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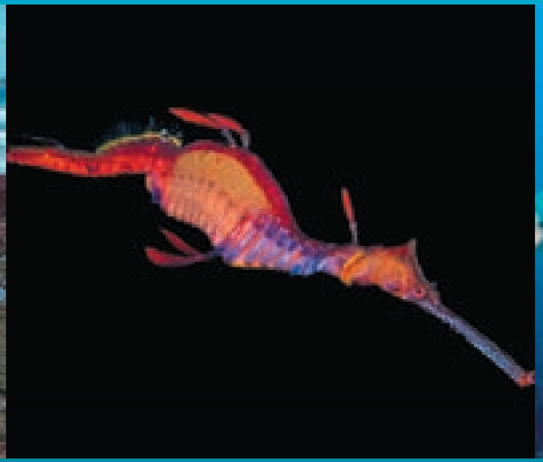

PARKS VICTORIA TECHNICAL SERIES

NUMBER 27

Victorian Subtidal Reef Monitoring Program

The Reef Biota at Wilsons Promontory Marine National Park

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February 2006

First published 2006

Published by Parks Victoria
Level 10, 535 Bourke Street, Melbourne Victoria 3000

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National Library of Australia
Cataloguing-in-publication data

Includes bibliography.
ISSN 1448-4935

Citation

Lindsay, M. and Edmunds, M. (2006). *Victorian Subtidal Reef Monitoring Program: The Reef Biota at Wilsons Promontory Marine National Park.* Parks Victoria Technical Series No. 27. Parks Victoria, Melbourne.

Printed on environmentally friendly paper

Parks Victoria Technical Series No. 27

Victorian Subtidal Reef Monitoring Program:

The Reef Biota at Wilsons Promontory Marine National Park

Malcolm Lindsay

Matt Edmunds

Australian Marine Ecology Pty Ltd

February 2006

EXECUTIVE SUMMARY

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

The monitoring program in, and around, the now Wilsons Promontory Marine National Park began in 1999. Since that time between 20 and 28 sites have been surveyed over 9 census events. The monitoring involves standardised underwater visual census methods to a depth of 10 m. This report aims to provide:

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

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

1. Abundance and size structure of large fishes;
2. Abundance of cryptic fishes and benthic invertebrates;
3. Percentage cover of macroalgae; and
4. Density of a dominant kelp species (*Macrocystis angustifolia*).

To date, over 300 different species have been observed during the monitoring program in, and around, Wilsons Promontory Marine National Park. Three algal assemblages were idenitifed: a *Phyllospora* dominated assemblage, an *Ecklonia*-*Seirococcus* dominated assemblage; and a mixed brown algal assemblage. Algal species richness and diversity appears to be stable over time at most sites. The common invertebrate assemblages appear to differ according to the exposure at the different sites. The invertebrate species richness ranged from 13–20 species with a relatively stable species diversity. The common fish species included blue-throated wrasse, purple wrasse, herring cale, magpie perch, barber perch, silver sweep and old wife. Species richness of fishes was higher this survey, between 10 and 28 at most sites. This survey reflects an increase in richness and abundances that is contrary to the gradual decline over the previous 5 years. Species diversity appears to be variable over time for all sites.

The results in this report present a snapshot in time for community structures and species population trends, which operate over long time scales. As monitoring continues and longer-term datasets are accumulated (over multiple years to decades) the program will be able to more adequately reflect the average trends and ecological patterns occurring in the system.

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1.0 INTRODUCTION

1.1 Subtidal Reef Ecosystems of Victoria

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

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

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

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

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

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

1.2 Subtidal Reef Monitoring Program

1.2.1 Objectives

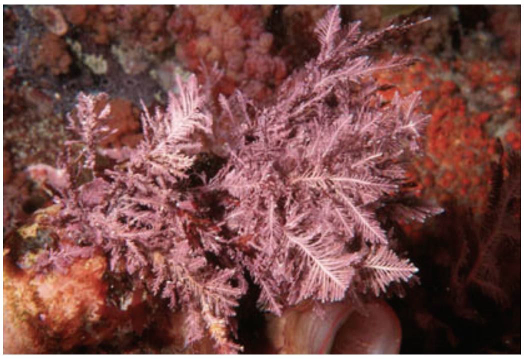
An important aspect in the management and conservation of Victorian marine natural resources and assets is assessing the condition of the ecosystem and how this changes over time. Combined with an understanding of ecosystem processes, this information can be used to manage any threats or pressures on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

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

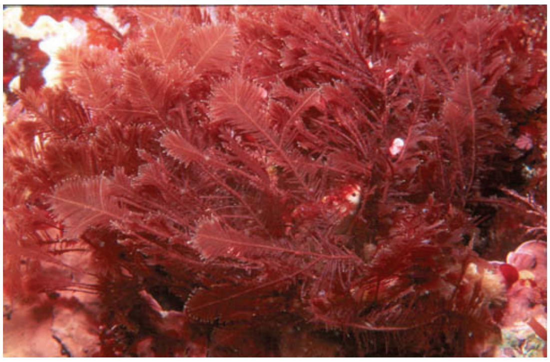
Green algae *Caulerpa flexilis*

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

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



Red coralline algae *Haliptilon roseum*



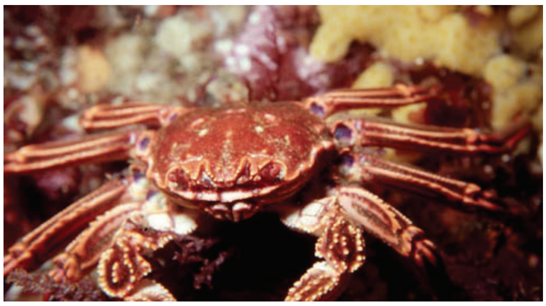
Thallose red algae *Ballia callitricha*

Crayweed *Phyllospora comosa* canopy

Common kelp *Ecklonia radiata* canopy

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

Southern rock-lobster *Jasus edwardsii*

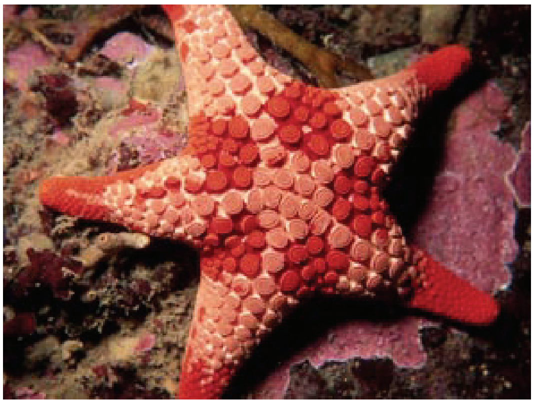


Red bait crab *Plagusia chabrus*

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

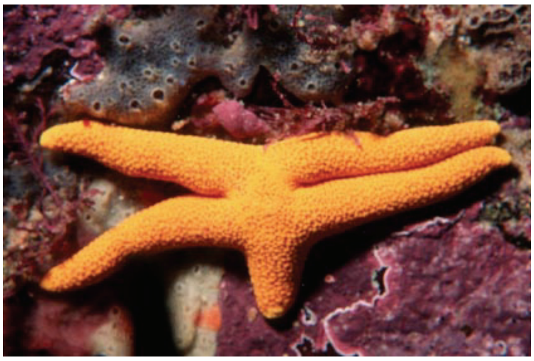
Blacklip abalone *Haliotis rubra*

Feather star *Cenolia trichoptera*



Nectria ocellata

Common sea urchin *Heliocidaris erythrogramma*



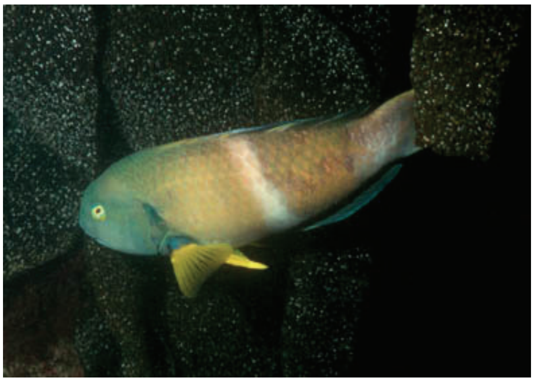
Fromia polypora

Red velvet fish *Gnathanocanthus goetzeei*

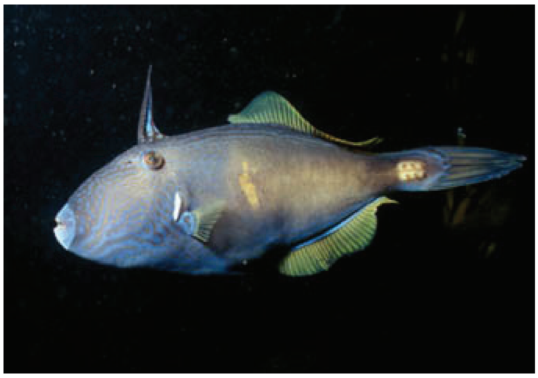
Figure 1.2. Cont. Examples of species of invertebrates and cryptic fish found on Victorian subtidal reefs

Sea sweep *Scorpis aequipinnis*, and butterfly perch *Caesioperca lepidoptera*

Scalyfin *Parma victoriae*



Blue-throated wrasse *Notolabrus tetricus* (male)



Six-spined leatherjacket *Meuscheni freycineti* (male)

Magpie morwong *Cheilodactylus nigripes*

Old-wife *Enoplosus armatus*

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

Information from the SRMP will allow managers to better understand and interpret long-term changes in the population and community dynamics of Victoria's reef flora and fauna. As a longer time series of data are collected, the SRMP will allow managers to:

- compare changes in the status of species populations and biological communities between highly protected marine national parks and marine sanctuaries and other Victorian reef areas (*e.g.* Edgar and Barrett 1997, 1999);
- determine associations between species and between species and environmental parameters (*e.g.* depth, exposure, reef topography) and assess how these associations vary through space and time (*e.g.* Edgar *et al.* 1997; Dayton *et al.* 1998; Edmunds, Roob and Ferns 2000);
- provide benchmarks for assessing the effectiveness of management actions, in accordance with international best practice for quality environmental management systems (Holling 1978; Meredith 1997); and
- determine the responses of species and communities to unforeseen and unpredictable events such as marine pest invasions, mass mortality events, oil spills, severe storm events and climate change (*e.g.* Ebeling *et al.* 1985; Edgar 1998; Roob *et al.* 2000; Sweatman *et al.* 2003).

A monitoring survey gives an estimate of population abundance and community structure at a small window in time. Patterns seen in data from periodic surveys are unlikely to exactly match changes in the real populations over time or definitively predict the size and nature of future variation. Graphs of changes over time are unlikely to match the changes in real populations because changes over shorter time periods and actual minima and maxima may not be adequately sampled (Figure 1.4). Furthermore, because the nature and magnitude of environmental variation is different over different time scales, variation over long periods may not be adequately predicted from shorter-term data. Sources of environmental variation can operate at the scale of months (*e.g*. seasonal variation), years (*e.g.* el Niño), decades (*e.g.* extreme storm events) or even centuries (*e.g.* global warming). Other studies indicate this monitoring program will begin to adequately reflect average trends and patterns as the surveys continue over longer periods (multiple years to decades). Results always need to be interpreted within the context of the time scale over which they have been measured.

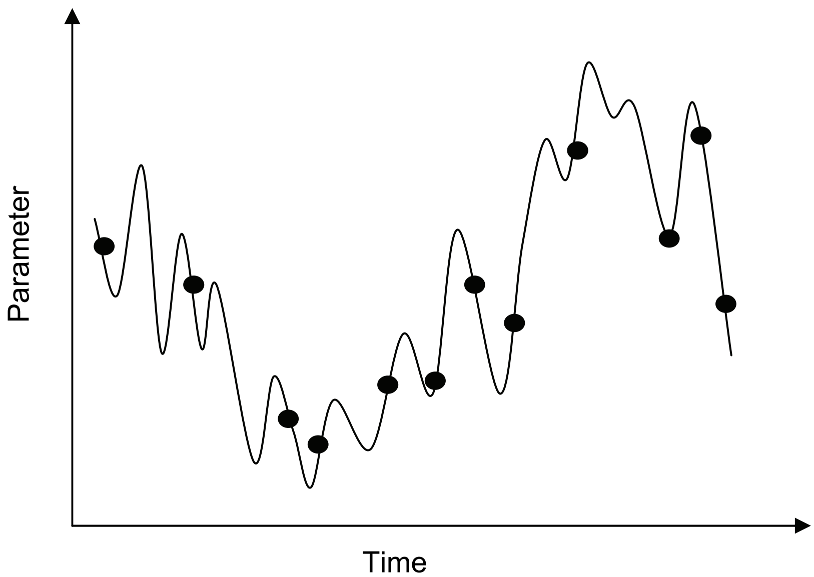


Figure 1.4 An example plot depicting change in an environmental, population or community variable over time (days, months or years). The black circles denote examples of monitoring times. Note how data from these times may not necessarily reflect patterns over shorter time periods, or true maxima or minima over longer time periods. Note further how data from any window of 2 or 3 consecutive monitoring times fails to adequately estimate the patterns or variation over the longer time period.

1.2.2 Monitoring Protocols and Locations

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

The SRMP was initiated in May 1998 with 15 sites established on subtidal reef habitats in the vicinity of Port Phillip Heads Marine National Park. In 1999 the SRMP was expanded to reefs in the vicinity of the Bunurong Marine National Park, Phillip Island, and Wilsons Promontory Marine National Park.

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

1.3 Marine Protected Areas at Wilsons Promontory

1.3.1 Previous marine protected areas

Prior to the declaration of the Wilsons Promontory Marine National Park, the coast of Wilsons Promontory formed part of the South Gippsland Marine and Coastal Parks, declared in 1986. There were three types of conservation zone: Wilsons Promontory Marine Park along the northwest and north east coasts; Western and Eastern Protection Zones at Norman Bay and Refuge Cove; and Wilsons Promontory Marine Reserve along the southern coast (CFL 1989; O'Toole and Turner 1990; Figure 1.1). The western boundary of the Marine Park extended from Shallow inlet out to Shellback Island, and then in a line joining the headlands to just before Norman Point.

The Marine Reserve encompassed a 300 m wide band along the southern shore, from Norman Point to Refuge Cove. The eastern part of the Marine Park continued northward from Refuge Cove, also with the boundary 300 m from the shore (Figure 1.1).

Recreational fishing was allowed in the Marine Park zone, however spearfishing, and the collection of abalone were not allowed on scuba and there was a rock lobster bag limit of one per day. Recreational fishers could only line fish in the Protection Zones and no fishing was allowed in the Marine Reserve. Commercial fishing was allowed throughout the Wilsons Promontory conservation areas, with the principal reef fisheries being for rock lobster, abalone and live wrasse/morwong.

The intertidal zone of the Wilsons Promontory coast was wholly protected as part of the Wilsons Promontory National Park. The National Park was declared in 1898, with the intertidal zone being added to the Park in 1965 (Ivanovici 1984).

1.3.2 Wilsons Promontory Marine National Park

Following proposals from the Environment Conservation Council (ECC 1999; 2000), the Wilsons Promontory Marine National Park was declared on 16 November 2002 (Figure 1.2). The Marine National Park encompasses areas in the pre-existing Wilsons Promontory Marine Reserve (except for the islands of the Glennie Group, and coasts north of Cape Wellington). The boundaries of the Marine National Park extend further offshore to fully encompass the islands of the Anser Group and Wattle Island. Reef habitats within the Marine

National Park include sheltered and exposed granite habitats with a variety of smooth bedrock, rubble, boulder, bombie and pinnacle type structures.

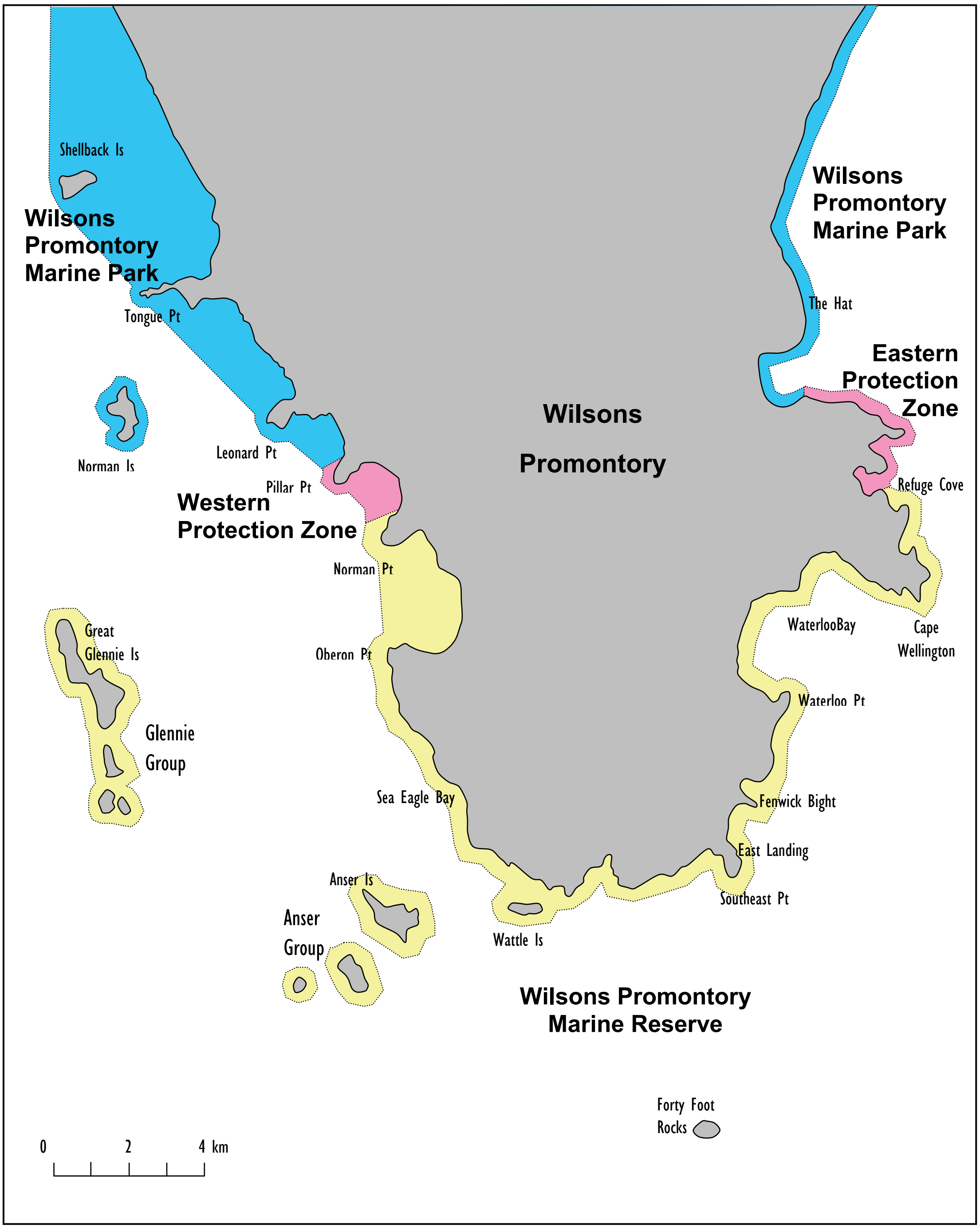


Figure 1.5. Previous marine protected areas at Wilsons Promontory: (blue) Wilsons Promontory Marine Park; (pink) Western and Eastern Protection Zones; and (yellow) Wilsons Promontory Marine Reserve. The southern, eastern and island boundaries are not to scale, being only 300 m from the shore (exaggerated here for clarity).

The level of protection for marine environments within the Marine National Park has been extended to restrict all forms of recreational and commercial fishing. Recreational line fishing and commercial fishing is only permitted in areas retaining Marine Park or Marine Reserve status.

1.4 Subtidal Reef Monitoring at Wilsons Promontory

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

This report provides a description of the monitoring program, and its status, at Wilsons Promontory. Summaries of the data are provided, building on the results from previous reports (Edmunds, Roob and Blake 1999; Edmunds, Roob, Austin and Callan 2000; Edmunds, Roob and Ling 2000; Edmunds, Roob and Callan 2001; Edmunds, Finn and Roob 2001, Edmunds and Finn 2002a, 2002b). Objectives of this report are to:

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

Figure 1.6. Wilsons Promontory Marine National Park (tan) and Marine Park (blue)

2.0 METHODS

2.1 Census method

2.1.1 Transect Layout

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

At most monitoring locations in Victoria, the 5 m depth contour is considered optimal because diving times are not limited by decompression schedules and these reefs are of interest to natural resource managers. However, many of the reefs at Port Phillip Heads sites were only present in shallower or deeper water. Consequently, site depths vary between 2 and 7 m depth (Table 2.1).

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

For each transect line, four different census methods were used to obtain adequate descriptive information on reef communities at different spatial scales. These involved the census of: (1) the abundance and size structure of large fishes; (2) the abundance of cryptic fishes and benthic invertebrates; (3) the percent cover of macroalgae; and (4) the density of string-kelp *Macrocystis* plants. Over 300 species were observed during the monitoring program at Port Phillip Heads (Table 2.3, Table 2.4). The depth, horizontal visibility, sea state and cloud cover are recorded for each site. Horizontal visibility is gauged by the distance along the transect line to detect a 100 mm long fish. All field observations are recorded on underwater paper.

2.1.2 Method 1 – Mobile Fishes and Cephalopods

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

2.1.3 Method 2 – Invertebrates and Cryptic Fishes

Cryptic fishes and megafaunal invertebrates (non-sessile: *e.g.* large molluscs, echinoderms, crustaceans) are counted along the transect lines used for the fish survey. A diver counts animals within 1 m of one side of the line (a total of four 1 x 50 m sections of the transect). A pole carried by the diver is used to standardise the 1 m distance. The maximum length of abalone and the carapace length and sex of rock lobsters are measured *in situ* using vernier callipers whenever possible. Selected specimens are collected for identification and preservation in a reference collection.

2.1.4 Method 3 – Macroalgae

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

2.1.5 Method 4 – *Macrocystis*

In addition to macroalgal cover, the density of *Macrocystis angustifolia* plants is estimated. While swimming along the 200 m transect line, a diver counts all observable plants within 5 m either side of the line, for each 10 m section of the transect (giving counts for 100 m^2 sections of the transect). This survey component commenced during spring 1999.

Table 2.1. Macroalgae (Method 3) taxa censused on the central coast of Victoria.

