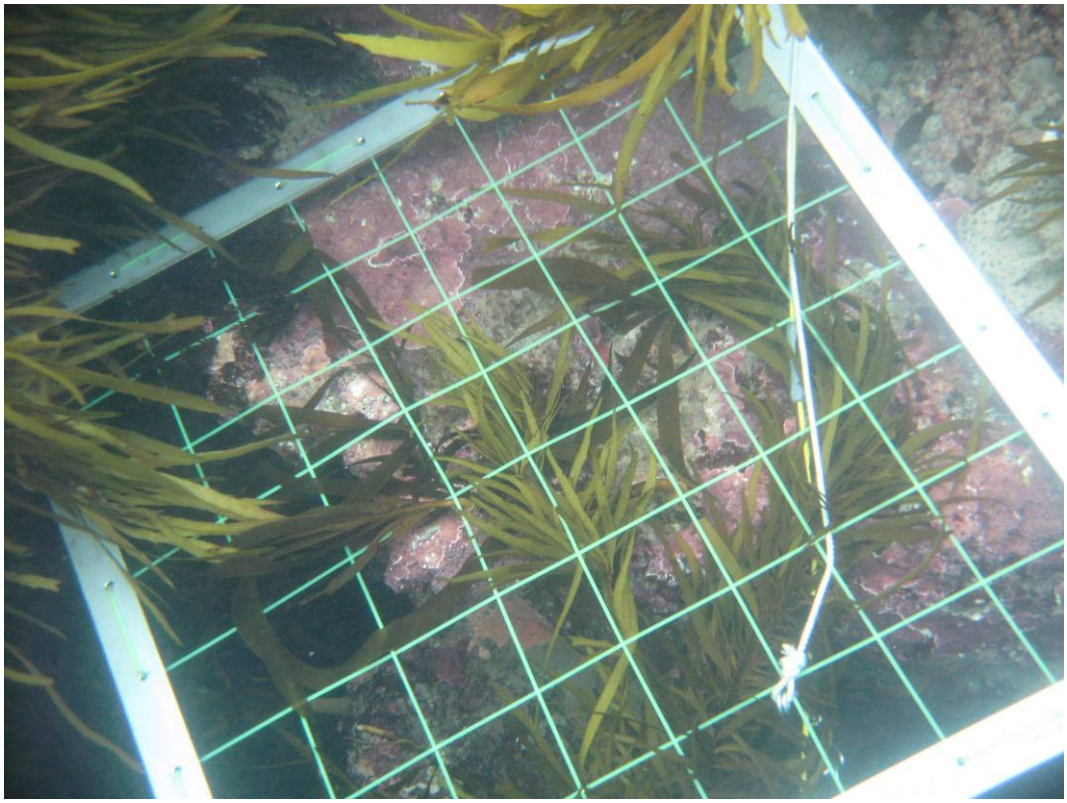


Figure 2.2. The cover of macrophytes is measured by the number of points intersecting each species on the quadrat grid.

2.3 Data Analysis

2.3.1 Community Structure

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

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

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

2.3.2 Depiction of Community Differences

The hyper-dimensional information in the dissimilarity matrix was simplified and depicted using non-metric multidimensional scaling (MDS; Clarke 1993). This ordination method finds the representation in fewer dimensions that best depicts the actual patterns in the hyper-dimensional data (reduces the number of dimensions while depicting the salient relationships between the samples). The MDS results were then depicted graphically to show differences between the replicates at each location. The distance between points on the MDS plot is representative of the relative difference in community structure.

Kruskall stress is an indicator statistic calculated during the ordination process and indicates the degree of disparity between the reduced dimensional data set and the original hyper-dimensional data set. A guide to interpreting the 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. Where high stress was encountered with a two-dimensional data set, three-dimensional solutions were sought to ensure an adequate representation of the higher-dimensional patterns.

2.3.3 Species Diversity

Species diversity involves the consideration of two components: species richness and heterogeneity. Species richness is the number of species present in the community while heterogeneity related to the distribution of abundances between species. Species diversity is a combination of species richness and the relative abundance of each species, and is often referred to as species heterogeneity. Measures of diversity give an indication of the likelihood that two individuals selected at random from a community are different species.

Species richness (S) was enumerated by the total species count per site. This value was used for calculation of evenness and heterogeneity statistics. Species diversity (*i.e.* heterogeneity among species) was described using the reciprocal of Simpson's index ($1/D_{Simpson}$ = Hill's N_2). This value describes species diversity as a combination of species richness (*i.e.* the number of species) and species evenness (*i.e.* the equitability of the abundances of the species). The value varies between 1 and s (*i.e.* the total number of species in the sample) with higher values indicating higher diversity. In general, Hills N_2 gives

an indication of the number of dominant species within a community. Hills N_2 provides more weighting for common species, in contrast to indices such as the Shannon-Weiner Index (Krebs 1999), which weights the rarer species. The weighting of common species was considered more appropriate for this study because the sampling regime is designed to target the more common species.

2.3.4 Species Populations

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

3 REGIONAL COMMUNITY ANALYSIS

3.1 Macroalgae

The algal community structures were compared between the thirteen times for the core sites 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).

Four general groups of macroalgal assemblages were observed corresponding with four site groupings: well inside the Heads; Nepean Bay; Lonsdale Bight; and outside the Heads. These groupings corresponded with differences in wave exposure and depth between sites. The relatively sheltered sites inside the Heads and the exposed sites outside the Heads had the most different macroalgal communities, with intermediate assemblages at Lonsdale Bight and Point Nepean (Figure 3.1). There was less temporal and spatial variation in community structure at sites outside the Heads and greater variation between sites at Lonsdale Bight compared to Point Nepean.

The most sheltered sites, at Popes Eye (Site 12) and South Channel Fort (Site 4), were dominated by the kelp *Ecklonia radiata* and had a high predominance of the green algae *Cladophora prolifera* and *Caulerpa* species. Red algal species were generally absent at South Channel Fort (Site 4), possibly because of high silt loading. A moderate abundance of red algal species were present at Popes Eye. *Macrocystis angustifolia* has previously formed small stands at Popes Eye, though it was not recorded in 2006 and only at very low abundance during the most recent survey. *Caulocystis cephalornithos* and *Sargassum* species were prevalent at South Channel Fort.

The Nepean Bay sites (Sites 2, 3 and 8) and Point Franklin (Site 1) were reasonably shallow (2-4 m) and moderately exposed. Nepean Bay sites were dominated by patches of mixed brown algal species and monospecific stands of the seagrass *Amphibolis antarctica*. The brown algae generally included *Ecklonia radiata*, *Phyllospora comosa*, *Cystophora moniliformis*, *Cystophora monilifera* and *Cystophora retorta*. Point Franklin was more similar to sites inside the Heads than those in Nepean Bay, possibly because of the more sheltered nature of the site. *Phyllospora comosa* was not present at Point Franklin, and common algae included *Caulerpa* spp., *Codium duthieae* and *Sargassum* spp. *M. angustifolia* has historically been present at Nepean Outer (Site 2), but was not recorded in 2006 and only at very low abundance during the most recent survey.

The Lonsdale Bight sites (Sites 5, 6, 7, 9, 10, 11, 16 and 17) were deeper than Nepean Bay (4-8 m) but had a similar, moderate level of exposure. The predominant cover at Victory Shoal (Site 6) and Shortland Bluff (Site 5) was by *Ecklonia radiata*. Other predominant species included *Cladophora prolifera*, *Seirococcus axillaris*, *Phyllospora comosa* and *Cystophora moniliformis*. *Amphibolis antarctica* formed substantial patches at Lonsdale kelp inner (Site 11) and Shortland Bluff (Site 5). The algal assemblages at the more southern sites in Lonsdale Bight (Sites 7, 9, 10 and 11) had a higher dominance of *Phyllospora*, with *Ecklonia* also contributing a considerable portion of the canopy. Conversely, the eastern Lonsdale Bight sites (Sites 16 and 17) had greater cover of *E. radiata* and a very low cover of *P. comosa*. A relatively low cover of red algal species was present as an understorey at both the southern and eastern Lonsdale Bight sites. Understorey species included *Ballia callitricha*, *Areschougia congesta*, *Phacelocarpus peperocarpus* and *Plocamium* spp.

The four sub-maximally exposed sites outside the Heads (Sites 13, 14, 15 and 18) had a transition from a relatively high cover of *Ecklonia radiata* in the west (Site 14), to a *P. comosa* dominated canopy to the east (Sites 13 and 18). *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, 15 and 18 may be

attributable to the lower profile reef at Site 14, which was prone to covering and scour by sand (the wave surge characteristics may also be different). A small patch of *Amphibolis antarctica* was present on the western end of Site 18. All four outer sites had a high cover of understorey species, such as *Haliptilon roseum*, *Phacelocarpus peperocarpus*, *Pterocladia lucida*, *Ballia callitricha* and *Areschougia congesta*.

The macroalgal species richness at each site generally ranged between 20-50 species per site per survey. The mean algal species richness of sites within the Marine National Park at Port Phillip Heads increased between 1998 and 2002, and has remained relatively stable since. The mean species richness of reference sites at Port Phillip Heads has been relatively stable since monitoring began (Figure 3.6). There have been general increasing trends at some individual sites, including Point Franklin (Site 1) and three sites outside the heads (Sites 13, 14 and 15). No obvious trends were apparent at any of the other sites.

Macroalgal diversity generally ranged between 2 and 16 at each site. There were no overall trends in the mean diversity of either marine protected area sites or reference sites or reference sites (Figure 3.7). There was more variability in diversity at reference sites, particularly Shortland Bluff (Site 5) and Lonsdale Back Beach (Site 14). Lonsdale Back Beach had by far the highest diversity, increasing from 12 in 1998 to 24 in 2009. There have also been recent increasing trends in macroalgal diversity at Point Franklin (Site 1) and Victory Shoal (Site 6).

Species richness increased at Popes Eye (Site 12) between 1998 and 2005, but has subsequently declined slightly, while species richness at the reference site South Channel Fort (Site 4; Figure 3.6) has been relatively stable. In contrast, species diversity was low and stable at Popes Eyes, while there was an increasing trend between 1999 and 2005 at South Channel Fort before a slight decline (Figure 3.7).

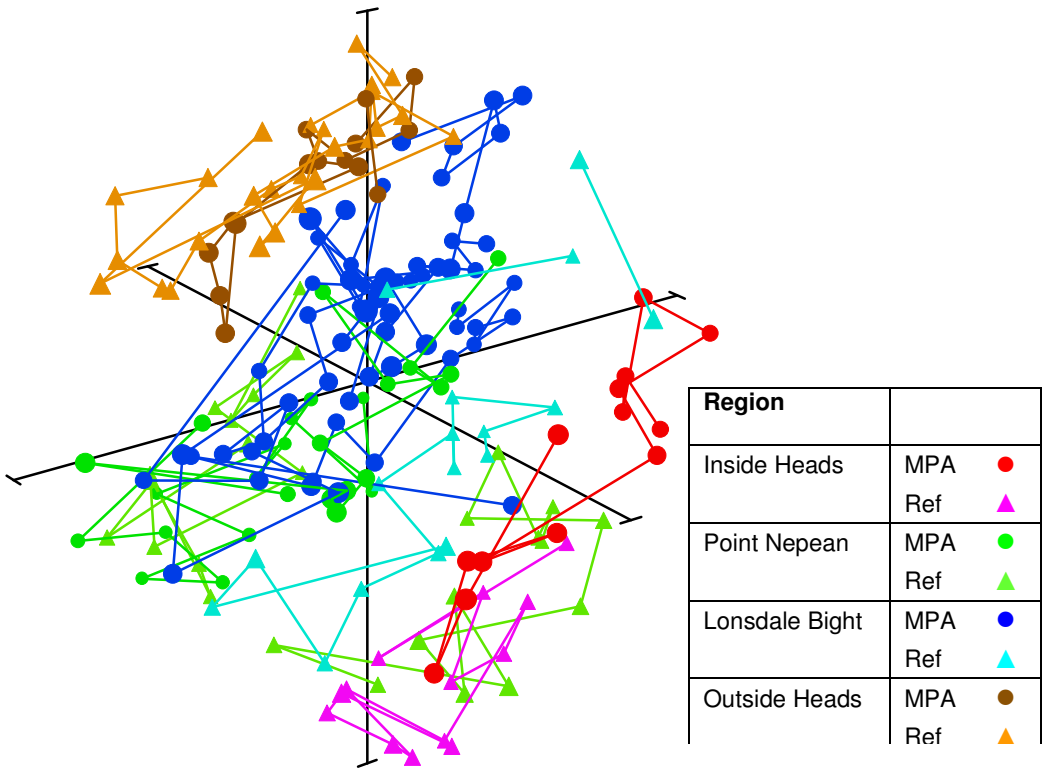


Figure 3.1. Three-dimensional MDS plot of algal assemblage structure for all Port Phillip Heads sites. Kruskal Stress value = 0.16.

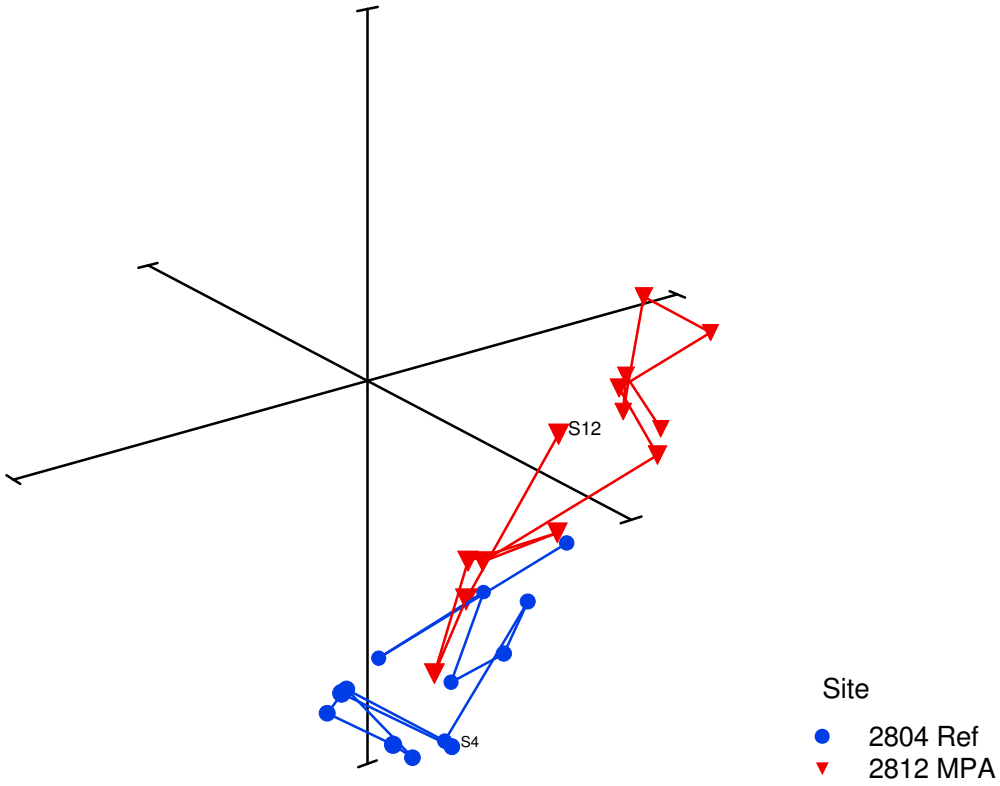


Figure 3.2. Three-dimensional MDS plot of algal assemblage structure at inner Heads sites. Kruskal Stress value = 0.16.

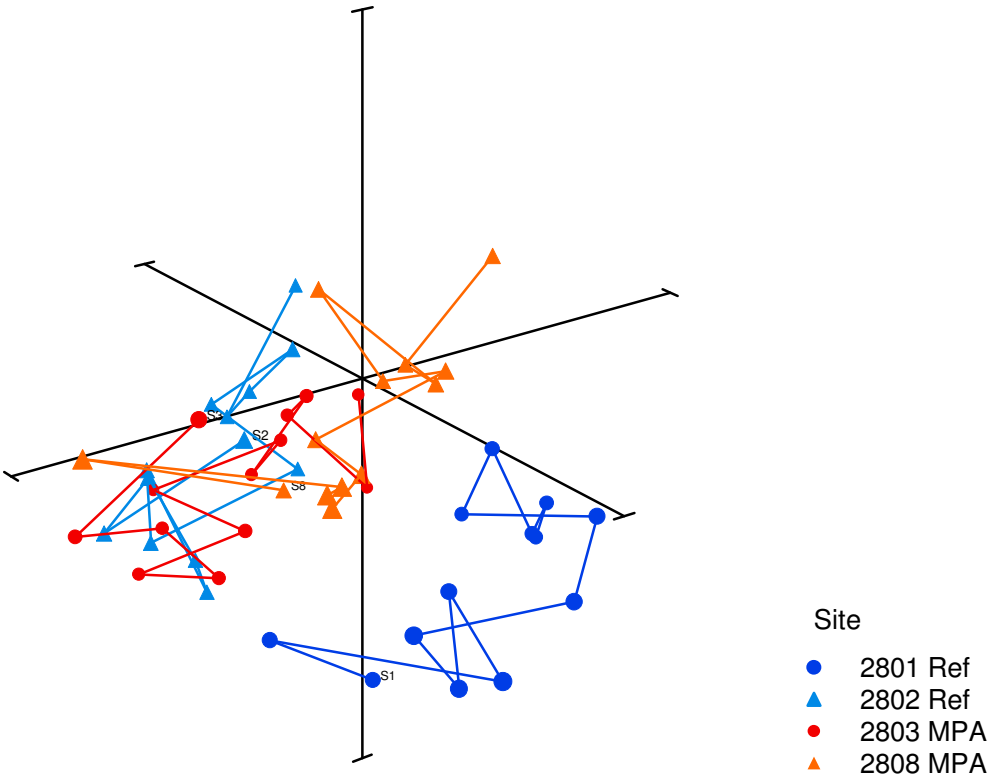


Figure 3.3. Three-dimensional MDS plot of algal assemblage structure at Nepean Bay sites. Kruskal Stress value = 0.16.

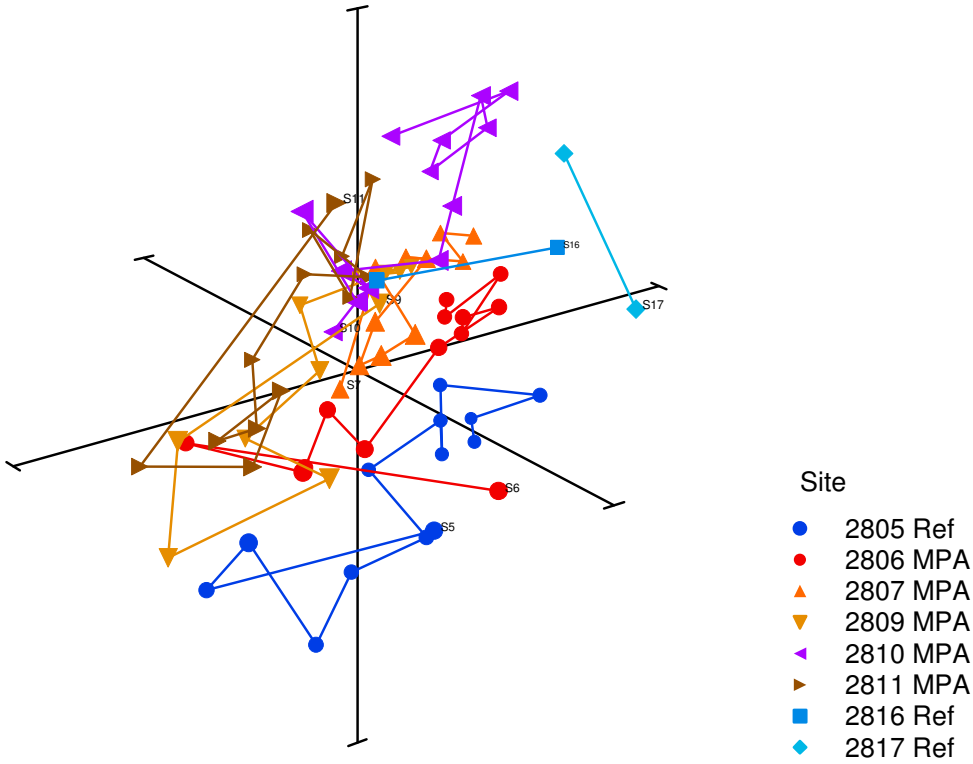


Figure 3.4. Three-dimensional MDS plot of algal assemblage structure at Lonsdale Bight sites. Kruskal Stress value = 0.16.

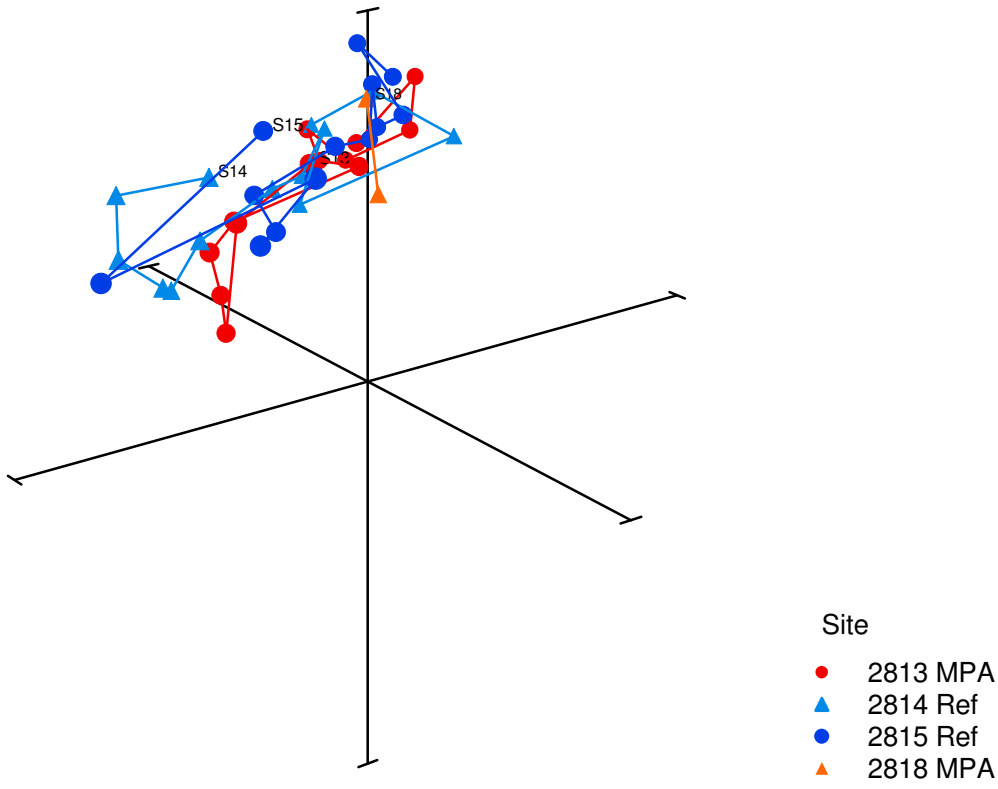
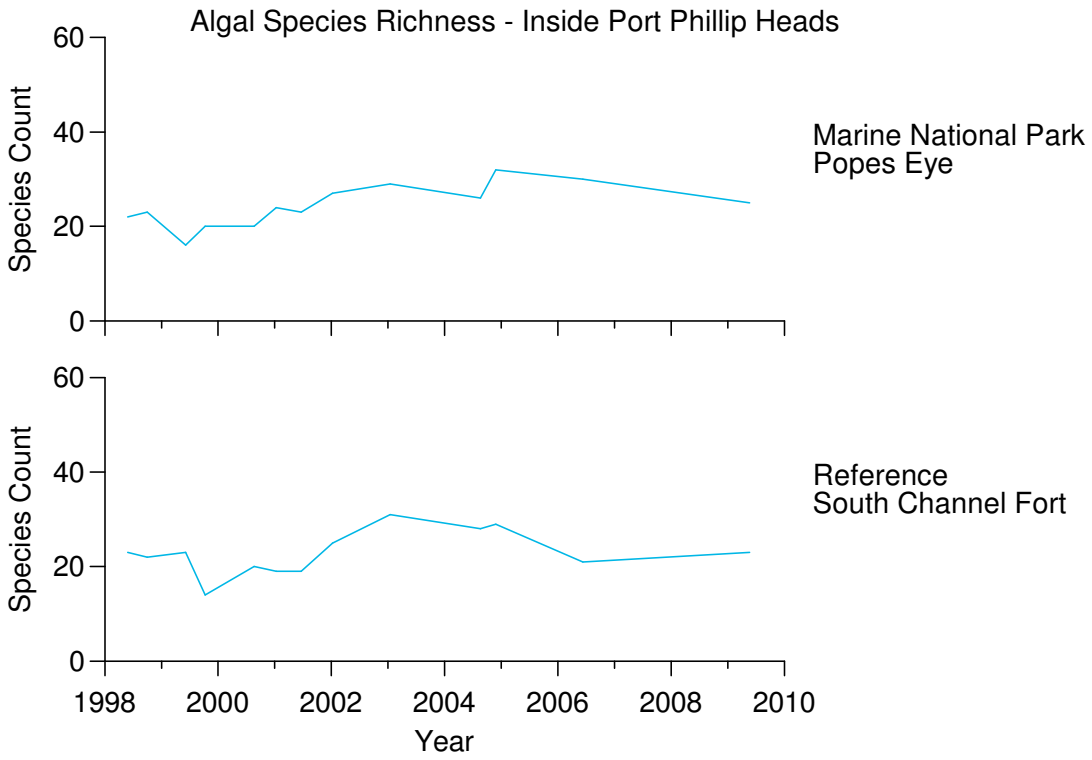


Figure 3.5. Three-dimensional MDS plot of algal assemblage structure at sites outside Port Phillip Heads. Kruskal Stress value = 0.16.

a.



b.

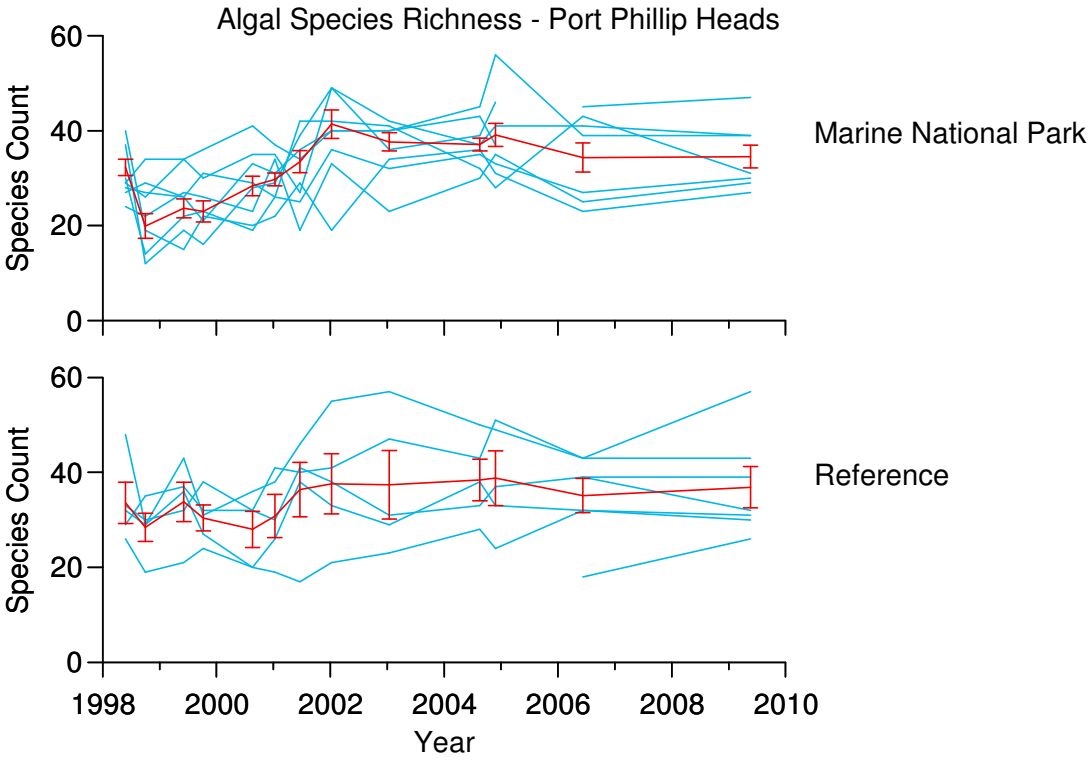
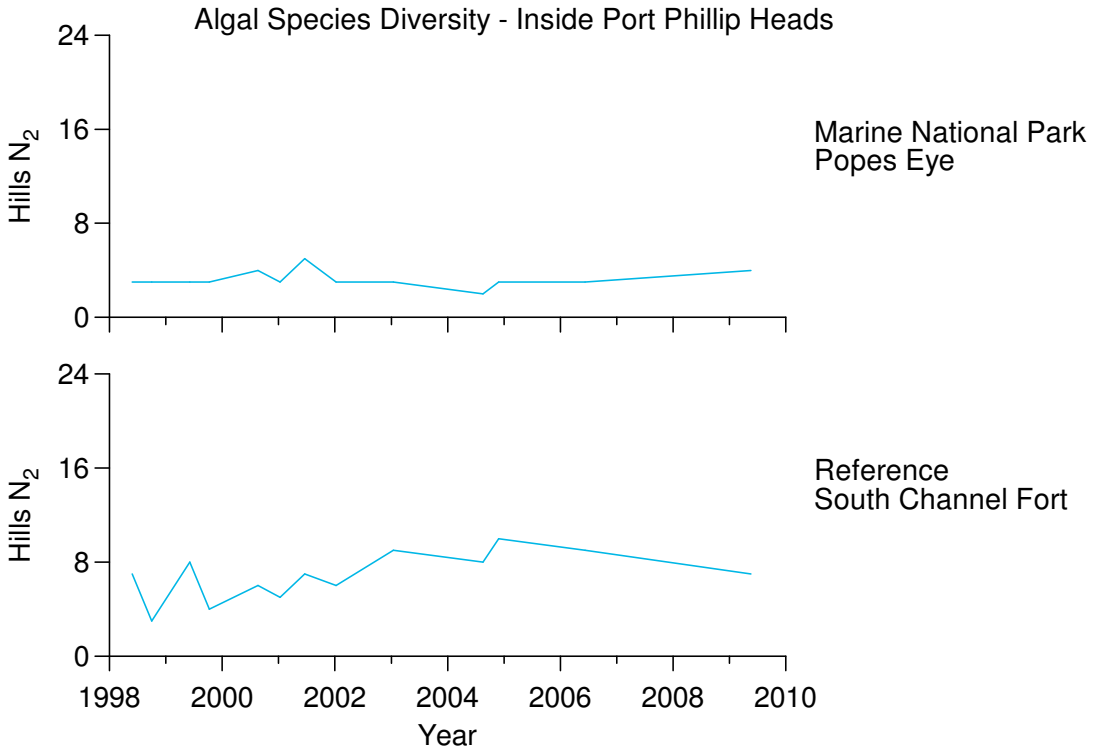


Figure 3.6. Trends in species richness of macrophytes at: (a) Popes Eye and South Channel Fort; and (b) Port Phillip Heads.

a.



b.