Method 3			
***Chlorophyta* (green algae)**	***Phaeophyta* (cont.)**	***Rhodophyta* (red algae)**	***Rhodophyta* (cont.)**
Chaetomorpha sp	*Zonaria turneriana*	*Gelidium asperum*	*Melanthalia abscissa*
Abjohnia laetevirens	*Lobophora variegata*	*Gelidium australe*	*Melanthalia concinna*
Cladophora spp	*Glossophora nigricans*	*Gelidium spp*	*Polyopes constrictus*
Caulerpa scalpelliformis	*Carpomitra costata*	*Pterocladia lucida*	*Halymenia plana*
Caulerpa trifaria	*Perithalia cordata*	*Pterocladia capillacea*	*Thamnoclonium dichotomum*
Caulerpa brownii	*Bellotia eriophorum*	*Pterocladiella capillacea*	*Plocamium angustum*
Caulerpa obscura	*Ecklonia radiata*	*Asparagopsis armata*	*Plocamium costatum*
Caulerpa flexilis	*Macrocystis angustifolia*	*Delisea pulchra*	*Plocamium patagiatum*
C. flexilis var. muelleri	*Durvillaea potatorum*	*Ptilonia australasica*	*Plocamium mertensii*
Caulerpa geminata	*Xiphophora chondrophylla*	*Asparagopsis spp.*	*Plocamium dilatatum*
Caulerpa annulata	*Phyllospora comosa*	*Metamastophora flabellata*	*Plocamium preissianum*
Caulerpa cactoides	*Seirococcus axillaris*	*Amphiroa anceps*	*Plocamium cartilagineum*
Caulerpa vesiculifera	*Scaberia agardhii*	*Corallina officinalis*	*Plocamium leptophyllum*
Caulerpa simpliciuscula	*Caulocystis cephalornithos*	*Arthrocardia wardii*	*Rhodymenia australis*
Codium lucasi	*Acrocarpia paniculata*	*Haliptilon roseum*	*Rhodymenia obtusa*
Codium pomoides	*Cystophora platylobium*	*Cheilosporum sagittatum*	*Rhodymenia prolificans*
Codium duthieae	*Cystophora moniliformis*	*Metagoniolithon radiatum*	*Rhodymenia spp*
Codium spp	*Cystophora monilifera*	*Geniculate corralines*	*Cordylecladia furcellata*
***Phaeophyta* (brown algae)**	*Cystophora expansa*	*Encrusting corallines*	*Ballia callitricha*
Halopteris spp	*Cystophora siliquosa*	*Corallines unidentified*	*Euptilota articulata*
Dictyota spp.	*Cystophora retroflexa*	*Callophyllis lambertii*	*Hemineura frondosa*
Dictyota diemensis	*Cystophora subfarcinata*	*Callophyllis rangiferinus*	*Dictymenia harveyana*
Dictyota dichotoma	*Carpoglossum confluens*	*Nizymenia australis*	*Laurencia filiformis*
Dilophus marginatus	*Sargassum decipiens*	*Sonderopelta coriacea*	*Laurencia spp*
Pachydictyon paniculatum	*Sargassum sonderi*	*Peyssonelia novaehollandiae*	*Echinothamnion sp*
Lobospira bicuspidata	*Sargassum varians*	*Sonderopelta/ Peyssonelia*	*Echinothamnion hystrix*
Dictyopteris acrostichoides	*Sargassum verruculosum*	*Phacelocarpus alatus*	Filamentous red algae
Chlanidophora microphylla	*Sargassum fallax*	*Phacelocarpus peperocarpus*	Other thallose red alga
Distromium flabellatum	*Sargassum vestitum*	*Callophycus laxus*	***Magnoliophyta***
Distromium spp	*Sargassum lacerifolium*	*Areschougia congesta*	*Halophila ovalis*
Homeostrichus sinclairii	*Sargassum spinuligerum*	*Areschougia spp*	*Amphibolis antarctica*
Homeostrichus olsenii	*Sargassum spp*	*Acrotylus australis*	
Zonaria angustata	Brown algae unidentified	*Curdiea angustata*	
Zonaria spiralis		*Melanthalia obtusata*	

Table 2.2. Invertebrates, cryptic fish (Method 2) and mobile fish (Method 1) taxa censused on the central coast of Victoria

Method 2		**Method 1**	
Crustacea	***Cephalopoda (cont.)***	**Mobile Sharks and Rays**	**Mobile Bony Fishes (cont.)**
Jasus edwardsii	*Sepia apama*	*Heterodontus portusjacksoni*	*Dotalabrus alleni*
Paguristes frontalis	*Sepioteuthis australis*	*Cephaloscyllium laticeps*	*Dotalabrus aurantiacus*
Strigopagurus strigimanus	***Echinodermata***	*Myliobatis australis*	*Eupetrichthys angustipes*
Pagurid unidentified	*Cenolia trichoptera*	*Urolophus paucimaculatus*	*Notolabrus tetricus*
Nectocarcinus tuberculatus	*Cenolia tasmaniae*	**Mobile Bony Fishes**	*Notolabrus fucicola*
Plagusia chabrus	*Tosia australis*	*Engraulis australis*	*Pseudolabrus psittaculus*
Petrocheles australiensis	*Tosia magnifica*	*Aulopus purpurissatus*	*Pictilabrus laticlavius*
Mollusca	*Pentagonaster dubeni*	*Synodus variegatus*	*Odax acroptilus*
Haliotis rubra	*Nectria ocellata*	*Lotella rhacina*	*Odax cyanomelas*
Haliotis laevigata	*Nectria macrobranchia*	*Pseudophycis bachus*	*Siphonognathus caninus*
Haliotis scalaris	*Nectria multispina*	*Pseudophycis barbata*	*Siphonognathus attenuatus*
Scutus antipodes	*Nectria wilsoni*	*Genypterus tigerinus*	*Siphonognathus radiatus*
Clanculus undatus	*Petricia vernicina*	*Phyllopteryx taeniolatus*	*Siphonognathus tanyourus*
Calliostoma armillata	*Fromia polypora*	*Helicolenus percoides*	*Siphonognathus beddomei*
Calliostoma ciliaris	*Plectaster decanus*	*Aetapcus maculatus*	*Neoodax balteatus*
Phasianotrochus eximius	*Echinaster arcystatus*	*Platycephalus bassensis*	*Haletta semifasciata*
Phasianella australis	*Nepanthia troughtoni*	*Caesioperca lepidoptera*	*Cristiceps aurantiacus*
Phasianella ventricosa	*Patiriella brevispina*	*Caesioperca rasor*	*Thyristes atun*
Turbo undulatus	*Coscinasterias muricata*	*Trachinops caudimaculatus*	*Acanthaluteres vittiger*
Astralium tentoriformis	*Uniophora granifera*	*Vincentia conspersa*	*Brachaluteres jacksonianus*
Cypraea angustata	*Goniocidaris tubaria*	*Dinolestes lewini*	*Scobinichthys granulatus*
Charonia lampas rubicunda	*Centrostephanus rodgersii*	*Trachurus declivis*	*Meuschenia australis*
Cabestana tabulata	*Amblypneustes spp.*	*Caranx dentex*	*Meuschenia flavolineata*
Cabestana spengleri	*Holopneustes porosissimus*	*Caranx wrightii*	*Meuschenia freycineti*
Cymatium parthenopeum	*Holopneustes inflatus*	*Arripis georgiana*	*Meuschenia galii*
Dicathais orbita	*Holopneustes purpurascens*	*Upeneichthys vlaminghii*	*Meuschenia hippocrepis*
Pleuroploca australasia	*Heliocidaris erythrogramma*	*Pempheris multiradiata*	*Meuschenia scaber*
Penion mandarinus	*Heliocidaris tuberculata*	*Girella tricuspidata*	*Eubalichthys gunnii*
Penion maxima	*Neothyonidium spp.*	*Girella elevata*	*Aracana aurita*
Conus anemone	*Stichopus mollis*	*Girella zebra*	*Aracana ornate*
Amoria undulata	**Cryptic Fishes**	*Scorpis aequipinnis*	*Tetractenos glaber*
Cymbiola magnifica	*Heteroclinus johnstoni*	*Scorpis lineolata*	*Diodon nichthemerus*
Sagaminopteron ornatum	*Parascyllium variolatum*	*Atypichthys strigatus*	*Arctocephalus pusillus*
Nudibranch	*Conger verreauxi*	*Tilodon sexfasciatus*	
Tambja verconis	*Pseudophycis barbata*	*Enoplosus armatus*	
Neodoris chrysoderma	*Paratrachichthys trailli*	*Pentaceropsis recurvirostris*	
Ceratosoma brevicaudatum	*Heteroclinus perspicillatus*	*Parma victoriae*	
Chromodoris tinctoria	*Helicolenus percoides*	*Parma microlepis*	
Chromodoris tasmaniensis	*Scorpaena papillosa*	*Chromis hypsilepis*	
Chromodoris splendida	*Aetapcus maculatus*	*Aplodactylus arctidens*	
Perplex digidentis	*Gnathanacanthus goetzii*	*Cheilodactylus nigripes*	
Hypselodoris bennetti	*Pseudolabrus psittaculus*	*Cheilodactylus spectabilis*	
Mesopeplum tasmanicum	*Bovichtus angustifrons*	*Nemadactylus macropterus*	
Chlamys asperimus	*Parablennius tasmanianus*	*Nemadactylus douglasi*	
Ostera angasi	*Norfolkia clarkei*	*Dactylophora nigricans*	
Cephalopoda	*Forsterygion varium*	*Latridopsis forsteri*	
Octopus sp	*Heteroclinus tristis*	*Ophthalmolepis lineolata*	

2.2 Data Analysis

2.2.1 Community Structure

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

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

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

2.2.2 Depiction of Community Differences

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

Kruskall stress is an indicator statistic calculated during the ordination process and indicates the degree of disparity between the reduced dimensional data set and the original hyper-dimensional data set. A guide to interpreting the Kruskal stress indicator is given by Clarke (1993): (< 0.1) a good ordination with no real risk of drawing false inferences; (< 0.2) can lead to a usable picture, although for values at the upper end of this range there is potential to mislead; and (> 0.2) likely to yield plots which can be dangerous to interpret. These guidelines are simplistic and increasing stress is correlated with increasing numbers of samples. In this case, three-dimensional solutions were sought to ensure an adequate representation of the higher-dimensional patterns.

2.2.3 Trends in Community Structure

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

2.2.4 Species Diversity

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

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

2.2.5 Species Populations

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

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

2.3 Site Establishment

During the first survey at Wilsons Promontory, every effort was made to survey as many sites as possible, with the intention of sampling a surplus of sites. The benefits of this were to: provide the most comprehensive description of the marine flora and fauna around the Promontory; enable selection of the most appropriate sites for the long-term monitoring program; and safeguard the monitoring design against possible boundary changes before the sanctuary zone was declared. Additional field assistance was provided by Dr Nev Barrett and Alistair Morton from the Tasmanian Aquaculture and Fisheries Institute, and the sea conditions enabled the census of three sites a day, for much of the excursion. Consequently, twenty-eight sites were sampled between 30 November and 9 December 1999.

The sites were located in four general regions around the Promontory: northwest reference area, north of the Marine National Park; western Marine National Park; eastern Marine National Park; and northeast reference area (Figure 2.1; Table 2.1). Three island sites were sampled outside the proposed sanctuary, on Shellback and Norman Islands, and three inside the proposed sanctuary, on Great Glennie and Anser Islands. The sites encompassed the full range of reef habitats present at the Promontory, including sub-maximally exposed sites at Norman Island, Great Glennie Island and Sea Eagle Bay, to relatively sheltered habitats at north Shellback Island, Great Glennie Island, Waterloo Bay and The Hat north of Sealers Cove; Figure 2.1). The reef structures varied from steep plunging or stepped reefs, to more gently sloping (but high relief) boulder and bombie fields, to relatively flat bedrock and rubble reefs. A brief description of each site is provided in Table 2.1.

2.4 Core Monitoring Site Selection

The monitoring program uses repeated measurements of sites fixed in space. A statistical consequence of this design is that all sites must be sampled during each survey period. The 28 sites established in November 1999 were too numerous to reliably sample during each survey, especially in winter when the weather and shorter daylight period is less suitable for diving. Therefore, it was necessary to select a sub-set of core monitoring sites that are targeted for sampling during each excursion (with as many other sites as possible also being sampled).

Analyses from the first survey in November 1999 identified floral and faunal assemblages had both north-south and east-west differences (Edmunds et al. 1999e). Consequently, the original sites were divided into four groups:

1. Western reference, northwest coast;
2. Western Marine National Park, southwest coast;
3. Eastern Marine National Park, southeast coast; and
4. Eastern reference, northeast coast.

A total sample of twenty sites was considered a logistically achievable minimum number of sites to be sampled during each excursion. This would provide five sites within each of the four quadrants.

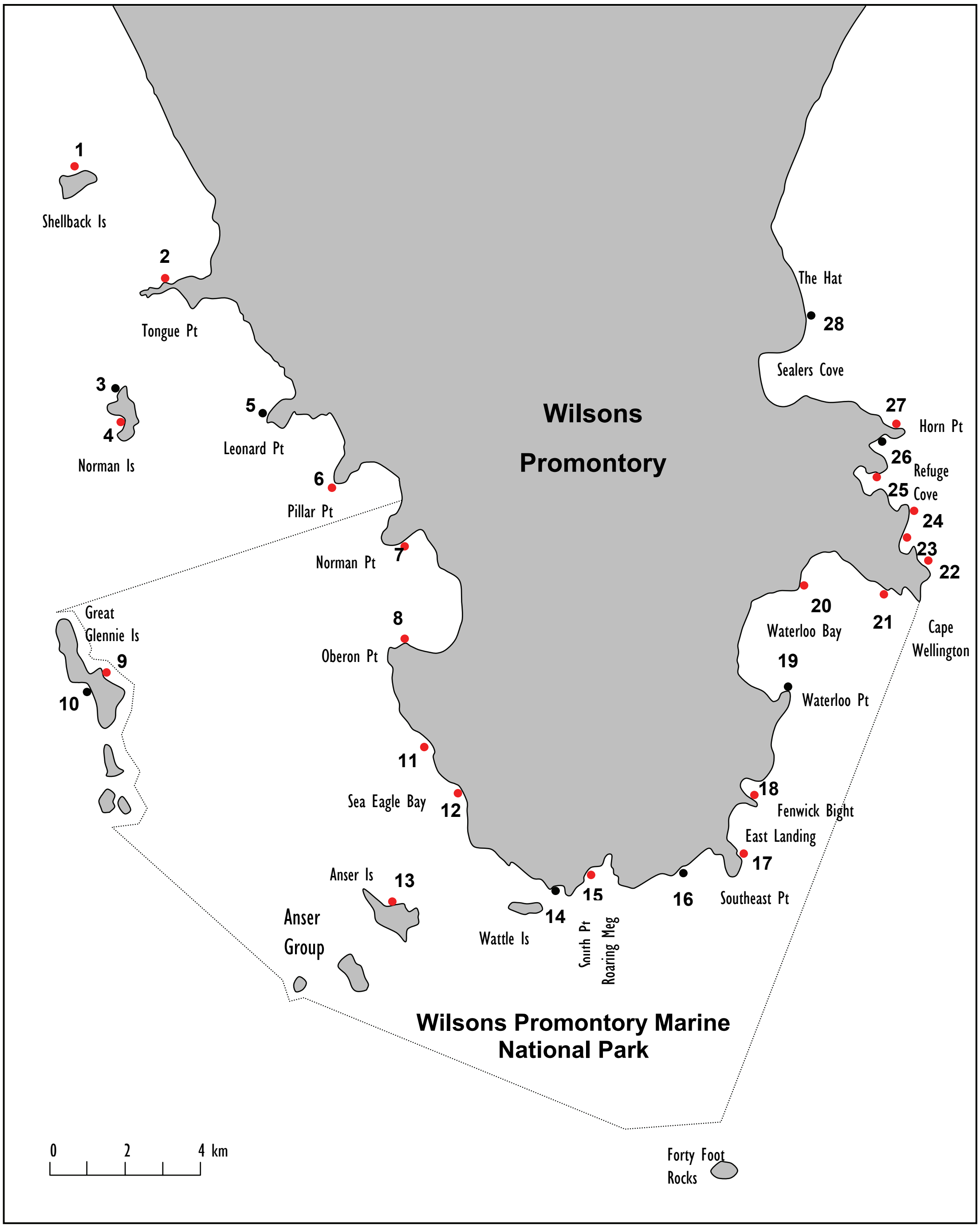


Figure 2.1. Location of monitoring sites at Wilsons Promontory. The Wilsons Promontory Marine National Park boundary is also shown. Core monitoring sites are marked in red.

Table 2.3. Physical descriptions of sites at Wilsons Promontory: (A) aspect; (Exp) exposure ranking; and (CI) complexity index. The exposure and reef complexity indices follow those used by Edgar (1981; see Table footnotes). Legend: (RZ) Reference zone; (MNP) Marine National Park.

Site	A (° T)	Exp*	CI†	Depth (m)	Substratum Description
Northwest RZ					
1 North Shellback Is	350	6	1.5	10	Bedrock with small boulder clusters and rubble.
2 North Tongue Pt	340	5	1.5	10	Bedrock and boulder fields 0.5-2 m.
3 North Norman Is	285	3	1.5	10	Steep bedrock with deep gullies and 5-10 m drop-offs, boulders to west.
4 West Norman Is	270	3	3	10	Medium to large boulders 1-4 m, interspersed by slab reef.
5 Leonard Pt	240	4	3.5	10	Large boulders 1-4 m, bombies, slab reef.
6 Pillar Pt	195	4	4	10	Large boulders 1-3 m, occasional tall bombies.
Southwest MNP					
7 South Norman Pt	145	5	2.5	10	Boulder field 1-3 m.
8 Oberon Pt	330	5	2	10	Boulder field 1-2 m and irregular bedrock
9 East Glennie Is	45	5	1.5	10	Steeply sloping slab with occasional bombies.
10 West Glennie Is	250	3	4	10	Boulders 5-10 m across, deep crevices between, smaller boulders to north.
11 North of Sea Eagle	240	3	3	10	Boulders 1 m, some larger outcrops, moderately high relief.
12 Sea Eagle Bay	24	4	3	10	Boulder field 1-2 m, occasional 3-5 m bombies.
13 North Anser Is	15	4	1.5	10	Steeply sloping bedrock with occasional bombies.
Southeast MNP					
14 South Pt	180	3	3	10	Boulder field 1-3 m with 3-5 m bombies.
15 Roaring Meg Bight	120	3	3	10	Steeply sloping fractured bedrock with some large boulders.
16 West Landing	150	3	3	10	Large boulders 2-4 m, large interstitial space, occasional bombies.
17 East landing	55	4	2.5	10	Rock slab stepping and sloping steeply, some bombies.
18 Fenwick Pt	35	5	3.5	10	Boulders 2-4 m interspersed by bombies 3-4 m, smaller boulders to west
19 Waterloo Pt	90	5	3	10	Slab reef, some boulder fields 2-3 m
20 Central Waterloo	130	5	2.5	10	Low boulders interspersed with bombies 3-5 m.
21 North Waterloo	180	4	3.5	10	Reef slabs, stepping 3-4 m, large bombies.
22 Cape Wellington	65	5	2.5	10	Sloping smooth bedrock with ledges, interspersed with boulder fields 2-4 m.
Northeast RZ Cont.					
23 Bareback Bay	100	5	2	10	Flat bedrock, occasional bombies, to boulder field in west.
24 South Refuge	180	5	3	10	Boulders 2-3 m, bombies 3-5 m, flat bedrock.
25 North Refuge	135	5	2	10	Sloping bedrock with occasional cracks and overhangs.
26 Horn Bay	150	5	2.5	10	Flat bedrock, small boulders 1-3 m interspersed by bombies
27 North Horn Pt	20	6	2.5	10	Mostly boulder field 0.5-2 m, some slab reef.
28 The Hat	90	6	2	10	Boulder field 1-2 m.

* Exp = Exposure Index:

1 maximal

3 submaximal
5 moderate
7 sheltered open coast
9 sheltered bays
† CI = Complexity Index:
1 flat rock substratum with low relief, broken occasionally by crevices and ledges
2 boulders or bedrock of moderate relief (0.5 m), ledges and crevices common
3 moderately high relief (1-2 m) substratum with ledges and crevices common
4 highly structured, high relief (> 2 m) with high interstitial volume

Prior to the second survey in winter 2000, a sub-set of the 28 sites were selected as core monitoring sites, as described in Edmunds, Roob, Austin and Callan (2000). This selection process was based on sanctuary boundaries proposed by the Environment Conservation Council in 1999. However, these boundaries were altered for the final proposals released in 2000, which excluded the Glennie Group from the sanctuary zone (ECC 2000). We revised the selection of core monitoring sites, as described below.

The sub-set of sites were selected according the criteria:

1. Sites are accessible for diving under average or usual weather conditions over a ten day excursion period;
2. Biota at each site are representative of the sub-region; and
3. Biota are as similar as possible between sites inside and outside the proposed protected area.

Three sites (3, 16 and 28) were excluded as core-monitoring sites based on their suitability for diving. North Norman Point (Site 3) is near vertical and swell prone, making it very difficult for divers to work at in even low swell and sea conditions. West of West Landing (Site 16) is highly exposed to the prevailing north-westerly to southerly weather and seas, and is particularly prone to high winds funnelling down the hills above the bay (note: strong north-westerly winds funnel around the southern tip of the Promontory, affecting southern sites as well). These presumptions were confirmed during the second survey, when none of these sites could be surveyed. The Hat (Site 28) was excluded as it is prone to bad visibility from sediment-laden water moving down the coast from Corner Inlet.

Six sites (1, 6, 7, 21, 22, 27) were included as core monitoring sites to enable an examination of boundary effects, and biological trends with distance from the boundary. Sites 6, 7, 21 and 22 are located either side of the western and eastern boundaries respectively and sites 1 and 27 are the further-most reference sites from the sanctuary area. Site 1 (Shellback Island) was also included because it has a relatively high algal and fish species richness, making it an interesting site to monitor in its own right.

With the above exclusion/inclusion limitations, there were 400 possible combinations of 20 sites (with five in each quadrant) that could be selected for core monitoring. An optimal combination of sites was selected based on differences in algal, fish and invertebrate assemblage structure. Matrices of differences in community composition between each site were calculated using the Bray-Curtis dissimilarity coefficient (with the matrices for fish, invertebrates and algae combined using the average B-C value for each site-comparison).

Using the Bray-Curtis coefficient, statistics calculated for each possible site combination were:

1. Average difference between sites within proposed sanctuary zone (*i.e.* within sanctuary zone variation, $BC_{within\ sanctuary}$);

2. Average difference between sites within proposed reference zones (*i.e.* within reference zone variation, $BC_{within\ reference}$);
3. Comparison of within-zone variations ($|BC_{within\ sanctuary} - BC_{within\ reference}|$);
4. Average difference between sites within all groups (*i.e.* total within variation, BC_{within});
5. Average difference between sites from different zones (*i.e.* total between variation, $BC_{between}$); and
6. Difference in community structure between sanctuary and reference zones ($|BC_{between} - BC_{within}|$).

The comparison of within-zone variations, $|BC_{within\ sanctuary} - BC_{within\ reference}|$, is akin to a measure of heterogeneity of variance (in community structure) between the sanctuary and reference sites. Heterogeneity of variation between the two groups being compared (sanctuary and reference sites) can confound the ability to detect changes, and should therefore be minimised where possible. The statistic $|BC_{between} - BC_{within}|$ is a measure of the relative difference in community structure between sanctuary and reference zones. Changes related to the implementation of sanctuaries are easier to detect if baseline (before) differences between the sanctuary and reference zones are small. Consequently, the optimal combination of sites was selected whereby both $|BC_{within\ sanctuary} - BC_{within\ reference}|$ and $|BC_{between} - BC_{within}|$ were minimised.

Table 2.4. Indices for selecting an optimal set of core monitoring sites at Wilsons Promontory. Values given are average Bray-Curtis coefficients of difference in community structure for: (BCS) between sites within the park; (BCR) between sites within the reference area; (BCW) all within-area differences between sites; (BCB) all between-zone differences between sites (see text for further explanation of calculations). Optimal combinations have similar variations between sites within the park and reference areas (|BCR-BCS| is minimised) and similar community structure between park and reference areas (|BCB-BCW| is minimised). The first ten of 400 possible combinations with lowest values for |BCR-BCS| are listed, along with minimum, mean and maximum values. The combination shown in bold was selected as for the Wilsons Promontory monitoring program.

Site excluded								BC_S	BC_R	$\lvert BC_R - BC_S\rvert$	BC_W	BC_B	$\lvert BC_B - BC_W\rvert$
3	5	10	14	16	19	23	28	37.82	45.61	7.78	41.71	42.30	0.59
3	5	10	14	16	19	24	28	37.82	45.75	7.93	41.79	42.81	1.03
3	5	10	14	16	19	25	28	37.82	45.84	8.02	41.83	42.12	0.29
3	5	10	14	16	19	26	28	37.82	45.84	8.02	41.83	42.04	0.21
3	9	10	14	16	19	23	28	37.82	46.17	8.35	42.00	42.79	0.79
3	9	10	14	16	19	25	28	37.82	46.38	8.56	42.10	42.61	0.50
3	9	10	14	16	19	26	28	37.82	46.44	8.62	42.13	42.53	0.40
3	4	10	14	16	19	23	28	37.82	46.48	8.65	42.15	42.68	0.53
3	9	10	14	16	19	24	28	37.82	46.51	8.68	42.16	43.30	1.13
3	5	10	14	16	17	23	28	36.91	45.61	8.70	41.26	41.97	0.71
Statistics for All Combinations													
Minimum								33.56	45.61	7.78	39.58	40.73	0.01
Average								35.81	47.15	11.34	41.54	42.15	0.67
Maximum								37.82	48.47	14.91	43.43	43.74	2.14

The heterogeneity of variance in community structure within the park and reference zones ($|BC_{within\ park} - BC_{within\ reference}|$), and difference in community structure ($|BC_{between} - BC_{within}|$) were somewhat correlated, with a higher degree of heterogenity of variances associated in increased apparent differences in community structure (Figure 2.3). The different site combinations had a greater affect on heterogeneity of variances (range of 7%) than between zone differences in community structure (range of 2.1%; Figure 2.3; Table 2.4). A reasonable degree of heterogenity of community variation was detected, with the reference zone having greater between-site variation than the park (Table 2.4). This will have to be examined carefully during statistical analysis, as such spatial confounding may increase the chance of incorrectly detecting a change (Type II error). The selected optimal site combination excluded Sites 10, 19 and 26, in addition to the sites excluded before the analysis (Sites 3, 16 and 28). In summary, the sites selected for core monitoring were:

1. Sites 1, 2, 4, 6 and 9, western reference;
2. Sites 7, 8, 11, 12 and 13, western park;
3. Sites 15, 17, 18, 20 and 21, eastern park; and
4. Sites 22, 23, 24, 25 and 27, eastern reference.

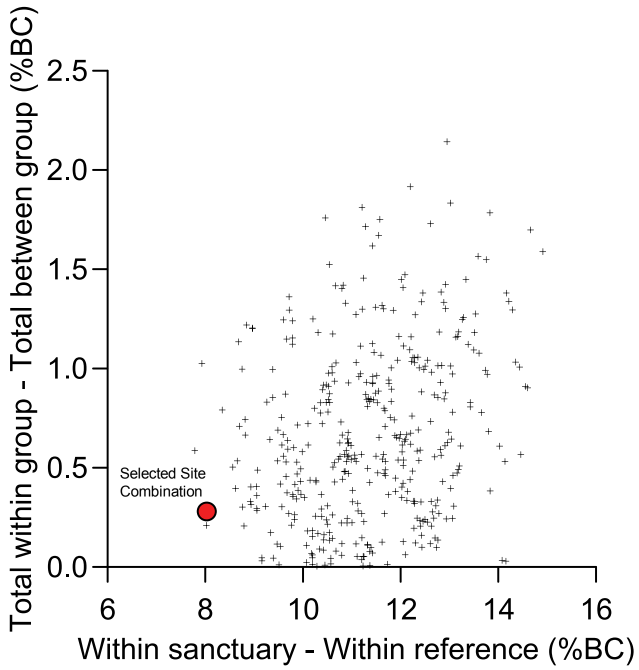


Figure 2.2. Plot for selecting an optimal set of core monitoring sites at Wilsons Promontory. Indices of within-area and between-area differences in community structure were plotted for each of 400 possible site combinations (see text and Table 2.2 for further details of calculations). Optimal combinations have similar variations between sites within the park and reference areas (Within park – Within reference is minimised) and similar community structure between park and reference areas (Within – Between is minimised). The site combination for the point circled on the graph was selected as for the Wilsons Promontory monitoring program.

This represents a slight change from the core monitoring sites selected prior to the Environment Conservation Council 2000 proposals. This change will have to be taken into account during analysis of the long-term, fixed site monitoring data (probably necessitating the inclusion of surrogate data).

2.5 Survey Times and Sites

The original twenty-eight sites were surveyed during the first survey in November/December 1999. The first survey was conducted during a good weather period, enabling diving throughout the ten-day excursion.

This contrasted with the second survey in May 2000, during which time a persistent westerly air stream limited diving to the east coast of the Promontory. After five days, the weather became stormy, and the survey was postponed until the weather was suitable for diving again in mid June (Table 2.4). Twenty-two sites were surveyed during the second survey: all sites except Sites 3, 10, 11, 14, 16, and 28.

The third survey was in late November 2000. As with the first survey, the third survey was assisted by Dr Neville Barrett and Mr Alistair Morton from the Tasmanian Aquaculture and Fisheries Institute. All sites except Sites 3 and 28 were surveyed during this period.

The fourth survey was during May 2001. Twenty-two sites were surveyed, consisting of the core monitoring sites and Sites 5 and 19.

The fifth survey was during late November, and early December 2001. Twenty-one sites were surveyed, consisting of the core monitoring sites and Site 5. Southerly weather prevented surveying at Site 19. The same 21 sites were surveyed during the sixth survey in late May and early June 2002.

The seventh survey was between 5 and 15 November 2002. Twenty-three sites were surveyed including all core monitoring sites as well as Site 5, Site 19 and Site 26.

The eighth survey was during the last two weeks of August 2004. Only nineteen of the twenty core sites were surveyed.

The ninth survey was during the first two weeks of March 2005. All twenty core sites were surveyed.

Table 2.5. Survey times for monitoring at Wilsons Promontory.

Survey	Season	Survey Period
1	Early summer 1999	30 Nov to 9 Dec 1999
2	Early winter 2000	16-20 May and 11-15 Jun 2000
3	Early summer 2000	13-17 Nov and 25-29 Nov 2000
4	Early winter 2001	30 Apr to 4 May and 25-27 May 2001
5	Early summer 2001	30 Nov to 3 Dec and 14-16 Dec 2001
6	Early winter 2002	26-30 May and 4-6 June 2002
7	Early summer 2002	5-15 November 2002
8	Winter 2004	21-28 August 2004
9	Late Summer 2005	2-10 March 2005

Figure 2.3. School of butterfly perch *Caesioperca lepidoptera* at East Landing, Wilsons Promontory.

3.0 MACROALGAE

3.1 Community Structure

Three general macroalgal assemblages were identified at Wilsons Promontory: a *Phyllospora* dominated assemblage, an *Ecklonia*-*Seirococcus* dominated assemblage; and a mixed brown algal assemblage. The *Phyllospora* dominated assemblage was the most common, being at twenty-one of the surveyed sites: Sites 2 to 19 and Sites 22 and 24 (sites in the centre and right side of plots in Figure 3.1). This assemblage consisted of a canopy of predominantly *Phyllospora comosa* (> 30% cover) and a lesser proportion of *Ecklonia radiata*. The associated understorey had a sparse cover of thallose red algae, with much of the underlying rock covered by encrusting corallines. Common understorey species included *Phacelocarpus peperocarpus*, *Plocamium angustum*, *Plocamium dilatum*, *Pterocladia lucida*, *Ballia callitricha*, *Haliptilon roseum* and *Melanthalia obtusata*.

The *Phyllospora* assemblage was present at the most exposed sites, particularly on the western and southern coasts of the Promontory. *Phyllospora* had higher abundances, and *Ecklonia* proportionately less so, at the most exposed sites, particularly Norman Island, Leonard Point, Pillar Point, Great Glennie Island, Sea Eagle Bay and West Landing (Sites 3, 4, 5, 6, 10, 11, 12 and 16). At slightly less exposed sites, *Ecklonia* had a greater proportion of cover in the canopy, particularly Oberon Point, east Great Glennie Island, East Landing and Fenwick Bight (Sites 8, 9, 17 and 19).

Pillar Point (Site 6) had a dense canopy of *Phyllospora*, but was notably different from other *Phyllospora* assemblages in having virtually no algal understorey and a high cover of sessile invertebrates instead. This reef community is possibly influenced by freshwater flows from Tidal River, on the south side of Pillar Point.

Ecklonia radiata and *Seirococcus axillaris* comprised the dominant proportion of the canopy cover at moderate to sheltered sites. These sites were at north Shellback Island, Waterloo Bay, Bare-Back Bay, Refuge Cove and Horn Point (Sites 1, 20, 23, 25, 26, 27; sites clustering to the left of MDS plots in Figure 3.1). *Phyllospora comosa* was also present, but contributed less than 20% of the canopy cover. Thallose understorey algae were a greater component of the *Ecklonia*-*Seirococcus* assemblage, with 50-70% cover compared with less than 30% cover for the *Phyllospora* assemblage during the first survey. As with the *Phyllospora* assemblage, *Phacelocarpus peperocarpus*, *Melanthalia obtusata*, *Plocamium angustum* and *Pterocladia lucida* were predominant understorey species. However, *Ballia callitricha* and the erect coralline *Haliptalon roseum* were generally reduced in abundance, with smaller brown species more prevalent. These brown species included *Sargassum verruculosum*, *Sargassum sonderi*, *Perithalia cordata* and *Acrocarpia paniculata*.

The relatively sheltered site at The Hat (Site 28 just north of Sealers Cove) was generally depauperate of algae. This site had a high silt cover on both the algae and rock substratum, this silt probably originating from the extensive area of estuaries and shallow inlets to the north (Corner and Nooramunga Inlets). There was no canopy of large brown algae, the assemblage consisting of *Acrocarpia paniculata*, *Sargassum verruculosum*, *Sargassum fallax*, *Carpoglossum confluens*, *Phacelocarpus peperocarpus* and *Pterocladia lucida*.

There were considerable differences in the temporal stability in macrophyte community structure between sites: some sites displayed little temporal variation (*e.g.* Sites 7, 12, 19, 21 and 22) with other sites having large variations between times (*e.g.* Sites 1, 2, 5, 8, 15, 18, 23, 26 and 27; Figure 3.1). In general, the *Phyllospora* dominated assemblages had smaller temporal differences than the other assemblages.

Tests for progressive changes (trends) in species composition over the monitoring surveys detected significant trends ($p \leq 0.05$) in all sites except Sites 8, 9, 12, 17, 21, 24 and 27

(Table 3.1). The sites that have changed throughout the nine surveys were typically those dominated by the *Ecklonia/Seirococcus*. This agrees with the greater temporal variation of seen in these sites on the MDS plots. These temporal shifts were related to changes in the abundance and diversity of thallose red algae, which were more abundant in the *Ecklonia*/*Seirococcus* assemblages than the *Phyllospora* assemblages.

3.2 Diversity

The species richness and diversity of the macroalgal communities was lowest at the exposed western and southwestern sites, where the canopy was predominantly Phyllospora with a reduced cover of understorey species. In contrast, the species richness and diversity was markedly higher at the more sheltered Ecklonia/Seirococcus assemblages (Sites 1, 20, 23, 25 and 27; Figures 3.2 and 3.3). Species richness and diversity appeared to be relatively stable over time at most. Relative to the Phyllospora communities, the Ecklonia/Seirococcus communities showed larger variation in diversity through time.

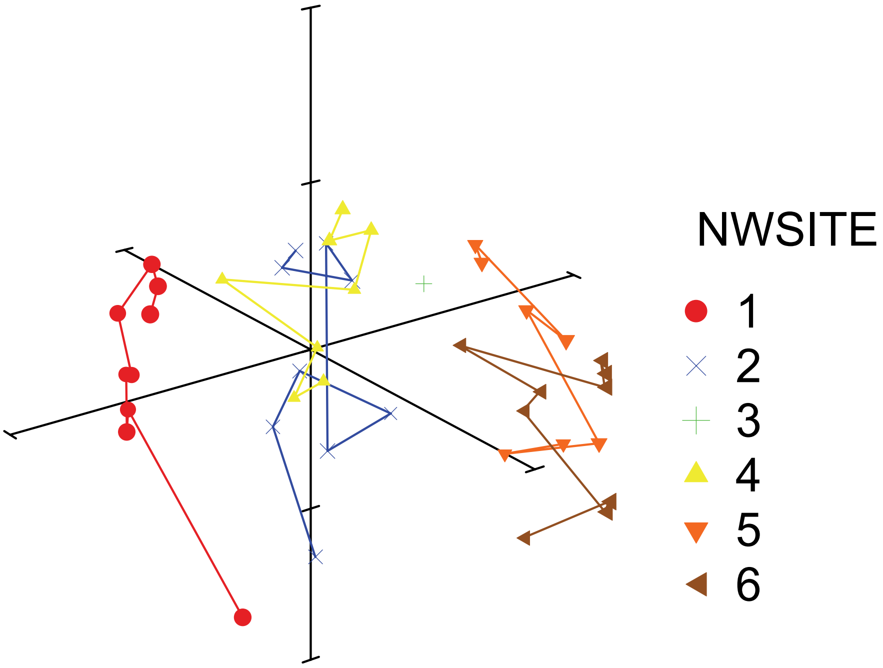


Figure 3.1a. Three-dimensional MDS plot of algal assemblage structure for north-western sites at Wilsons Promontory. Stress = 0.18.

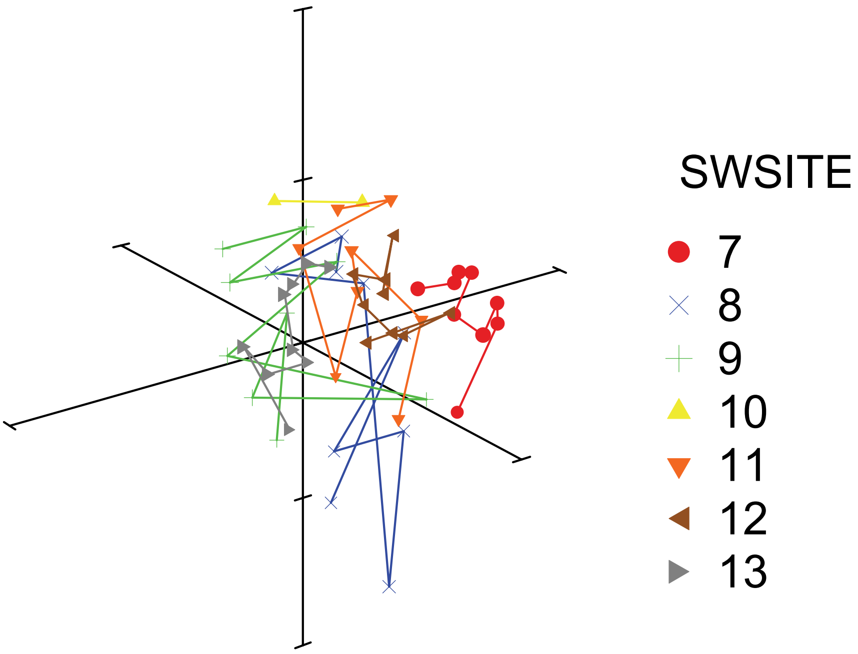


Figure 3.1b. Three-dimensional MDS plot of algal assemblage structure for south-western sites at Wilsons Promontory. Stress = 0.18.

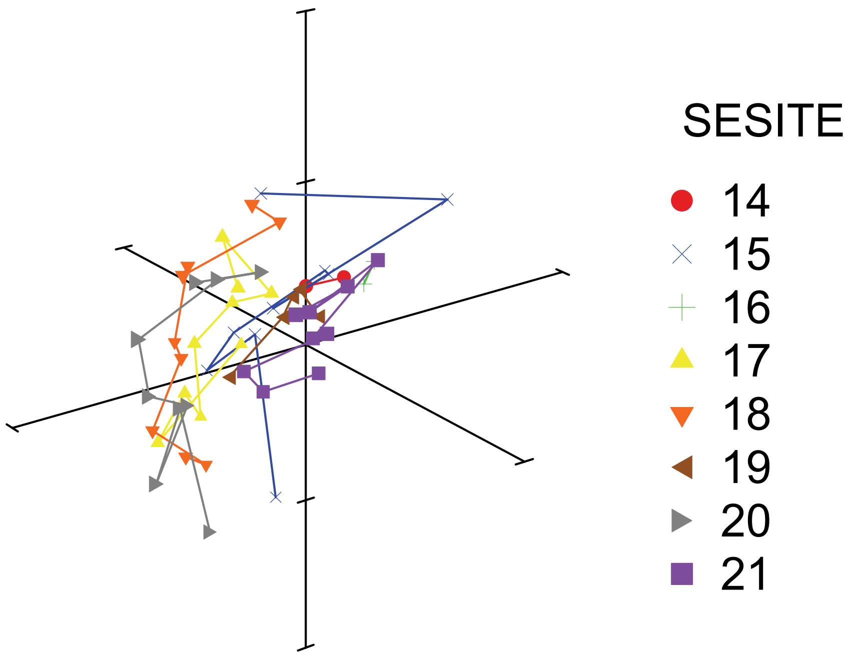


Figure 3.1c. Three-dimensional MDS plot of algal assemblage structure for south-eastern sites at Wilsons Promontory. Stress = 0.18.

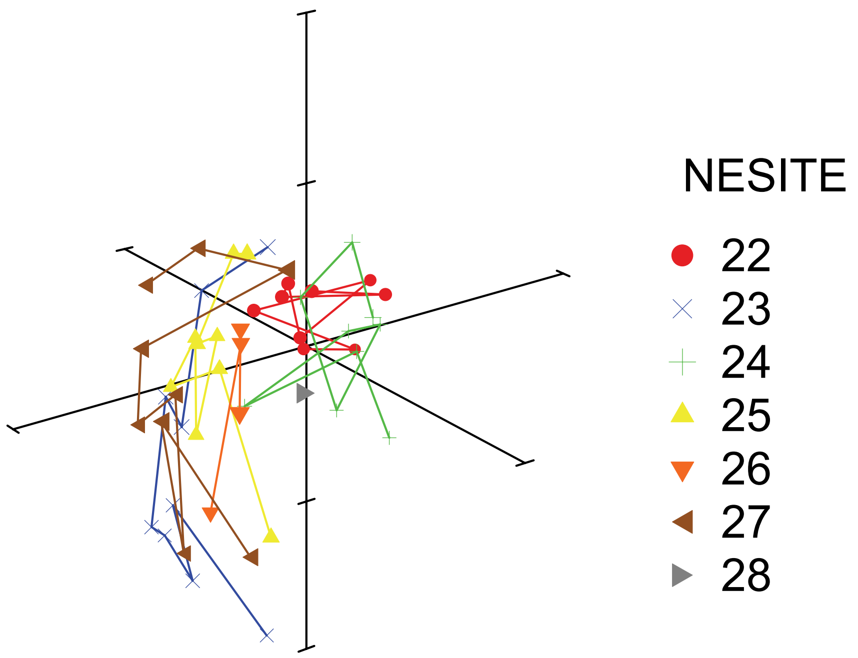


Figure 3.1d. Three-dimensional MDS plot of algal assemblage structure for north-eastern sites at Wilsons Promontory. Stress = 0.18.

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

Site	Mantel r_M	Probability	% B-C Dissimilarity (first to last)
1	0.49	0.02	44
2	0.46	0.01	45
6	0.43	0.01	57
7	0.47	0.02	41
8	0.28	0.11	43
9	0.18	0.20	47
12	0.07	0.38	29
13	0.56	0.01	39
15	0.40	0.05	42
17	0.36	0.07	34
18	0.70	0.00	44
20	0.62	0.00	46
21	0.33	0.06	28
22	0.44	0.02	33
23	0.55	0.01	54
24	0.26	0.14	44
25	0.53	0.01	44
27	0.32	0.08	48

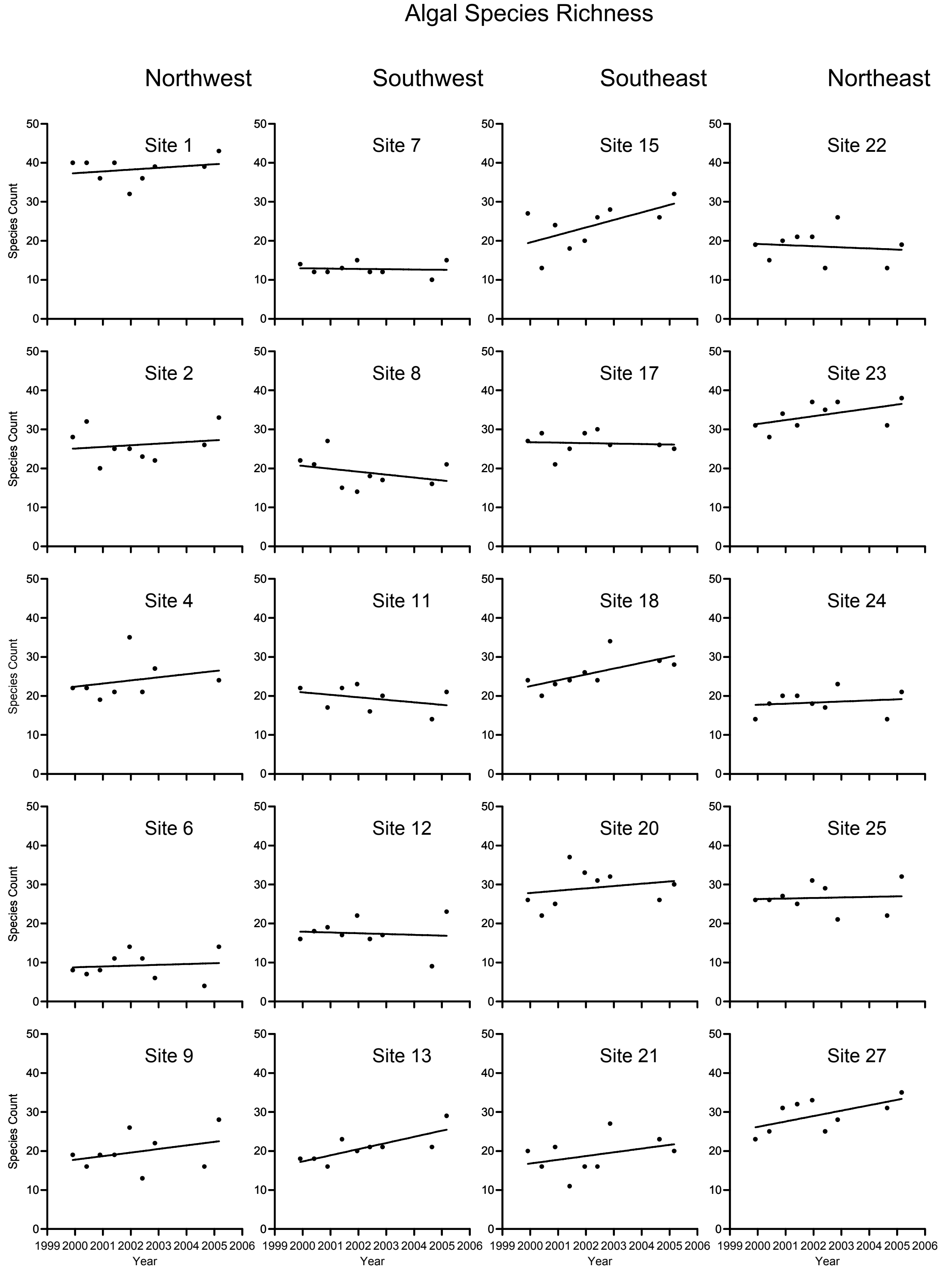


Figure 3.2. Trends in macroalgal species richness at Wilsons Promontory.