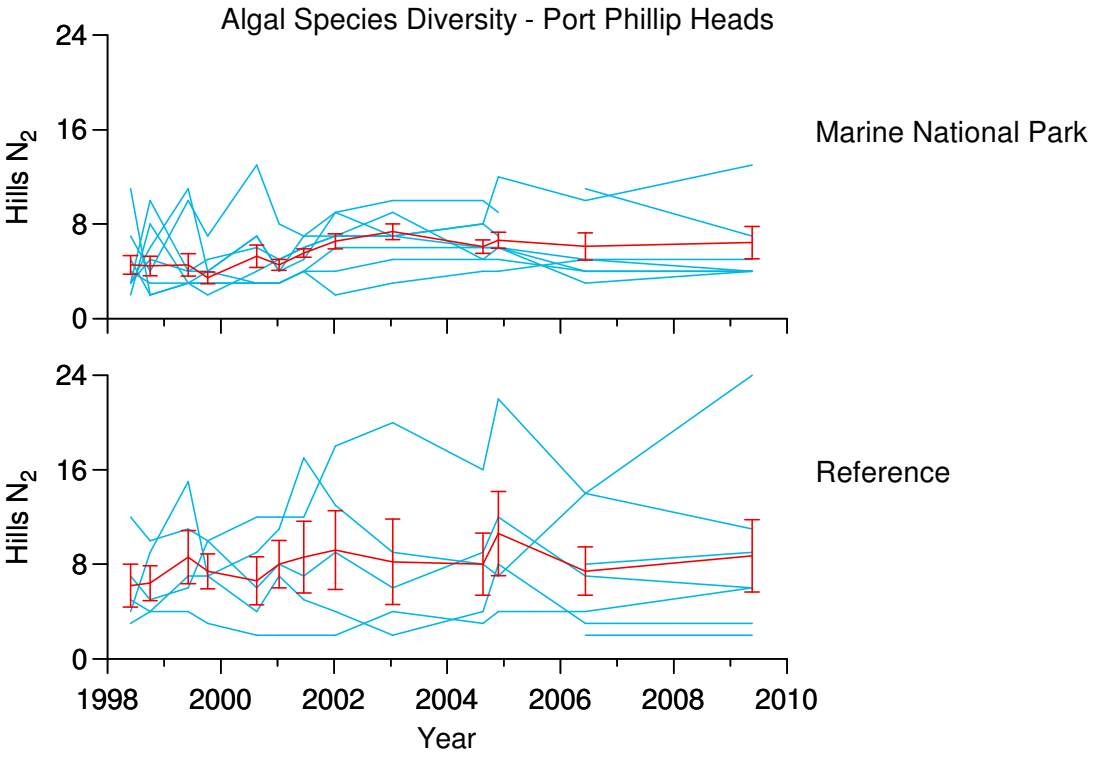


Figure 3.7. Trends in species diversity of macrophytes at: (a) Popes Eye and South Channel Fort; and (b) Port Phillip Heads.

3.2 Invertebrates

As observed with macroalgae assemblages, there were four general groups of invertebrate assemblages, corresponding to the four site groupings: well inside the Heads; Nepean Bay; Lonsdale Bight; and outside the Heads (Figure 3.8).

There was the greatest difference between the invertebrate assemblages of sites inside the heads and sites outside the Heads and these regions were the most distinct through time, reflecting their greater geographic separation from other sites.

In many cases, the variation between times was generally more than the variation between sites. Invertebrate assemblages in Lonsdale Bight and Nepean Bay were generally highly variable between surveys, with the exceptions of Nepean Inner West (Site 8) and Merlan Outer (Site 10). The largest variations were observed at Sites 2 and 3 in Nepean Bay (Figure 3.10) and Site 9 in Lonsdale Bight (Figure 3.11). There was less spatial and temporal variation in invertebrate assemblages at sites outside the heads and well inside the Heads (Figures 3.9 to 3.12).

As with macroalgae, the invertebrate assemblage at Point Franklin (Site 1) was more similar to sites inside the Heads than it was to Nepean Bay sites. These sites were characterised by low abundances of abalone species *Haliotis rubra and H. laevigata*, and moderate to high abundances of the urchin *Heliocidaris erythrogramma*. South Channel Fort and Popes Eye differed from Point Franklin in having high abundances of the featherstar *Comanthus trichoptera*.

The Nepean Bay sites were characterised by having moderate 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 *Comanthus trichoptera*.

Shortland Bluff (Site 5) distinct from other Lonsdale Bight sites by having a high abundances of the seastar *Patiriella brevispina* and *Heliocidaris erythrogramma*. *Comanthus trichoptera* and *Haliotis* species, including the small *H. scalaris*, were in moderate abundances, however the gastropods *Turbo undulatus* and *Dicathais orbita* were usually absent.

The remaining sites in Lonsdale Bight and outside the heads were characterised by having moderate to high abundances of *Haliotis rubra* and low abundances of *Heliocidaris erythrogramma* and *Comanthus 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.

Invertebrate species richness was in the range of 5-15 species for most sites (Figure 3.13). Species richness was highly variable, making it difficult to identify any trends. There were increasing trends apparent at Shortland Bluff (Site 5) and Victory Shoal (Site 6) and a potentially a decreasing trend at Nepean Inner West (Site 3). No notable trends in species richness were apparent at any other site (Figure 3.13).

Invertebrate species diversity was relatively stable through time at most sites. Diversity increased at both Popes Eye and South Channel Fort between 2006 and 2009 surveys. There were no other apparent trend in invertebrate diversity (Figure 3.14).

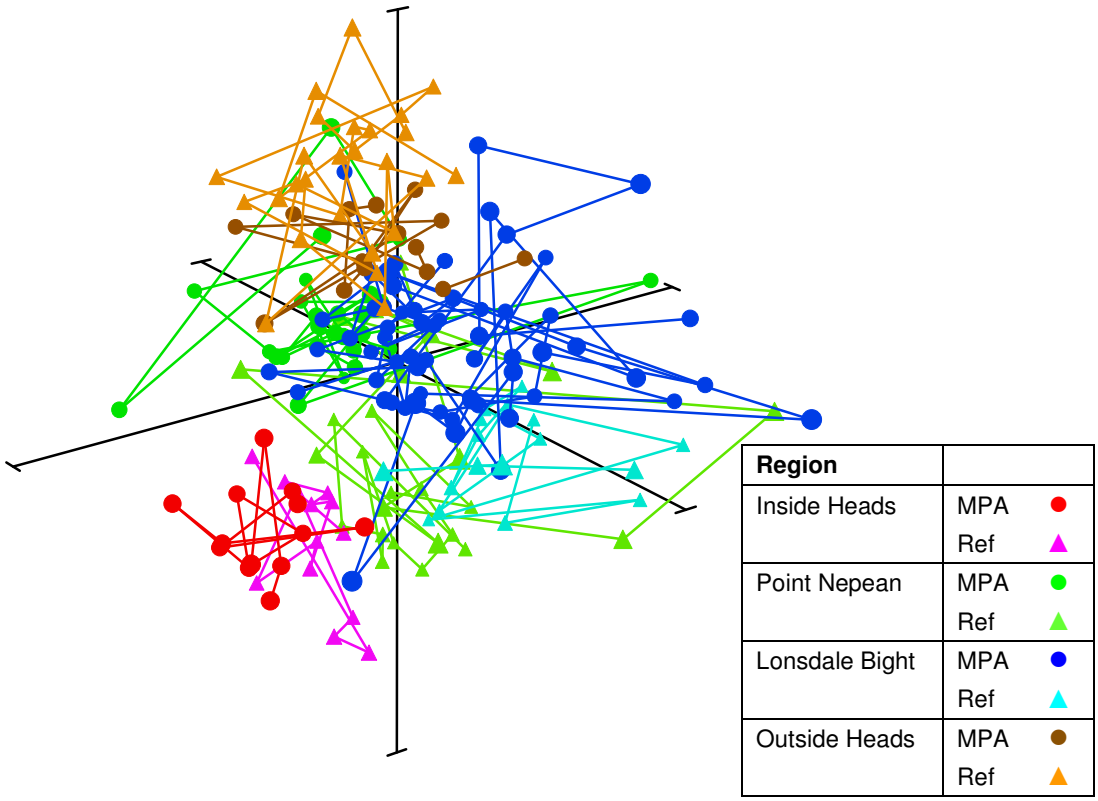


Figure 3.8. Three-dimensional MDS plot of invertebrate assemblage structure for all Port Phillip Heads sites. Kruskal Stress value = 0.17.

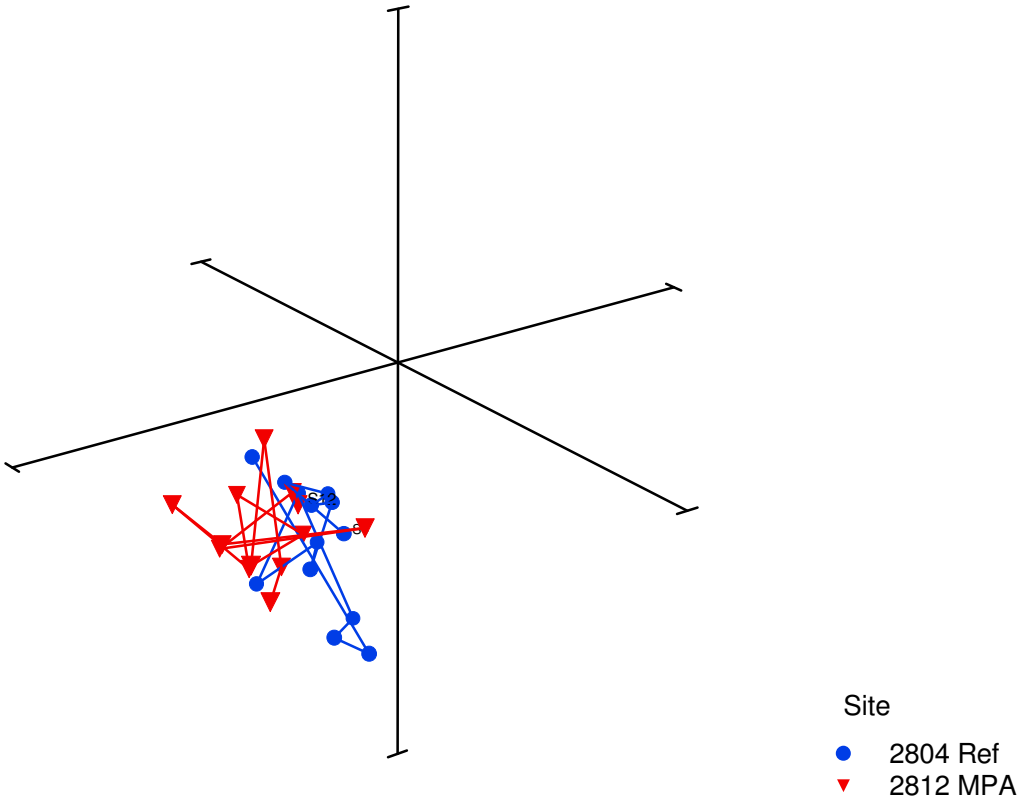


Figure 3.9. Three-dimensional MDS plot of invertebrate assemblage structure for inner Heads region. Kruskal Stress value = 0.17.

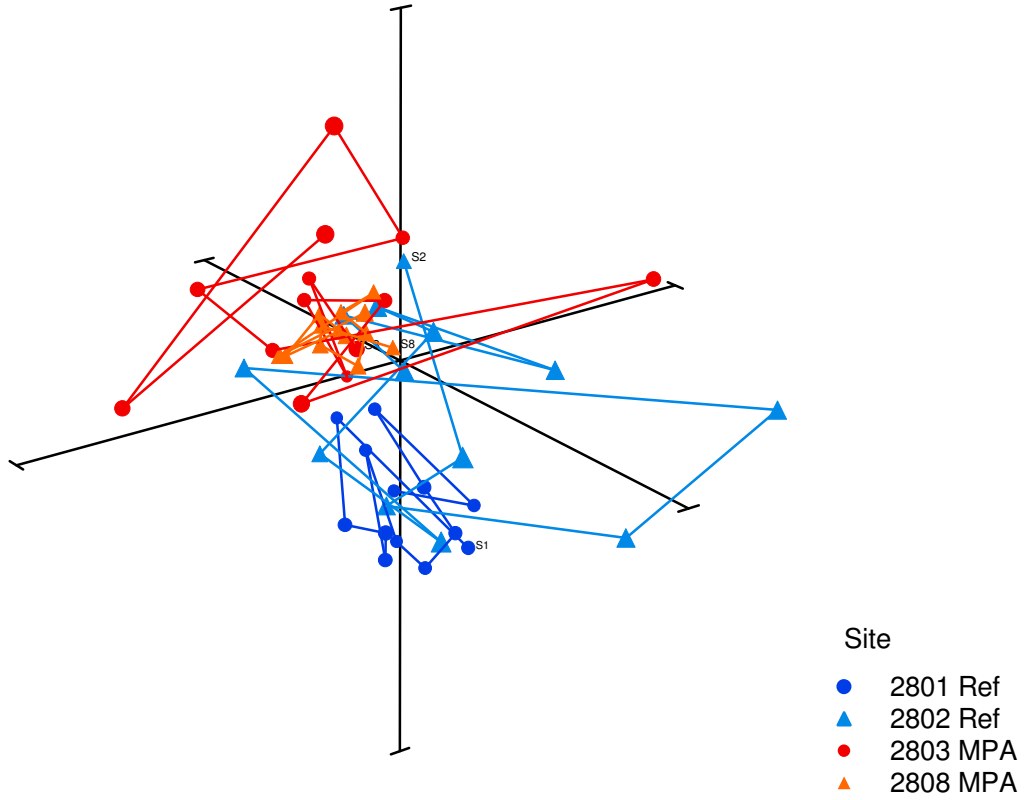


Figure 3.10. Three-dimensional MDS plot of invertebrate assemblage structure at Point Nepean sites. Kruskal Stress value = 0.17.

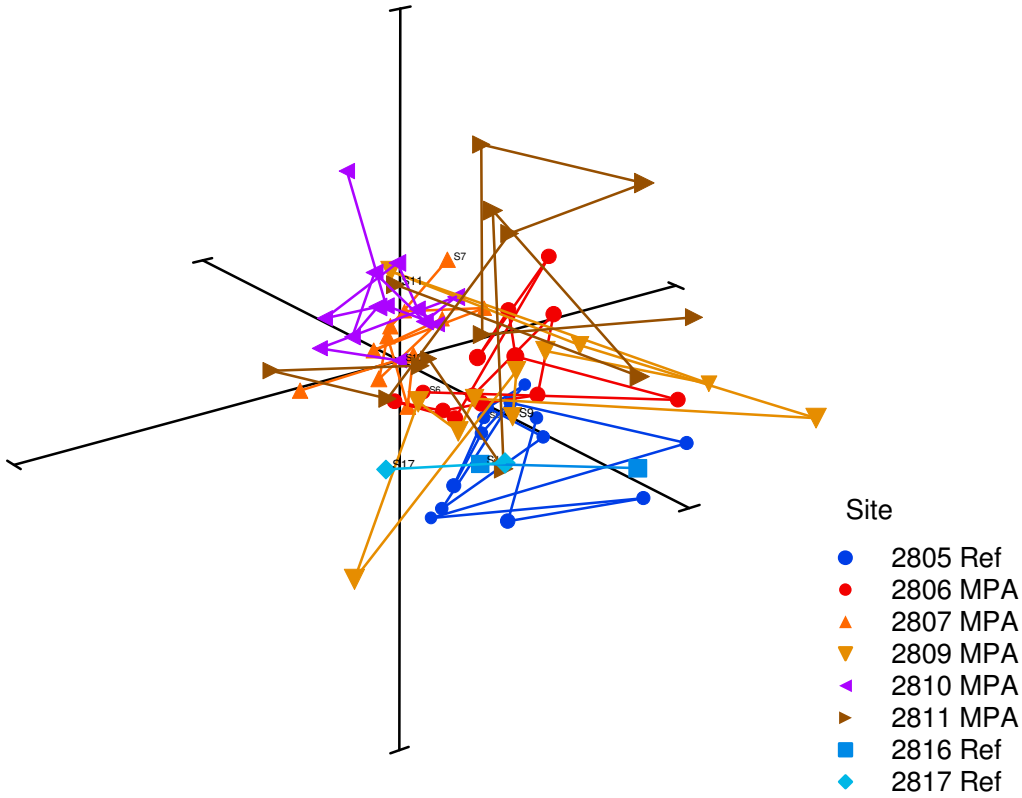


Figure 3.11. Three-dimensional MDS plot of invertebrate assemblage structure for Lonsdale Bight sites. Kruskal Stress value = 0.17.

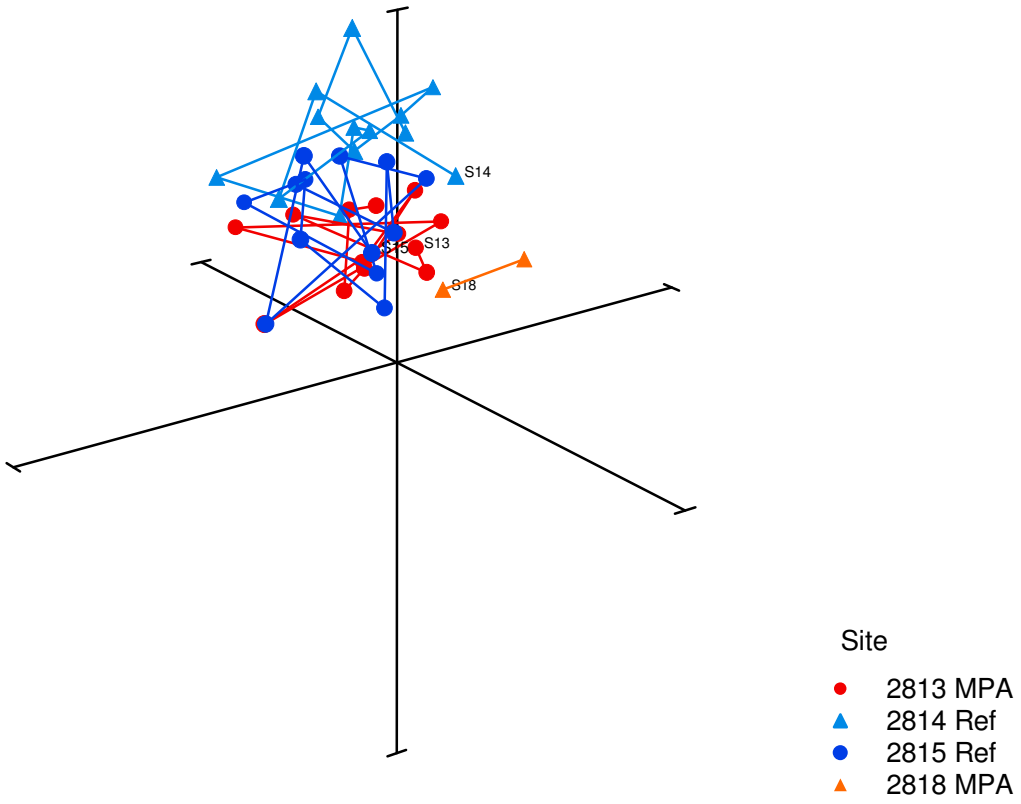
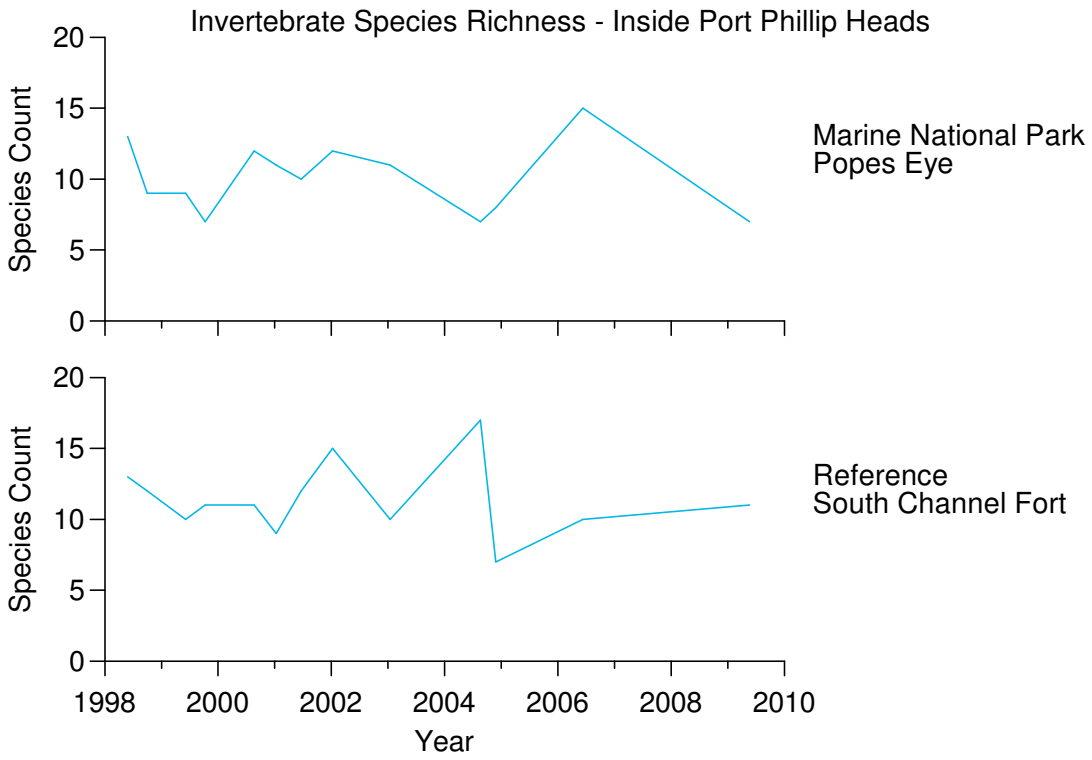


Figure 3.12. Three-dimensional MDS plot of invertebrate assemblage structure for sites outside the Heads. Kruskal Stress value = 0.17.

a.



b.

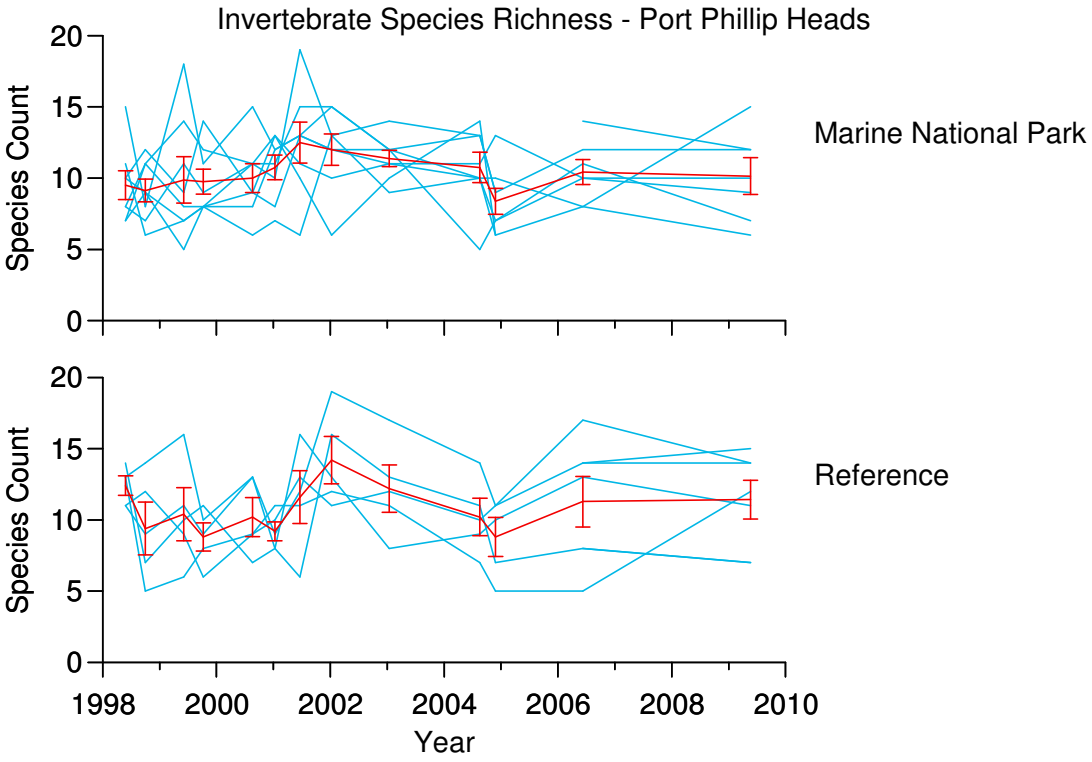
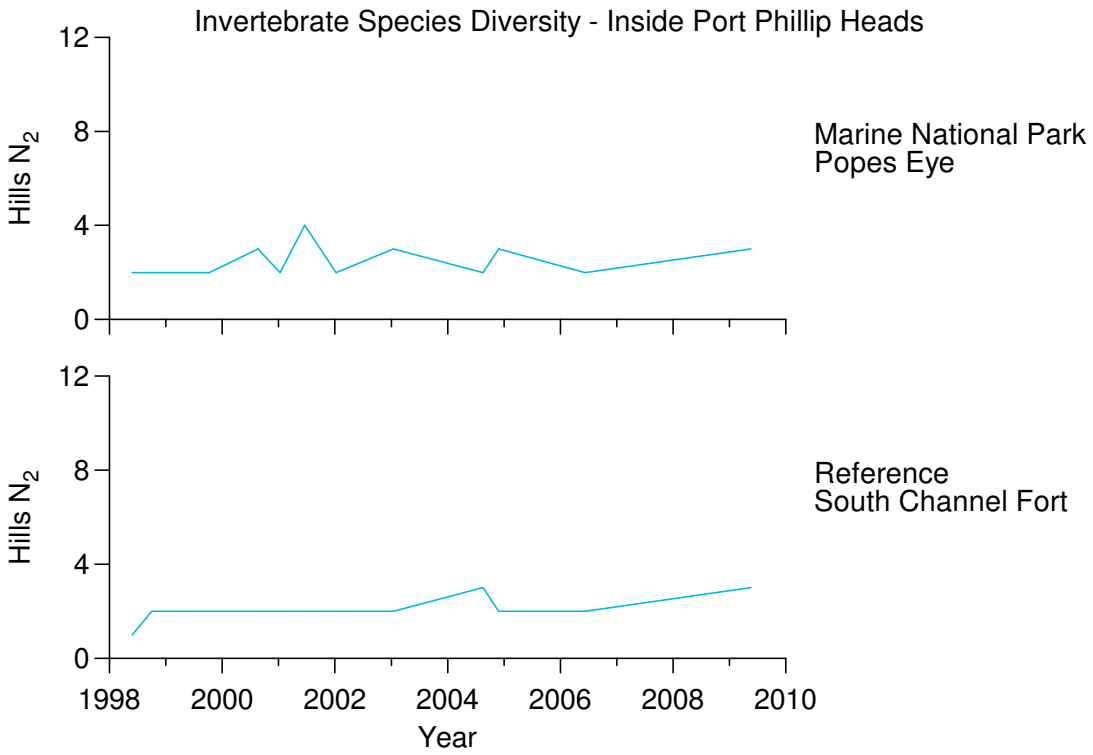


Figure 3.13. Trends in species richness of invertebrates at: (a) Popes Eye and South Channel Fort; and (b) Port Phillip Heads.

a.



b.

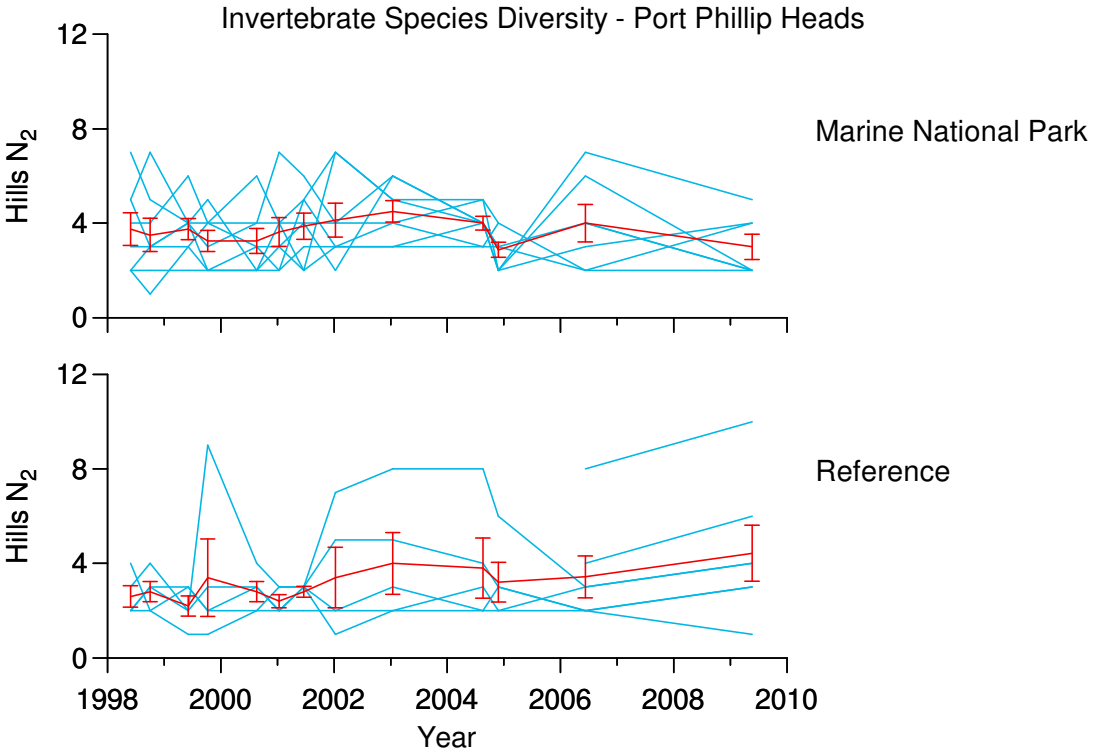


Figure 3.14. Trends in species diversity of invertebrates at: (a) Popes Eye and South Channel Fort; and (b) Port Phillip Heads.

3.3 Fishes

There was less distinct grouping of fish assemblages than was apparent for both macroalgae and invertebrate assemblages (Figures 3.15 to 3.19). The community structure at Lonsdale Bight and Nepean Bay were the least constant through time (Figure 3.15). This variability may relate to the relatively low abundance of fishes at these sites which inherently makes them more susceptible to small magnitude temporal changes. The exposed sites from the general region outside the heads (Sites 13, 14, 15 and 18) were consistently the most similar to each other throughout the surveys (Figure 3.19). Popes Eye, South Channel Fort and, to a lesser degree, Point Franklin and South Channel Fort had fish assemblages that were distinct from other sites possibly reflecting an exposure gradient and/or the larger geographic separation of the sites (Figures 3.16 to 3.18).

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 Bight and outside the Heads were similar to Nepean Bay, except for increased abundances of zebra fish *Girella zebra* and *Cheilodactylus nigripes* inside Lonsdale Bight and increased abundances of *Parma victoriae* and *Pictilabrus laticlavius* outside the Heads.

Popes Eye (Site 12) a distinct assemblage of fishes that showed little temporal variation (Figure 3.16). Prior to November 2002, Popes Eye was the only 'no-take' reserve in the region and is characterised by higher species richness and much higher abundances of most fish species than anywhere else. Several species, including sea sweep *Scorpis aequipinnis* and rosy wrasse *Pseudolabrus psittaculus* were rarely observed at sites other than Popes Eye during the surveys.

South Channel Fort also had a distinct assemblage, but this was more variable with time than Popes Eye (Figure 3.16). Barber perch *Caesioperca razor* and southern hula fish *Trachinops caudimaculatus* were common to both South Channel Fort and Popes Eye, but generally not elsewhere. Scalyfin *Parma victoriae*, purple wrasse *Notolabrus fucicola*, senator wrasse *Pictilabrus laticlavius*, globefish *Diodon nichthemerus* and various leatherjackets were also typical at South Channel Fort.

Point Franklin was initially the most different to Popes Eye (Figure 3.17), with very low abundances of all species, including the typically ubiquitous wrasse *Notolabrus tetricus*. This site is subject to exceptional line and spear fishing pressure, with casual observations indicating this site is likely to have amongst 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. There has been a steady increase in fish species richness, diversity and abundance at Point Franklin and its fish assemblage is now one of the most similar to Popes Eye (Figure 3.17).

Shortland Bluff was also characterised by low fish species richness and abundances, the assemblage generally consisting of low numbers of *N. tetricus*, goat fish *Upeinichthys vlaminghii* and *Cheilodactylus nigripes*.

Mean fish species richness and mean species diversity decreased between 2003 and early 2004, before recovering by late 2004. This decrease was not large, but is unusual, as it occurred at so many sites (Figures 3.20 and 3.21). There was corresponding variation in species richness across most marine protected area sites. This generally matched variation in the mean species richness of the reference sites, though species richness at individual reference sites was more variable (Figure 3.20).

Species richness was consistently greater within the Popes Eye sanctuary, where there was an increasing trend between 1999 and 2006 before a slight decrease to 2009 (Site 12; Figure 3.20). Despite Popes Eye (Site 12) having high species richness, the diversity was not markedly higher than other sites (Figure 3.21). This was because of a high dominance in

abundance of some species, particularly *Trachinops caudimaculatus*, *Parma victoriae* and *Notolabrus tetricus*. Diversity has been increasing at Popes Eye since 2005 (Figure 3.21).