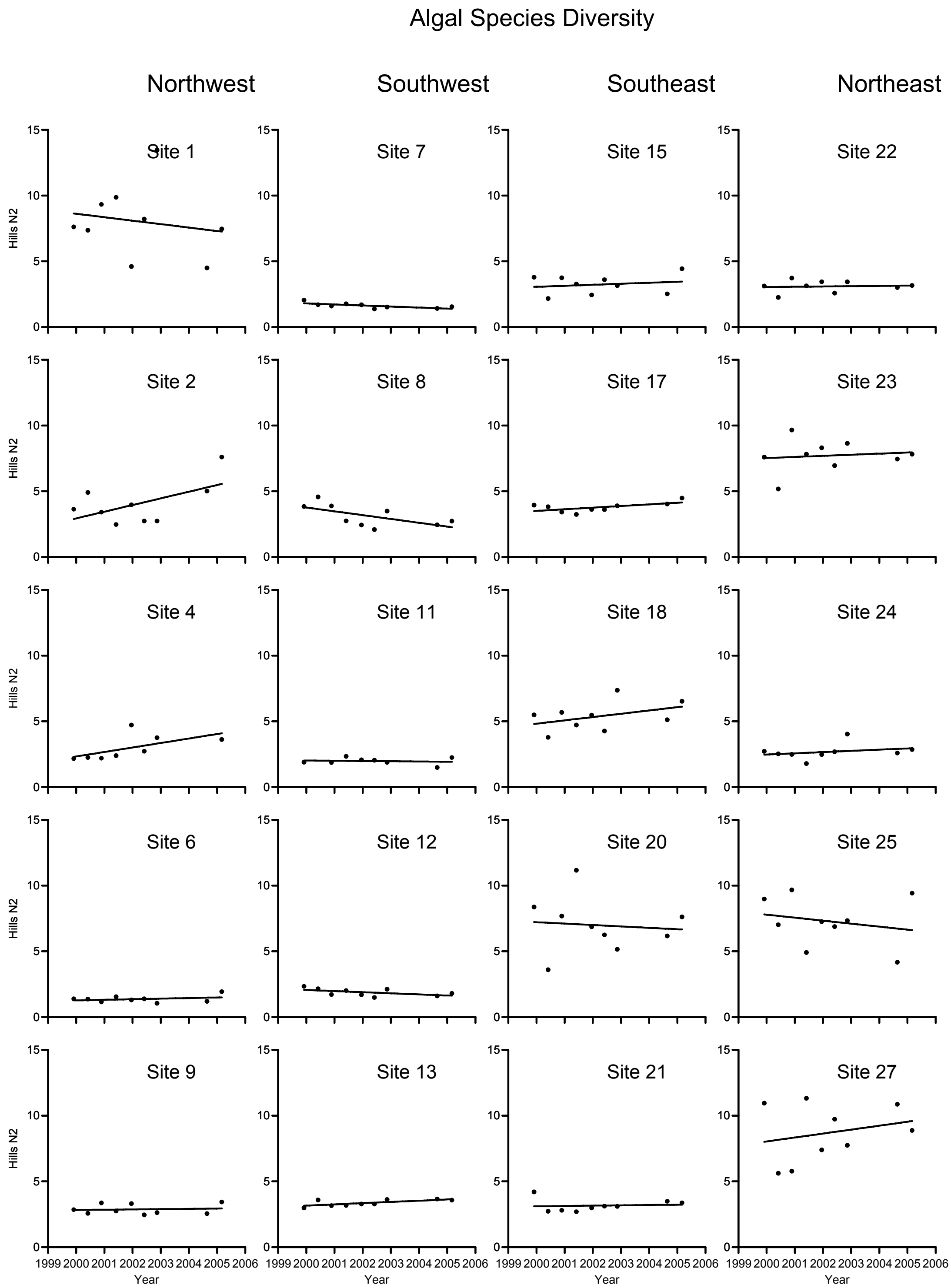


Figure 3.3. Trends in macroalgal species diversity at Wilsons Promontory.

3.3 Population Abundances

Examples of population abundances of selected species are given for each site in Figures 3.4 to 3.9. At some sites both *Ecklonia* and *Phyllospora* were relatively abundant (Sites 15, 23, 18, 25, 9, 13 and 21), while at other sites only *Phyllospora* (Sites 7, 2, 4, 11, 24, 6 and 12) or *Ecklonia* (Sites 1, 17, 20 and 27) dominated. However, the dominance of these large brown alga is shifting through time at some sites. At South Norman Point (Site 7) and Oberon Point (Site 8) a gradual decline in *Ecklonia* over the years corresponds to a gradual increase in *Phyllospora* cover, while at Cape Wellington (Site 22) the reverse pattern is apparent, with a decrease in *Phyllospora* corresponding to an increase in *Ecklonia* cover.

Seirococcus axillaris was generally most abundant at Tongue Point (Site 2), Oberon Point (Site 8) and North Refuge (Site 25; Figure 3.6). Large temporal variations were observed at these three sites. *Seirococcus axillaris* was not observed at all at Tongue Point (Site 2) or Bareback Bay (Site 23) during May 2002 (Survey 6), indicating a large decrease of 19.8 % cover from the previous survey at Tongue Point and 6.8 % cover at Bareback Bay (note the poor fit of the regression lines in Figure 3.6).

The abundances of *Haliptilon roseum*, *Phacelocarpus peperocarpus* and *Plocamium angustum* are shown in Figures 3.7 to 3.9. At most sites, these three red algae have remained constant through time. Exceptions include: a large decrease in *Haliptilon roseum* at South Refuge and Shell back Is (Sites 24 and 1; Figure 3.7) , a decrease in *Phacelocarpus peperocarpus* at North Shellback Is (Site 1; Figure 3.8) and a large increase in the cover of *Plocamium angustum* at West Norman Is (Site 4) and North Horn Pt (Site 27; Figure 3.9).

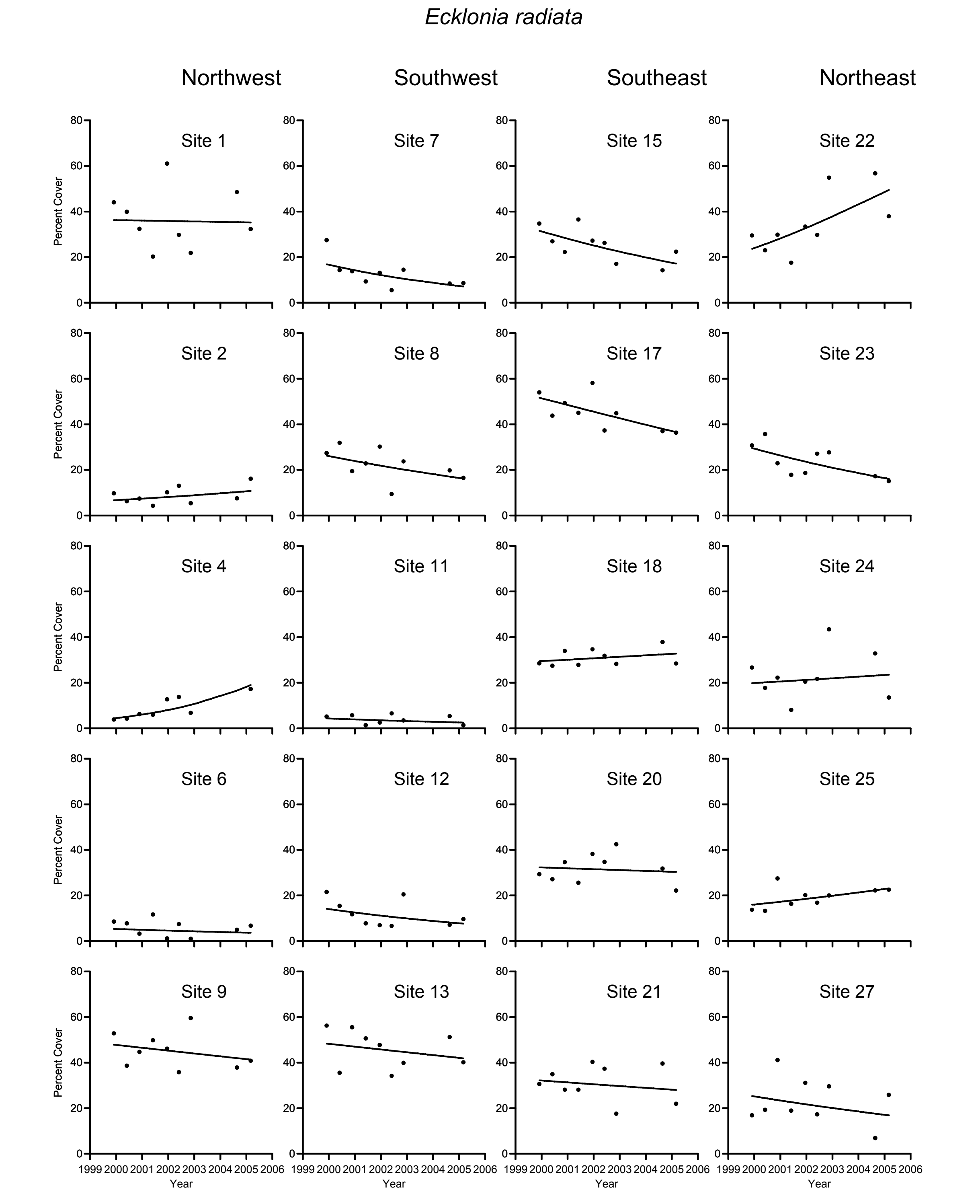


Figure 3.4 Abundances of *Ecklonia radiata* at Wilsons Promontory.

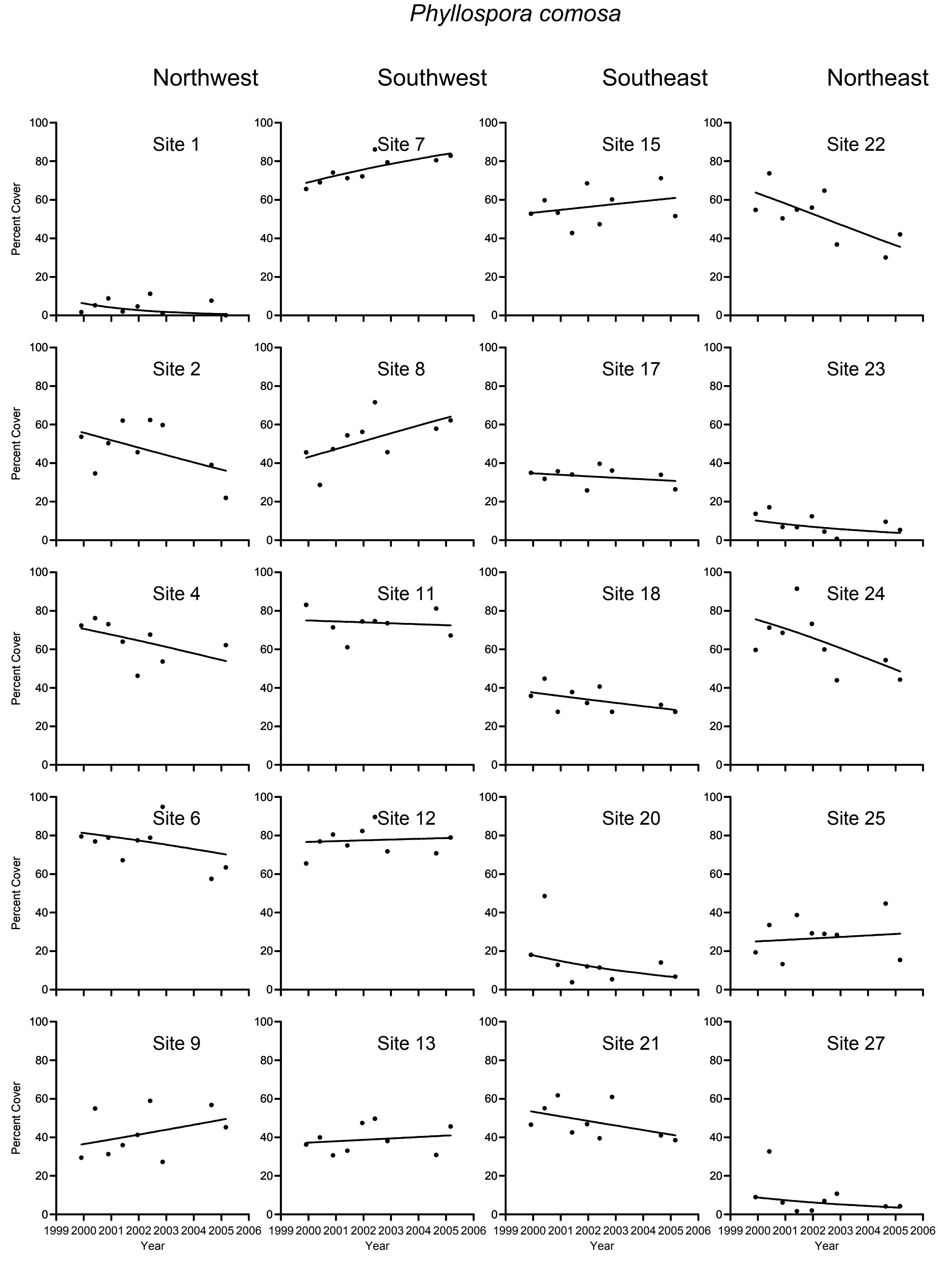


Figure 3.5 Abundances of *Phyllospora comosa* at Wilsons Promontory.

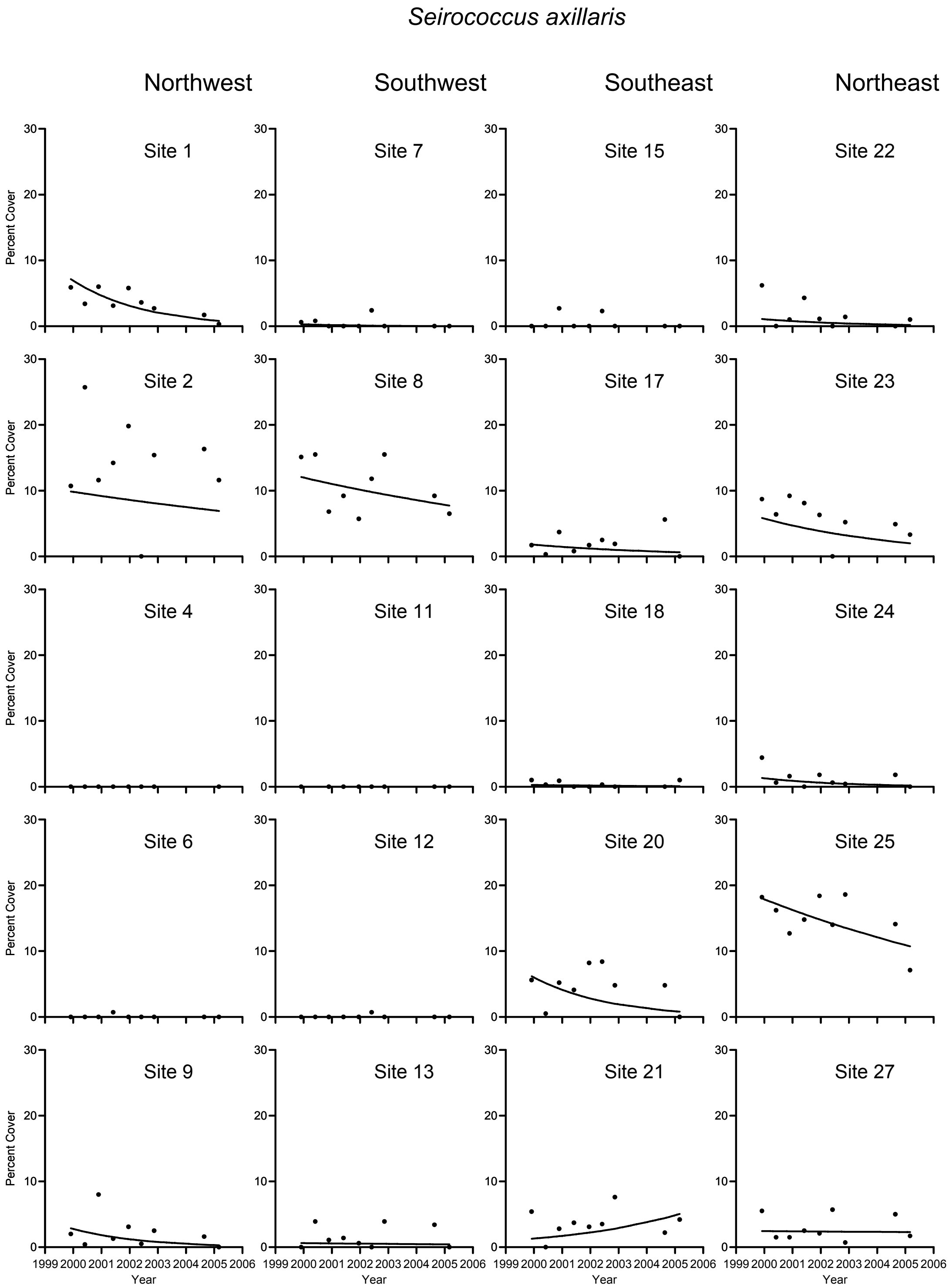


Figure 3.6 Abundances of *Seirococcus axillaris* at Wilsons Promontory.

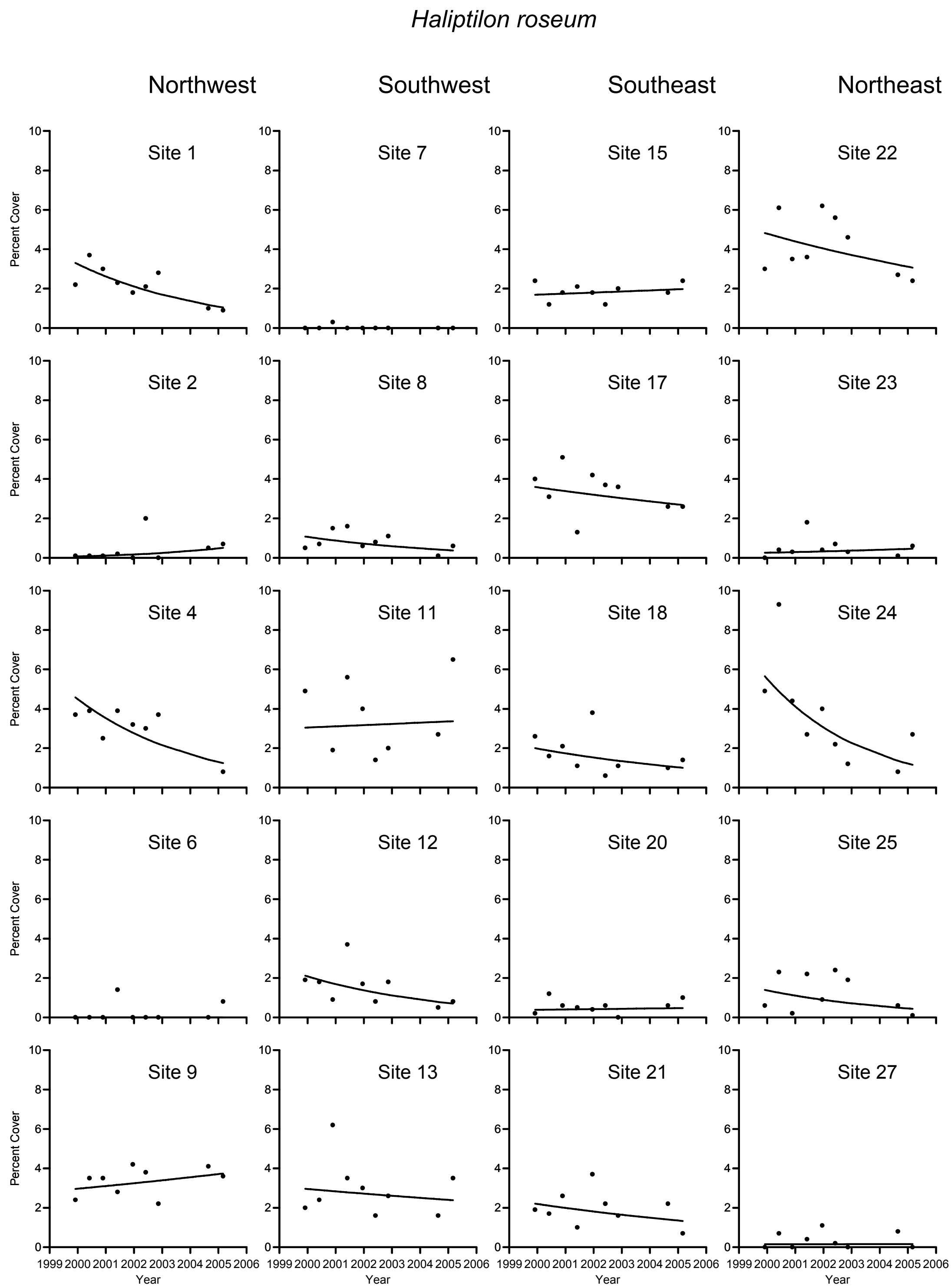


Figure 3.7 Abundances of *Haliptilon roseum* at Wilsons Promontory.

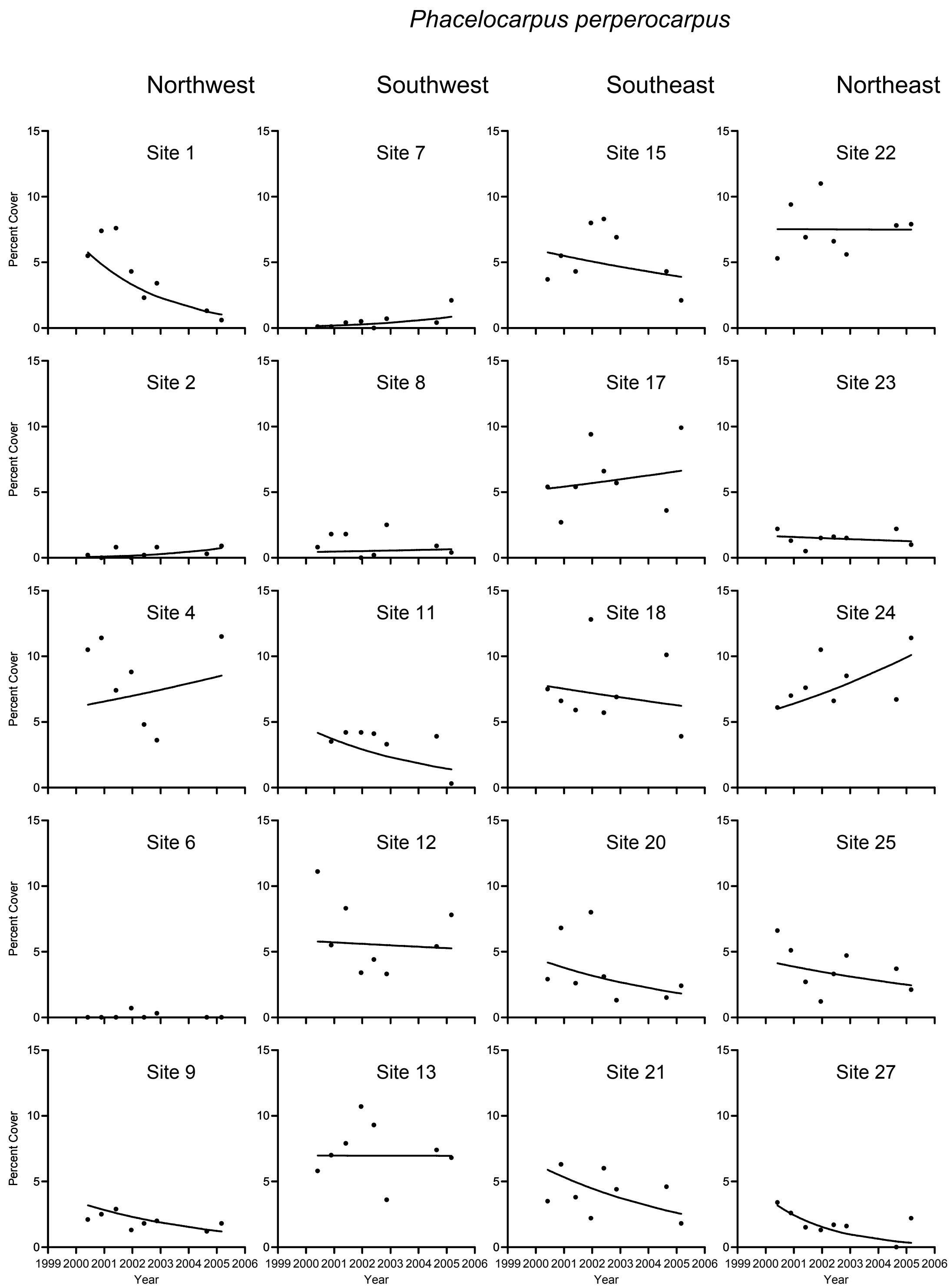


Figure 3.8 Abundances of *Phacelocarpus peperocarpus* at Wilsons Promontory.

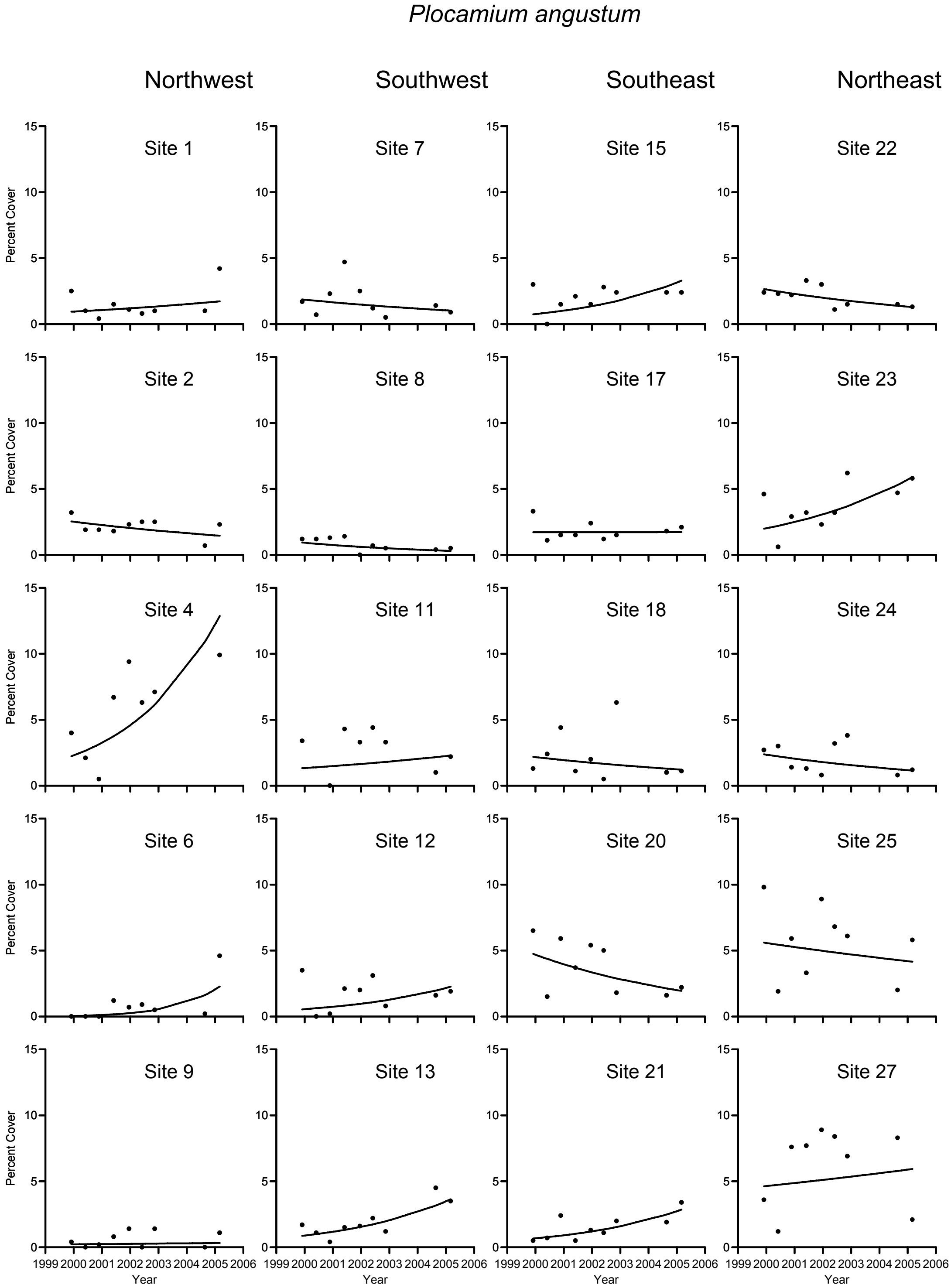


Figure 3.9 Abundances of *Plocamium angustum* at Wilsons Promontory.

4.0 INVERTEBRATES

4.1 Community Structure

The invertebrate assemblages at Wilsons Promontory had both north/south and east/west differences in species structure (eastern sites to right and western sites to left of Figure 4.1; northern sites to lower and southern sites to upper regions of Figure 4.1). The north/south differences correlate with an exposure gradient, the southern region of the Promontory being more exposed than the northern region. Assemblage structure at the more sheltered sites consisted of a high abundance of the sea urchin *Heliocidaris erythrogramma* and moderate abundances of blacklip abalone *Haliotis rubra* and the featherstar *Cenolia trichoptera*. The sea stars *Nectria ocellata*, *Nectria macrobrachia* and *Plectaster decanus* were also common.

At more exposed sites, *Haliotis rubra* was more dominant in abundance and *Heliocidaris erythrogramma* was relatively less abundant. *Cenolia trichoptera* and *Nectria ocellata* were generally in similar abundances between exposed and moderately sheltered sites, but *Nectria macrobrachia* and *Plectaster decanus* was less abundant than at the less exposed sites. The periwinkle *Turbo undulatus* tended to be more abundant at the exposed sites.

Sites at North Norman Island, west Great Glennie Island and south of Refuge Cove (Sites 3, 10 and 24) had moderate to high abundances of *Haliotis rubra*, but had very low abundances of *Heliocidaris erythrogramma* and *Cenolia trichoptera*. The sea stars *Petricia vernicina* and *Plectaster decanus* were common at these sites. The central Waterloo Bay and north Refuge Cove sites (Sites 20 and 25) had high abundances of *Heliocidaris erythrogramma* and low abundances of *Cenolia trichoptera* and *Haliotis rubra*.

North Horn Point and North Shellback Island (Sites 1 and 27) had high abundances of *Cenolia trichoptera* and *Heliocidaris erythrogramma* and low abundances of *Haliotis rubra*. *Nectria ocellata* and *Nectria macrobranchia* were also common at both these sites. These two sites had substrata of rubble and smaller boulders, creating many small interstices suitable for *Heliocidaris* and *Cenolia*.

There were differences in the temporal stability in invertebrate community structure between sites. Some sites displayed little temporal variation (*e.g.* Sites 2, 5, 7, 11, 12, 15, 21, 22, 23 and 27) while other sites varied largely between times (*e.g.* Sites 1, 6, 9, 13, 25, and 24; Figure 3.1). In general, there were greater differences between sites through time in the western sites than the eastern sites. This maybe attributed to a degree of spatial autocorrelation as the eastern sites are generally closer to one another than the western sites.

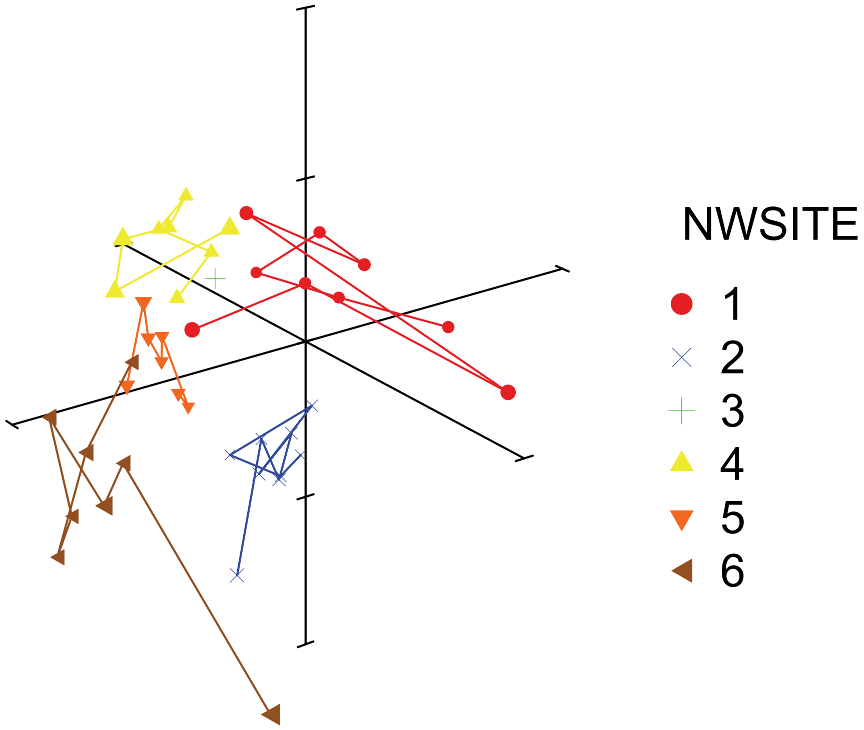


Figure 4.1a. Three-dimensional MDS plot of invertebrate assemblage structure for north-western sites at Wilsons Promontory. Stress = 0.18.

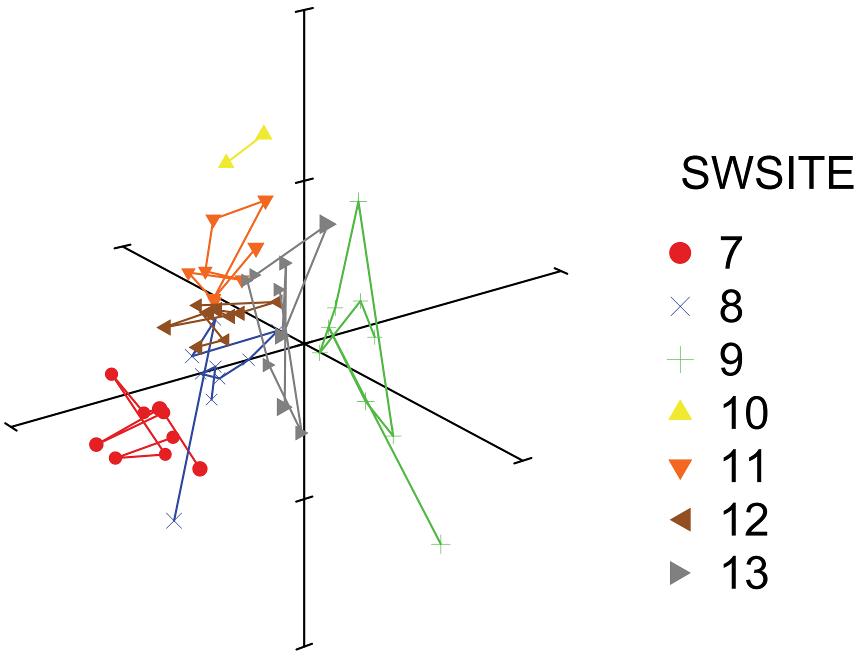


Figure 4.1b. Three-dimensional MDS plot of invertebrate assemblage structure for south-western sites at Wilsons Promontory. Stress = 0.18.

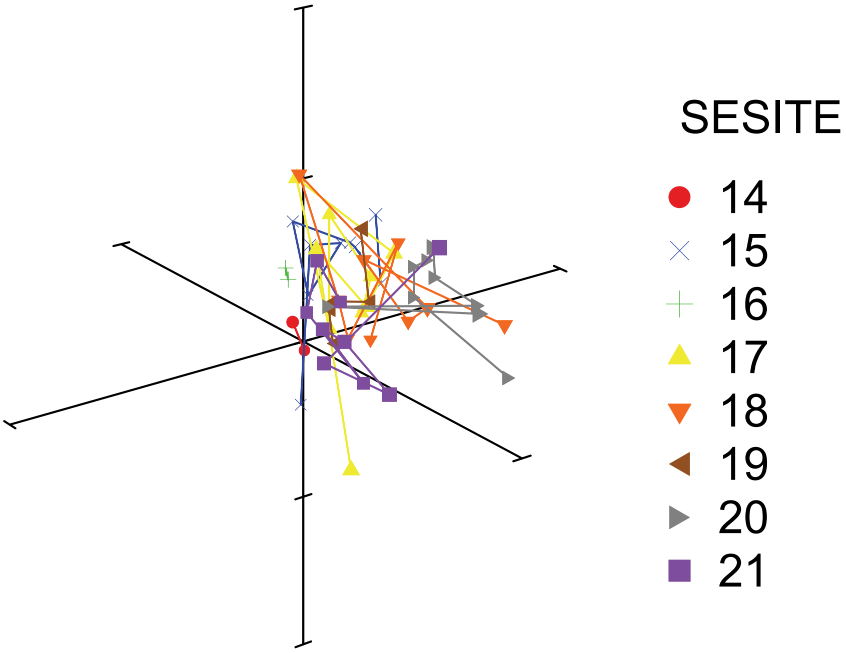


Figure 4.1c. Three-dimensional MDS plot of invertebrate assemblage structure for south-eastern sites at Wilsons Promontory. Stress = 0.18.

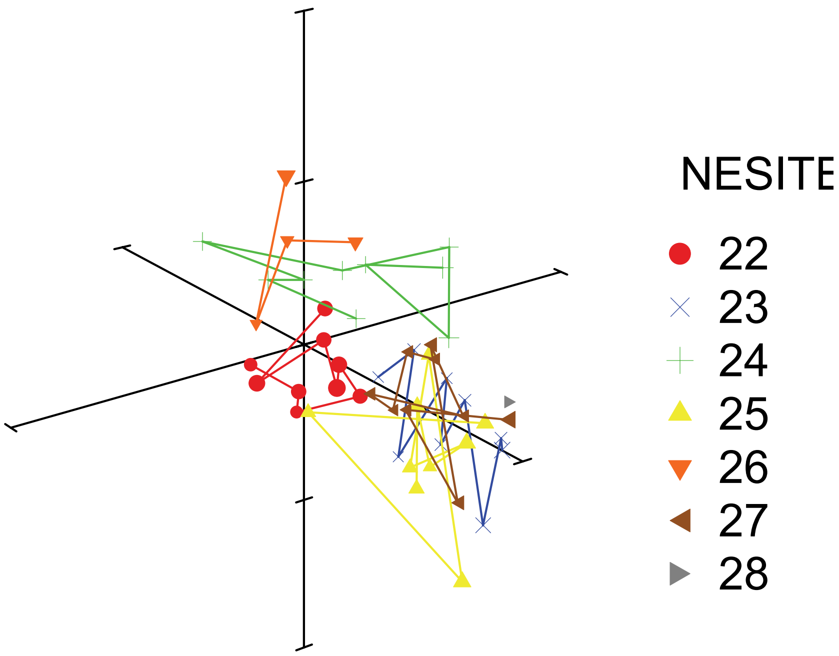


Figure 4.1d. Three-dimensional MDS plot of invertebrate assemblage structure for north-eastern sites at Wilsons Promontory. Stress = 0.18.

Tests for progressive changes (trends) in species composition over the three monitoring years detected significant trends ($p \leq 0.05$) at Sites 2, 4, 8, 13, 18, 21 and 27 (Table 4.1). From the MDS plots however, it appears that the significant result at Sites 2, 8 and 21 is in response to either the first or last site being distinctly different from the rest of the survey times, thus representing less of a sustained trend over time (Figure 4.1).

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

Site	Mantel r_M	Probability	% B-C Dissimilarity (first to last)
1	0.10	0.32	32
2	0.42	0.04	50
4	0.53	0.01	42
5	0.17	0.17	32
6	0.39	0.06	41
7	0.19	0.21	35
8	0.38	0.04	27
9	-0.07	0.51	38
12	0.29	0.09	35
13	0.32	0.05	39
15	0.23	0.11	37
17	0.32	0.09	35
18	0.39	0.05	39
20	0.11	0.24	32
21	0.46	0.04	52
22	0.25	0.15	39
23	-0.01	0.47	42
24	0.25	0.13	35
25	0.10	0.32	32
27	0.42	0.04	50

4.2 Diversity

The species richness was quite variable through time, ranging between 5 and 19 species for most sites at Wilsons Promontory. Highest species richness occurred at North of Sea Eagle Bay (Site 11), Sea Eagle Bay (Site 12) and Waterloo Bay (Site 20; Figure 4.2). Species richness values were particularly low for all sites for this recent survey, reflecting a consistent decrease in species richness at some sites (Sites 15, 22, 23 and 4). Species diversity was comparatively stable over time, with 2-4 dominant species per site. Species diversity was consistently higher at Shellback Island, Tongue Point, Oberon Point and Anser Island (Sites 1, 2, 8 and 13; Figure 4.3). Sites with the lowest diversity were at east Great Glennie Island, north of Sea Eagle Bay and North Horn Pt (Sites 9, 11 and 27; Figure 4.3).

Figure 4.2 Observers positioning the site marker using differential GPS (Site 5, Leonard Point).

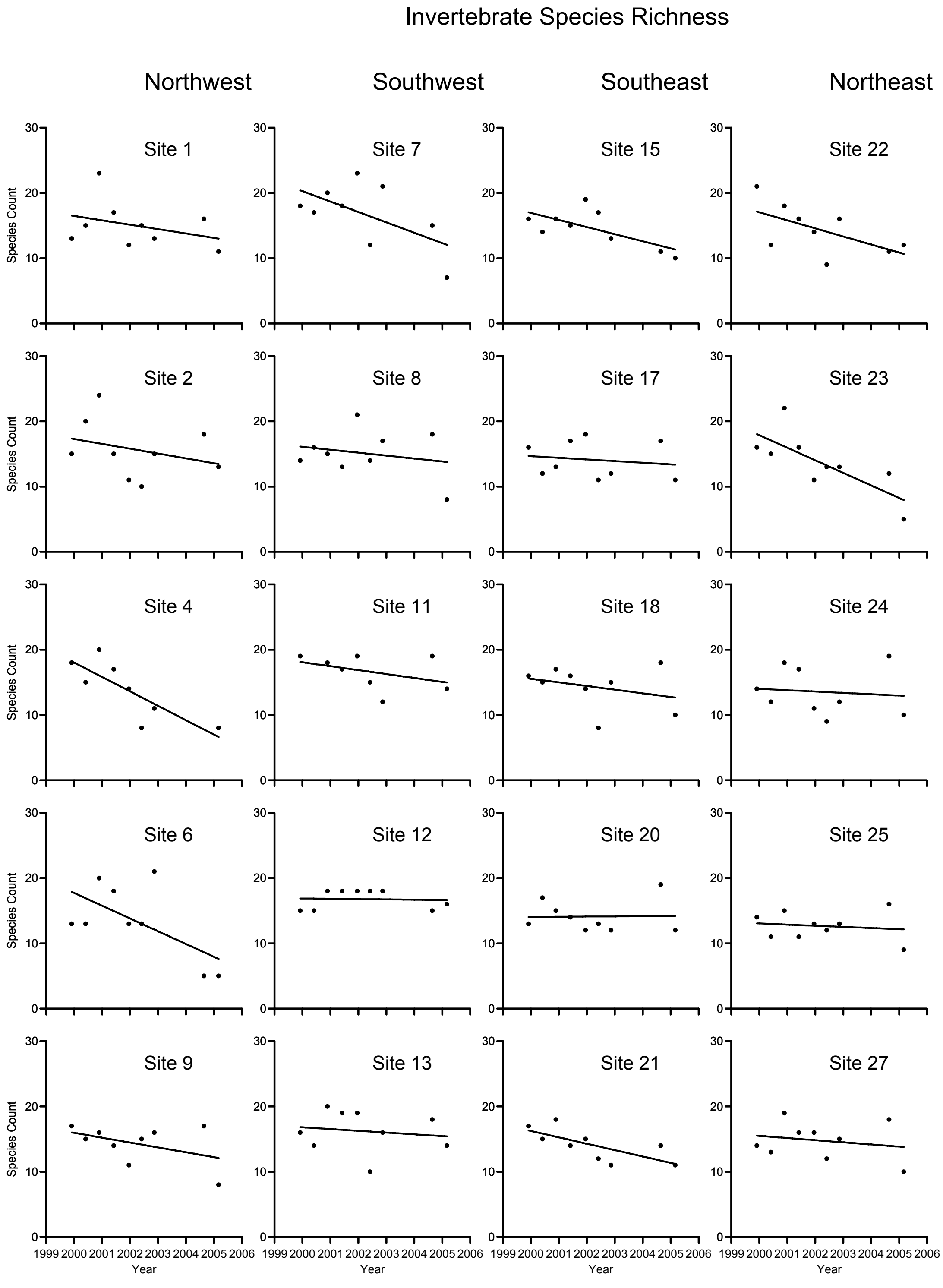


Figure 4.3. Invertebrate species richness at Wilsons Promontory.