Initially, Point Franklin had very low fish species richness and low diversity. The number fish species observed per survey have increased steadily; from 5 species in 1998 to 27 species in 2009. Fish diversity has also increased, and in 2009 Point Franklin had the highest fish diversity of any site (Figure 3.21).

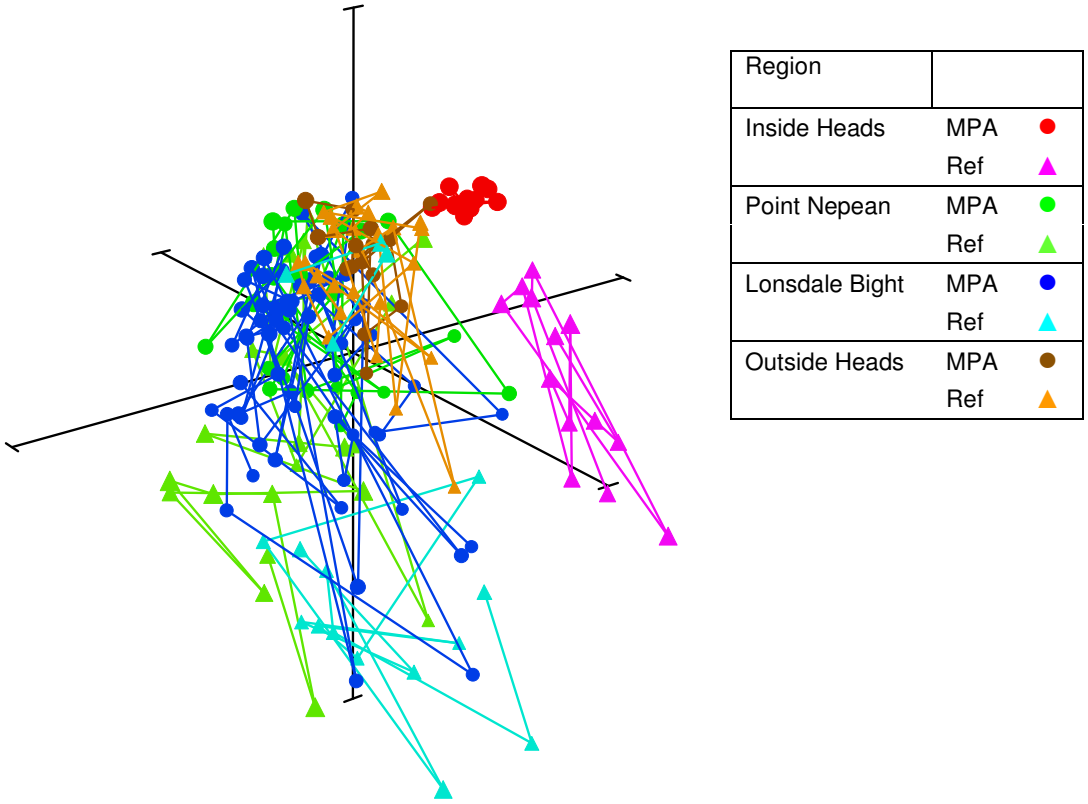


Figure 3.15. Three-dimensional MDS plot of fish assemblage structure for all sites at Port Phillip Heads. Kruskal Stress value = 0.17.

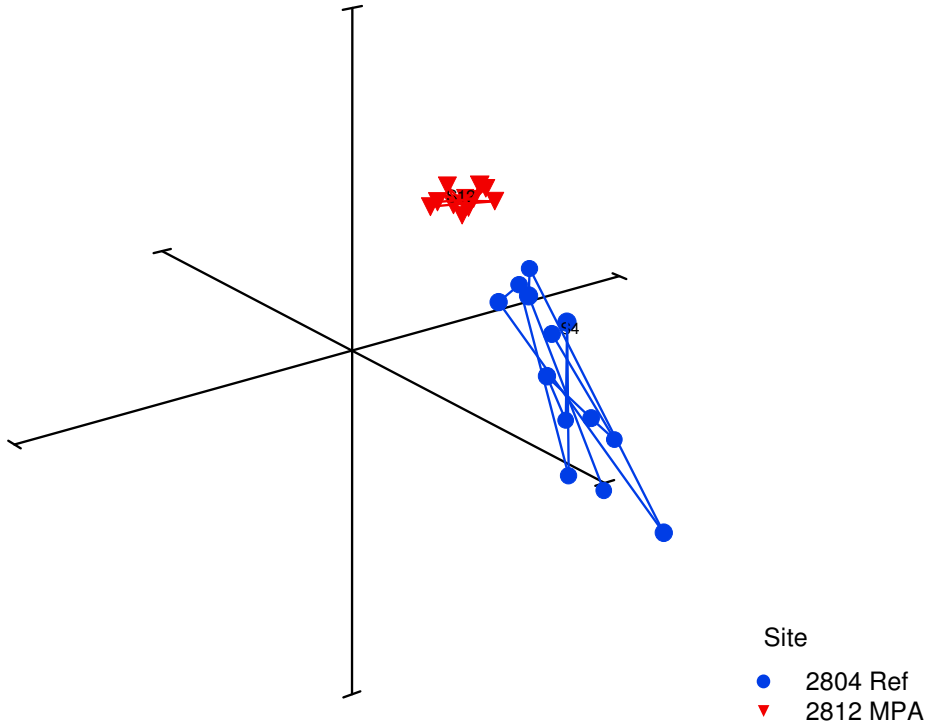


Figure 3.16. Three-dimensional MDS plot of fish assemblage structure for inner Heads sites. Kruskal Stress value = 0.17.

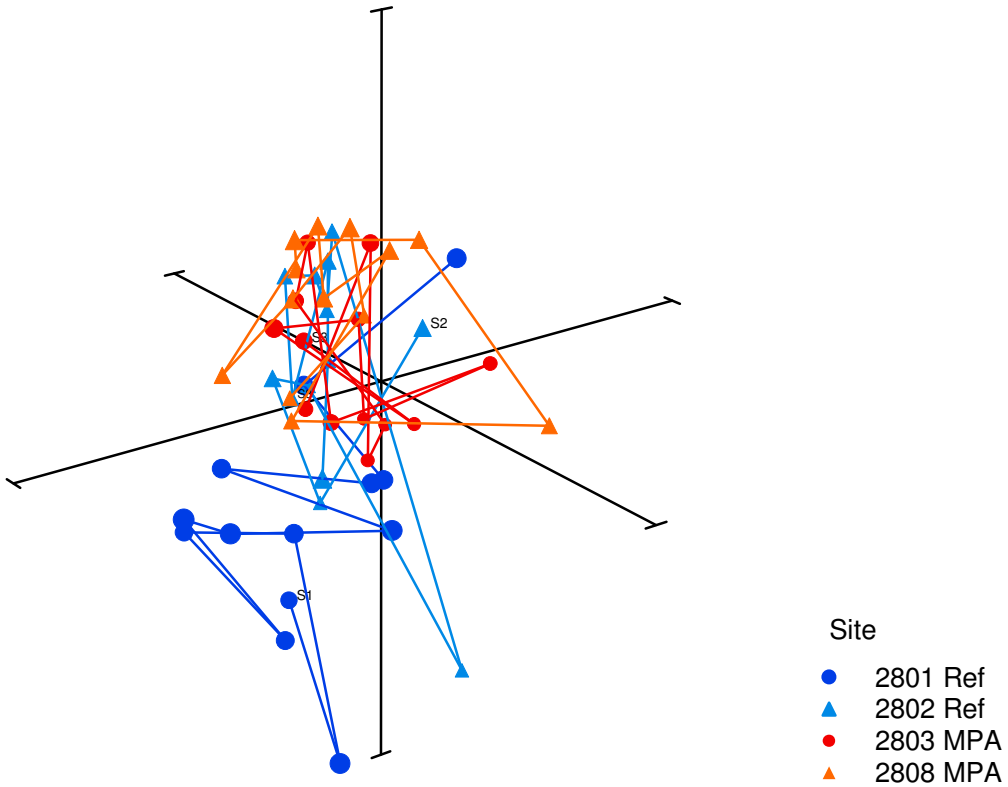


Figure 3.17. Three-dimensional MDS plot of fish assemblage structure for Nepean Bay sites. Kruskal Stress value = 0.17.

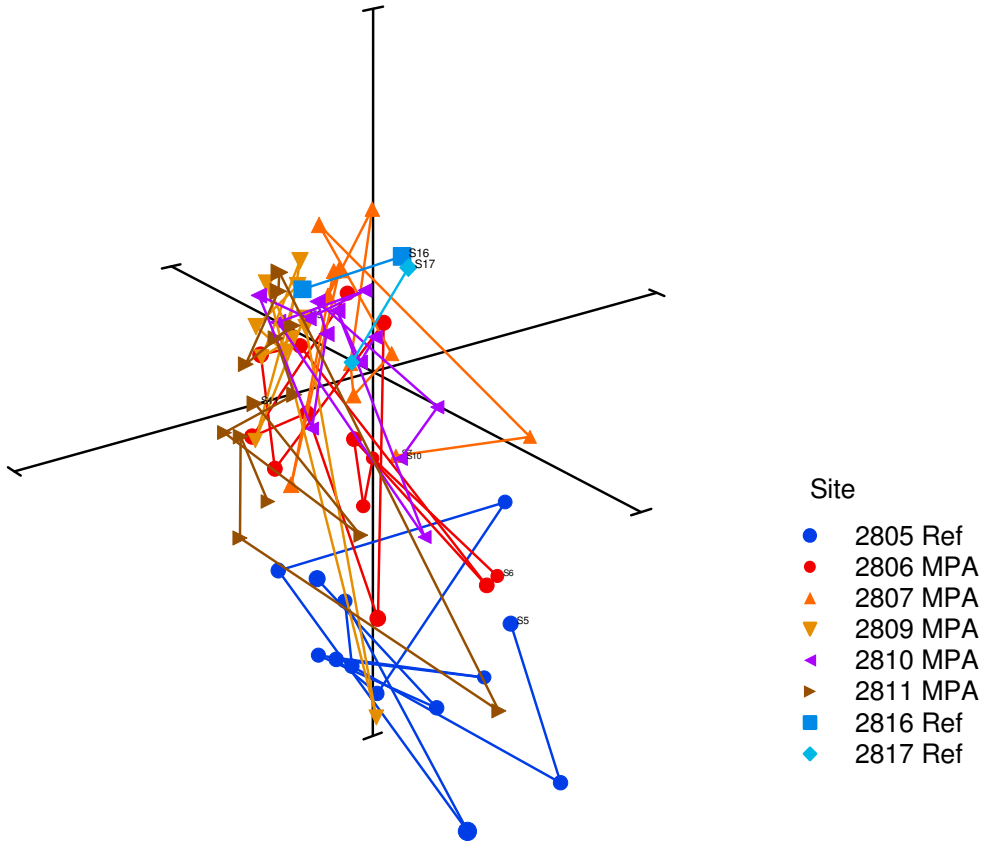


Figure 3.18. Three-dimensional MDS plot of fish assemblage structure for Lonsdale Bight sites. Kruskal Stress value = 0.17.

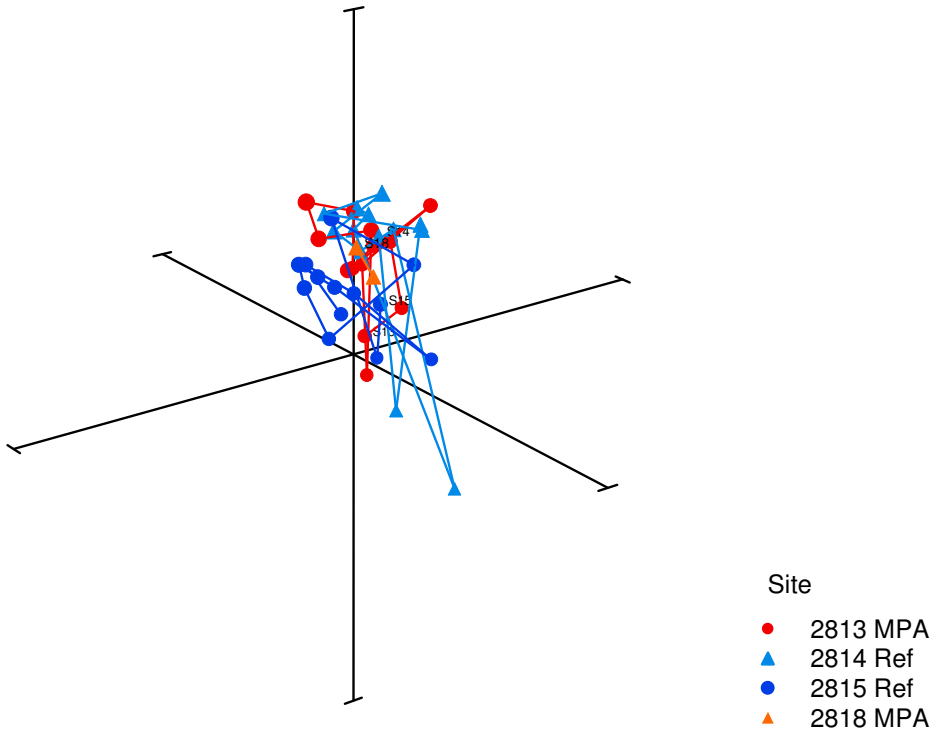
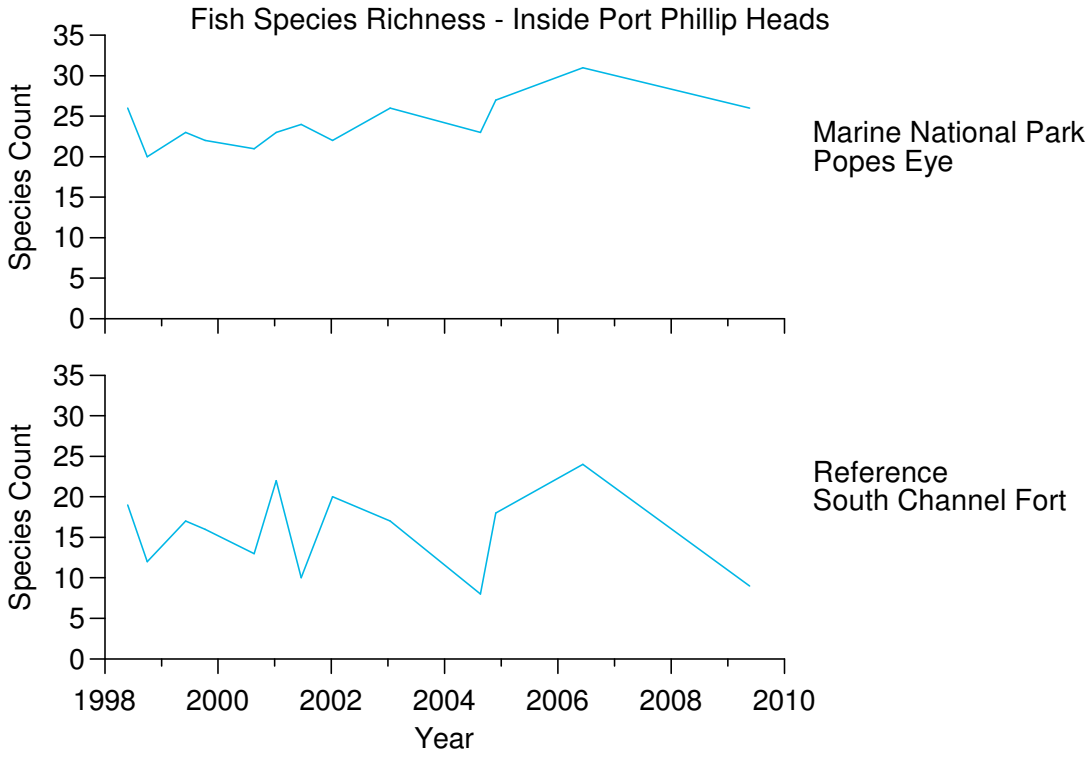


Figure 3.19. Three-dimensional MDS plot of fish assemblage structure for sites outside the Heads. Kruskal Stress value = 0.17.

a.



b.

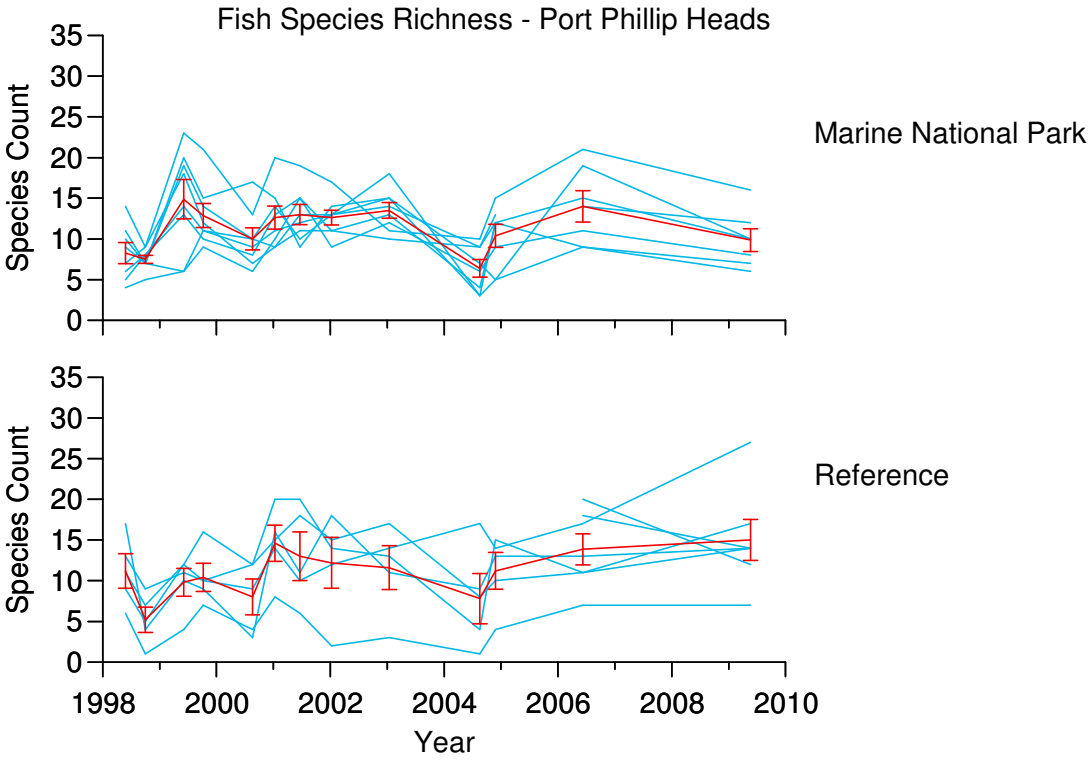
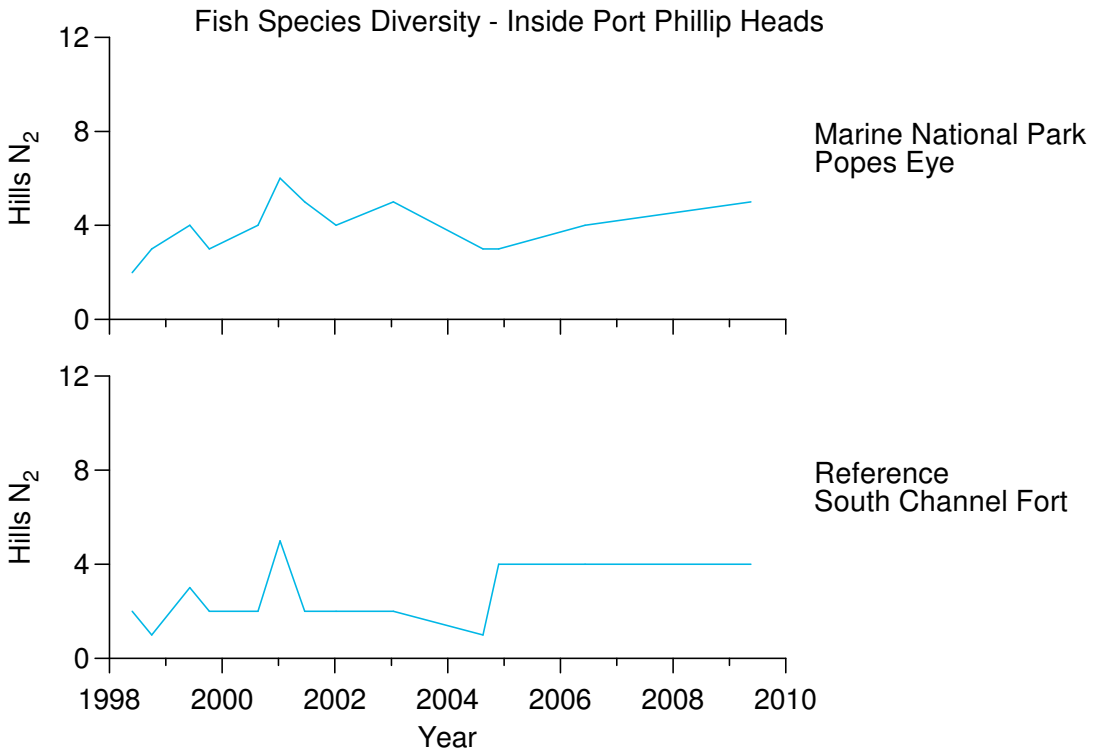


Figure 3.20. Trends in species richness of fishes at: (a) Popes Eye and South Channel Fort; and (b) Port Phillip Heads.

a.



b.

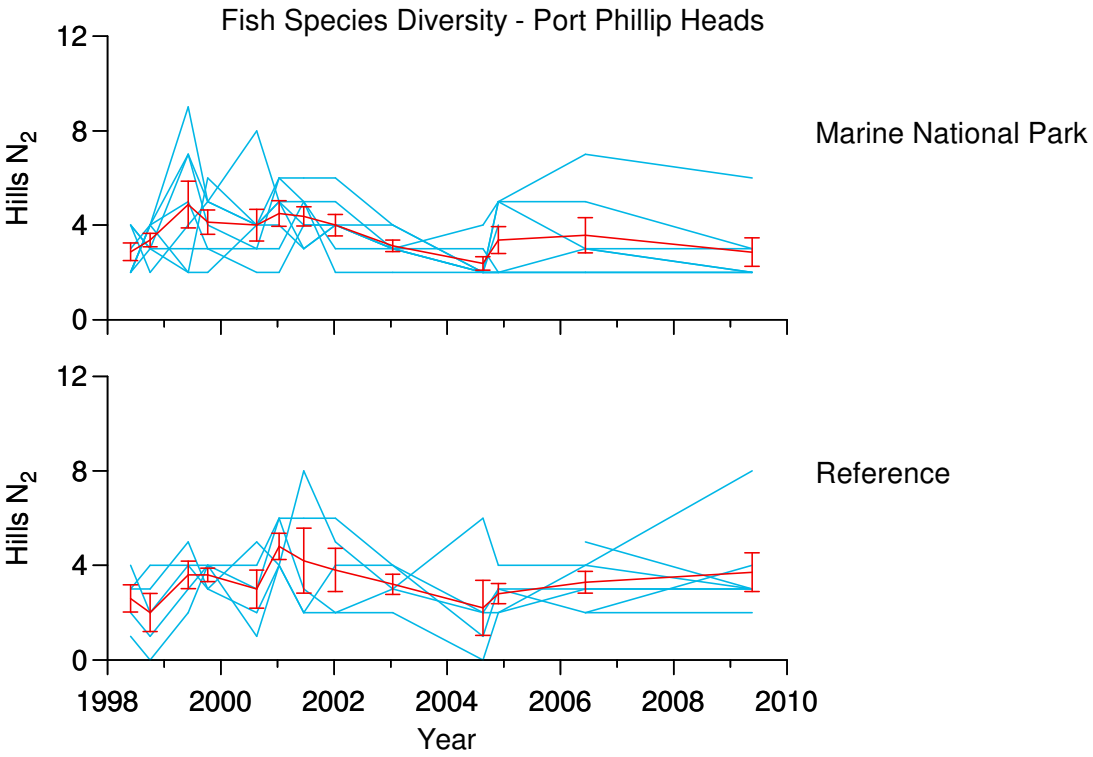


Figure 3.21. Trends in species diversity of fishes at: (a) Popes Eye and South Channel Fort; and (b) Port Phillip Heads.

4 PORT PHILLIP HEADS

4.1 Macroalgae

Examples of time trends in abundances of selected species are given for each site in Figures 4.1 to 4.10.

The green alga *Cladophora prolifera* was consistently present at Nepean Bay sites, but at low abundances. In Lonsdale Bight, *C. prolifera* was usually present, but its abundance was highly variable through time (Figure 4.1). Its abundance was generally highest at Victory Shoal (Site 6) and Shortland Bluff (Site 5), although it had a relatively low abundance at these sites in 2009. *Cladophora prolifera* was not recorded at any of the exposed sites outside Port Phillip Heads (Sites 13, 18, 15 and 14).

The common kelp *Ecklonia radiata* was abundant at most sites, with highest abundances at Kelp Fields and Point Franklin (Sites 1 and 17; Figure 4.2). Canopy cover at Kelp Fields (Site 17) was essentially monospecific, with almost 80 % *E. radiata* cover. Abundances appeared to be seasonally variable through time at Lonsdale Kelp Outer (Site 9) and Lonsdale Kelp Inner (Site 11), with higher coverage in spring/summer months. An increase in abundance during early surveys, followed by a declining trend in more recent surveys, was observed at Point Franklin, Victory Shoal, Merlan Outer, Lonsdale Kelp Outer and Lonsdale Back Beach (Sites 1, 6, 10, 11 and 14).

In 2009, substantial dieback of *Ecklonia* was observed on the eastern transects (T3 and T4) at Point Franklin (Site 1). This appeared to be a disease that caused necrosis of the blade and laterals fronds back to the stipe (Figure 4.11). In Lonsdale Bight, some small patches of dieback, only metres across, were observed at Lonsdale Kelp Inner in the marine national park (Site 11).

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 4.3). At several sites, including Nepean Inner east, Merlan Outer, Lonsdale Kelp Inner and Lonsdale Point (Sites 8, 10, 11 and 15), abundance decreased over the period 1998 – 2003, then increased between 2003 and 2009. This is the inverse of variations in *E. radiata* cover at these sites. *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.

The brown alga *Cystophora moniliformis* was most abundant at Nepean Bay sites and in the Lonsdale Bight sites Lonsdale Kelp Inner (Site 11), Victory Shoal (Site 6) and Shortland Bluff (Site 5; Figure 4.4). In 2009, a decrease in the abundance of *C. moniliformis* at Lonsdale Kelp Inner and Shortland Bluff interrupted an increasing trend at both of these sites. The abundance of *C. moniliformis* at Point Franklin (Site 1) appears to have declined during the monitoring period.

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*, *Phacelocarpus peperocarpus*, *Pterocladia lucida* and *Ballia callitricha*. These species tended to be more persistent at sites outside the Heads (Figures 4.5 to 4.9).

The seagrass *Amphibolis antarctica* was prevalent on the transects in Nepean Bay (Sites 2 and 3) and Lonsdale Kelp Inner (Site 11; Figure 4.10). This species is also abundant at Victory Shoal (Site 6), but not along the transect location. A small stand was recorded at the western end of Lonsdale Surf Club (Site 18).

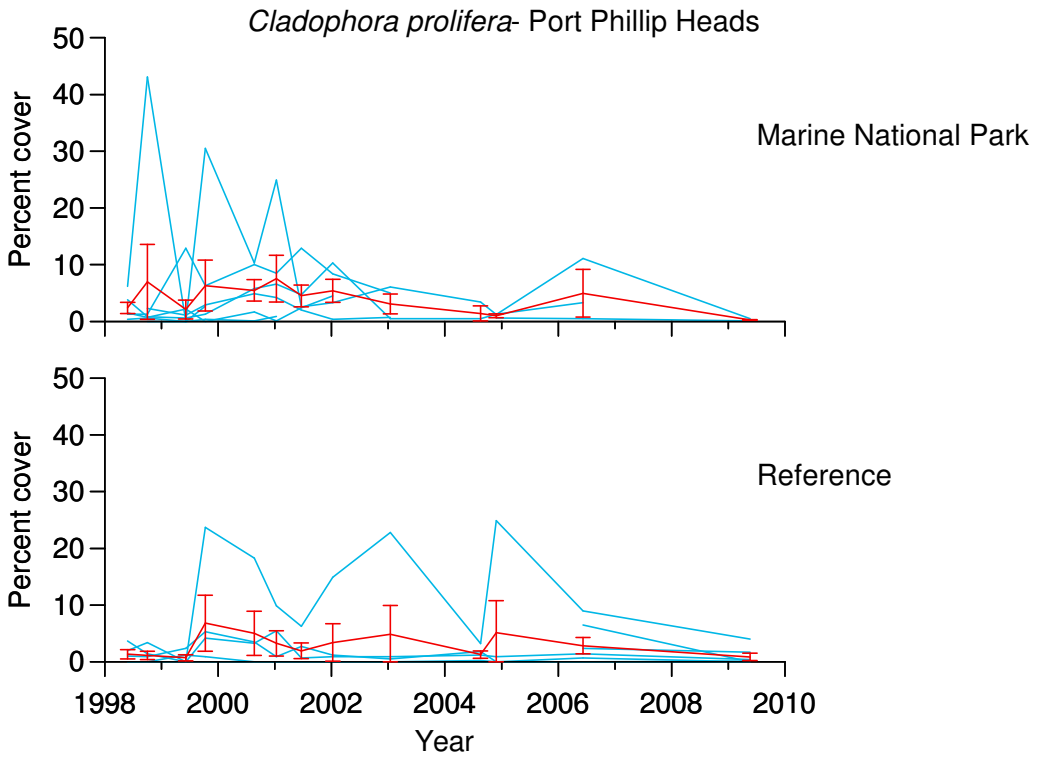


Figure 4.1. Trends in abundance of the filamentous green alga *Cladophora prolifera* at Port Phillip Heads.

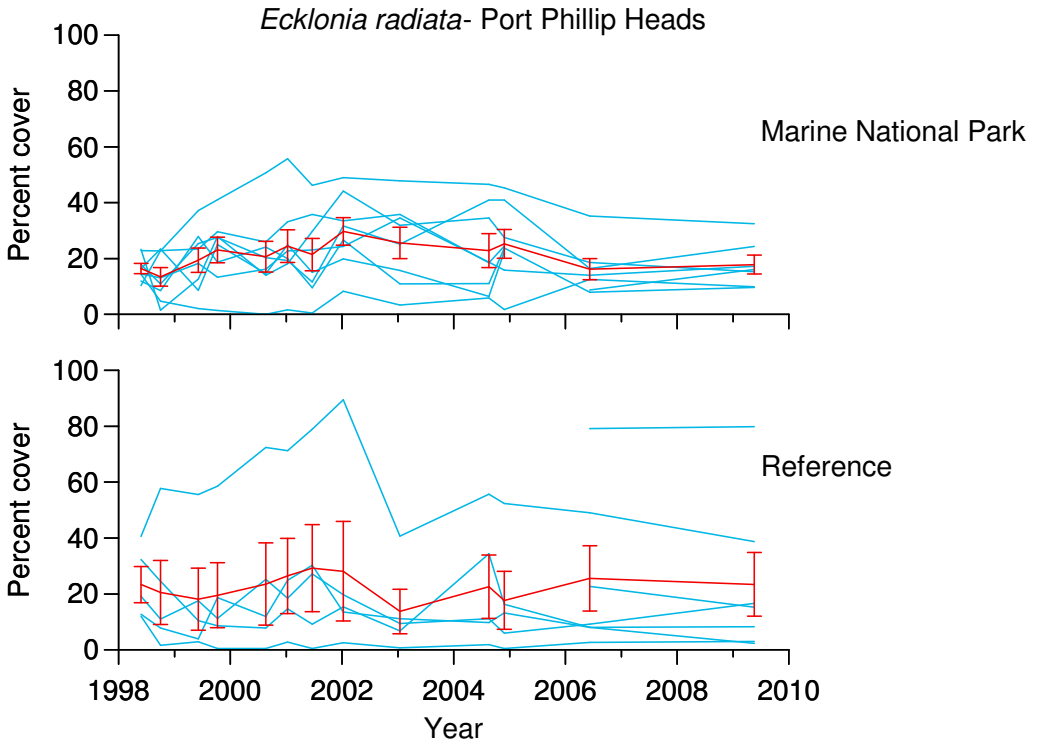


Figure 4.2. Trends in abundance of the common kelp *Ecklonia radiata* at Port Phillip Heads. Note the different scale for Site 17.