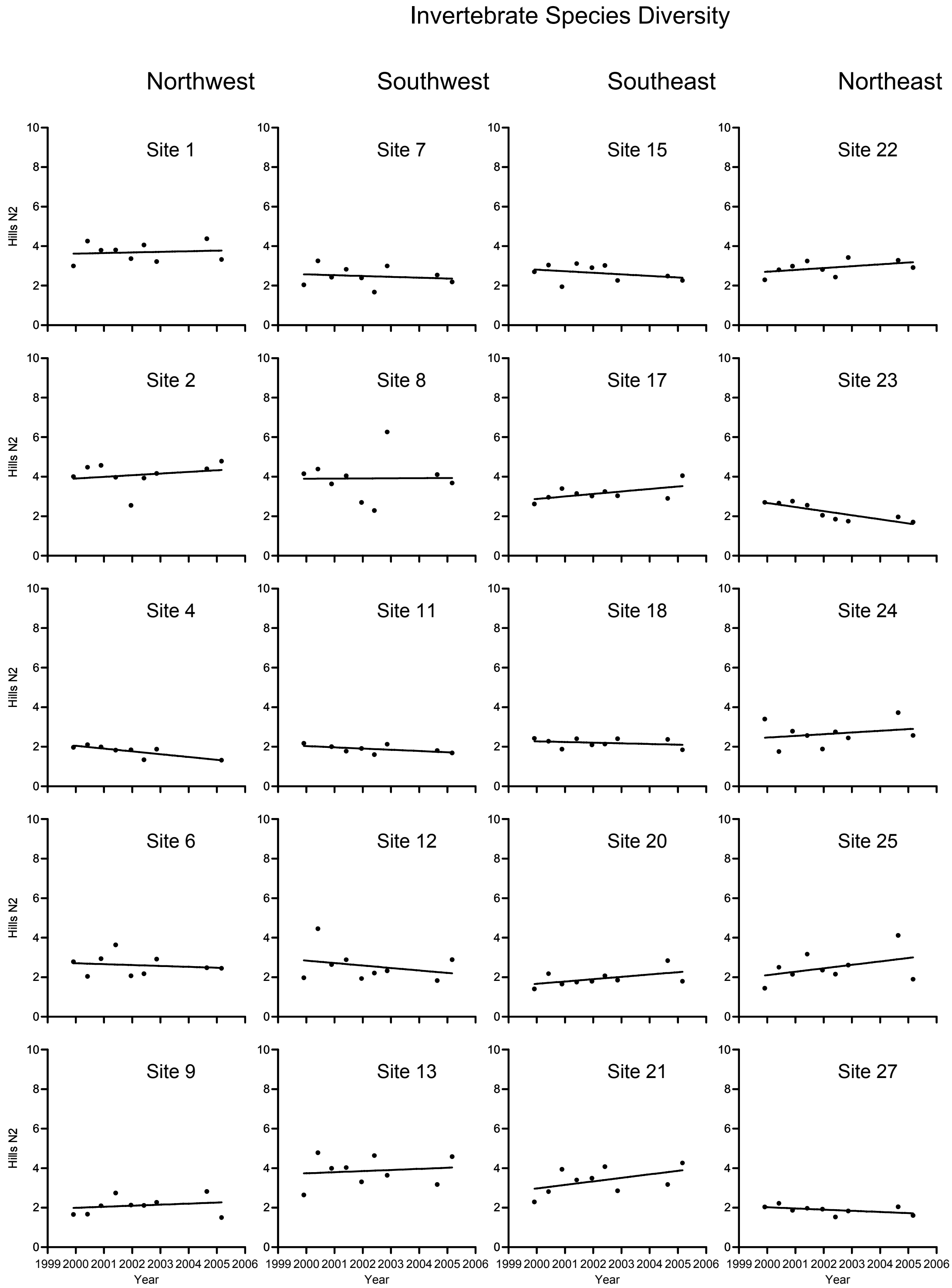


Figure 4.4. Invertebrate species diversity at Wilsons Promontory.

4.3 Population Abundances and Sizes

The abundances of common species are shown for each site in Figures 4.4 to 4.10. As mentioned above, *Haliotis rubra*, *Heliocidaris erythrogramma* and *Cenolia trichoptera* were common around much of the Wilsons Promontory (Figures 4.5 to 4.7). *Haliotis rubra* was most abundant at the exposed west and southwest sites (Sites 4, 7, 11, 12 and 6; Figure 4.5) while *Heliocidaris erythrogramma* tended to be more abundant at the more sheltered and northern sites (Sites 9, 20, 21, 25 and 27). *Heliocidaris erythrogramma* was also abundant at the southern Roaring Meg and Fenwick Bight sites (Sites 15 and 18). There appeared to be a decreasing trend in abundance of both *H. rubra* and *H. erythrogramma* at many sites, especially distinct for *H. rubra* at Sites 4 and 12 and *H. erythrogramma* at Sites 9, 20 and 27 (Figure 4.6).

The feather star *Cenolia trichoptera* tended to be more abundant at the northwest sites (Sites 1, 2, 7, 8 and 9), but was also very abundant at North Horn Point in the northeast (Site 27; Figure 4.7). There has been a general decline in *Cenolia trichoptera* abundance over the seven surveys at many sites. This decline was particularly marked North Horn Point (Site 27; Figure 4.7).

The seastar *Patiriella brevispina* was abundant at the western points, particularly Tongue Point, Pillar Point, Norman Point and Oberon Point (Sites 2, 6, 7 and 8; Figure 4.8). The sea star *Nectria ocellata* was common at most sites, with higher abundances tending to occur along the southwest coast (Figure 4.9). The southwest coast sites had a marked decrease through time. *Nectria macrobrachia* was most abundant along the east coast (Figure 4.10) and declined slightly in abundance over the eight surveys.

The abundances of *Haliotis rubra*, *Heliocidaris erythrogramma*, *Cenolia trichoptera* and *Nectria ocellata* appeared to be lower during the winter surveys (Figures 4.4, 4.5, 4.6 and 4.8). In addition, it appears that sites with higher abundances of these species have greater variations through time. Seasonal fluctuations in the abundance were not as evident for *Nectria macrobrachia*, although large fluctuations were observed at Roaring Meg and Waterloo Bay (Site 15 and 20; Figure 4.10).

Over the nine surveys, the urchin *Centrostephanus rodgersii* was found at two sites in low abundance (Figure 4.11). When in high densities *C. rodgersii* causes community shifts from macrophyte dominated reefs to urchin barrens (Andrew and Underwood 1993). This species is of particular interest as in recent years it has increased its range down the east coast of Australia to Tasmania, causing major losses in macrophyte reef communities. Wilsons Promontory appears to be a western satellite site for the urchin as it is found in high abundance in the Twofolds Bioregion on the east coast of Victoria, but not the Bunurong Marine Park on the central coast. The urchin has not yet increased its range westward, an occurrence that would have major consequences to Victorian subtidal reef communities. It is therefore important to monitor closely the density of *Centrostephanus rodgersii* at Wilsons Promontory for any increase indicative of a western extension.

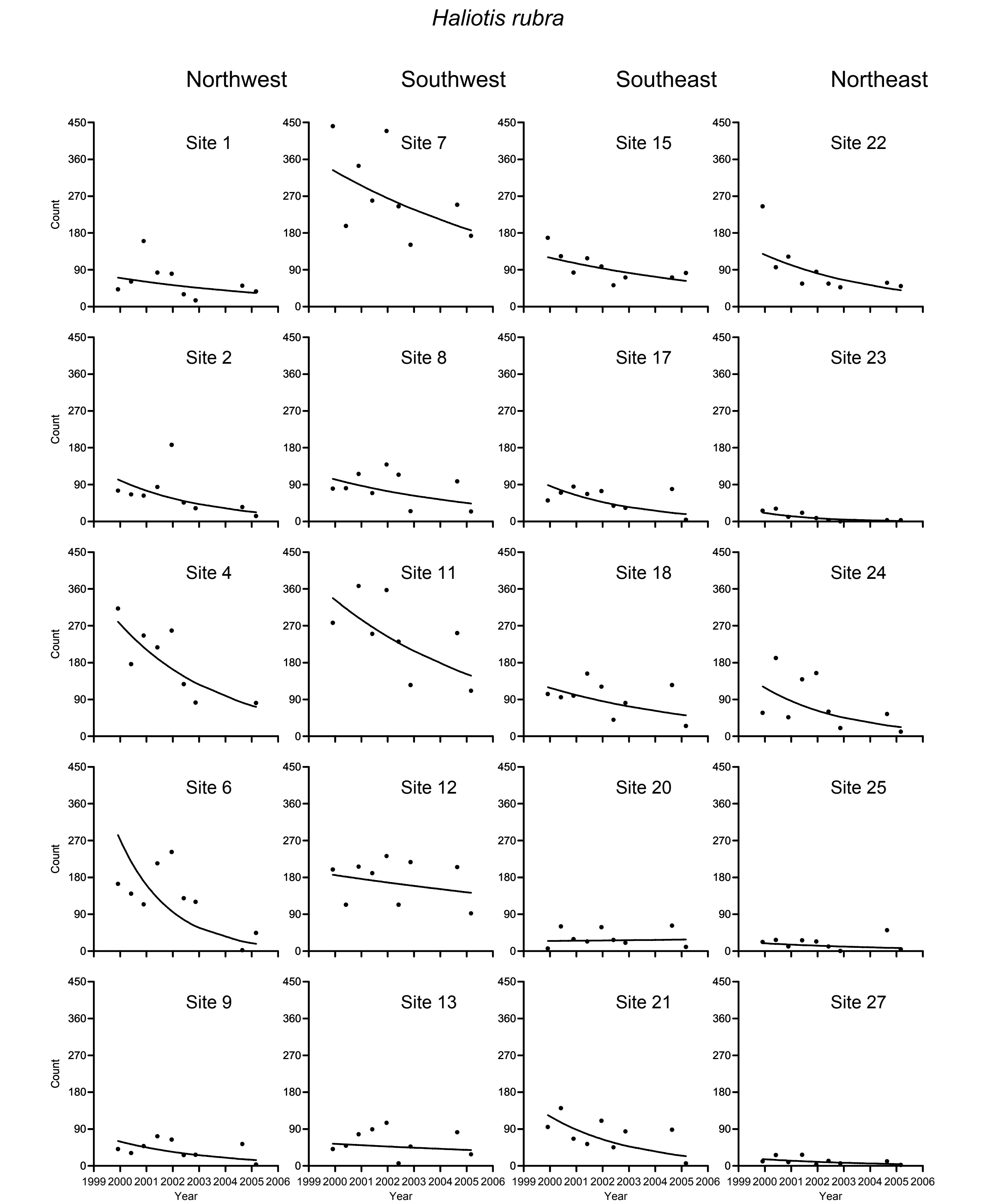


Figure 4.5. Abundances of *Haliotis rubra* at Wilsons Promontory.

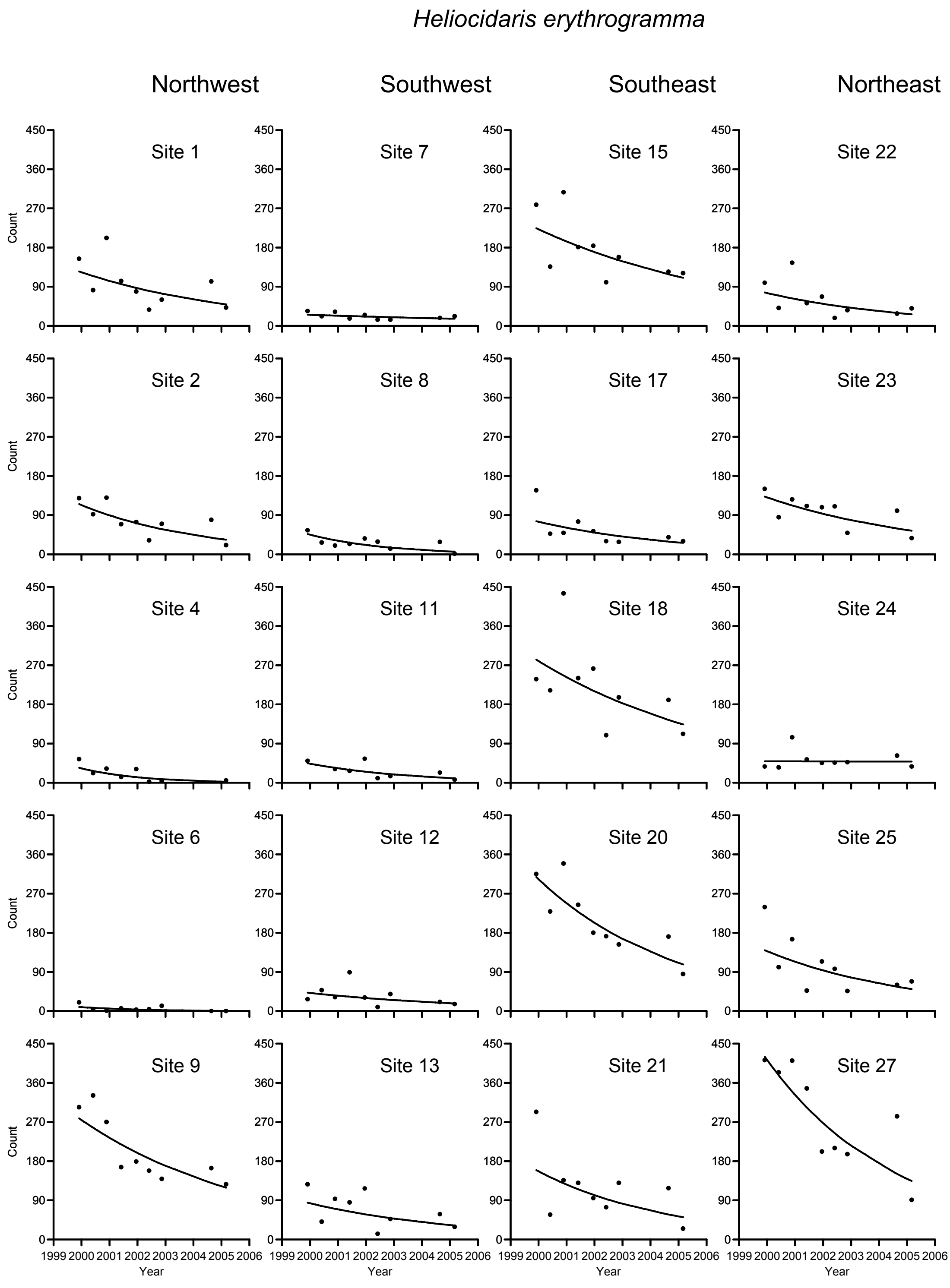


Figure 4.6 Abundances of *Heliocidaris erythrogramma* at Wilsons Promontory.

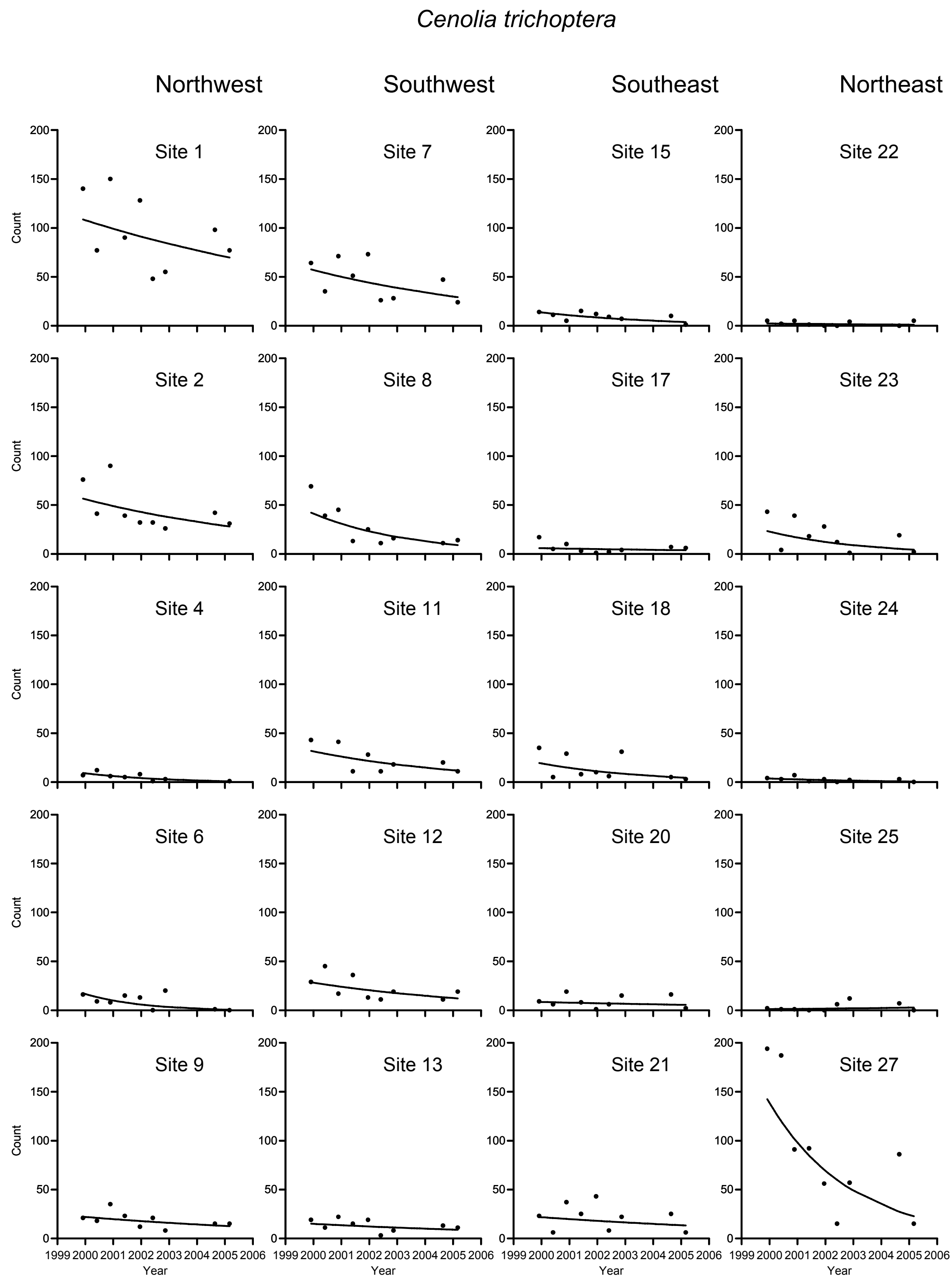


Figure 4.7. Abundances of *Cenolia trichoptera* at Wilsons Promontory.

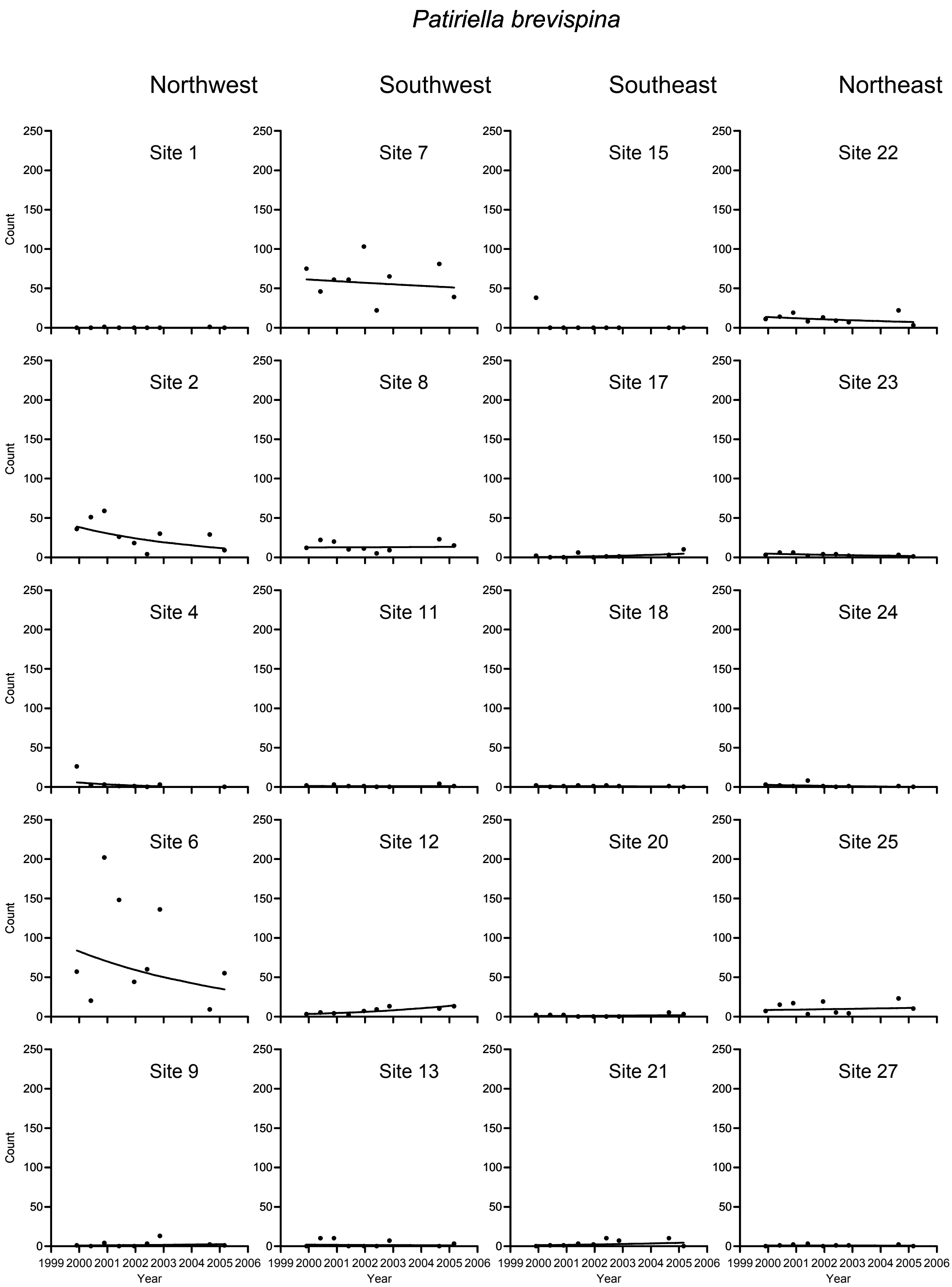


Figure 4.8. Abundances of *Patiriella brevispina* at Wilsons Promontory.

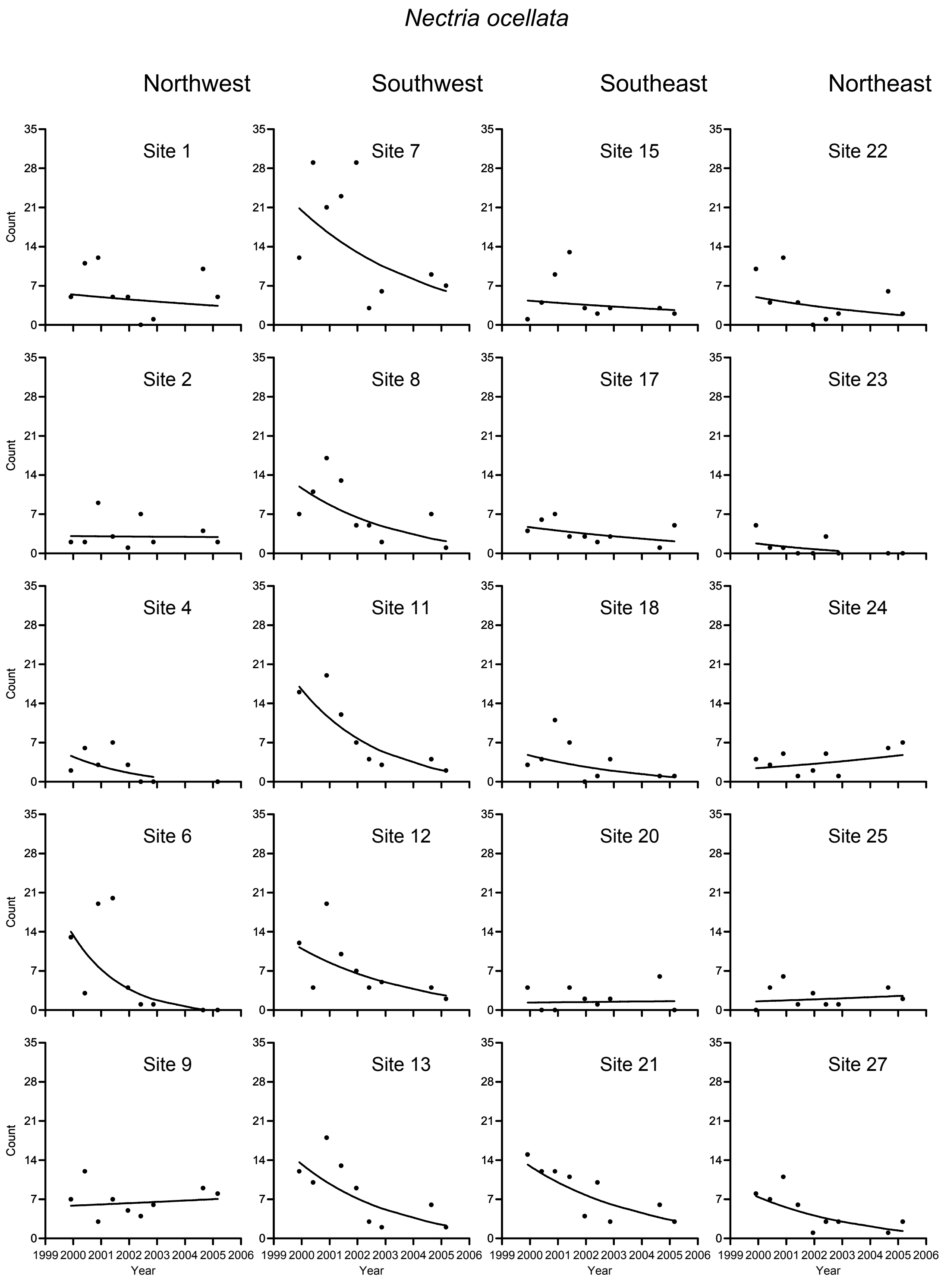


Figure 4.9. Abundances of *Nectria ocellata* at Wilsons Promontory.