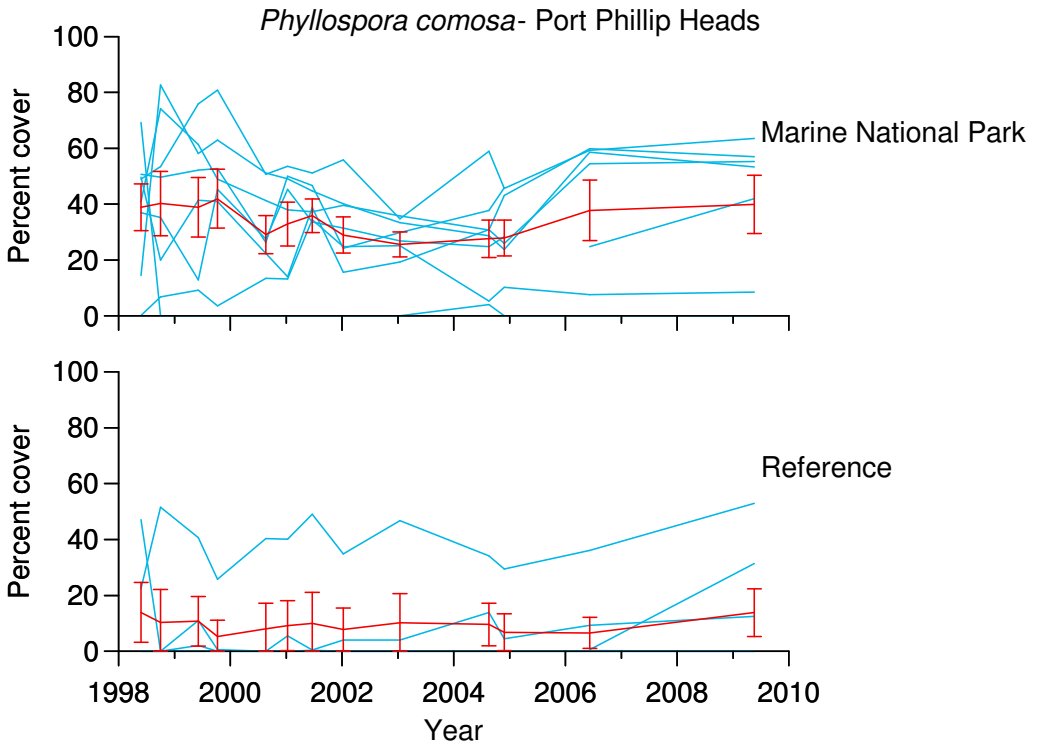


Figure 4.3. Trends in abundance of crayweed *Phyllospora comosa* at Port Phillip Heads.

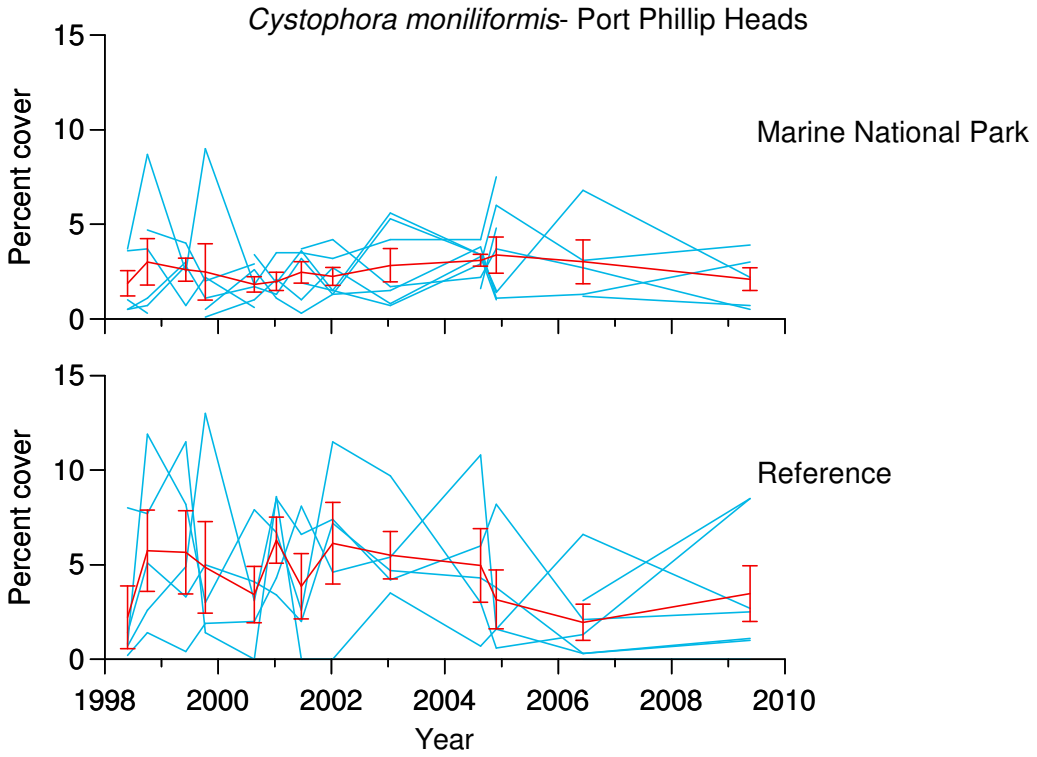


Figure 4.4. Trends in abundance of the brown alga *Cystophora moniliformis* at Port Phillip Heads.

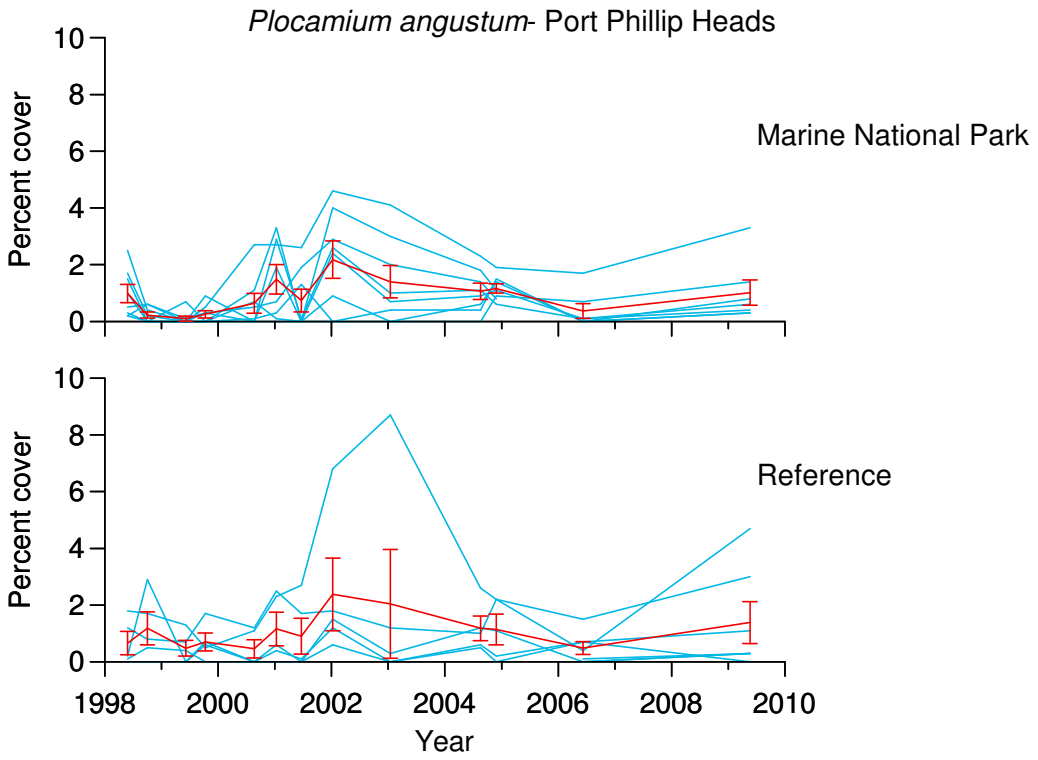


Figure 4.5. Trends in abundance of the red alga *Plocamium angustum* at Port Phillip Heads.

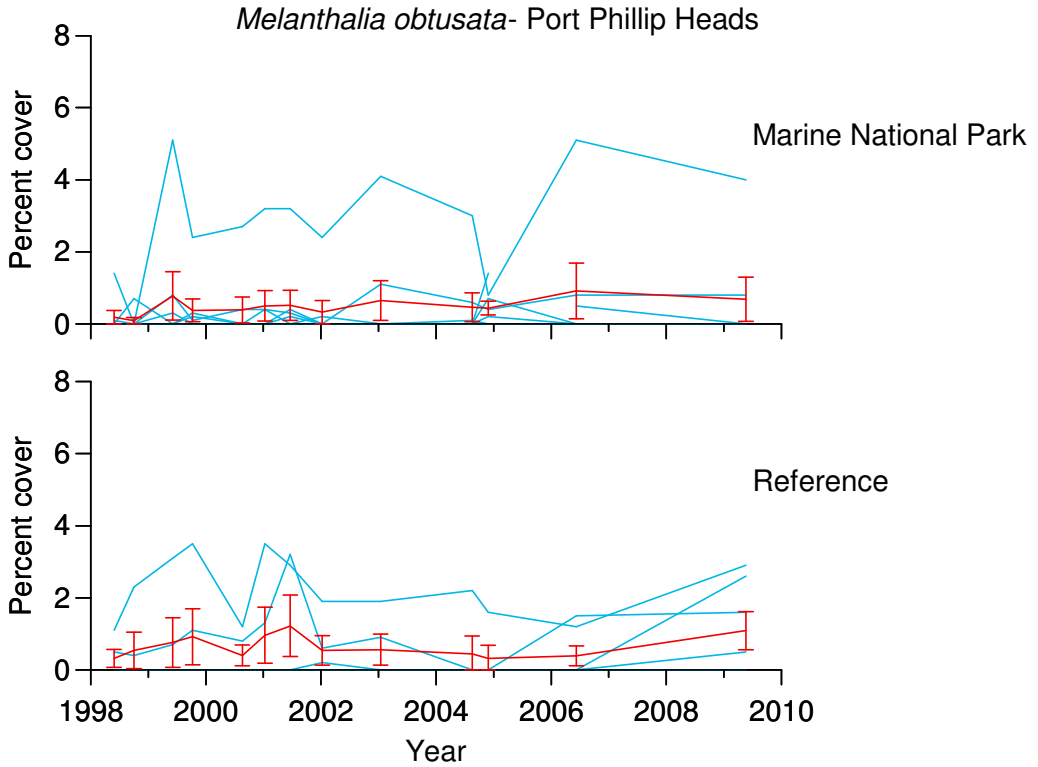


Figure 4.6. Trends in abundance of the red alga *Melanthalia obtusata* at Port Phillip Heads.

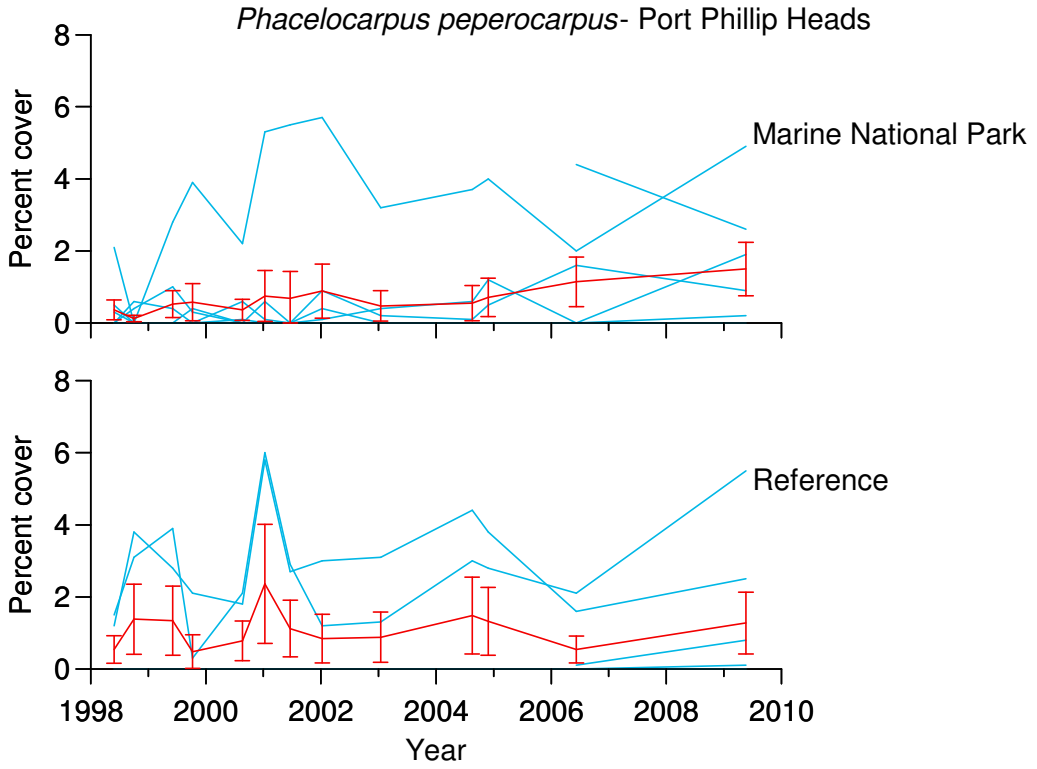


Figure 4.7. Trends in abundance of the red alga *Phacelocarpus peperocarpus* at Port Phillip Heads.

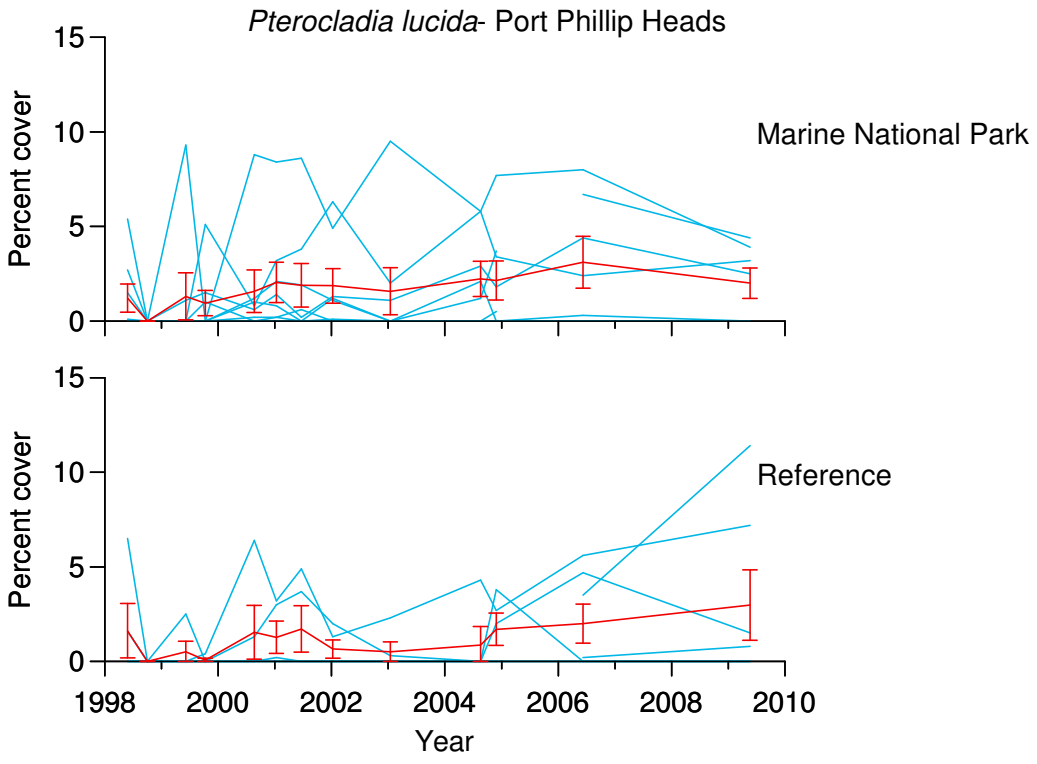


Figure 4.8. Trends in abundance of the red alga *Pterocladia lucida* at Port Phillip Heads.

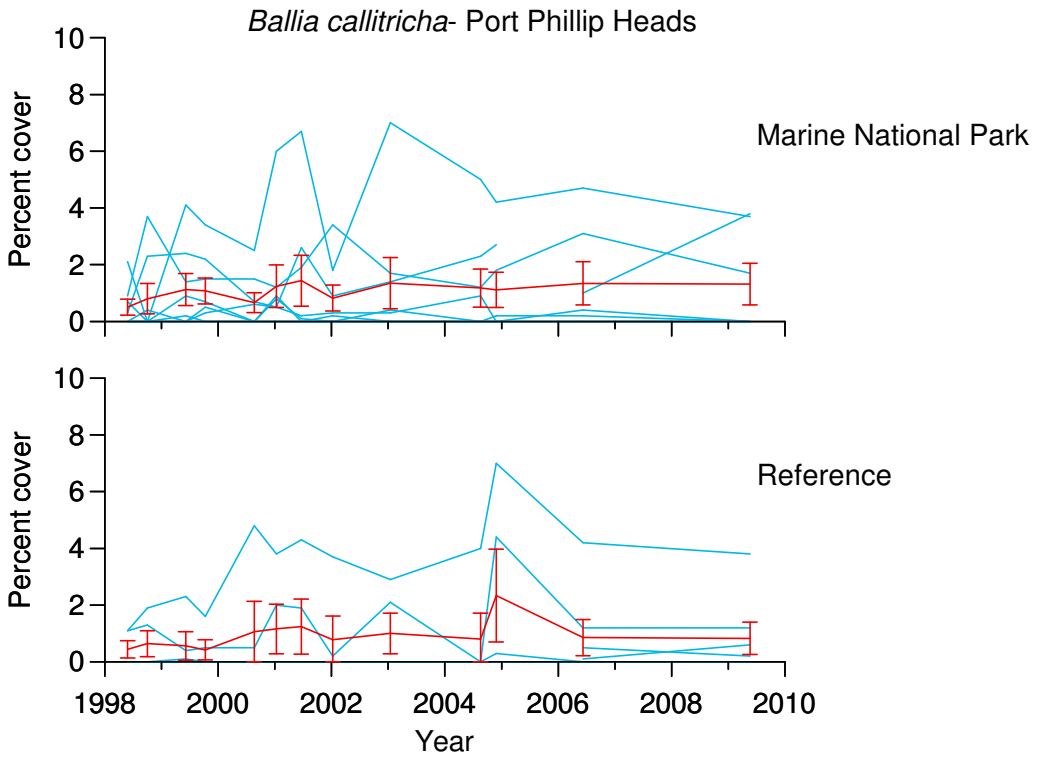


Figure 4.9. Trends in abundance of the red alga *Ballia callitricha* at Port Phillip Heads.

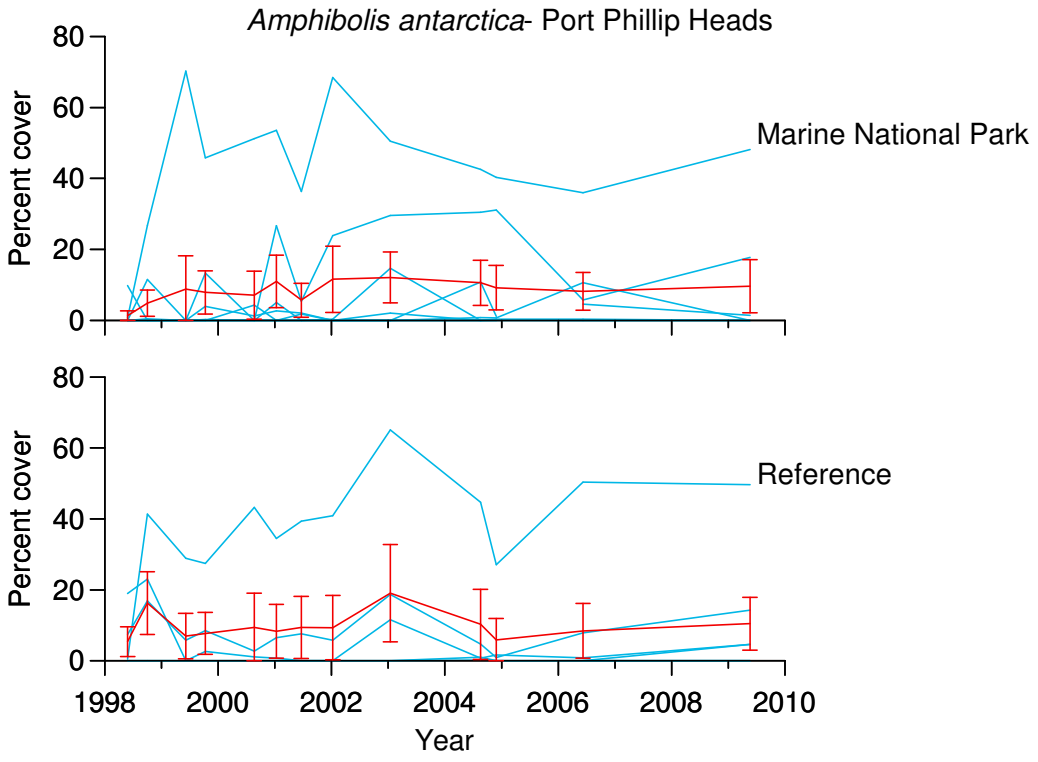


Figure 4.10. Trends in abundance of the reef inhabiting seagrass *Amphibolis antarctica* at Port Phillip Heads.

Figure 4.11. Dieback in kelp *Ecklonia radiata* at Point Franklin (Site 1). 2 June 2009.

4.2 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 Bight, where it covered most of Kelp Reef (Sites 9 and 11). Abundances of *M. angustifolia* have been reduced considerably for much of the past two decades. 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.

Macrocystis angustifolia abundances increased during the period of 2000-2002 at Nepean Offshore (Site 2; Figure 4.12). 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 and tenth surveys. On the tenth survey the density observed was only 5 plants per 2000 m², representing a decrease of 72 plants per 2000 m² over three years (Figure 4.12). A spike in plant numbers during the summer survey of 2004 temporarily reversed this trend, however the autumn/winter survey of 2006 recorded no plants and only two were observed in 2009.

The decline of *Macrocystis angustifolia* abundance in Port Phillip Heads was strikingly apparent, with few plants observed since 2005. These results correspond with observations at other subtidal reef monitoring sites across Victoria, where *M. angustifolia* has also substantially declined in abundance (Gilmour *et al.* 2005; Crozier *et al*. 2006; Stewart *et al.* 2006; Williams *et al.* 2006).

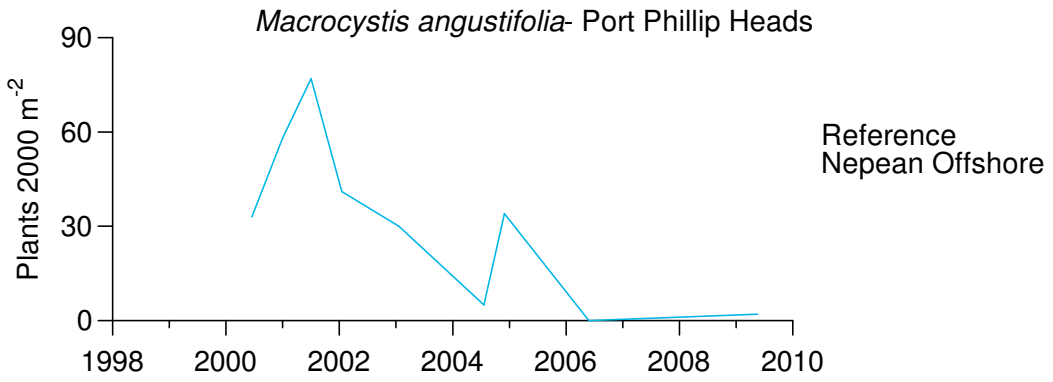


Figure 4.12. Density of string kelp *Macrocystis angustifolia* plants measured using Method 4 at Nepean Offshore (Site 2).

4.3 Invertebrates

Examples of time trends in abundances of selected species are given for each site in Figures 4.12 to 4.17. Most species had considerable differences between sites, with some sites having considerably more variation between times than others. Blacklip abalone *Haliotis rubra* were most common at the exposed Lonsdale Point (Site 13) and Merlan Outer (Site 10; Figure 4.13). Low abundances were recorded at Point Franklin (Site 1), Nepean Offshore (Site 2) and Lonsdale Bight sites 9, 16 and 17. Declining trends in abundance were evident at Merlan Inner (Site 7) and Lonsdale Point SW (Site 15; Figure 4.13). Abundances increased at Nepean Inner West (Site 3) and Shortland Bluff (Site 5) between 2006 and 2009, interrupting a declining trend.

Greenlip abalone *Haliotis laevigata* were generally less common than blacklip abalone *H. rubra* (Figure 4.14). Highest abundances were recorded at Lonsdale Bight Sites 5 and 6. Abundances increased at these sites between 2006 and 2009, particularly at Shortland Bluff.

The warrener *Turbo undulatus* was initially most abundant at the inner Nepean Bay sites (Sites 3 and 8), but numbers have declined since the start of the monitoring program (Figure 4.15). The sea urchin *Heliocidaris erythrogramma* was highest in abundance at Point Franklin (Site 1; Figure 4.16) and moderately high at Shortland Bluff (Site 5). Over time however, there appears to have been a declining trend in abundance at these sites (Figure 4.16).

The abundance of the common biscuit star *Tosia australis* was highly variability through time. This species was present at all sites during the most recent surveys (Survey 12), with the exception of Nepean Inner West (Site 3) where none were recorded (Figure 4.17). There was an increasing trend in abundance at Shortland Bluff (Site 5) after initial declines. There were sharp decreases in abundance at the newer sites Kelp Bed Drift and Kelp Fields (Sites 16 and 17). The feather star *Comanthus trichoptera* was present at most sites and most abundant at Nepean Inner East (Site 8; Figure 4.18).

The blacklip abalone *Haliotis rubra* was present in sufficient abundance to obtain a useful number of size measurements at Nepean Inner East (Site 8), Merlan Outer (Site 10), Lonsdale Point (Site 13) and the reference site Lonsdale Point SW (Site 15). The mean size of outside the Heads was equal to, or above, the minimum legal recreational fishing length of 110 mm (Victorian Central Zone; Sites 13 and 15; Figure 4.19). In Port Phillip Heads, Site 8 had the largest mean size, 122 mm, well above the minimum Port Phillip Bay recreational length of 100 mm (Figure 4.19). No obvious trends were apparent across the monitoring period at any of the sites.

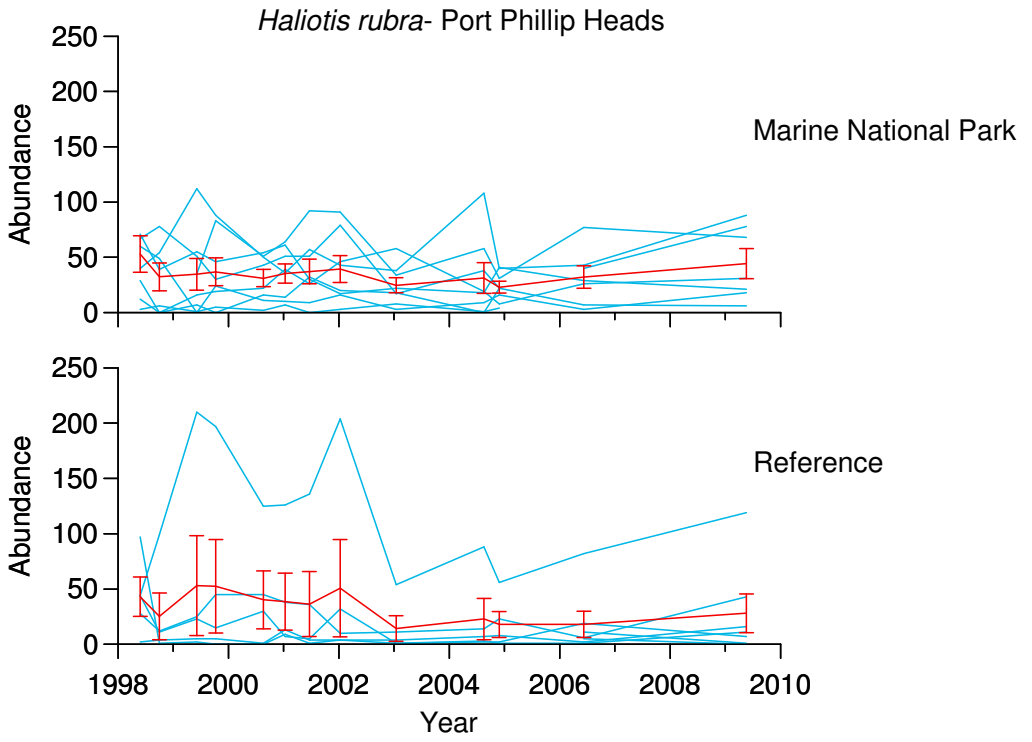


Figure 4.13. Densities (number per 2000 m^2) of the blacklip abalone *Haliotis rubra* at Port Phillip Heads.

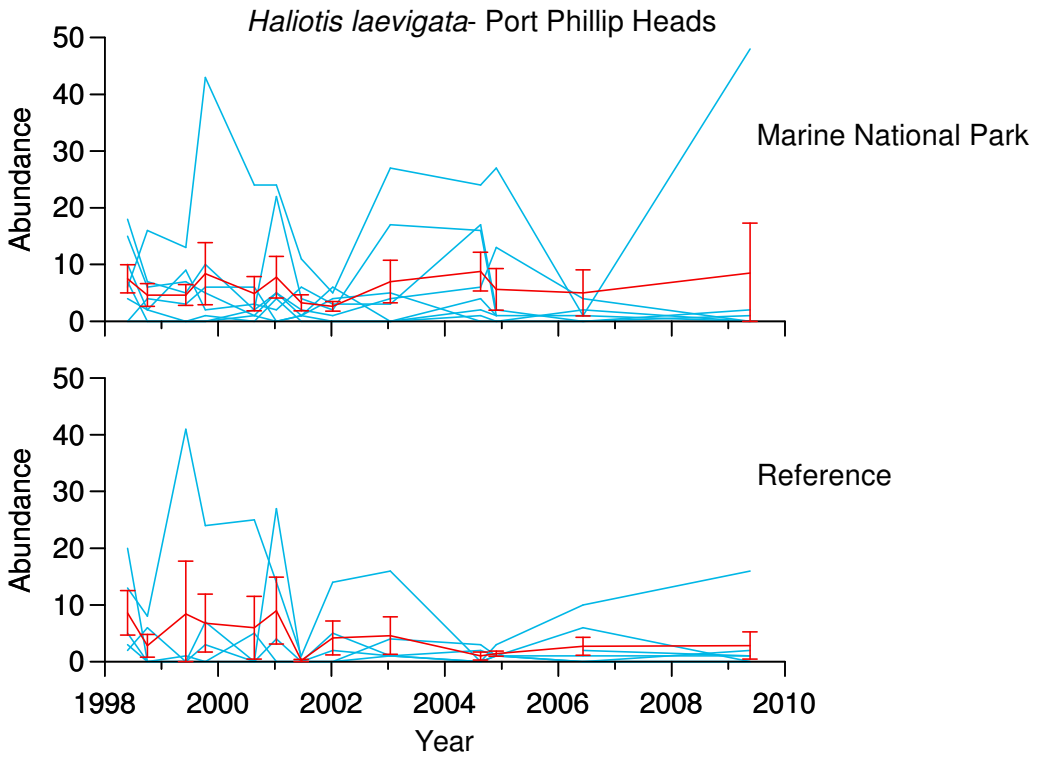


Figure 4.14. Densities (number per 2000 m^2) of the greenlip abalone *Haliotis laevigata* at Port Phillip Heads.

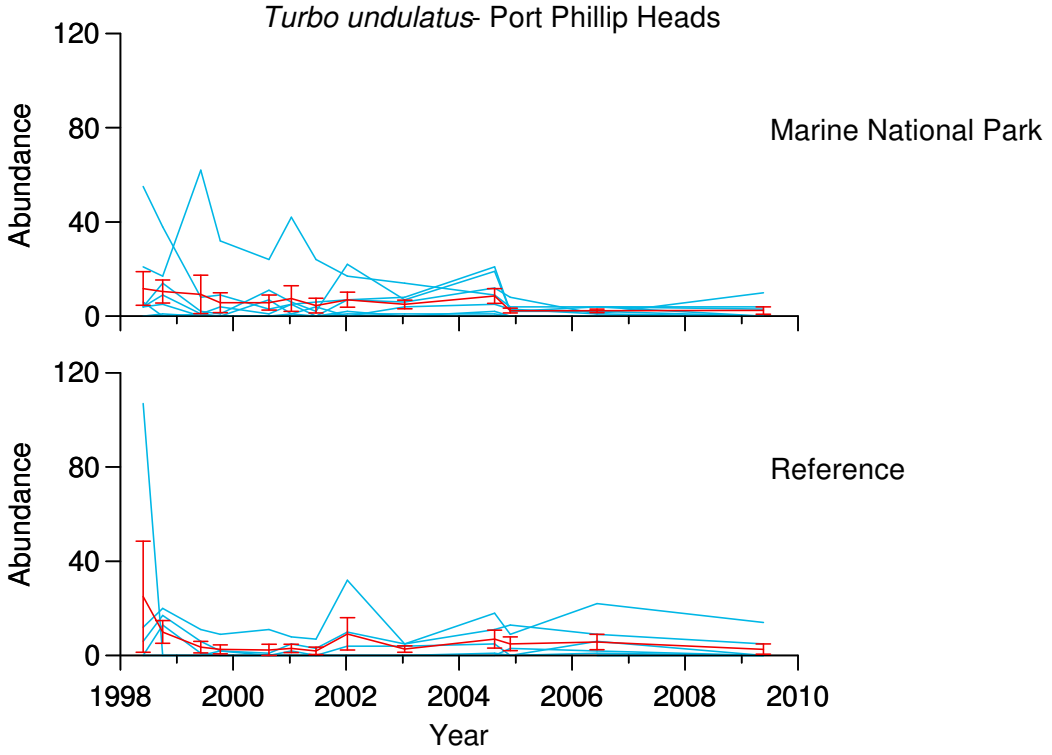


Figure 4.15. Densities (number per 2000 m^2) of the warrener *Turbo undulatus* at Port Phillip Heads.

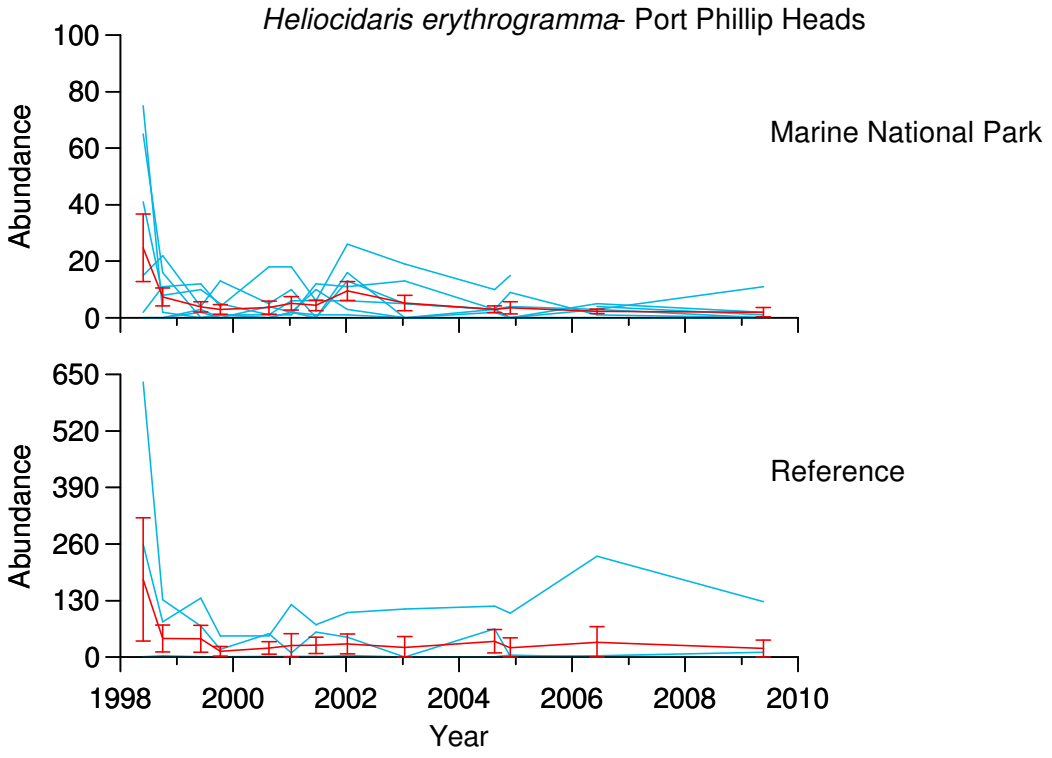


Figure 4.16. Densities (number per 2000 m^2) of the sea urchin *Heliocidaris erythrogramma* at Port Phillip Heads. Note the different scales.

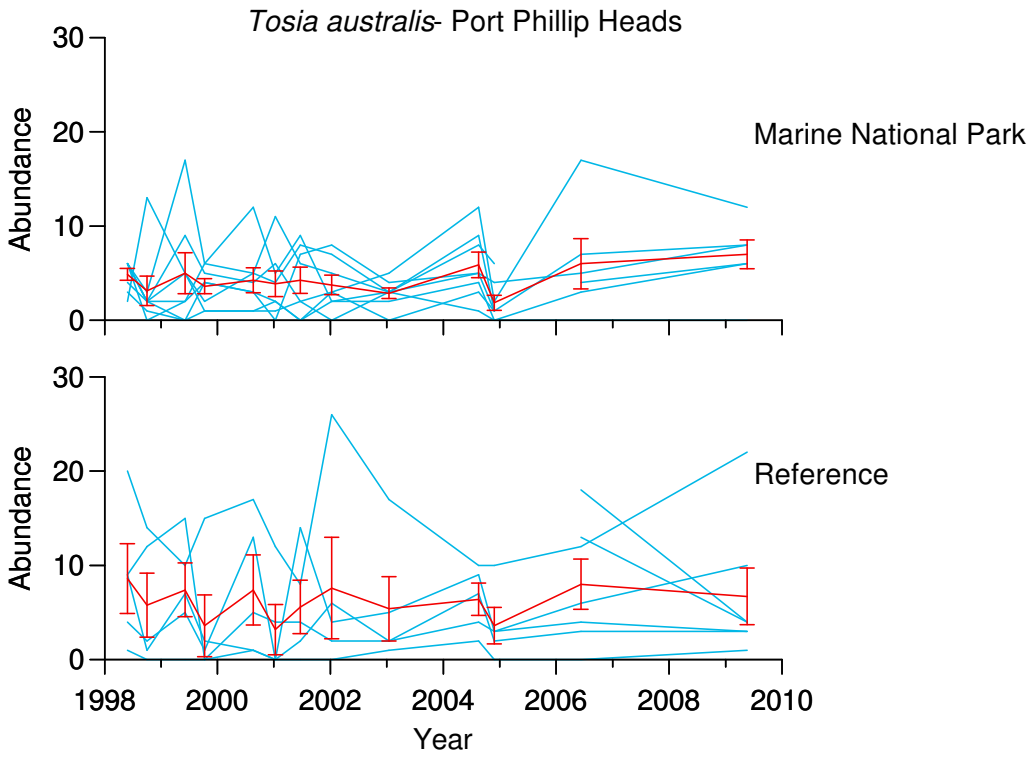


Figure 4.17. Densities (number per 2000 m^2) of the common biscuit star *Tosia australis* at Port Phillip Heads.

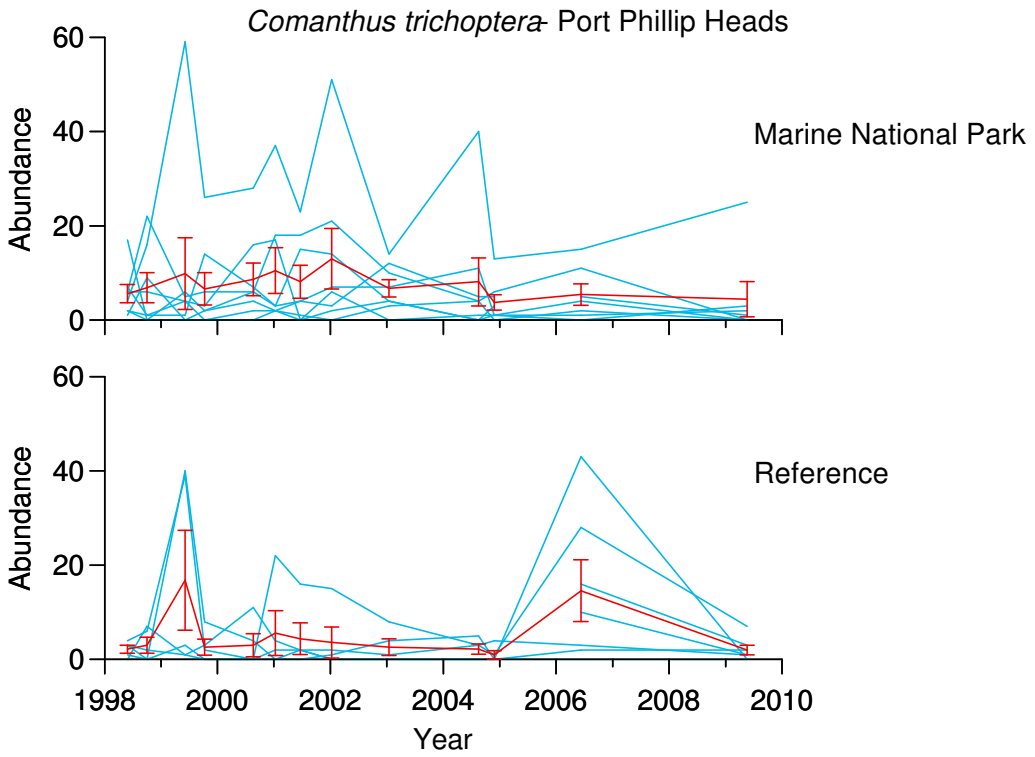


Figure 4.18. Densities (number per 2000 m^2) of the feather star *Comanthus trichoptera* at Port Phillip Heads.

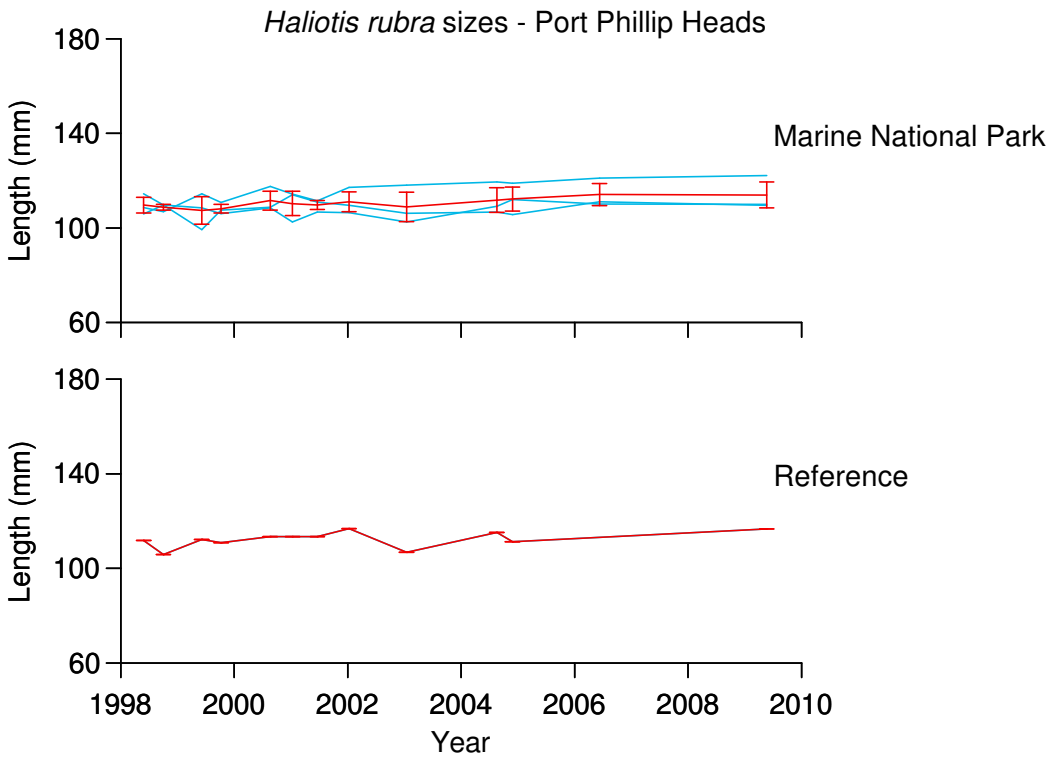


Figure 4.19. Trends in mean length (± 95% CI) of blacklip abalone *Haliotis rubra* at Port Phillip Heads. Marine National Park sites: Nepean Inner East (Site 8); Merlan Outer (Site 10); and Lonsdale Point (Site 13). Reference site: Lonsdale Point Southwest (Site 15).

4.4 Fishes

Examples of time trends in abundances of selected species are given for each site in Figures 4.19 to 4.24. Most species displayed considerable variation between times at some sites.

There was a large increase in *Notolabrus tetricus* abundances at Nepean Inner West (Site 3) during the most recent survey (Figure 4.20). No consistent trends were evident at any other sites.

After increasing early in the monitoring program, the abundance of *P. victoriae* at Lonsdale Back Beach (Site 14) appears to have declined in the three most recent surveys, particularly during Survey 10 where abundances declined to the lowest recorded levels. Large increases in the abundance of the horseshoe leatherjacket *Meuschenia hippocrepis* were apparent at Nepean Inner East and Lonsdale Point (Sites 8 and 13) during Survey 12 (Figure 4.25).

The observed size structures of common fishes, such as *Parma victoriae, Notolabrus tetricus*, *Notolabrus fucicola*, and *Odax cyanomelas* are given in Figures 4.26-4.27. There were no marked differences in mean sizes between sites.

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). Sites 9, 7 and 10 in Lonsdale Bight also had a reasonably high proportion of males (10-25 %), while the other sites had a very low proportion of males (0-10 %).

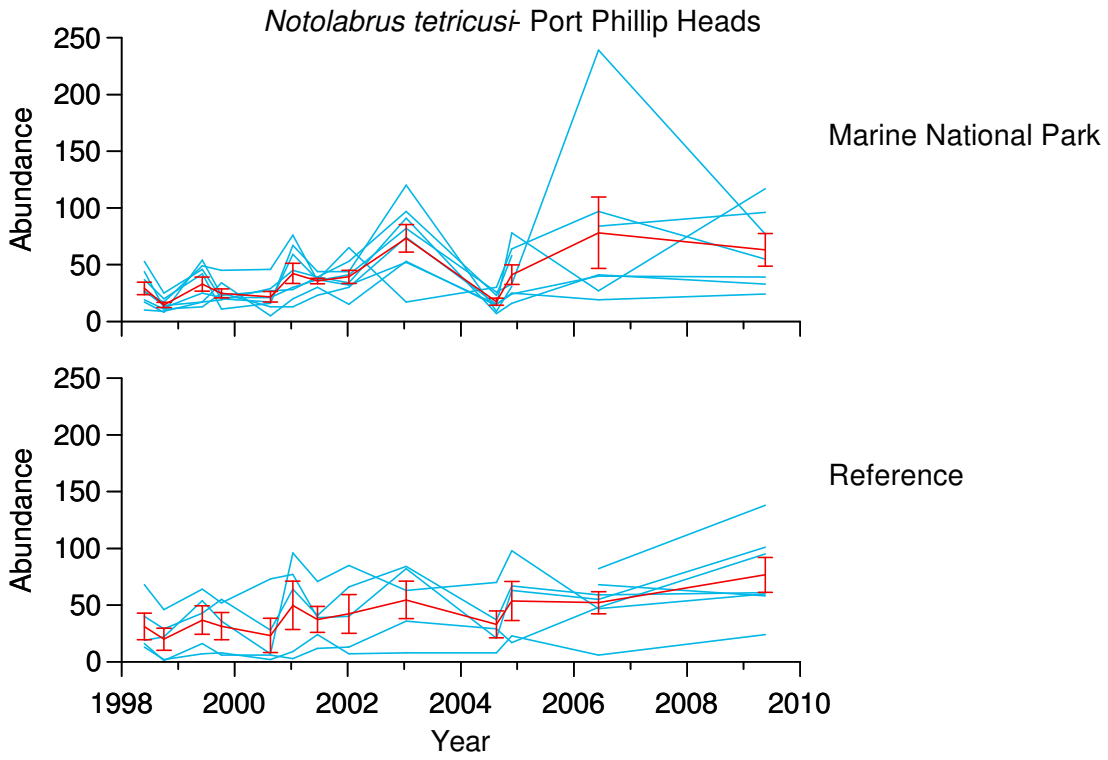


Figure 4.20. Densities (number per 2000 m^2) of blue-throated wrasse *Notolabrus tetricus* at Port Phillip Heads.

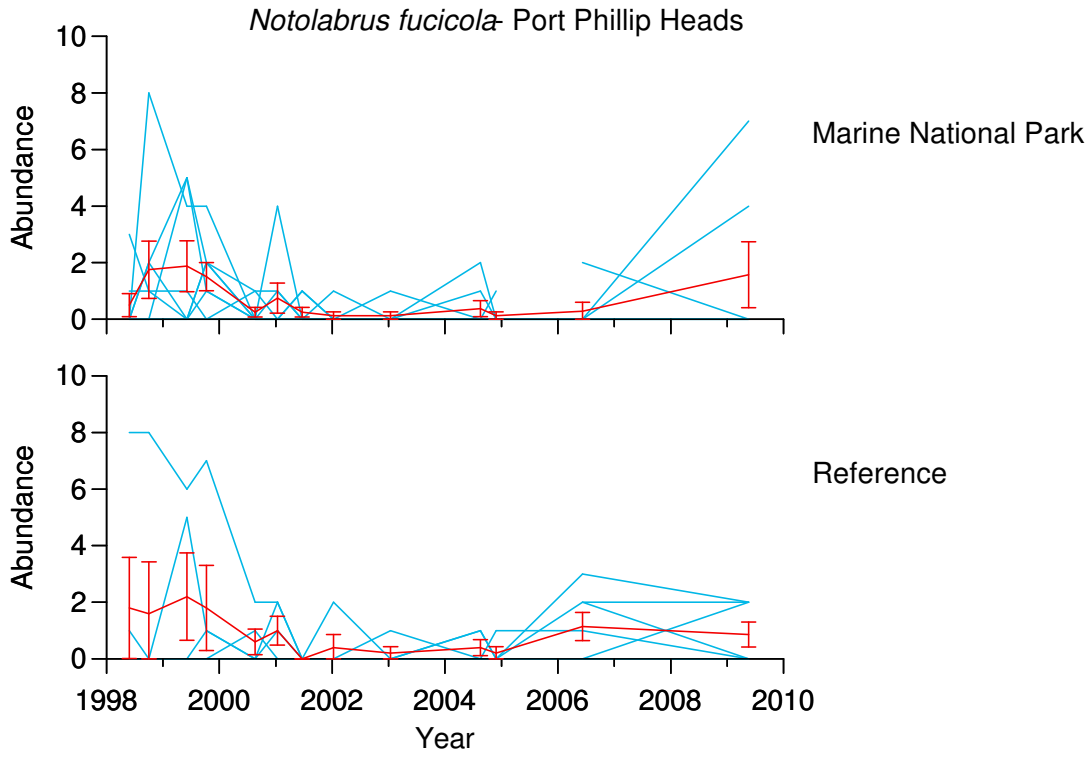


Figure 4.21. Densities (number per 2000 m^2) of purple wrasse *Notolabrus fucicola* at Port Phillip Heads. Note the different scale for Site 12.

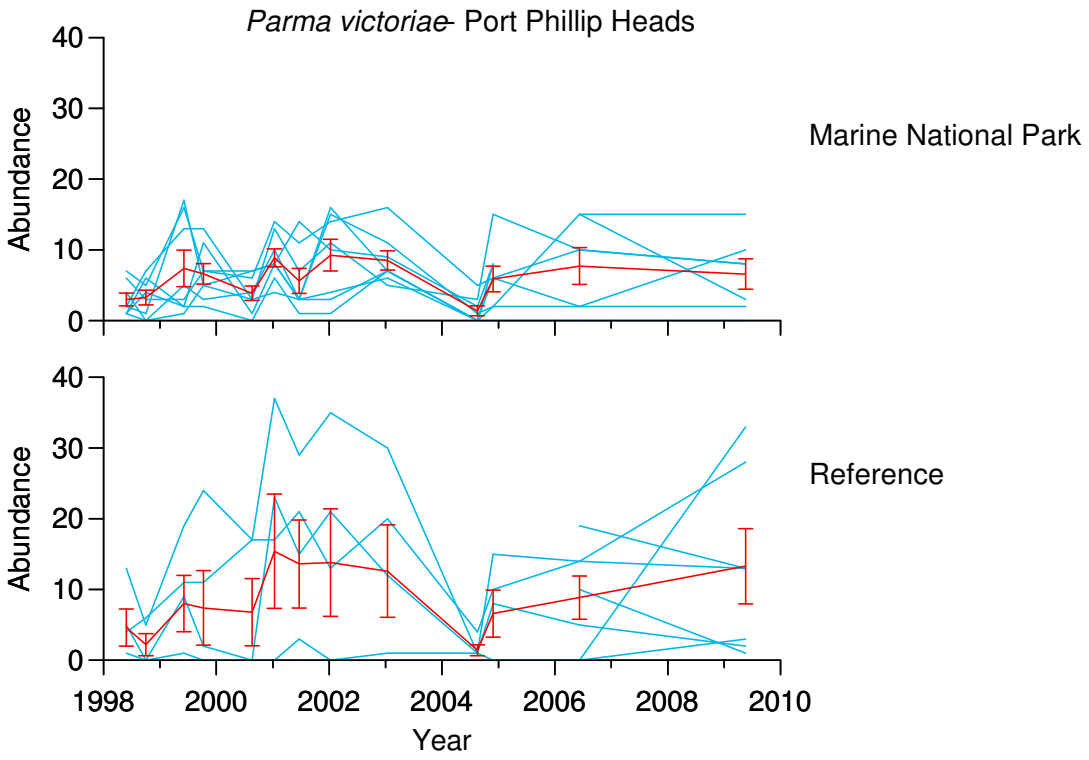


Figure 4.22. Densities (number per 2000 m^2) of scalyfin *Parma victoriae* at Port Phillip Heads. Note the different scale for Site 12.

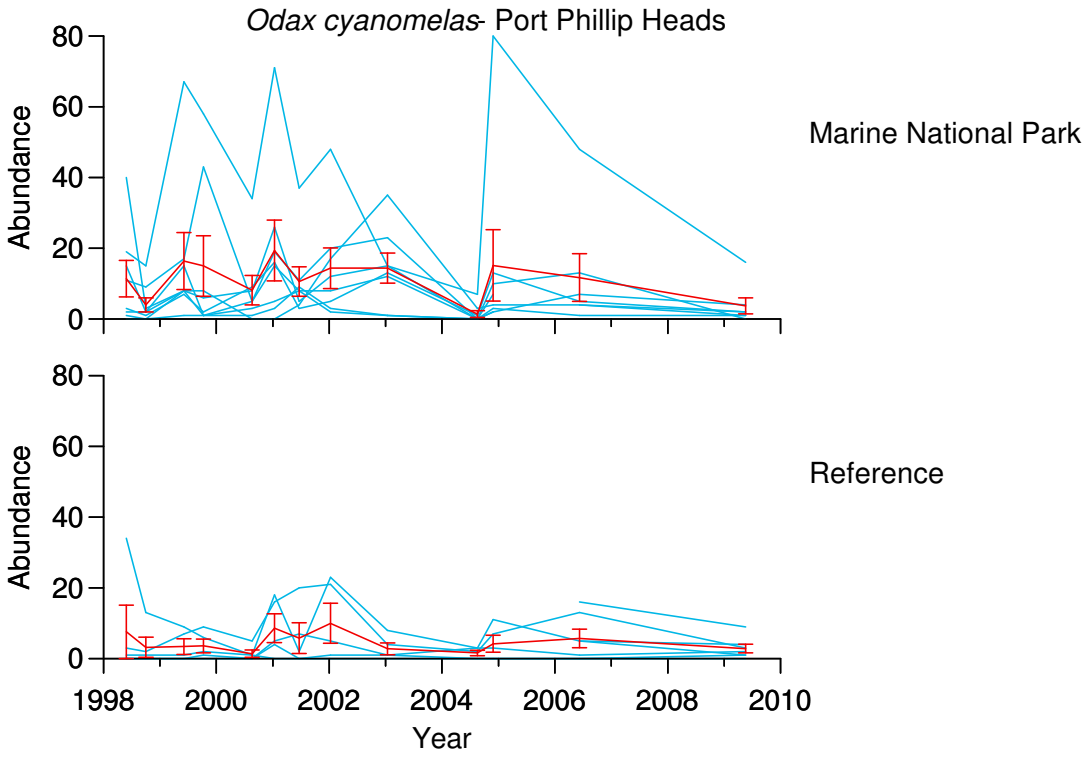


Figure 4.23. Densities (number per 2000 m^2) of herring cale *Odax cyanomelas* at Port Phillip Heads.

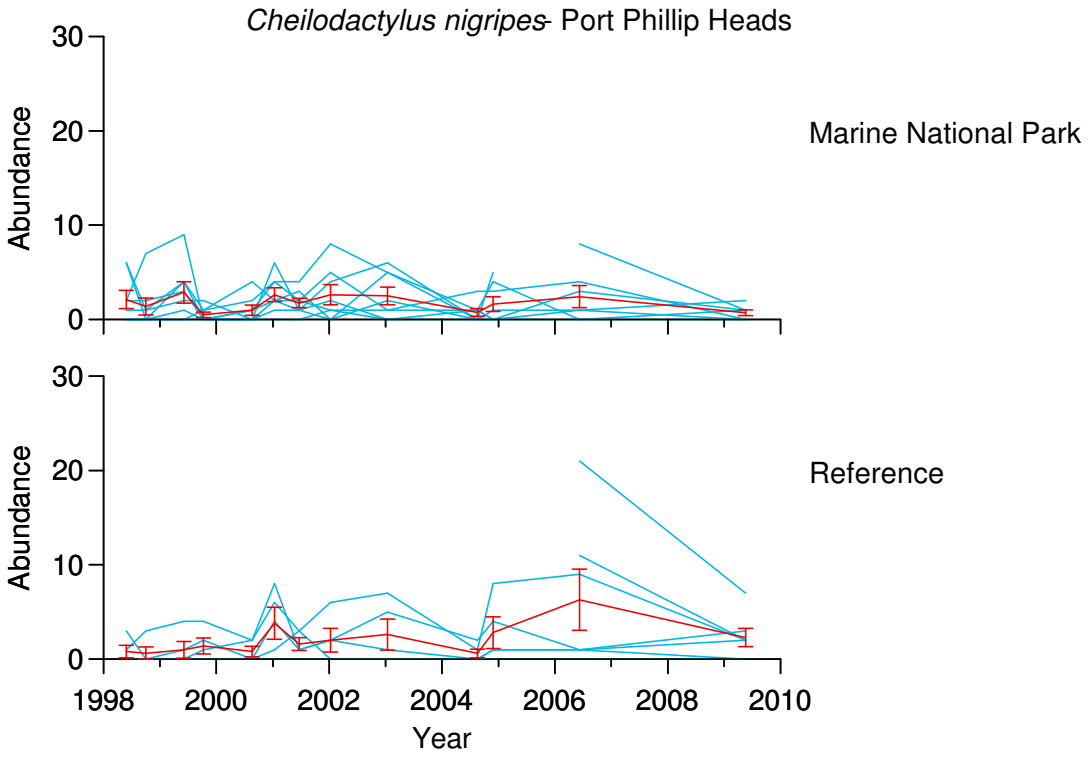


Figure 4.24. Densities (number per 2000 m^2) of magpie morwong *Cheilodactylus nigripes* at Port Phillip Heads. Note the different scales for Sites 12 and 17.

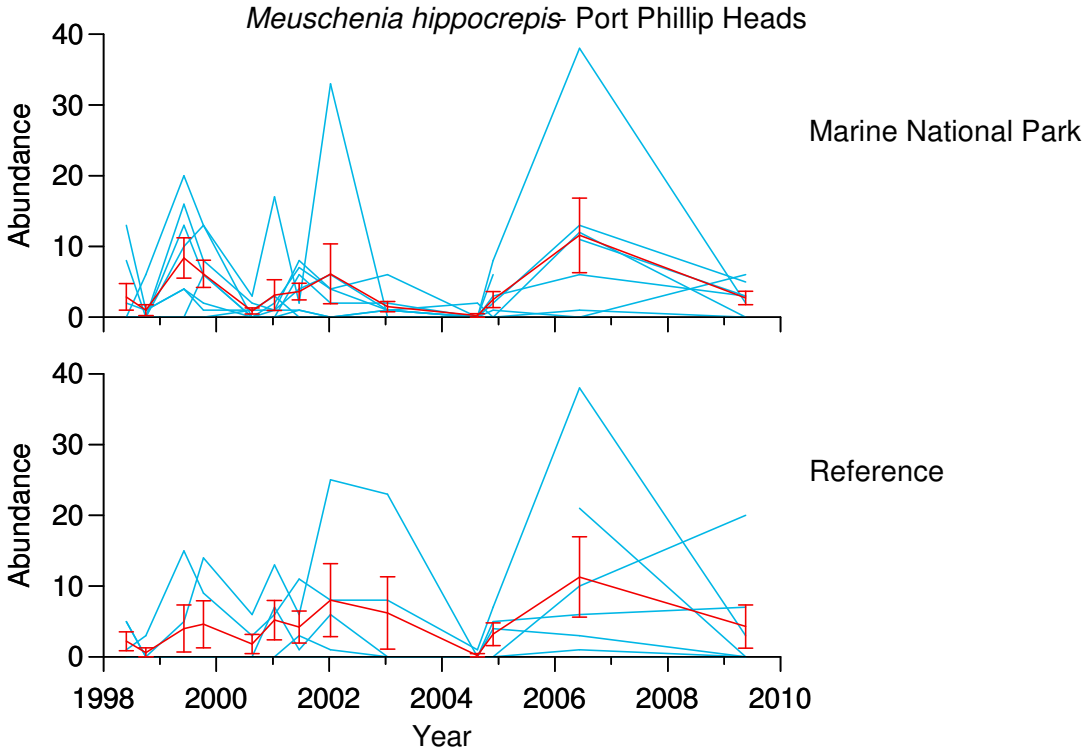


Figure 4.25. Densities (number per 2000 m2) of horseshoe leatherjacket *Meuschenia hippocrepis* at Port Phillip Heads.