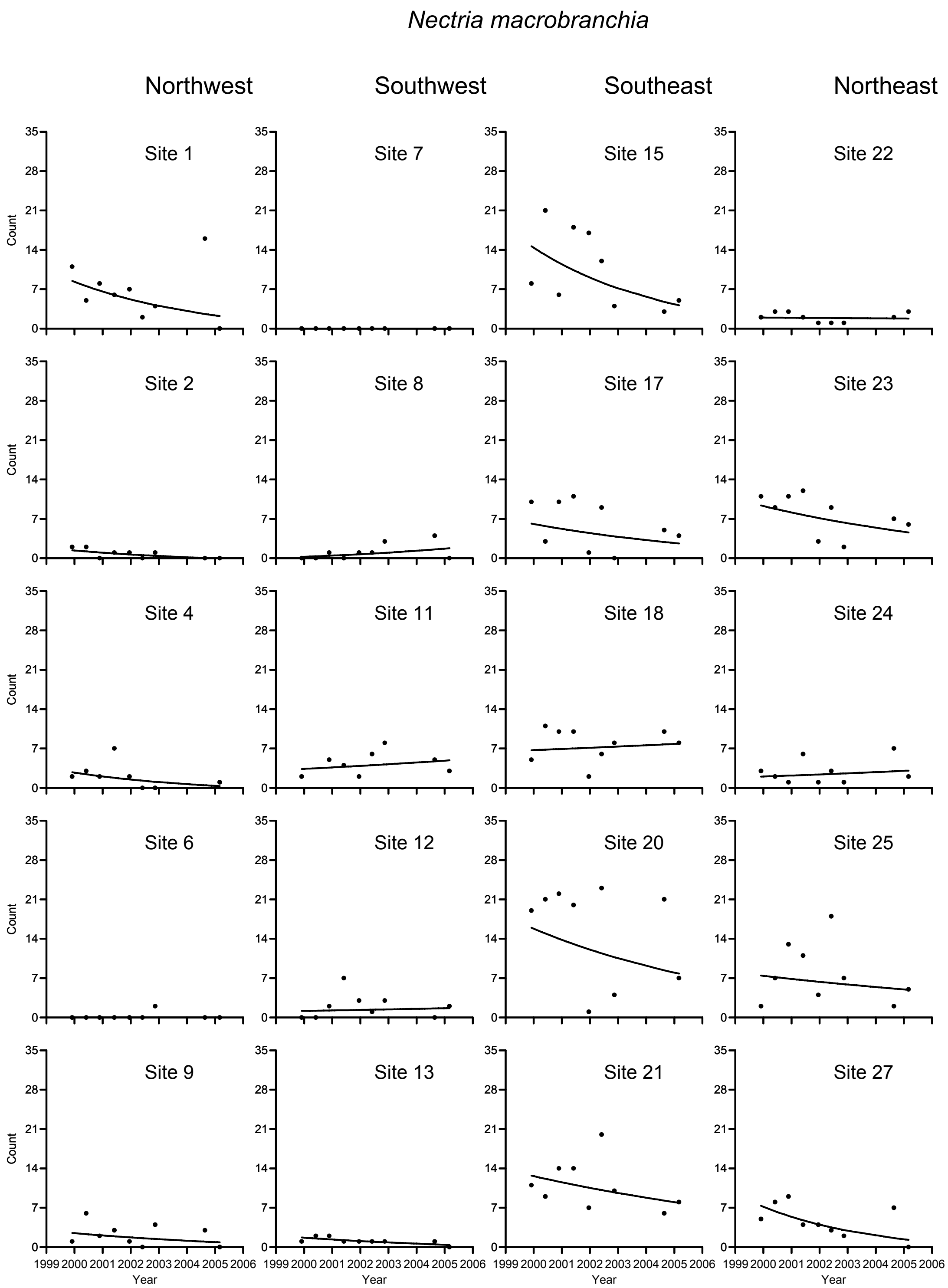


Figure 4.10. Abundances of *Nectria macrobranchia* at Wilsons Promontory.

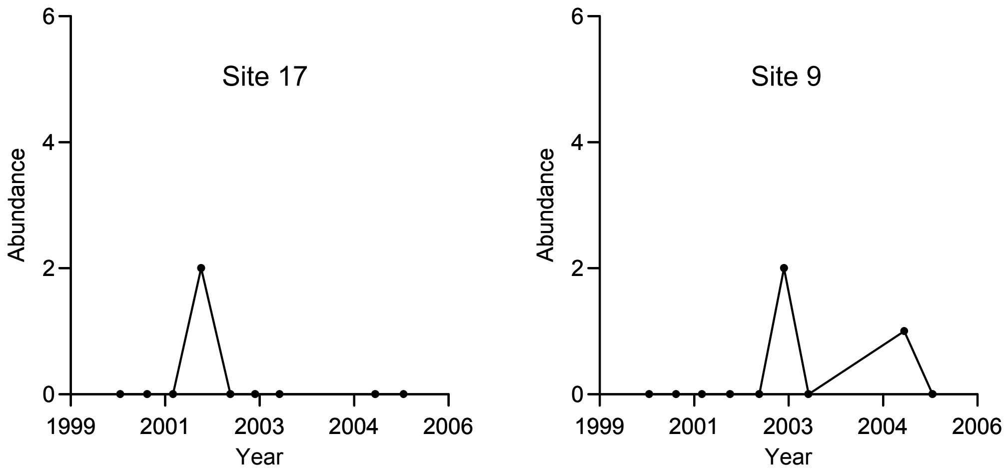


Figure 4.11 Abundance of *Centrostephanus rodgersii* at Wilsons Prom over the nine surveys.

The size structure of the abalone populations varied substantially around the promontory, with the largest mean sizes occurring along the southwest coast (Sites 4 to 12; Figure 4.12). Mean sizes were generally between 100 and 112 mm in this region, with sizes generally below 105 mm to the northwest, south and east of this region. Although mean sizes tended to be higher along the southwest coast, this was not reflected in the pattern of abundances, with both high and low abundances occurring at these sites (Figure 4.5). The size structure tended to be similar between surveys at most sites (Figure 4.12).

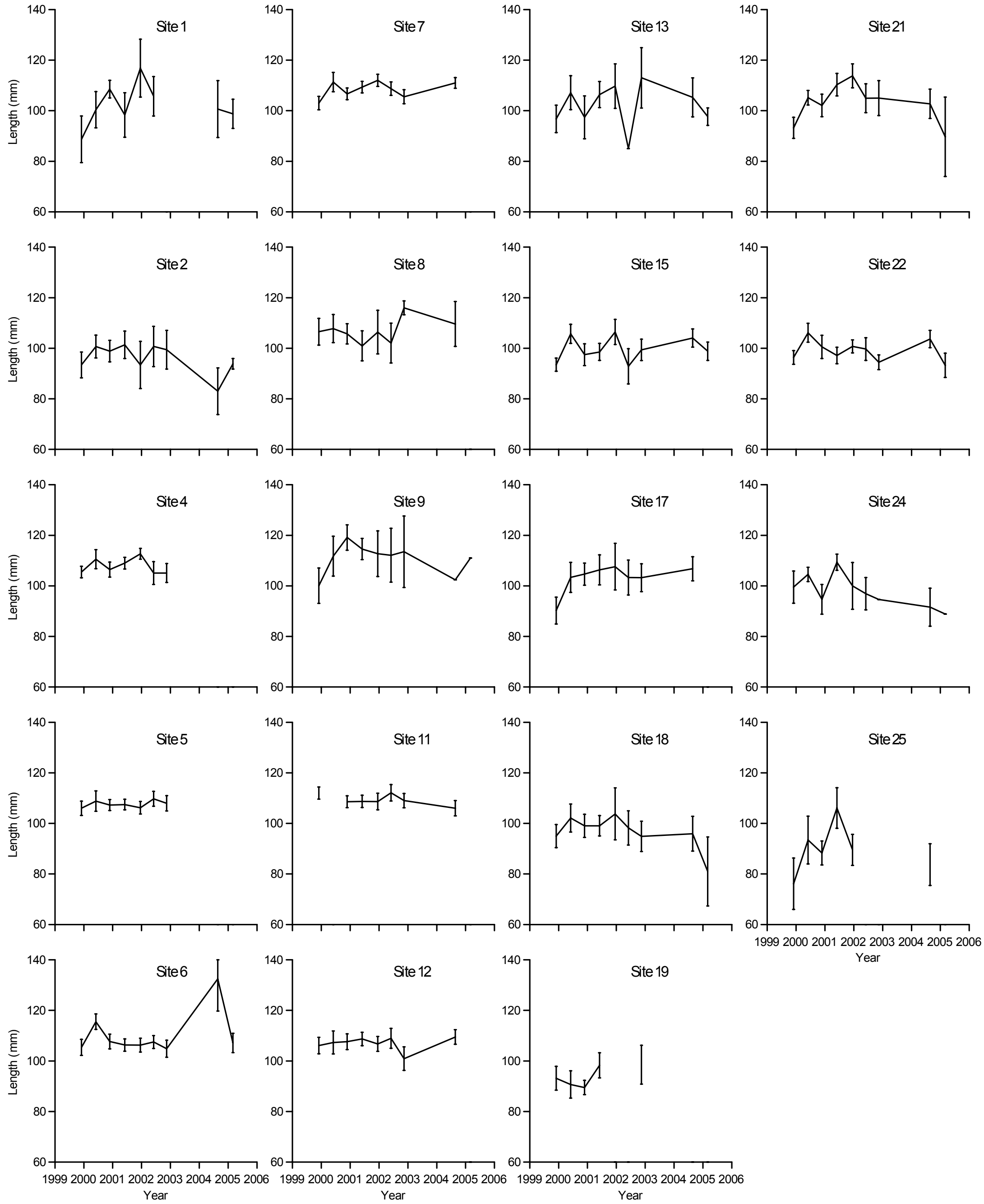


Figure 4.12. Mean sizes (± 95% confidence intervals, where n > 30) of black lip abalone Haliotis rubra at Wilsons Promontory.

5.0 FISH

5.1 Community Structure

The predominant fish species at Wilsons Promontory were the blue-throated wrasse *Notolabrus tetricus*, purple wrasse *N. fucicola*, herring cale *Odax cyanomelas*, magpie perch *Cheilodactylus nigripes*, barber perch *Caesioperca rasor*, silver sweep *Scorpis lineolata* and old wife *Enoplosus armatus*. Other common species included the toothbrush leatherjacket *Acanthaluteres vittiger*, pygmy rock whiting *Siphonognathus beddomei*, mado sweep *Atypichthys strigatus*, sea sweep *Scorpis aequipinnis*, long-finned pike *Dinolestes lewini* and southern hula fish *Trachinops caudimaculatus*.

The MDS ordination for fishes indicated there were both north-south (sheltered/exposed) and east/west affinities in assemblage structure (Figure 5.1).

The differences between the western and eastern sites were largely because of higher abundances of *Odax cyanomelas*, *Trachinops caudimaculatus*, *Notolabrus fucicola*, *Dinolestes lewini*, *Scorpis aequipinnis*, *Pictilabrus laticlavius*, *Meuschenia freycineti* and *Girella zebra* in the west and higher abundances of *Scorpis lineolata* and *Atypichthys strigatus* in the east. *Notolabrus fucicola* and *Caesioperca rasor* also tended to be higher in abundance at the southern, more exposed sites.

Temporal changes were variable in magnitude between sites, with the between survey variability as great as the between site variability. However, the east-west differences were apparent during all nine surveys (Figure 5.1).

Tests for progressive changes (trends) in species composition over the nine survey periods detected significant trends ($p \leq 0.05$) at Sites 1, 13, 21, 23 and 24 (Table 5.1).

5.2 Diversity

The species richness was between 10 and 25 species for most sites, but was lower for Cape Wellington (Site 6; Figure 5.2). Species diversity was quite variable, with few patterns apparent in the spatial and temporal differences (Figure 5.3). In particular Sites 1,13, 21,23 and 24 were highly variable, reflecting the community changes through time (Table 5.1). There was a decreasing trend in diversity at Norman Pt and Oberon Pt (Site 7 and 8). There was a decline in diversity at Sites 7 and 8 (Figure 5.3).

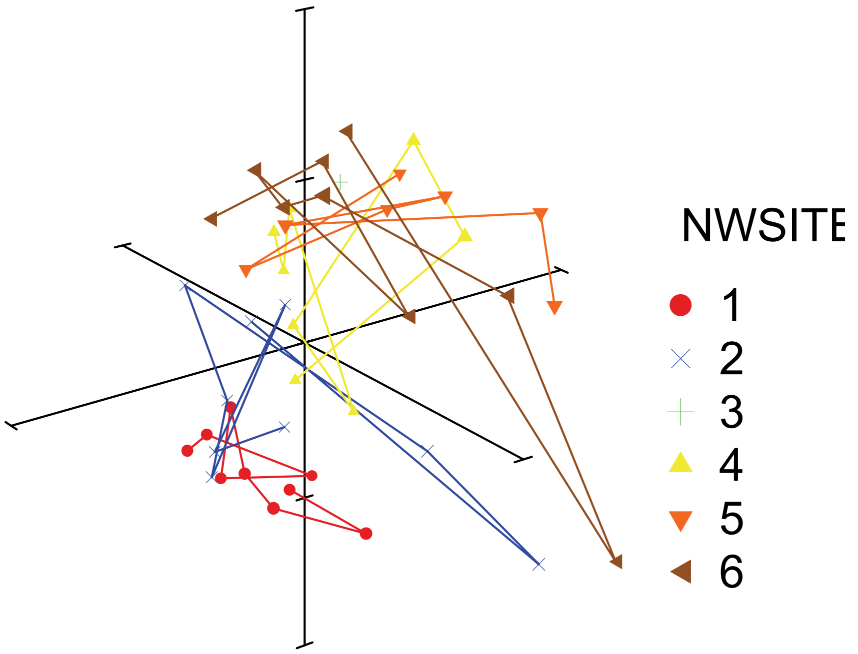


Figure 5.1a. Three-dimensional MDS plot of fish assemblage structure for north-western sites at Wilsons Promontory. Stress = 0.19.

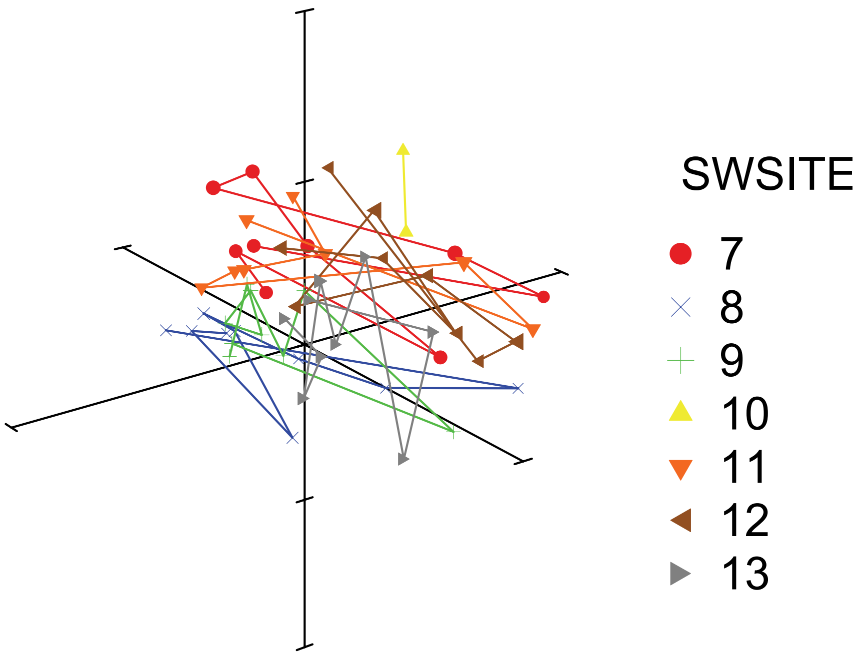


Figure 5.1b. Three-dimensional MDS plot of fish assemblage structure for south-western sites at Wilsons Promontory. Stress = 0.19.

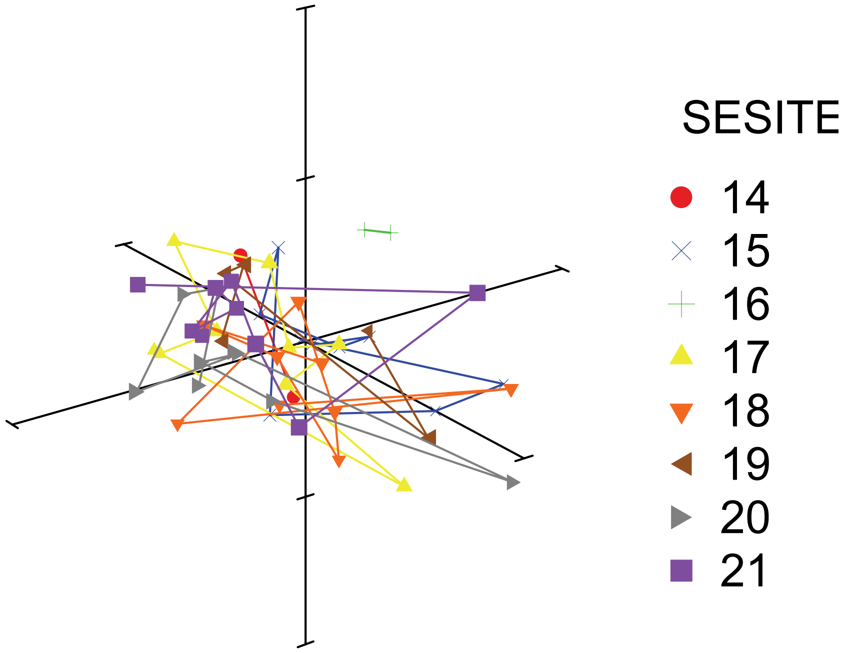


Figure 5.1c. Three-dimensional MDS plot of fish assemblage structure for south-eastern sites at Wilsons Promontory. Stress = 0.19.

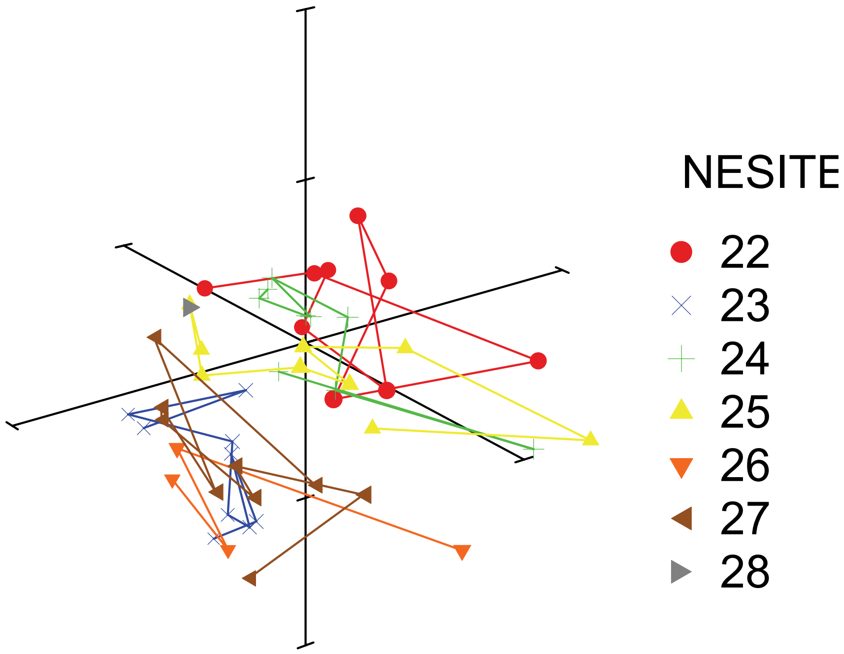


Figure 5.1d. Three-dimensional MDS plot of fish assemblage structure for north-eastern sites at Wilsons Promontory. Stress = 0.19.