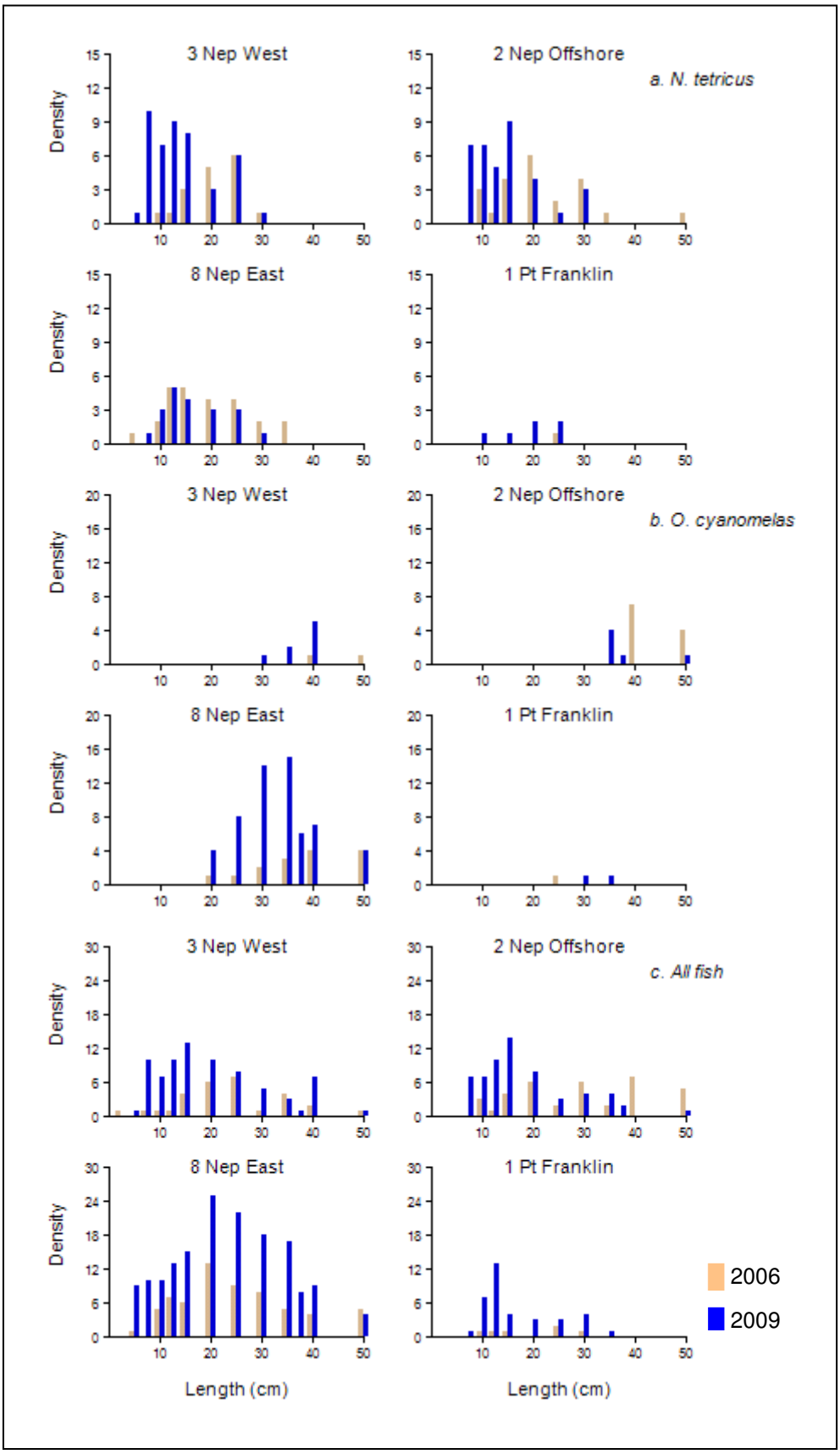


Figure 4.26. Fish size-densities (number per 200m²) in the vicinity of Point Nepean: (a) blue throat wrasse *Notolabrus tetricus*; (b) herring cale *Odax cyanomelas*; and (c) all observed fish.

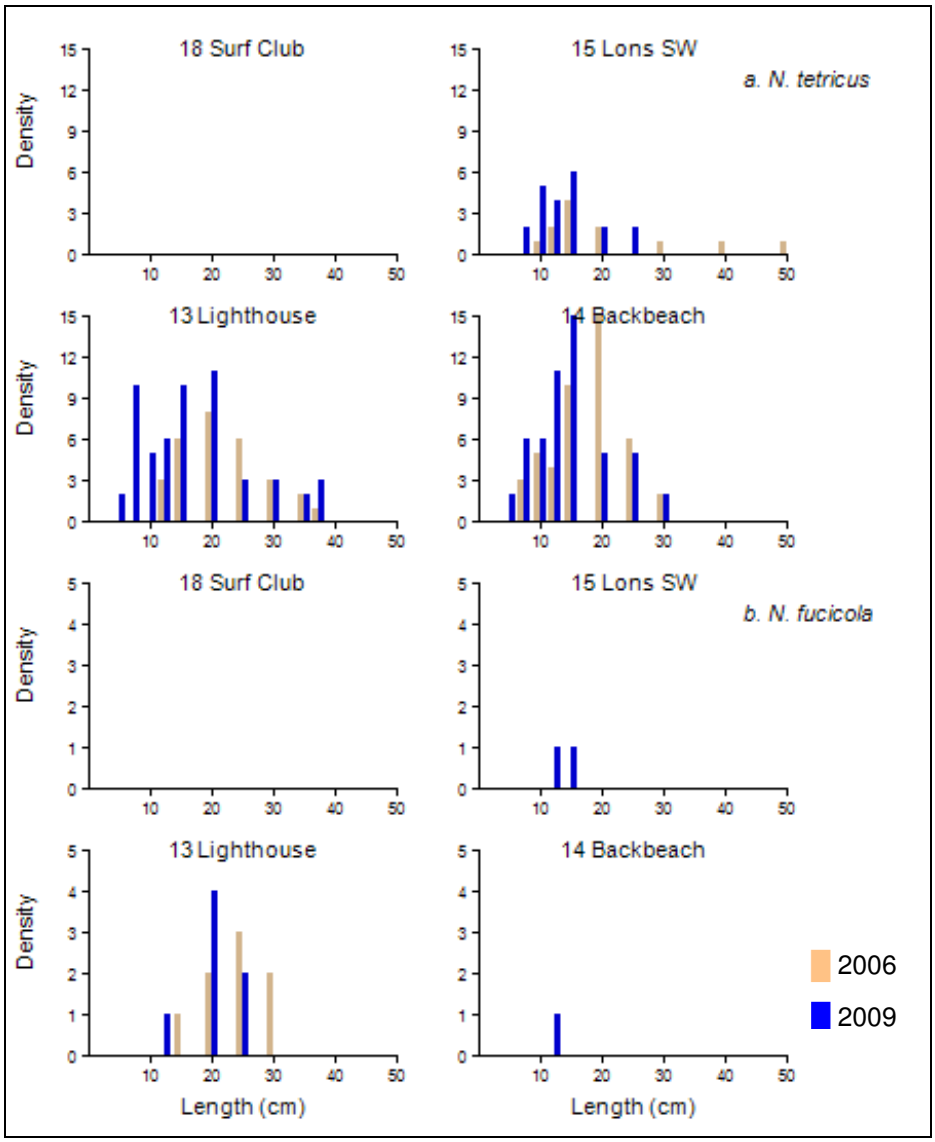


Figure 4.27. Fish size-densities (number per 200m²) in the vicinity of Point Lonsdale: (a) blue throat wrasse *Notolabrus tetricus*; and (b) purple wrasse *Notolabrus fucicola*.

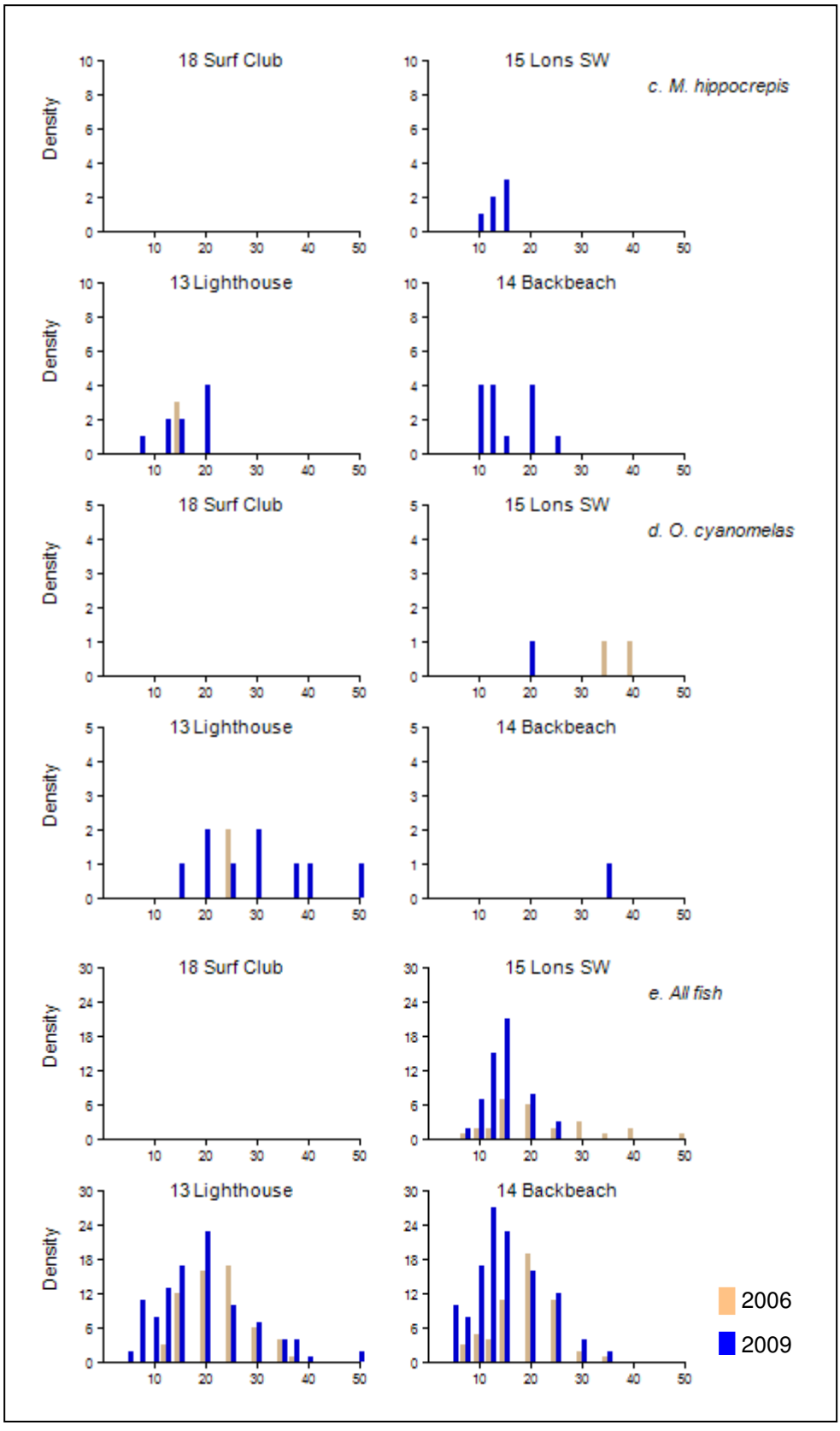


Figure 4.27 (continued). Fish size-densities (number per 200m²) in the vicinity of Point Lonsdale: (a) horseshoe leatherjacket *Meauschenia hipposcrepis*; (b) herring cale *Odax cyanomelas;* and (e) all observed fish.

5 THE ANNULUS AND SOUTH CHANNEL FORT

5.1 Site descriptions

The Annulus (Popes Eye) and South Channel Fort are both artificial structures, built in the 1880's as part of a strategic set of fortifications to protect the entrance of Port Phillip Bay.

The construction of the Annulus was never completed. It forms a semicircular reef of basalt blocks rising from sand at 10 to 12 m depth. It is a seal haul-out and supports a significant breeding colony of Australasian gannets *Morus serrator*. The Annulus was included in the Harold Holt Marine Reserves proclaimed in 1979.

South Channel Fort is an island with 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*. A jetty on the western side of the island was demolished and replaced in the late 1990's, with reconstruction and rock revetment work complete by summer 2000. The jetty construction did not appear to affect the average abundance of most common plant and animal species at this site (Gilmour *et al*, 2007).

5.2 Macroalgae

Popes Eye (Site 12) and South Channel Fort (Site 4) are relatively sheltered and were dominated by the kelp *Ecklonia radiata*. It was particularly abundant at Popes Eye, were it had around 60 % coverage (Figure 5.2). *Phyllospora comosa*, which dominates the more exposed Port Phillip Heads sites, was not recorded at either Popes Eye or South Channel Fort.

The green alga *Cladophora prolifera* (Figure 5.1) and *Caulerpa* species were consistently abundant at the inner Heads sites but were uncommon in other areas of Port Phillips Heads.

The brown algae *Cystophora moniliformis* occurred at low density at South Channel Fort but was not recorded at Popes Eye (Figure 5.3). *Caulocystis cephalornithos* and *Sargassum* species were prevalent at South Channel Fort.

Red algal species, such as *Melanthalia obtuse*, *Phacelocarpus peperocarpus*, *Pterocladia lucida* and *Ballia callitricha*, were relatively common at most Port Phillip Heads sites. These species were generally absent at South Channel Fort (Site 4), possibly because of high silt loading, and only occurred irregularly at low densities at Popes Eye (Site 12; Figures 5.5 to 5.8).

The seagrass *Amphibolis antarctica* was not recorded at either Inner Heads sites.

5.3 String Kelp *Macrocystis angustifolia*

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 (Figure 5.9). By autumn 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 radiata* canopy. Although a few tall plants were still present in the far eastern and far western clumps, 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 (Figure 5.10). A small number of plants were observed in the far west transect during the ninth survey, summer 2003, the tenth survey, winter of 2004, and the eleventh survey, summer of 2004. *Macrocystis angustifolia* was not recorded at Popes Eye in 2006 and only at very low abundance during the most recent survey.

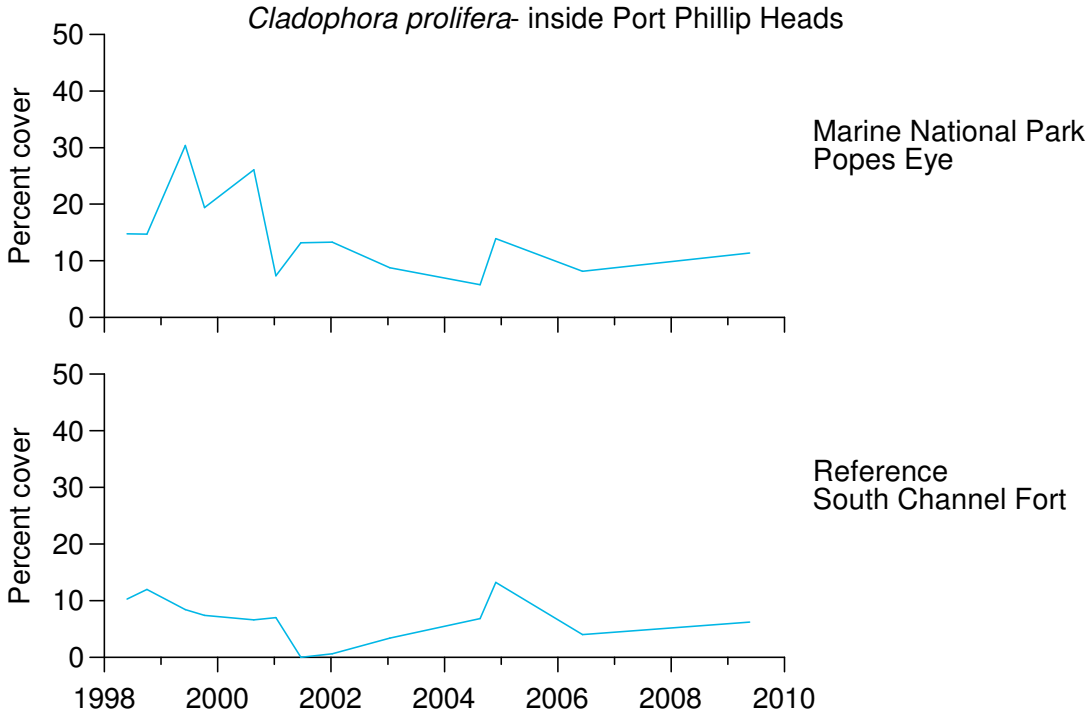


Figure 5.1. Trends in abundance of the filamentous green alga *Cladophora prolifera* at Popes Eye and South Channel Fort.

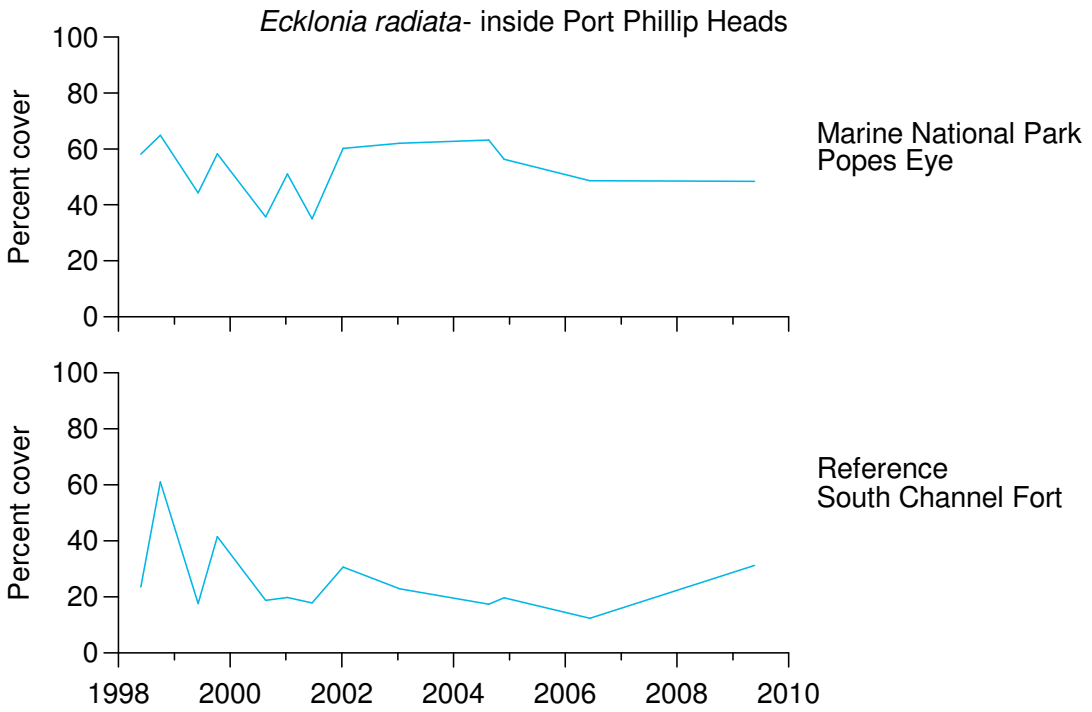


Figure 5.2. Trends in abundance of the common kelp *Ecklonia radiata* at Popes Eye and South Channel Fort. Note the different scale for Site 17.

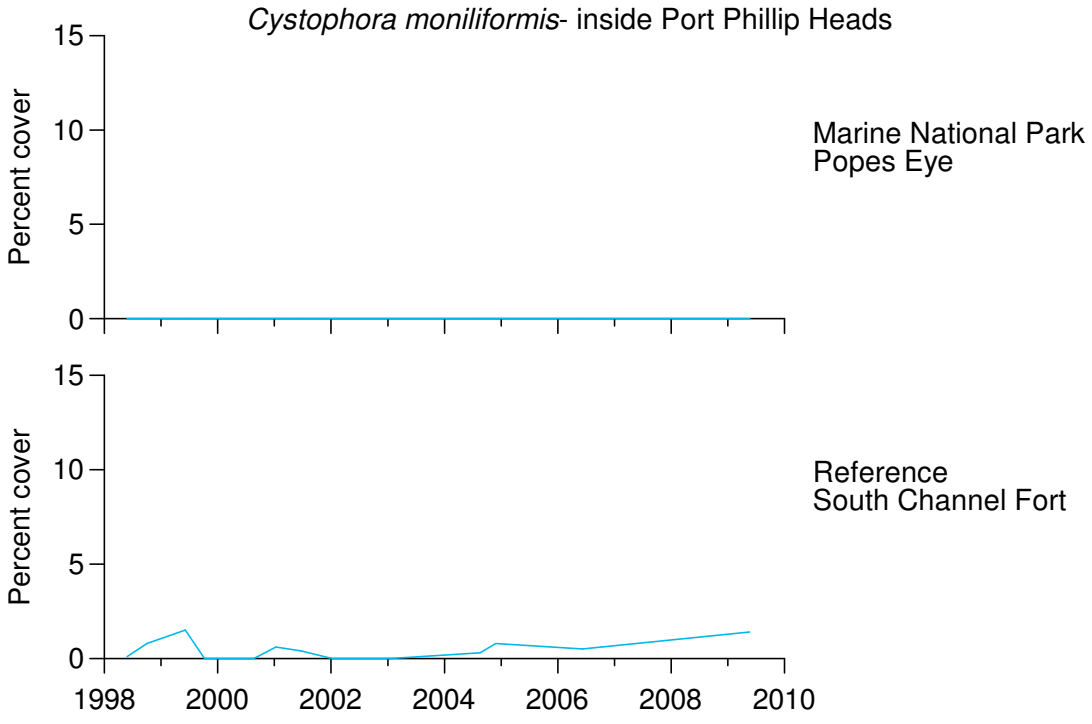


Figure 5.3. Trends in abundance of the brown alga *Cystophora moniliformis* at Popes Eye and South Channel Fort.

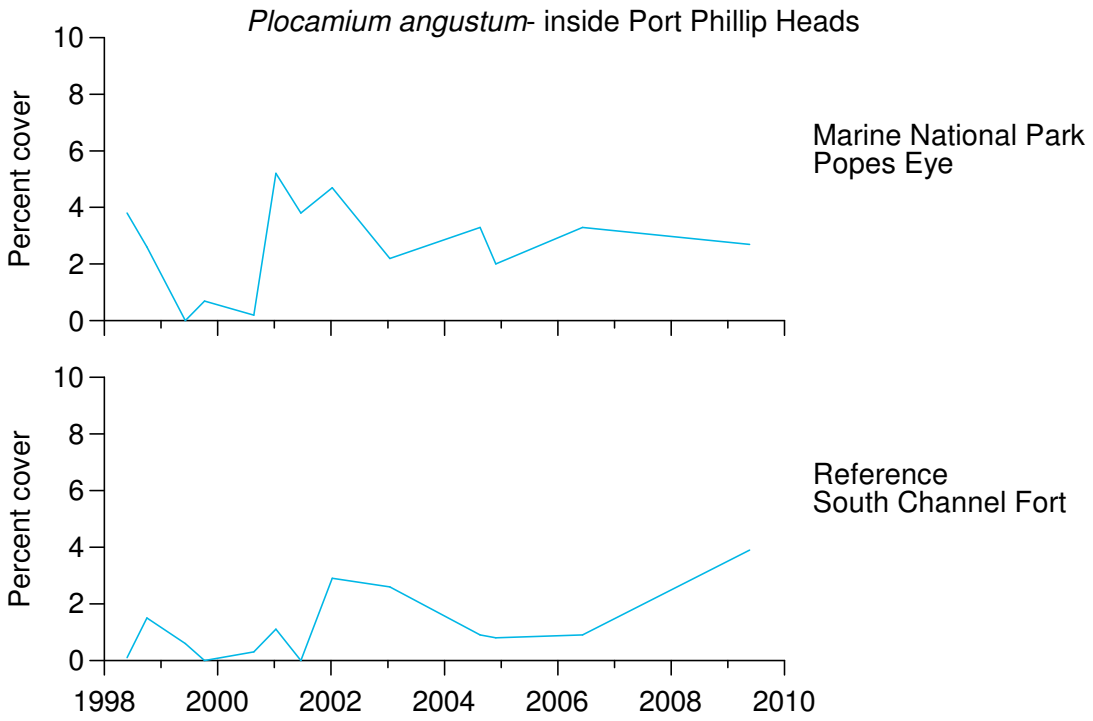


Figure 5.4. Trends in abundance of the red alga *Plocamium angustum* at Popes Eye and South Channel Fort.

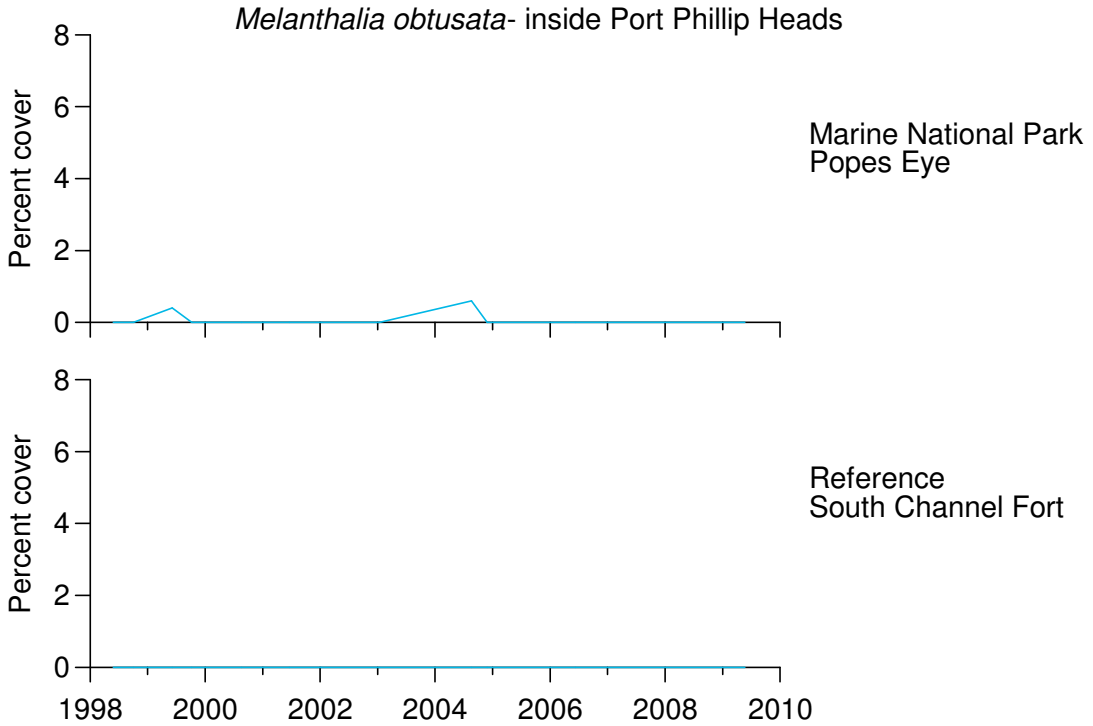


Figure 5.5. Trends in abundance of the red alga *Melanthalia obtusata* at Popes Eye and South Channel Fort.

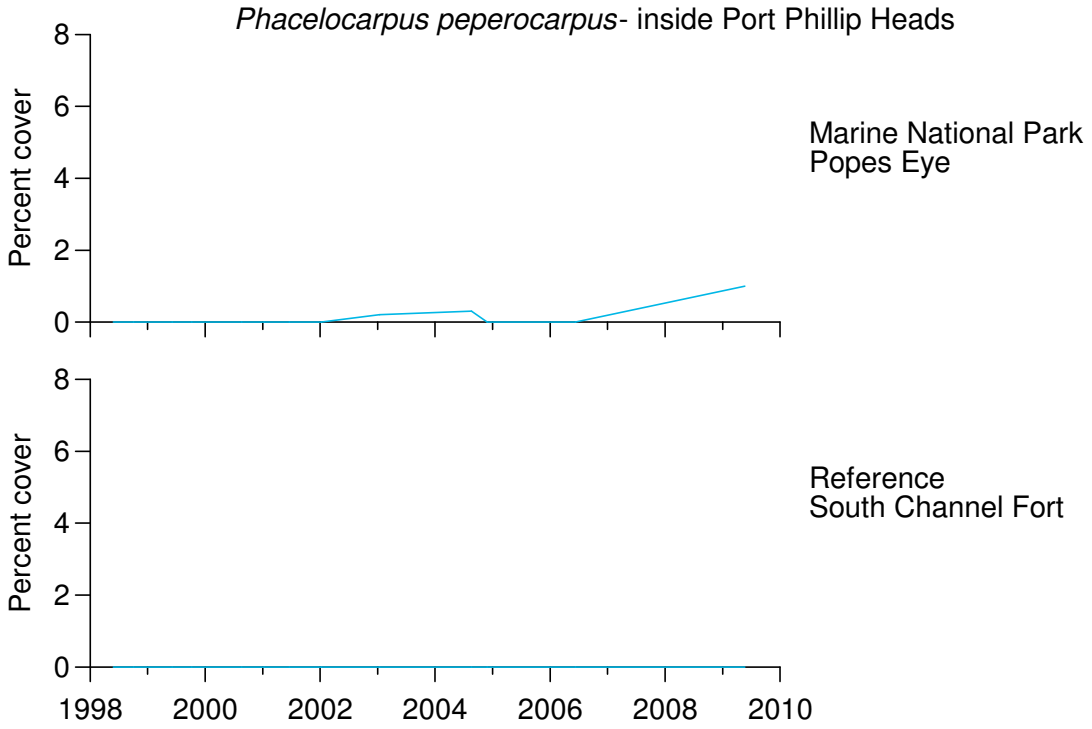


Figure 5.6. Trends in abundance of the red alga *Phacelocarpus peperocarpus* at Popes Eye and South Channel Fort.

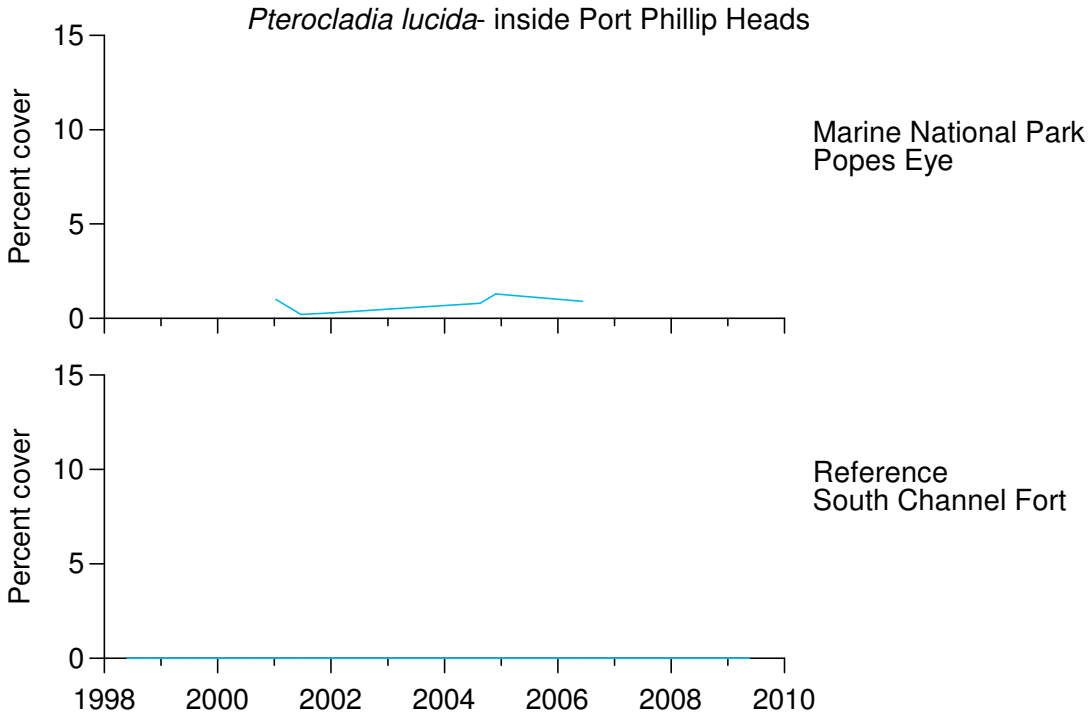


Figure 5.7. Trends in abundance of the red alga *Pterocladia lucida* at Popes Eye and South Channel Fort.

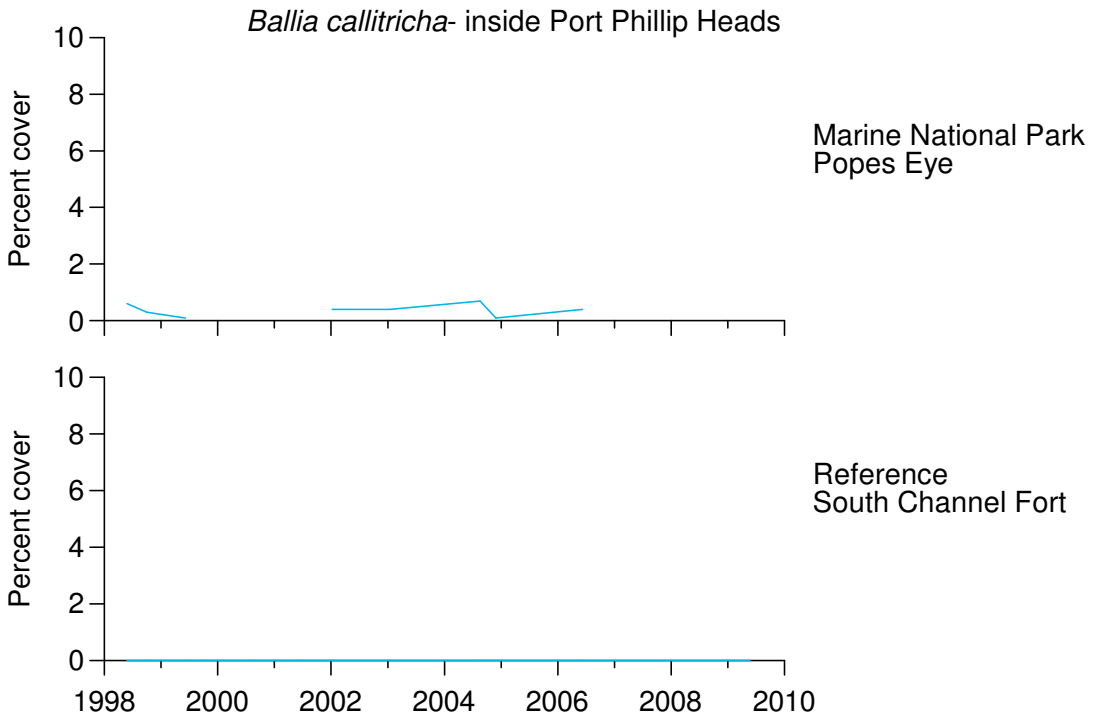


Figure 5.8. Trends in abundance of the red alga *Ballia callitricha* at Popes Eye and South Channel Fort.

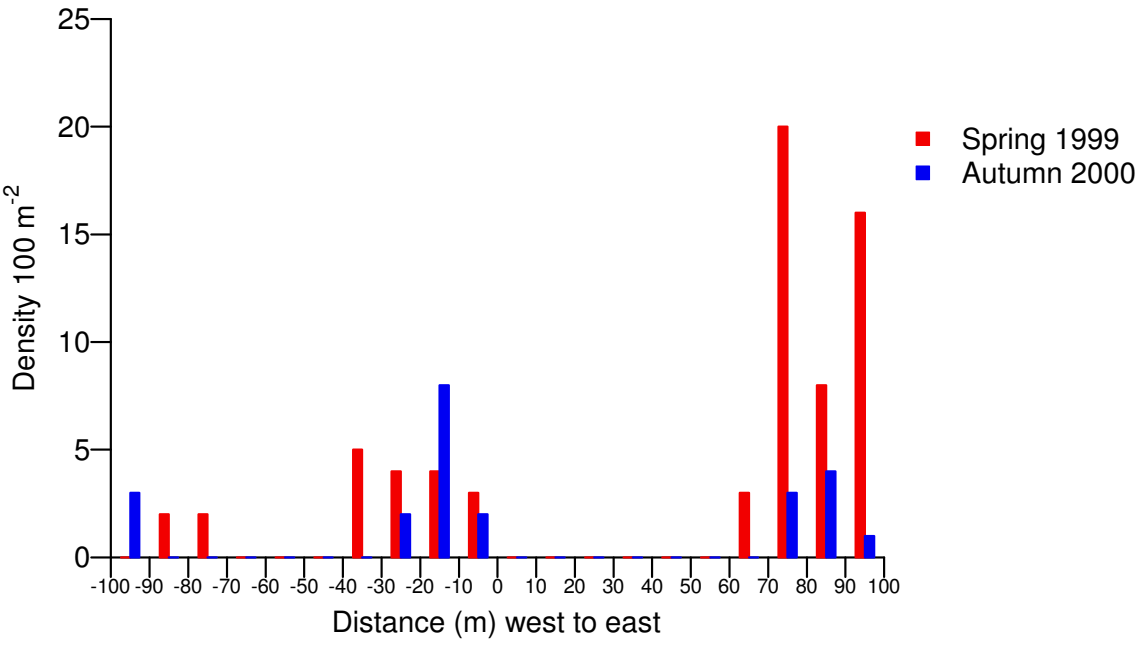


Figure 5.9. Distribution and abundance of string kelp *Macrocystis angustifolia* plants at Popes Eye (Site 12) during first two surveys using Method 4 (Survey 4 and 5).

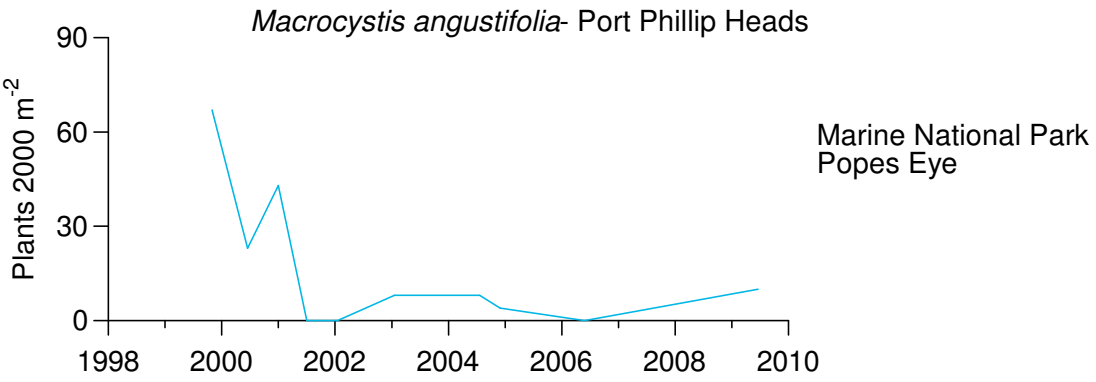


Figure 5.10. Density of string kelp *Macrocystis angustifolia* plants measured using Method 4 at: Popes Eye (Site 12).

5.4 Invertebrates

Abalone *Haliotis rubra* were in low abundances at Popes Eye (Sites 12) and particularly low at South Channel Fort (Site 4; Figure 5.11). No *H. laevigata* have been recorded at the Popes Eye site over the course of the monitoring program and only a single individual has been recorded at South Channel Fort, in 2009 (Figure 5.12).

The gastropod *Turbo undulatus*, which is common at most Port Phillip Heads sites, has not been recorded Popes Eye and only irregularly and at low density at South Channel Fort (Figure 5.13).

The urchin *Heliocidaris erythrogramma* was common, particularly at South Channel Fort, where there was a declining trend in its abundance, from 241 per 2000 m^2 in 1998 to 15 per 2000 m^2 in 2006 before a slight increase to 67per 2000 m^2 in 2009 (Figure 5.14).

Comanthus tricoptera was the most abundant macroinvertebrate recorded. It was particularly abundant in 2006, when densities at both sites increased fivefold, before returning to earlier levels in 2009 (Figure 5.16). A similar but smaller spike in abundance was observed at Port Phillip Heads sites Shortland Bluff (Site 5) and Nepean Offshore (Site 2).

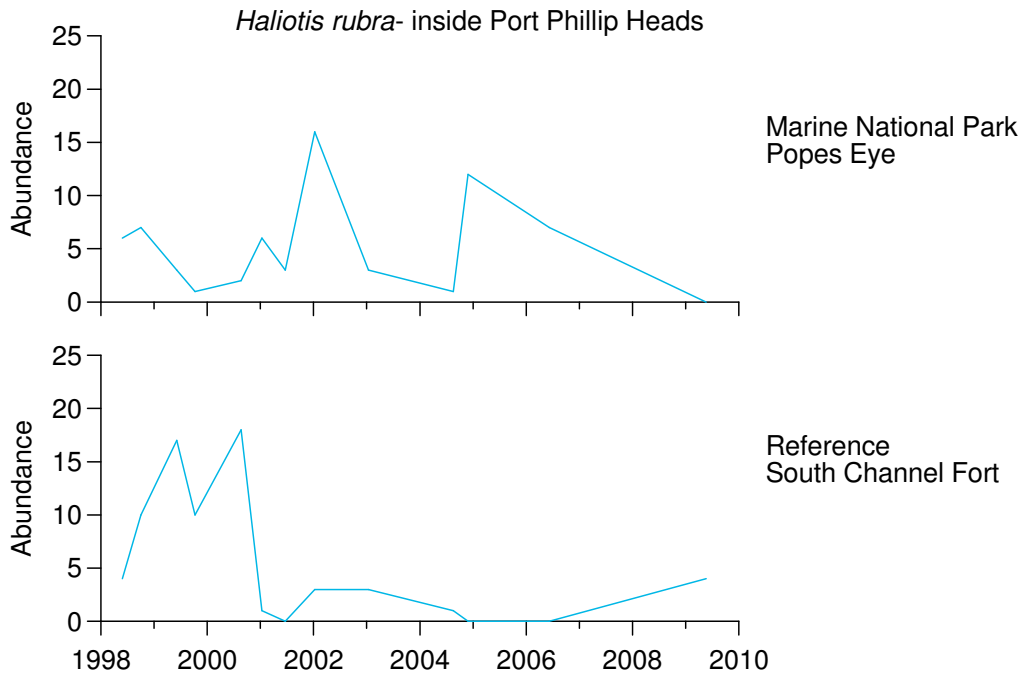


Figure 5.11. Densities (number per 2000 m^2) of the blacklip abalone *Haliotis rubra* at Popes Eye and South Channel Fort.

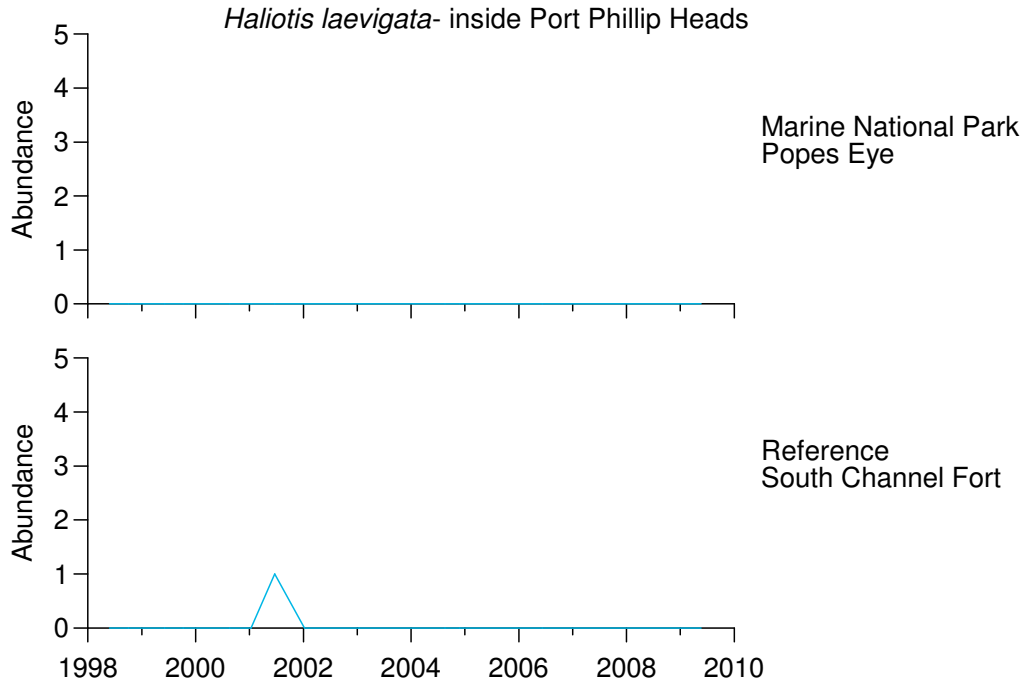


Figure 5.12. Densities (number per 2000 m^2) of the greenlip abalone *Haliotis laevigata* at Popes Eye and South Channel Fort.

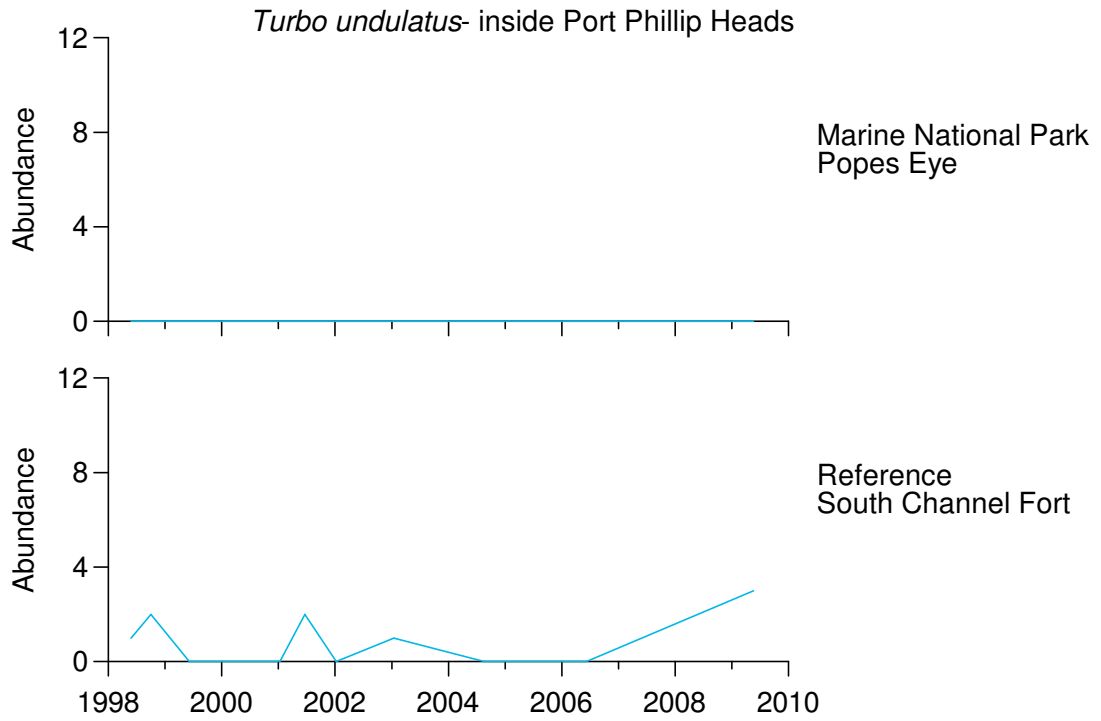


Figure 5.13. Densities (number per 2000 m^2) of the warrener *Turbo undulatus* at Popes Eye and South Channel Fort.

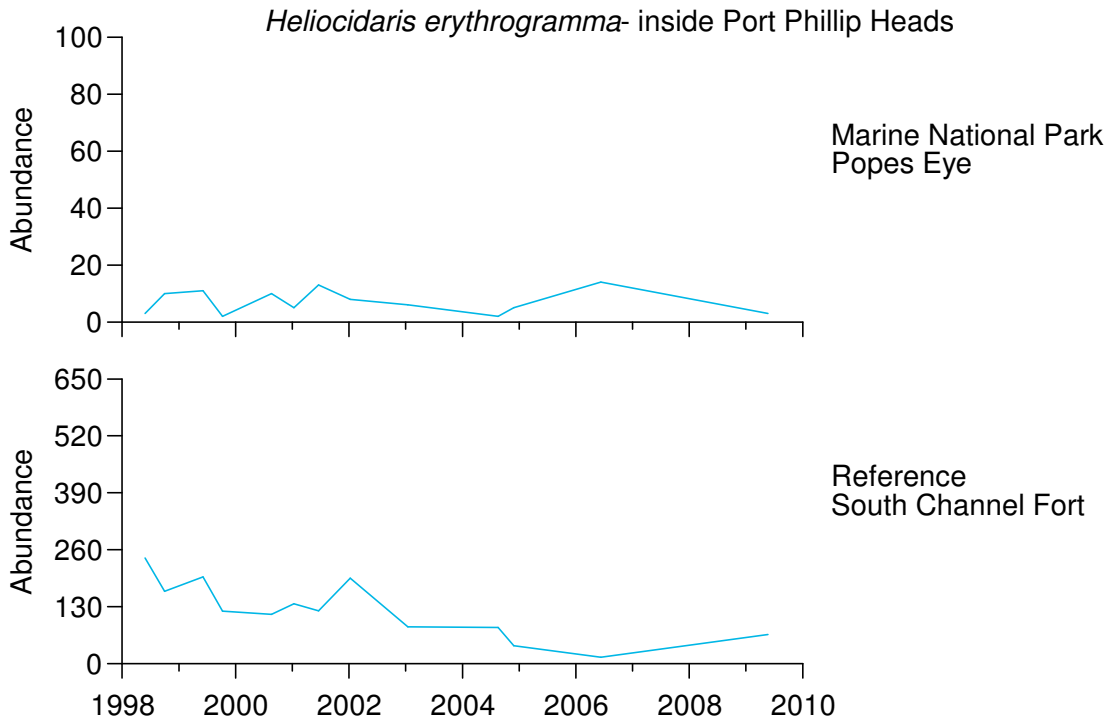


Figure 5.14. Densities (number per 2000 m^2) of the sea urchin *Heliocidaris erythrogramma* at Popes Eye and South Channel Fort. Note the different scales.

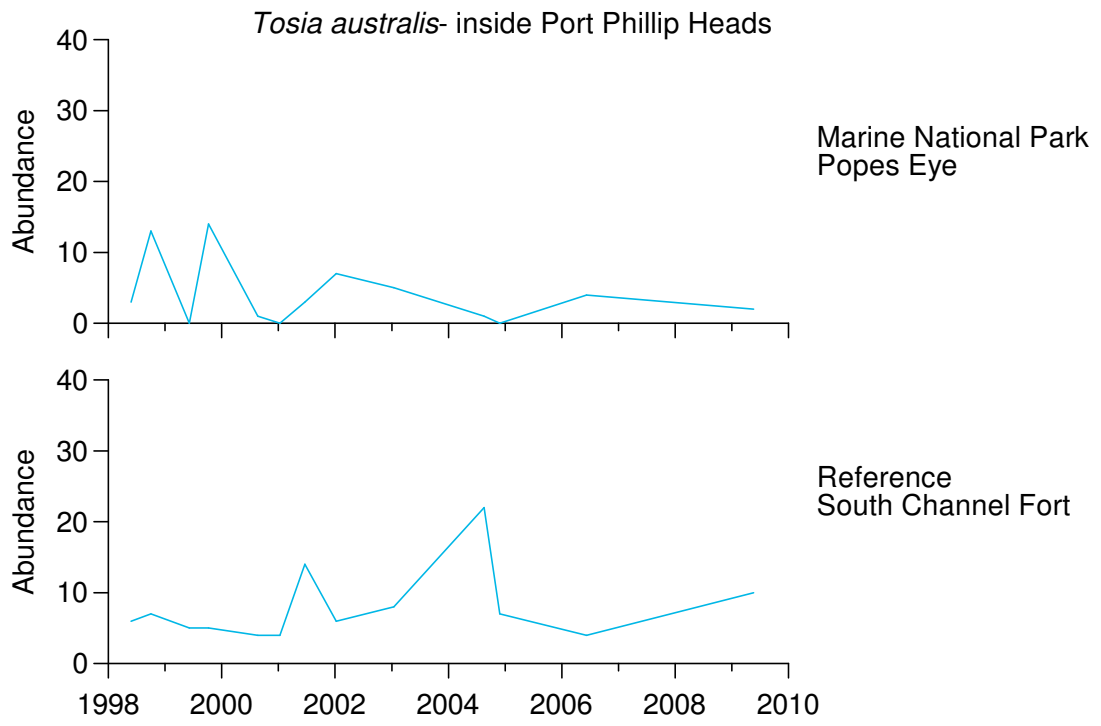


Figure 5.15. Densities (number per 2000 m^2) of the common biscuit star *Tosia australis* at Popes Eye and South Channel Fort.

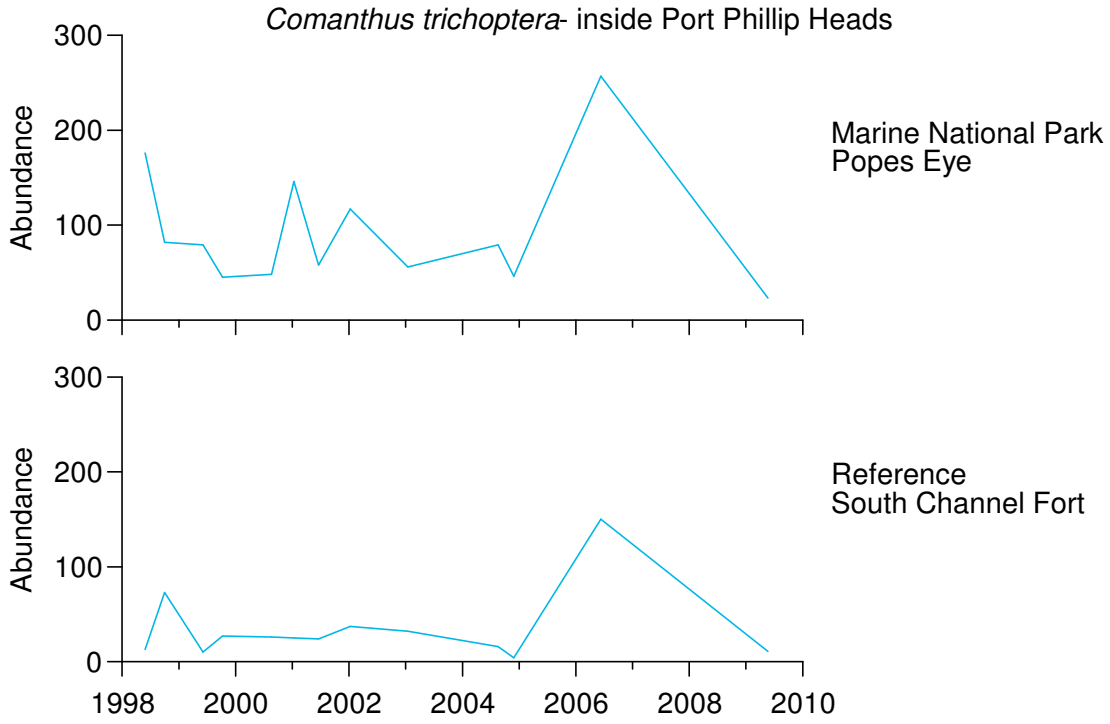


Figure 5.16. Densities (number per 2000 m^2) of the feather star *Comanthus trichoptera* at Popes Eye and South Channel Fort.

5.5 Fishes

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. 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.

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 generally not elsewhere. Barber perch *Caesioperca rasor*, were similarly only abundant at South Channel Fort and Popes Eye. Scalyfin *Parma victoriae*, purple wrasse *Notolabrus fucicola*, senator wrasse *Pictilabrus laticlavius*, globefish *Diodon nichthemerus* and various leatherjackets were also common at South Channel Fort.

There was an increasing trend in *Notolabrus tetricus* abundances over the monitoring period at Popes Eye (Site 12; Figure 5.17). There was an apparent increase in *N. fucicola* at Popes Eye (Site 12), until the two most recent surveys, when abundances declined sharply (Figure 5.18).

Scalyfin *Parma victoriae*, abundance was the highest ever recorded at Popes Eye during the Survey 11, but numbers decreased to previous levels by Survey 12 (Figure 5.19). The Survey 11 increase was largely attributed to a higher abundance of smaller individuals (Figure 5.24).

The southern hula fish *Trachinops caudimaculatus* was typically only observed at Popes Eye and South Channel Fort (Sites 12 and 4; Figure 5.23). There appears to have been an increasing trend in abundance of *T. caudimaculatus* at Popes Eye since 2000 and is approaching densities not recorded since the initial survey in 1998. No trend has been apparent at South Channel Fort.

The observed size structures of common fishes, such as *Parma victoriae, Notolabrus tetricus*, *Notolabrus fucicola*, and *Odax cyanomelas* are given in Figures 5.24. 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 %).

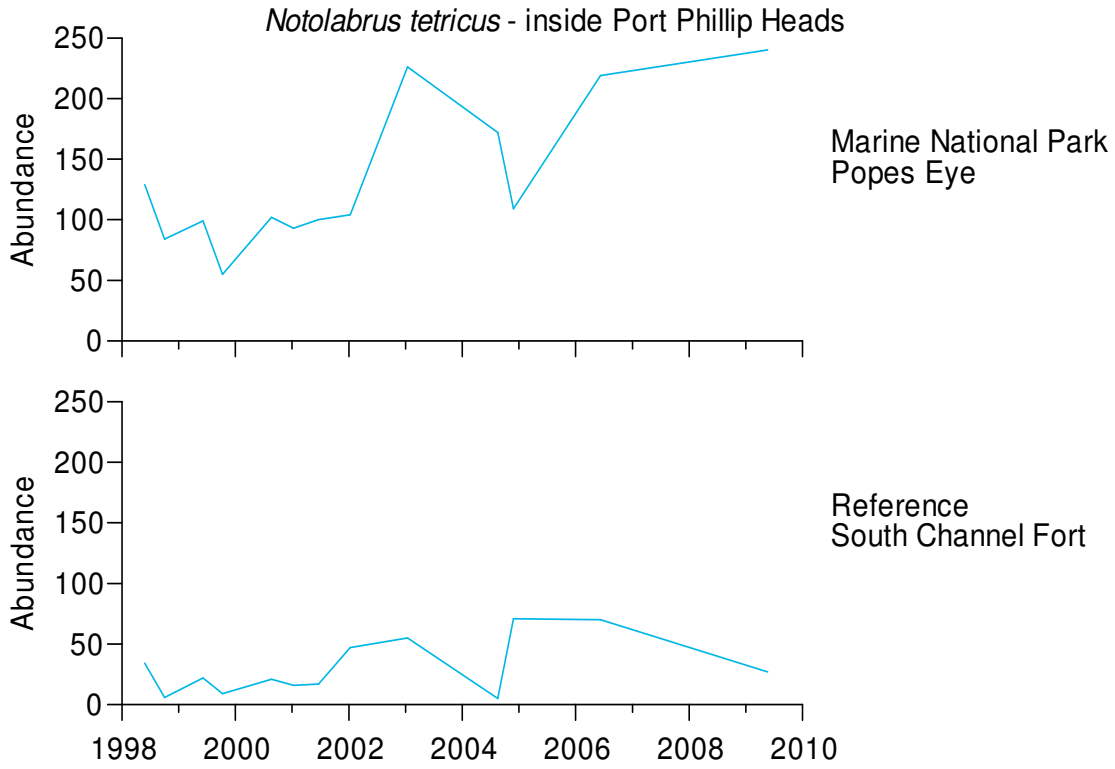


Figure 5.17. Densities (number per 2000 m^2) of blue-throated wrasse *Notolabrus tetricus* at Popes Eye and South Channel Fort.

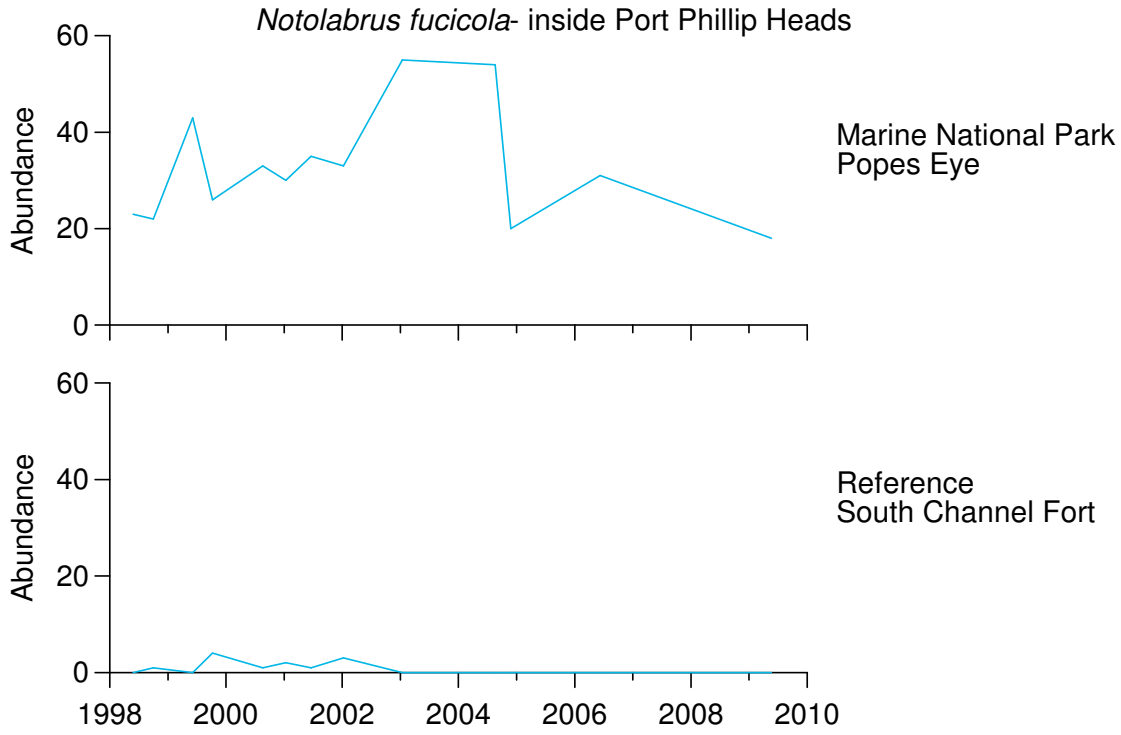


Figure 5.18. Densities (number per 2000 m^2) of purple wrasse *Notolabrus fucicola* at Popes Eye and South Channel Fort.

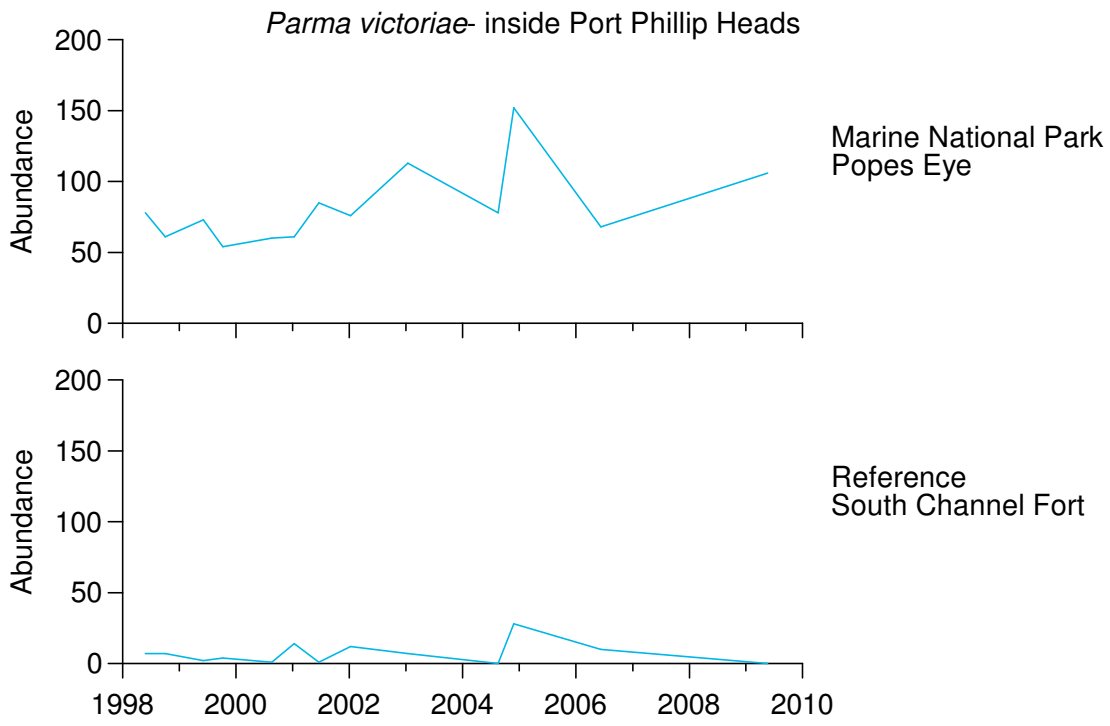


Figure 5.19. Densities (number per 2000 m^2) of scalyfin *Parma victoriae* at Popes Eye and South Channel Fort.

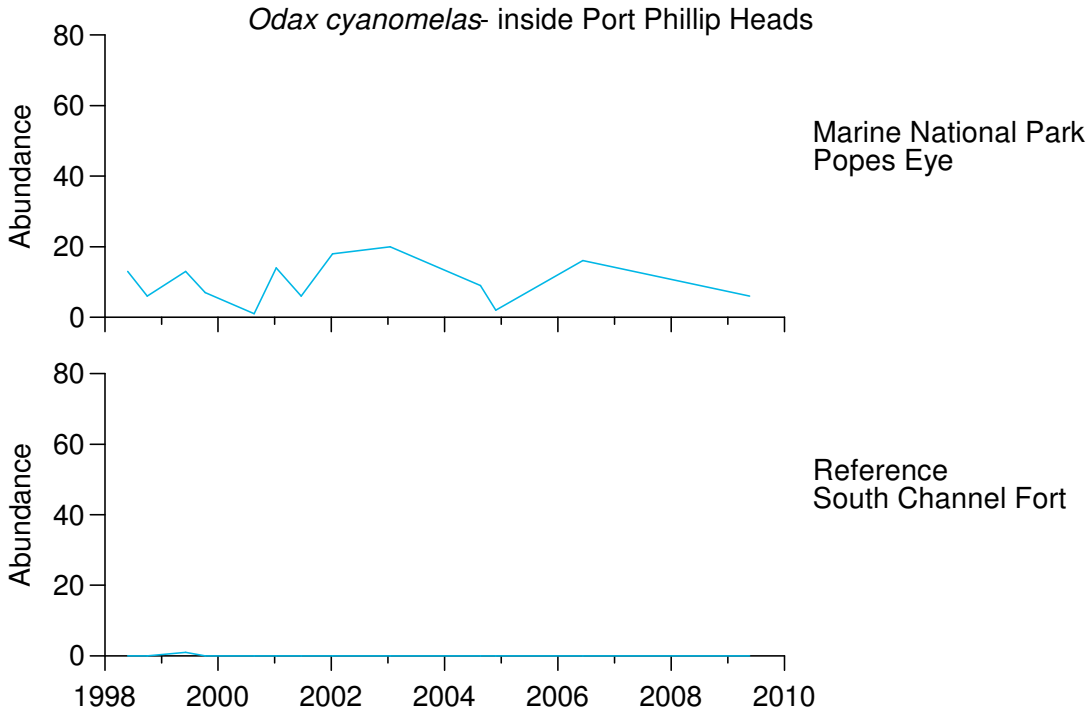


Figure 5.20. Densities (number per 2000 m^2) of herring cale *Odax cyanomelas* at Popes Eye and South Channel Fort.

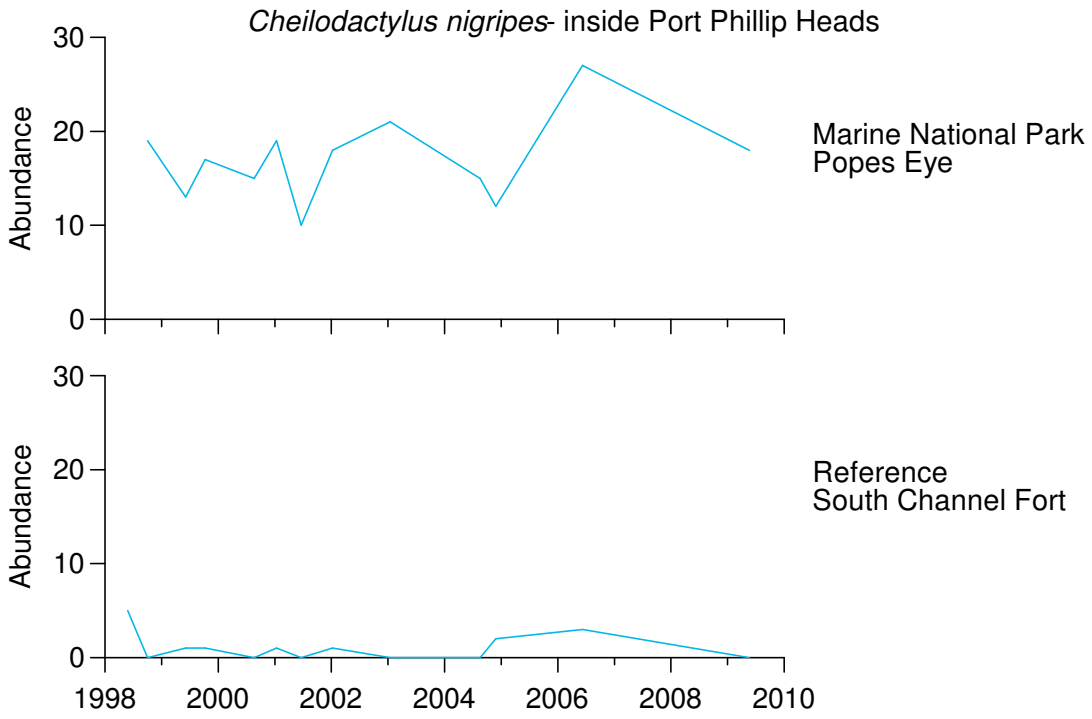


Figure 5.21. Densities (number per 2000 m^2) of magpie morwong *Cheilodactylus nigripes* at Popes Eye and South Channel Fort.

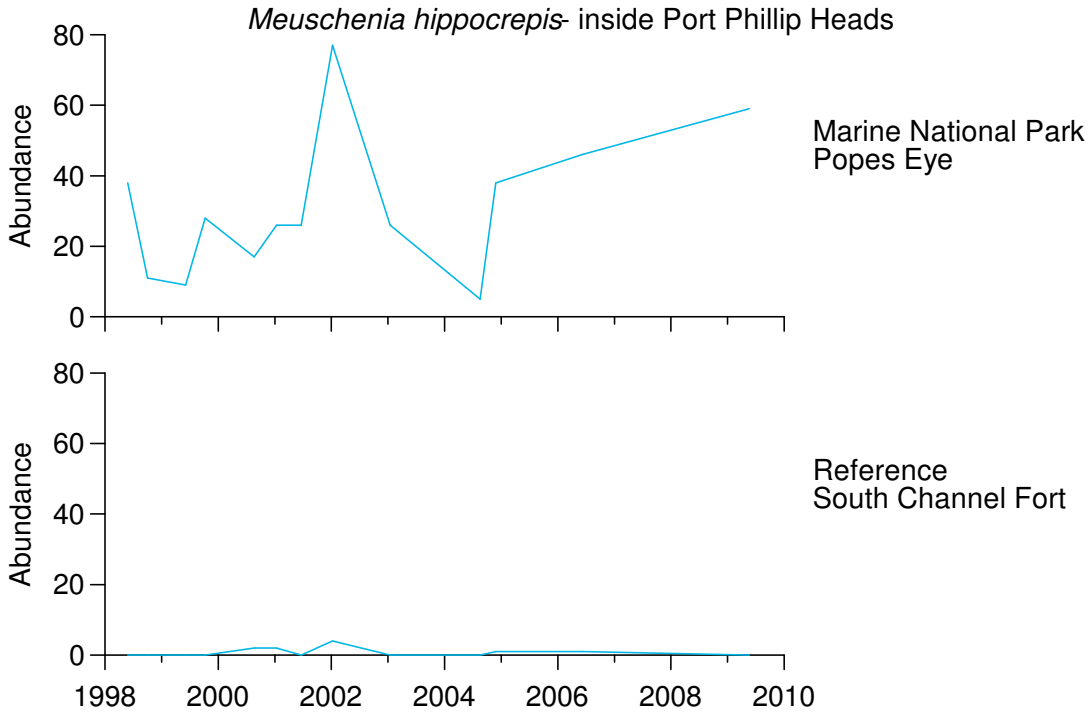


Figure 5.22. Densities (number per 2000 m^2) of horseshoe leatherjacket *Meuschenia hippocrepis* at Popes Eye and South Channel Fort.

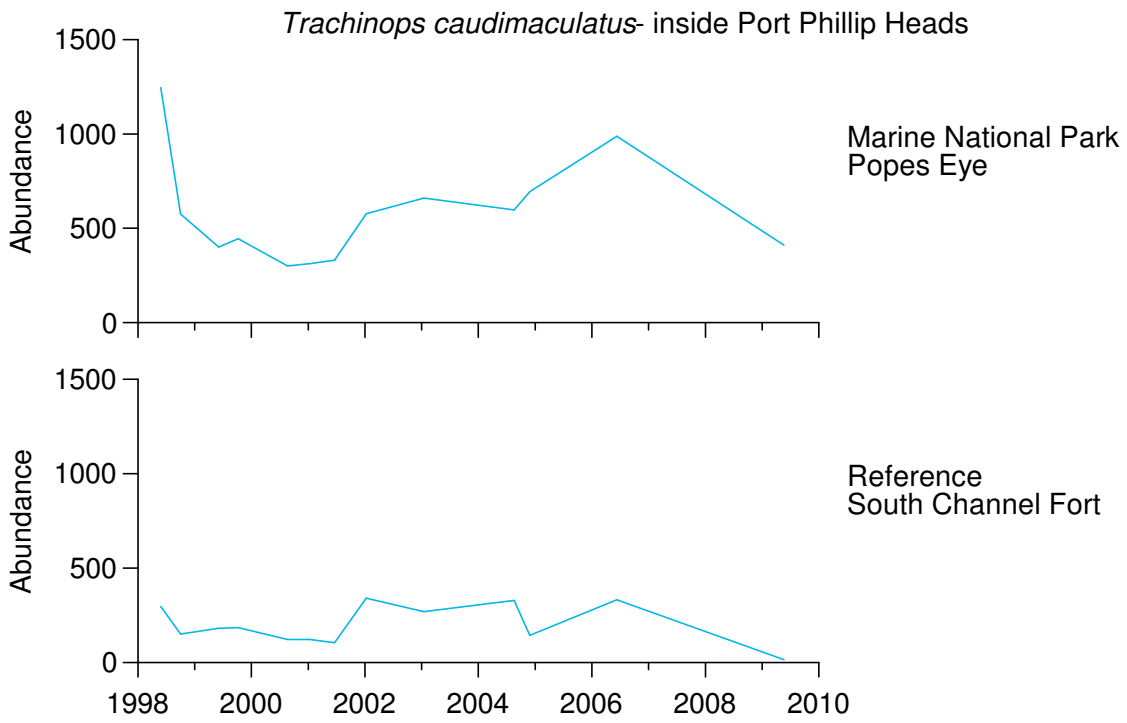


Figure 5.23. Densities (number per 2000 m^2) of southern hulafish *Trachinops caudimaculatus* at Popes Eye and South Channel Fort.

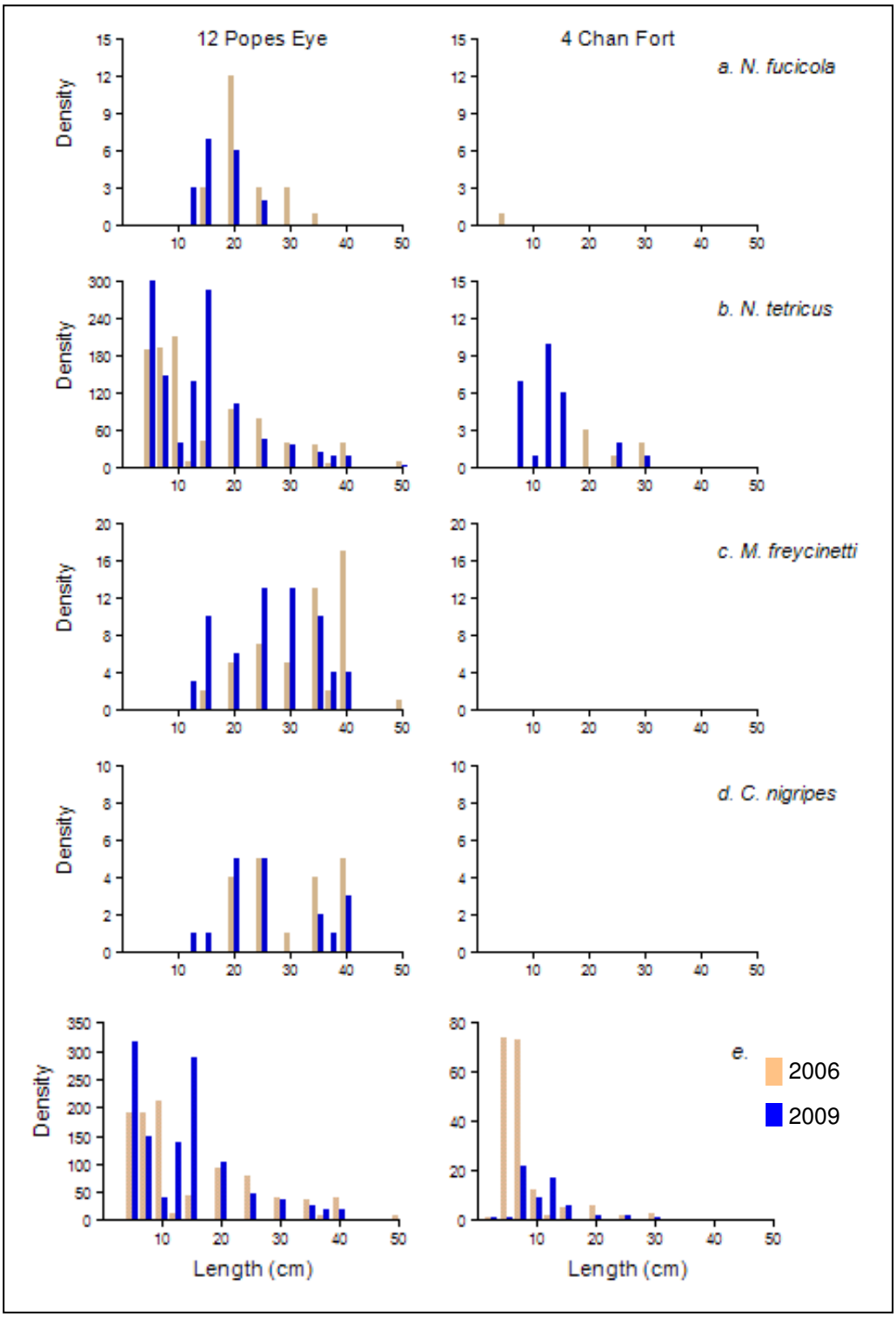


Figure 5.24. Fish size-densities (number per 200m²) at Popes Eye (Site 12) and South Channel Fort (Site 4): (a) purple wrasse Notolabrus fucicola; (b) blue throat wrasse *Notolabrus tetricus*; (c) six-spined leatherjacket *Meuschenia freycineti*; (d) magpie perch *Cheilodactylus nigripes*; and (e) all observed fish.

6 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.

No *Sabella* individuals were observed during the two most recent surveys.

Also observed at South Channel 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.

ACKNOWLEDGEMENTS

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APPENDIX 1

A1. Site Details

A1.1 Port Phillip Heads Marine National Park

Point Franklin – Site 2801

Site Description

Point Franklin is a reference site for Port Phillip Heads Marine National Park. The habitat structure at Point Franklin is generally flat low profile reef. There are some small sand patches a high ledge on the southern end of the reef. The marker is characterised by pavement reef with a variety of browns, particularly Sargassums. Stunted Ecklonia is found on T3 with Amphibolis patched along T4.

Transect Layout

The Point Franklin reference site is at 2 m depth. T2 and T1 are in a straight line westward from the marker and run parallel to a higher ledge on the left (south) as reeling out. T3 and T4 curve northeast around the point then to the east. The current runs particularly strong on T4.

Latest Survey Notes

Latest survey: 2/6/2009. Dieback of the kelp *Ecklonia radiata* was observed the 2009. This occurred along the eastern transects (T3 and T4) the disease caused necrosis of the blade and lateral fronds back to the stipe.

Figure A1.1. Site dive transects for Point Franklin (Site 2801), a reference site for Port Phillip Heads Marine National Park.

Table A1.1. Site details for Point Franklin (Site 2801), a reference site for Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.3173	144.7173	55	300435	5756513	2	N	Ref

Nepean Offshore – Site 2802

Site Description

Nepean Offshore is a reference site for Port Phillip Heads Marine National Park. This site is location on tilting bedrock. The slopes of the ridges are covered in Amphibolis while the ridge tops and faces have a higher abundance of Cystorphora, Sargassum and Caulerpa spp. Sand patches along the reef need to be crossed to get onto more patches of reef.

Transect Layout

T2 and T1 head southwest, following the line of the ridges, and T3 and T4 veer southeast but not directly into the bay.

Latest Survey Notes

Latest survey: 19/6/2009. String *Macrocystis angustifolia* was present during the 2009 survey after being absent in 2006, however only two plants were recorded.

Table A1.2. Site details for Nepean Offshore (Site 2802) in Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.3021	144.6587	55	295272	5758074	2	N	MPA

Nepean Inner West – Site 2803

Site Description

Nepean Inner West is located within the Port Phillip Heads Marine National Park and is relatively sheltered and shallow, located near a sandy inlet in the reef. The substratum consists of low profile reef with occasional sand patches. The western end of the transect runs over Amphobolis beds.

Transect Layout

T2 and T1 head in a westerly direction from the marker. T3 initially heads east for a short distance then curves northward and T4 does an easterly dogleg into the reef.

Latest Survey Notes

Latest survey: 19/5/2009. Abundances of blacklip abalone *Haliotis rubra* increased between 2006 and 2009 interrupting a decline trend. There was a notable increase in the abundance of blue throat wrasse *Notolabrus tetricus* during the most recent survey.

Table A1.3. Site details for Nepean Inner West (site 2803) in Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.3041	144.6558	55	295029	5757841	2	N	MPA

South Channel Fort – Site 2804

Site Description

South Channel Fort is the reference site for Annulus (Pope's Eye). South Channel Fort is an artificial reef in the south of Port Phillip Bay. The site is particularly shallow, the marker buoy cannot be set by boat due to the depth. The site is located on the western portion of the boulder area which is characterised by a variety of Sargassum spp. Generally boulders are interspersed by sand near the foot of the rubble slope.

Transect Layout

T2 heads east over the boulders then curves around the eastern side of the island into T1. T3 curves around the south of the fort at 2 m, T4 follows the isobath round the southwestern corner and then does a dog leg into the torpedo boat bay.

Latest Survey Notes

Latest survey: 18/6/2009. There was an increase in the abundance of kelp *Ecklonia radiata* between 2006 and 2009. There was a slight increase in urchin *Heliocidaris erythrogramma* between 2006 and 2009. Abundance of blue throat wrasse increased during the previous survey.

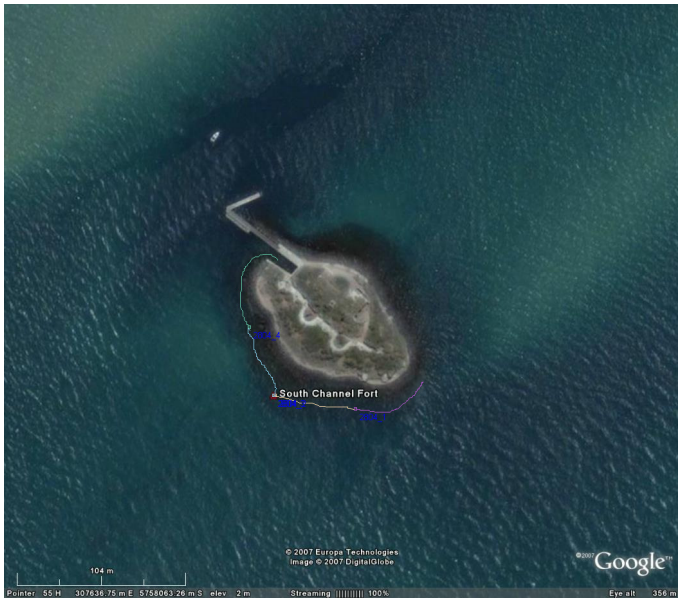

Figure A1.4. Site dive transects for South Channel Fort (Site 2804) a reference site for Port Phillip Heads Marine National Park.

Table A1.4. Site details for South Channel Fort (Site 2804) a reference site for Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.3069	144.801	55	307732	5757843	2	N	Ref

Shortland Bluff – Site 2805

Site Description

Shortland Bluff is a reference site for Port Phillip Heads Marine National Park. The substratum consists of generally patches of rubble and low reef outcrops with a mixture of fucaleans and Amphibolis.

Transect Layout

The transects are parallel to the short and the 2 m depth contour.

Latest Survey Notes

Latest survey: 21/5/2009. The green alga *Cladophora prolidera* had a relatively low abundance during the 2009 survey. This species had usually been present, although the abundance was variable over time. There was also a decrease in the abundance of brown alga *Cystophora moniliformis* interrupting an increase trend. Abundances of blacklip abalone *Haliotis rubra* increased between 2006 and 2009 interrupting a decline trend, coincided with an increase in the greenlip abalone *Haliotis laevigata.*

Figure A1.5. Site dive transects for Shortland Bluff (Site 2805) a reference site for Port Phillip Heads Marine National Park.

Table A1.5. Site details for Shortland Bluff (Site 2805) a reference site for Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2753	144.6555	55	294917	5761041	5	N	Ref

Victory Shoal – Site 2806

Site Description

Victory Shoal is located within the Port Phillip Heads Marine National Park. The substratum consists of low rocky outcrops interspersed by sand patches and sandy hollows. Some areas of boulders and cobble were interspersed with sand.

Transect Layout

The transect direction is generally in the same direction as the currents. There is a sandy patch to the east (offshore) from transect T4.

Latest Survey Notes

Latest survey: 3/6/2009. The green alga *Cladophora prolidera* had a relatively low abundance at Victory Shoal during the 2009 survey. This species was usually present although the abundance was variable over time.

Figure A1.6. Site dive transects for Victory Shoal (Site 2806) in Port Phillip Heads Marine National Park.

Table A1.6. Site details for Victory Shoal (Site 2806) in Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2802	144.6251	55	292269	5760431	5	N	MPA

Merlan Inner – Site 2807

Site Description

Merlan Inner is located within the Port Phillip Heads Marine National Park. The substratum consists of low profile reef and occasional bombies. The canopy includes Ecklonia, Phyllospora and Sierococcus, with a high diversity of understorey reds.

Transect Layout

T2 and T1 head towards Queenscliff with T3 and T4 towards the Rip.

Latest Survey Notes

Surveying discontinued at this site.

Latest survey: 24/11/2004

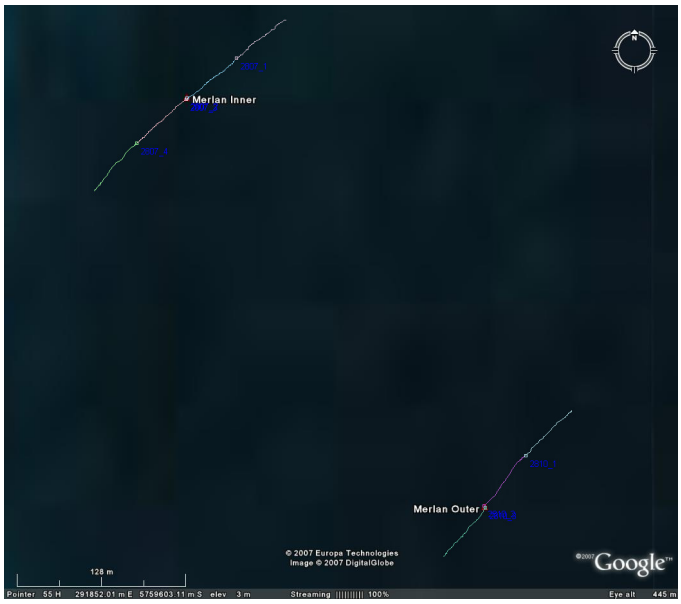

Figure A1.7. Site dive transects for Merlan Inner (Site 3207) in Port Phillip Heads Marine National Park.

Table A1.7. Site details for Merlan Inner (Site 3207) in Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2873	144.62	55	291846	5759624	5	N	MPA

Nepean Inner East – Site 2808

Site Description

Nepean Inner East is located within the Port Phillip Heads Marine National Park. The site is characterised by shallow reef with occasional outcrops. The habitat is predominantly *Cystophora moniliformis*, *Phyllospora comosa* and *Sargassum sonderi* (and many other fucales).

Transect Layout

T2 and T1 curve westward around the shallow reef with T3 and T4 curving around a bombie at the marker heading in an eastward direction.

Latest Survey Notes

Latest survey: 21/5/2009. Abundance of crayweed *Phyllospora comosa* continued to increase, a trend from 2003. This coincided with a decrease in kelp *Ecklonia radiata*. There was a notable increase in the abundance of horseshoe leatherjacket *Meuschenia hippocrepis* between 2006 and 2009.

Table A1.8. Site details for Nepean Inner East (Site 2808) in Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.3042	144.659	55	295302	5757834	2	N	MPA

Lonsdale Kelp Outer – Site 2809

Site Description

Lonsdale Kelp Outer is located within the Port Phillip Heads Marine National Park, located inside Point Lonsdale. These sites often have strong ground surge. The substratum consists of flat sand-affected reef.

Transect Layout

T2 and T1 head towards Queenscliff, and T3 and T4 towards the Rip. The transect is aligned with the currents.

Latest Survey Notes

Surveying discontinued at this site.

Latest survey: 26/11/2004

Figure A1.9. Site dive transects for Lonsdale Kelp Outer (Site 2809) in Port Phillip Heads Marine National Park.

Table A1.9. Site details for Lonsdale Kelp Outer (Site 2809) in Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2864	144.6296	55	292686	5759753	7	N	MPA

Merlan Outer – Site 2810

Site Description

Merlan Outer is located within the Port Phillip Heads Marine National Park. The site is similar to Merlan Inner (site 2807). The substratum consists of low profile reef and occasional bombies. The canopy includes Ecklonia, Phyllospora and Sierococcus, with a high diversity of understorey reds.

Transect Layout

T2 and T1 head towards Queenscliff with T3 and T4 towards the Rip. Transects run with the currents.

Latest Survey Notes

Latest survey: 22/5/2009. Abundance of crayweed *Phyllospora comosa* continued to increase, a trend from 2003. This coincided with a decrease in kelp *Ecklonia radiata*.

Figure A1.10. Site dive transects for Merlan Outer (Site 2810) in Port Phillip Heads Marine National Park.

Table A1.10. Site details for Merlan Outer (Site 2810) in Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2901	144.6226	55	292080	5759321	5	N	MPA

Lonsdale Kelp Inner – Site 2811

Site Description

Lonsdale Kelp Inner is located within the Port Phillip Heads Marine National Park, located inside Point Lonsdale. The site is similar to Lonsdale Kelp Outer (site 2809). These sites often have strong ground surge. The substratum consists of flat sand-affected reef.

Transect Layout

T2 and T1 head towards Queenscliff, and T3 and T4 towards the Rip. The transect is aligned with the currents.

Latest Survey Notes

Latest survey: 4/6/2009. Abundance of crayweed *Phyllospora comosa* continued to increase, a trend from 2003. This coincided with a decrease in kelp *Ecklonia radiata*. Evidence of *E. radiata* dieback was observed in small patches meters across. The disease caused necrosis of the blade and lateral fronds back to the stipe.

Figure A1.11. Site dive transects for Lonsdale Kelp Inner (Site 2811) in Port Phillip Heads Marine National Park.

Table A1.11. Site details for Lonsdale Kelp Inner (Site 2811) in Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2854	144.6275	55	292497	5759859	7	N	MPA

Annulus (Popes Eye) – Site 2812

Site Description

Popes Eye is located within the Port Phillip Heads Marine National Park, approximately 7 km inside the heads. The site curves around the outside of the annulus positioned on a 5 m contour along the sloping rock. There are high fish densities at this site, including transient species.

Transect Layout

T2 and T1 lay to the east curve around the annulus, T1 ending in boulders interspersed with sand habitat. T3 and T4 curve to the west.

Latest Survey Notes

Latest survey: 18/6/2009. Kelp *Ecklonia radiata* was highly abundant at Popes eye, contributing to around 60% of the algal cover.

Figure A1.12. Site dive transects for Annulus (Popes Eye) (Site 2812) in Port Phillip Heads Marine National Park.

Table A1.12. Site details for Annulus (Popes Eye) (Site 2812) in Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2767	144.6976	55	298606	5760976	5	N	MPA

Lonsdale Point – Site 2813

Site Description

Old Jetty Bay is located within the Port Phillip Heads Marine National Park, on the western side of Point Hicks, and is relatively sheltered and shallow. The substratum consists of flat rock slabs with low boulders and occasional bombies. Some areas of boulders and cobble were interspersed with sand.

Transect Layout

T2 and T1 head in a straight line to the south from the marker, and T3 and T4 in a northerly direction, parallel to shore.

Latest Survey Notes

Latest survey: 21/5/2009. Size measurements of blacklip abalone *Haliotis rubra* were taken for Lonsdale Point. There were no notable changes to the sizes over time.

Figure A1.13. Site dive transects for Lonsdale Point (Site 2813) a reference site for Port Phillip Heads Marine National Park.

Table A1.13. Site details for Lonsdale Point (Site 2813) a reference site for Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2967	144.613	55	291260	5758572	7	Y	Ref

Lonsdale Back Beach – Site 2814

Site Description

Lonsdale Back Beach is a reference site for Port Phillip Heads Marine National Park. The site is highly affected by ground surge. There are sand gutters on the T2T1 transect, where the surge is magnified, in addition to other gullies on the reef.

Transect Layout

The transects run parallel to shore, T1 and T2 to the east and T3 and T4 to the west.

Latest Survey Notes

Latest survey: 20/5/2009. The crayweed *Phyllospora comosa* was absent from Lonsdale Back Beach during the last survey, where it had previously been present. The abundance of scalyfin *Parma victoriae* continued declining, a trend from the three previous surveys.

Figure A1.14. Site dive transects for Lonsdale Back Beach (Site 2814) a reference site for Port Phillip Heads Marine National Park.

Table A1.14. Site details for Lonsdale Back Beach (Site 2814) a reference site for Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2902	144.5888	55	289128	5759236	5	N	Ref

Lonsdale Point Southwest – Site 2815

Site Description

Lonsdale Point Southwest is located within the Port Phillip Heads Marine National Park, on the southwest side of Point Lonsdale. The substratum consists of flat-topped reef with small steps and undercut ledges, as well as pavement reef and sand veneers.

Transect Layout

The transects run parallel to shore, T1 and T2 to the east and T3 and T4 to the west.

Latest Survey Notes

Latest survey: 20/5/2009. Abundance of crayweed *Phyllospora comosa* continued to increase, a trend from 2003. This coincided with a decrease in kelp *Ecklonia radiata*.

Figure A1.15. Site dive transects for Lonsdale Point Southwest (Site 2815) in Port Phillip Heads Marine National Park.

Table A1.15. Site details for Lonsdale Point Southwest (Site 2815) in Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2941	144.5983	55	289965	5758828	7	N	MPA

Kelp Bed Drift – Site 2816

Site Description

Kelp Bed Drift is a reference site for Port Phillip Heads Marine National Park. The substratum consists of low profile reef with rocky ledges and ridges. The site runs through an Amphibolis bed and ends in Heterozostera habitat.

Transect Layout

T2 and T1 head in a northeast direction from the marker, and T3 and T4 in a southwest direction.

Latest Survey Notes

Latest survey: 3/6/2009. There was a notable decrease in the common biscuit star *Tosia australis* from 2006.

Figure A1.16. Site dive transects for Kelp Bed Drift (Site 2816) a reference site for Port Phillip Heads Marine National Park.

Table A1.16. Site details for Kelp Bed Drift (Site 2816) a reference site for Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.283	144.6343	55	293088	5760135	5	N	Ref

Kelp Fields – Site 2817

Site Description

Kelp Fields is a reference site for Port Phillip Heads Marine National Park. The substratum consists of low profile reef with a dense kelp canopy.

Transect Layout

T2 and T1 head in a straight line south-southwest from the marker, and T3 and T4 in a north-northeast direction, in line with the currents.

Latest Survey Notes

Latest survey: 27/5/2009. Common kelp *Ecklonia radiata* was highly abundant at the Kelp Fields site. The canopy was essentially monospecific, with almost 80% *E. radiata* cover.

Figure A1.17. Site dive transects for Kelp Fields (Site 2817) a reference site for Port Phillip Heads Marine National Park.

Table A1.17. Site details for Kelp Fields (Site 2817) a reference site for Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2847	144.6365	55	293285	5759950	8	N	Ref

Lonsdale Surf Club – Site 2818

Site Description

Lonsdale Surf Club is located within the Port Phillip Heads Marine National Park, just outside the heads. The site runs between sand offshore and an inshore ledge.

Transect Layout

T2 and T1 head east-southeast in a straight line from the marker, and T3 runs west-southwest and T4 angles back in shore.

Latest Survey Notes

Latest survey: 20/5/2009

Figure A1.18. Site dive transects for Lonsdale Surf Club (Site 2818) in Port Phillip Heads Marine National Park.

Table A1.18. Site details for Lonsdale Surf Club (Site 2818) in Port Phillip Heads Marine National Park.

GDA latitude	GDA longitude	Zone	MGA Easting	MGA Northing	Depth (m)	Ab100	MPA/Ref
-38.2946	144.6103	55	291016	5758794	7	N	MPA

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