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

Site	Mantel r_M	Probability	% B-C Dissimilarity (first to last)
1	0.38	0.05	35
2	0.33	0.07	34
4	0.28	0.14	48
5	0.06	0.37	26
6	0.38	0.06	39
7	0.21	0.20	24
8	0.14	0.24	33
9	0.02	0.41	28
12	0.05	0.39	27
13	0.43	0.03	42
15	0.17	0.21	33
17	0.31	0.13	28
18	0.35	0.08	34
20	-0.03	0.52	29
21	0.41	0.02	38
22	0.22	0.21	26
23	0.61	0.00	40
24	0.42	0.01	41
25	0.38	0.05	35
27	0.33	0.07	34

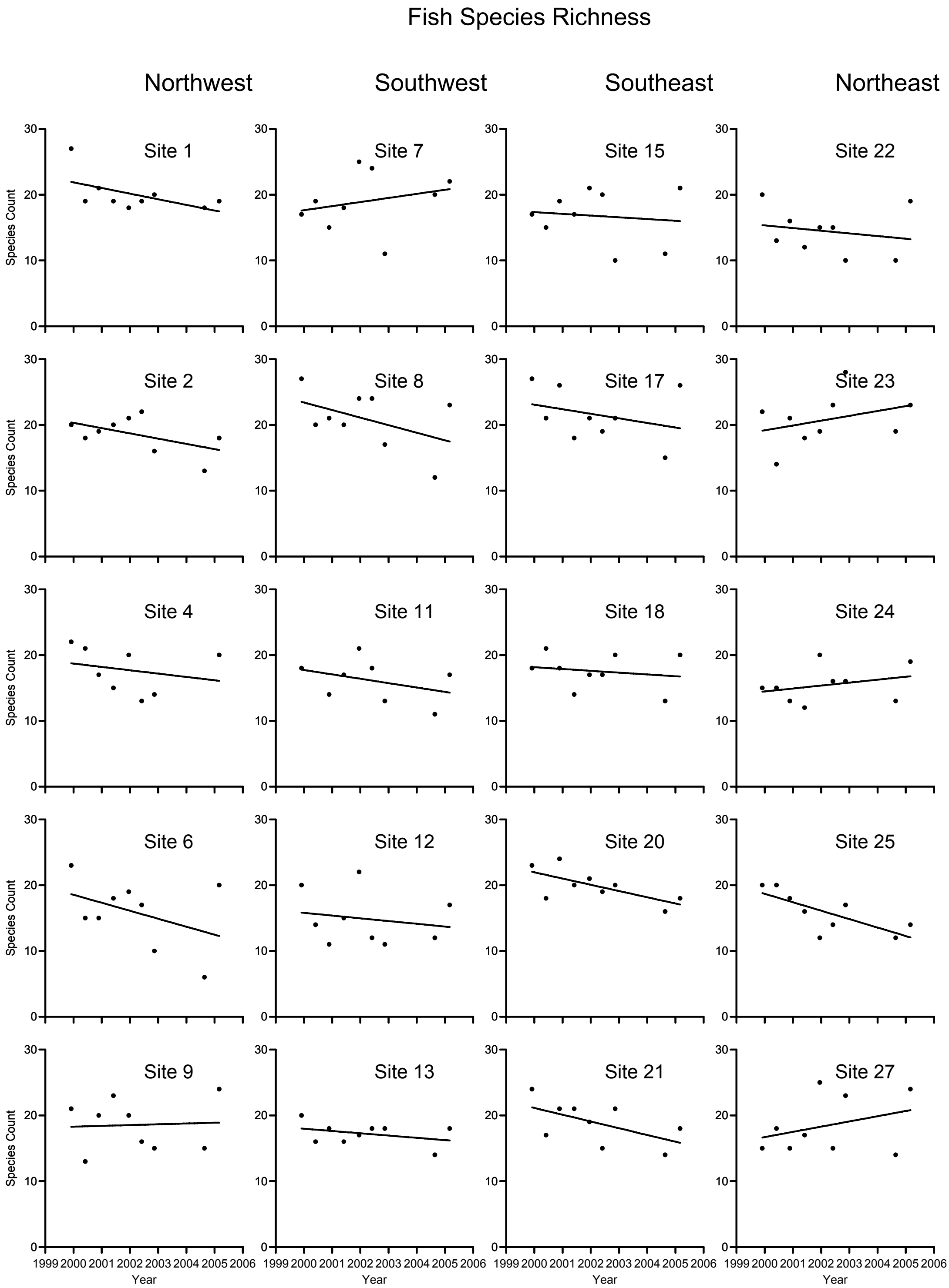


Figure 5.2. Fish species richness at Wilsons Promontory.

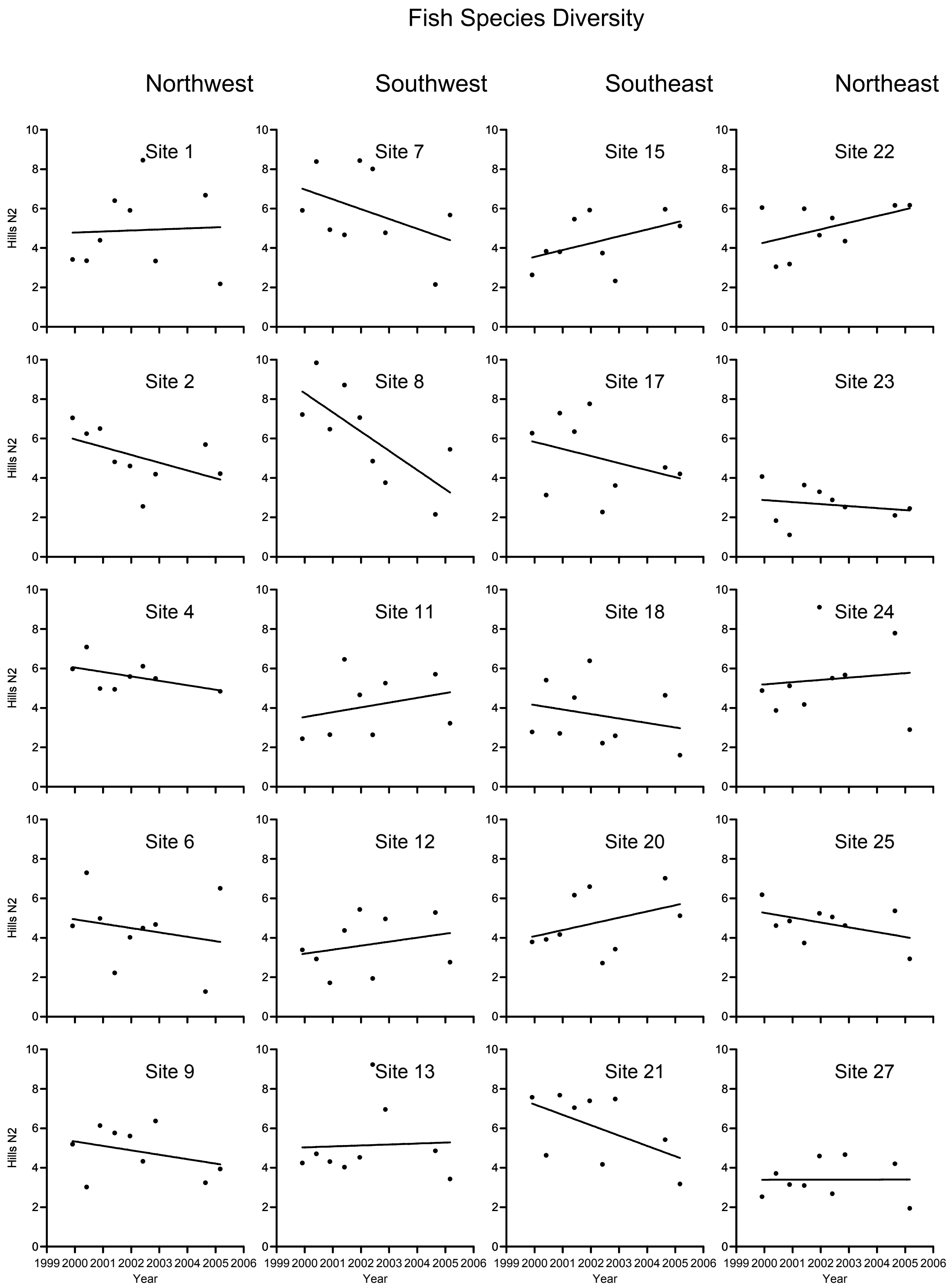


Figure 5.3. Fish species diversity at Wilsons Promontory.

5.3 Population Abundances and Sizes

The blue-throated wrasse *Notolabrus tetricus* was abundant at most sites around Wilsons Promontory (Figure 5.4). A marked seasonal fluctuation in abundance was observed at most sites, with abundances being higher during the summer surveys. There also appeared to be a declining trend at most western sites for *Notolabrus tetricus* (Figure 5.4).

Notolabrus tetricus is a protogynous hermaphrodite, with most 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 proportion of males at each site was generally highest along the southwestern, southern and southeastern coasts (Table 5.2).

The purple wrasse *Notolabrus fucicola* was abundant at most of the western sites, particularly between Tongue Point and South Point (Sites 2 to 14, Figure 5.5). Moderate abundances were present at the southeastern sites (Sites 15 to 21), but *N. fucicola* was largely absent from the northeastern sites. As with *N. tetricus,* there appeared to be a decline in *N. fucicola* density at most western sites. The mean sizes were similar at most sites, being between 150 and 250 mm total length (Table 5.3). One exception was Site 18 (Fenwich Bight), where a mean size of 106 mm was encountered, however this was based on only four individuals (Table 5.3).

The barber perch *Caesioperca rasor* was more abundant at the southern and eastern sites, with relatively low abundances between Tongue Point and Norman Point and at Great Glennie Island (Figure 5.6). Unlike the previous survey, large numbers of *C. rasor* were observed for survey 9 at all sites. These high numbers represent a change to the pattern of gradual decline of *C. rasor* over previous surveys at most sites. A large size range of *C. rasor* (from 75 mm juveniles to 250 mm adults) was observed at most sites, with the mean size ranging between 100 and 150 mm per site (Table 5.4). *Caesioperca rasor* is thought to be a protogynous hermaphrodite, as with *N. tetricus*. The sex ratio was highly variable between sites and times (Table 5.4).

The sea sweep *Scorpis aequipinnis* was highly variable in abundance between times at each site, with little consistency in this variation between sites (Figure 5.7). The magpie perch *Cheilodactylus nigripes* tended to be slightly more abundant at the eastern sites (contrasting with *N. fucicola*). Exceptions, however, are evident in high abundances at Shellback Island, Tongue Point, Oberon Point and east Great Glennie Island (Sites 1, 2, 8 and 9; Figure 5.8). There appears to have been a decline in *C. nigripes* over previous surveys reflecting the pattern seen in *Notolabrus tetricus*, *Notolabrus fucicola* and *Caesioperca rasor*.

The old wife *Enoplosus armatus* was common at the eastern sites (Sites 17 to 27), as well as the mid-western sites in the Pillar Point to Oberon Point region (Sites 6 to 9; Figure 5.9). Abundances were consistently much higher, during all surveys at Oberon Point (Site 8), with a large aggregation observed on Transect 1. These higher abundances on this transect were maintained throughout all surveys. It was concluded that Transect 1 at Site 8 is a biologically significant area for *Enoplosus armatus*.

Figure 5.4 Old wife Enoplosus armatus above canopy of *Phyllospora comosa* and *Ecklonia radiata*, East Landing (Site 17), Wilsons Promontory.

Table 5.2. Population structure of blue-throated wrasse *Notolabrus tetricus* at Wilsons Promontory.

Site	% males	Length (mm)			Length Class (mm)										
		n	mean	sd	75	100	125	150	200	250	300	350	375	400	500
Survey 8															
3101	11	28	195	72		1	5	8	6	4	2	1	1		
3102	0	14	146	49	1	2	5	2	3	1					
3106	50	4	219	107				2	1				1		
3107	25	20	219	90			2	6	6	1	2		1	2	
3108	0	7	204	77			1	2	2	1		1			
3109	29	24	219	77			2	7	6	3	2	4			
3111	17	24	207	86			7	5	3	3	3	1	2		
3112	8	14	211	88			3	3	4	1		2	1		
3113	24	17	228	98			1	7	3		2	1	2	1	
3115	25	8	238	76			1		3	2	1		1		
3117	15	20	211	74			2	5	7	3		2	1		
3118	19	16	189	82		2	2	5	3	2		1	1		
3120	27	22	211	101		1	2	8	2	1	2	3	2		
3121	28	29	209	84		1	6	6	6	3	2	5			
3122	23	13	229	79		1		2	4	3	1	1	1		
3123	8	37	172	61		2	7	17	5	3	1	2			
3124	10	10	193	53			1	3	4	1	1				
3125	15	27	212	77		1	3	7	6	3	4	3			
3127	9	23	166	64			9	8	4			2			
Survey 9															
3101	11	27	191	95		5	4	7	2	5	2	1		1	
3102	0	23	149	37	1	2	6	8	6						
3104	33	27	230	80			3	6	5	4	5	3	1		
3106	11	19	209	69			3	4	4	6		2			
3107	15	26	211	78			3	8	6	5		2	2		
3108	16	31	205	74			5	8	9	4	1	3	1		
3109	9	34	190	75		1	8	10	7	2	4	1		1	
3111	38	16	252	95				5	3	2		4	1	1	
3112	57	7	286	84					3		1	1	2		
3113	38	21	263	98			2	3	4	3	1	4	1	3	
3115	27	19	216	93			3	6	4	1	1	2	1	1	
3117	15	41	192	84	1	5	5	8	14	2	1	2	1	2	
3118	16	19	189	83		1	3	8	3	1		2	1		
3120	14	29	197	84		2	5	8	7	1	2	2	2		
3121	12	49	190	78	1	5	8	10	13	5	2	4		1	
3122	40	10	235	105	1	1			4		1	2	1		
3123	5	43	154	64	3	9	9	10	6	4	1		1		
3124	4	24	181	65		2	2	11	4	2	2	1			
3125	7	46	148	67	3	6	12	15	2	3	1	2			
3127	18	50	192	90	1	5	9	16	5	4	4	1	3	2	

Table 5.3. Population structure of purple wrasse *Notolabrus fucicola* at Wilsons Promontory.

Site	% males	Length (mm)			Length Class (mm)										
		n	mean	sd	75	100	125	150	200	250	300	350	375	400	500
Survey 8															
3101		1	350									1			
3106		2	200	71				1		1					
3107		4	169	38			1	1	2						
3108		9	233	71				3	1	1	4				
3109		12	200	6				6	2	2	2				
3111		13	183	49			1	6	4	1	1				
3112		13	212	55				4	4	3	2				
3113		20	178	33			2	7	1	1					
3115		3	200	87				2			1				
3117		3	183	29				1	2						
3118		9	206	3				1	6	2					
3120		11	175	42			3	2	5	1					
3121		12	165	27			1	7	4						
3122		5	200	35				1	3	1					
3124		2	150					2							
3125		8	156	32		1		5	2						
Survey 9															
3101		1	200	0					1						
3102		2	225	35					1	1					
3104		1	200	0					1						
3106		3	150	43			2		1						
3107		7	207	19					6	1					
3108		4	219	94			1		2			1			
3109		7	214	48				1	4	1	1				
3111		24	183	51			4	8	8	2	2				
3112		23	196	42		1		6	10	6					
3113		15	207	50				4	7	2	2				
3115		11	245	82				2	4	1	2	2			
3117		10	220	42				1	5	3	1				
3118		4	106	13		3	1								
3120		5	200	35				1	3	1					
3121		1	200	0					1						
3122		3	200	50				1	1	1					
3124		4	163	25				3	1						
3125		2	175	35				1	1						

Table 5.4. Population structure of barber perch *Caesioperca rasor* at Wilsons Promontory

Site	% males	Length (mm)			Length Class (mm)										
		n	mean	sd	25	50	75	100	125	150	200	250	300	350	375
Survey 8															
3101	25	4	150	41				1		2	1				
3102	50	2	175	35						1	1				
3107	25	4	150	35					2	1	1				
3108	0	3	117	14				1	2						
3109	14	14	100	22			4	7	2	1					
3111	0	13	140	19				2	1	10					
3112	0	30	103	8				27	3						
3113	8	36	97	20			13	16	6	1					
3115	13	10	123	14				2	7	1					
3117	3	39	127	18				5	28	5	1				
3119	13	23	127	13				2	17	4					
3120		5	170	27						3	2				
3121	50	2	150	0						2					
3122	50	2	175	35						1	1				
3123	4	347	127	11				19	283	44	1				
3124	11	9	106	17				8		1					
3127	12	58	125	26			1	17	30	6	4				
Survey 9															
3101	6	204	142	32			13	25	26	119	19	2			
3102	6	53	171	54		7	5	11	12	16	1				
3104	0	61	83	13			43	16	2						
3106	67	3	217	58						1		2			
3107	26	39	137	40				11	14	8	4	2			
3108	9	57	109	27		4	4	24	20	4	1				
3109	8	220	160	40			3	55	91	35	27	8			
3111	3	211	124	26			19	58	47	87					
3112	2	203	128	27		5	7	42	63	81	5				
3113	7	152	131	34			9	23	77	32	5	6			
3115	3	78	128	24			1	14	43	18	1	1			
3117	4	196	123	25			10	55	88	35	8				
3118	2	316	109	17			31	148	133	4					
3120	13	85	133	41			8	23	15	28	8	3			
3121	8	453	139	24			17	48	95	276	17				
3122	17	30	129	49		1	8	2	7	5	7				
3123	2	303	120	32	1		42	92	90	60	17	1			
3124	11	175	144	36			8	19	54	62	28	4			
3125	3	137	133	30			21	16	1	98	1				
3127	3	296	120	38		8	49	75	94	39	29	2			

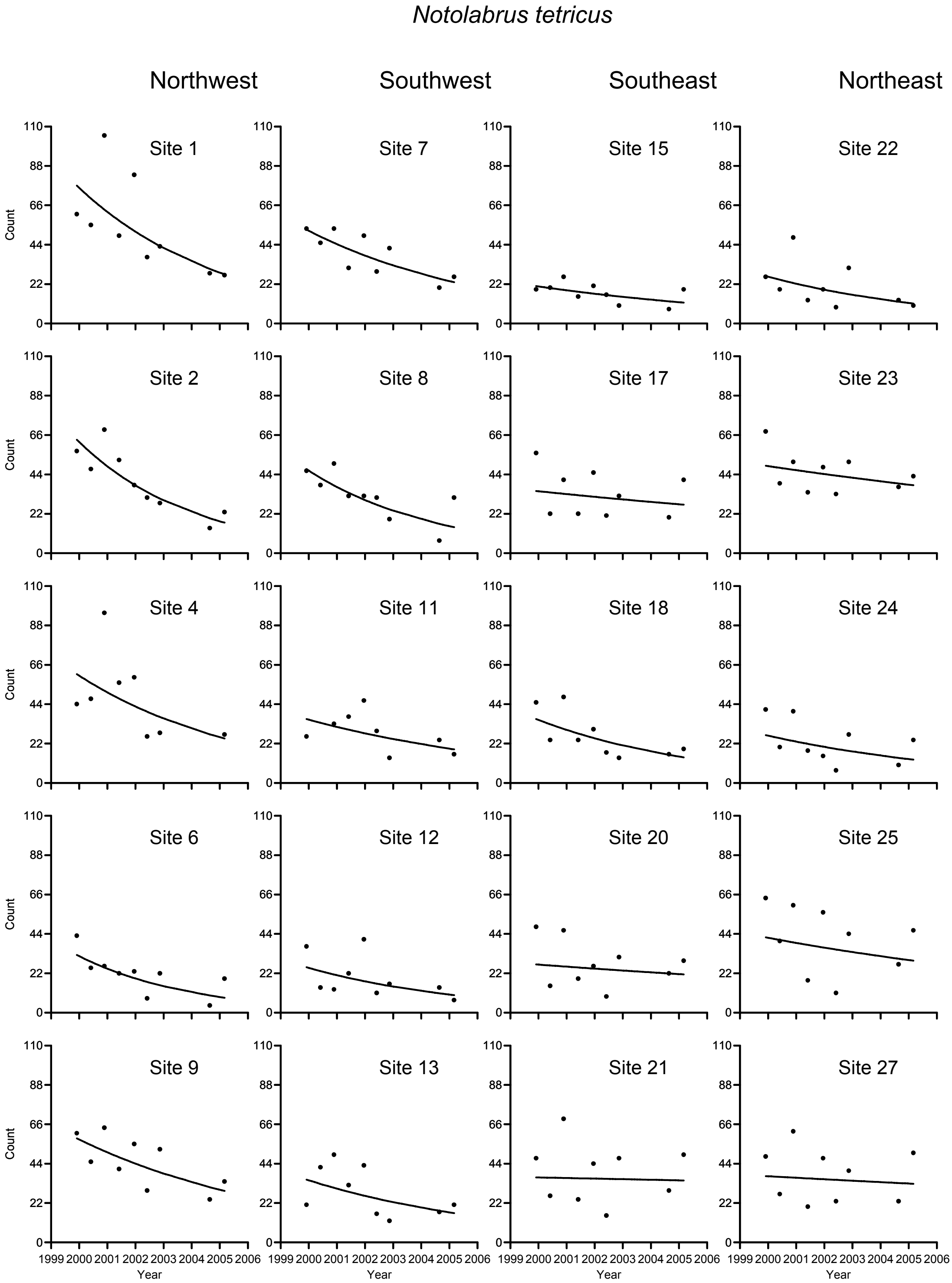


Figure 5.5. Abundances of blue-throat wrasse *Notolabrus tetricus* at Wilsons Promontory.

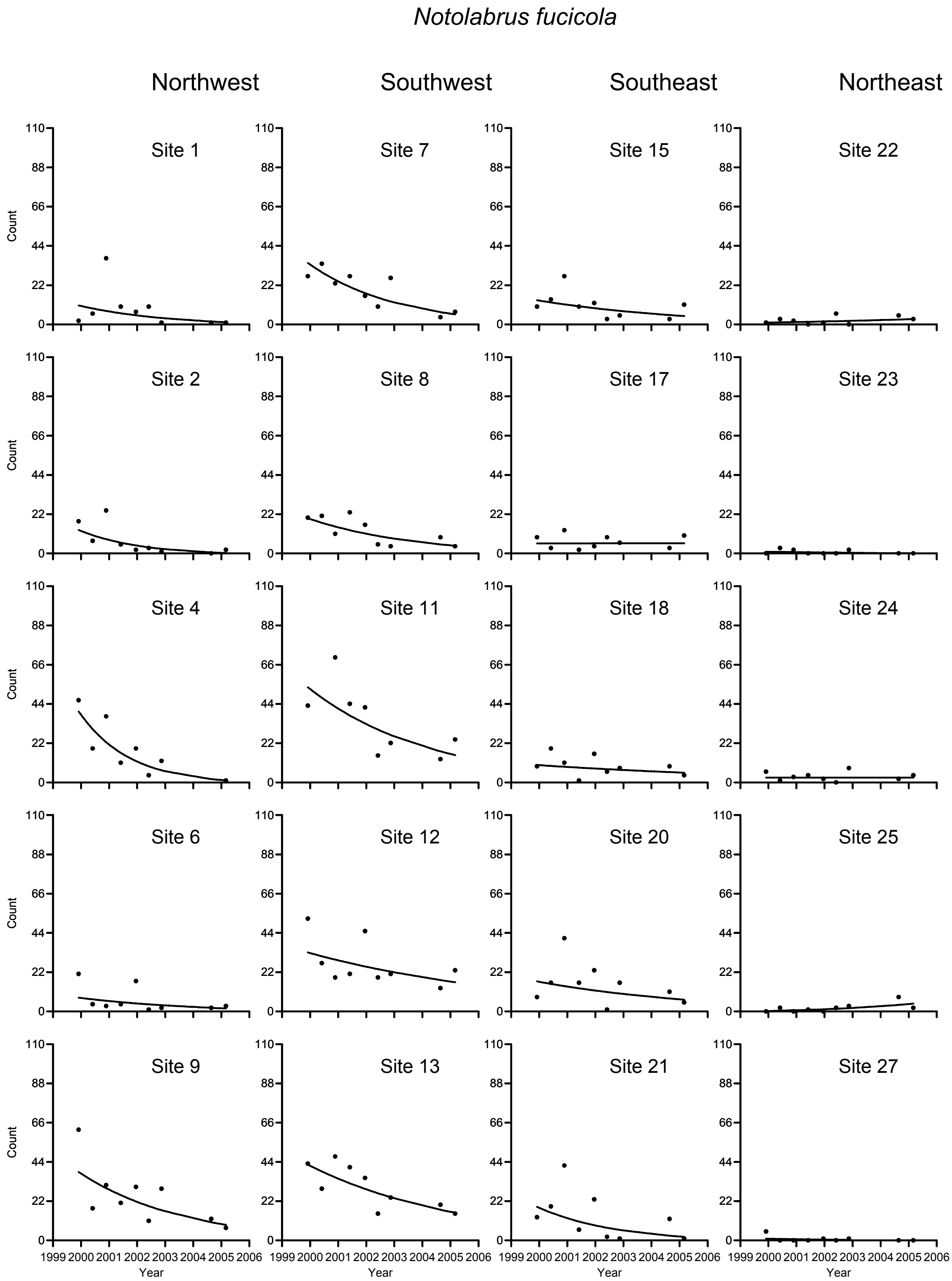


Figure 5.6 Abundances of purple wrasse *Notolabrus fucicola* at Wilsons Promontory.

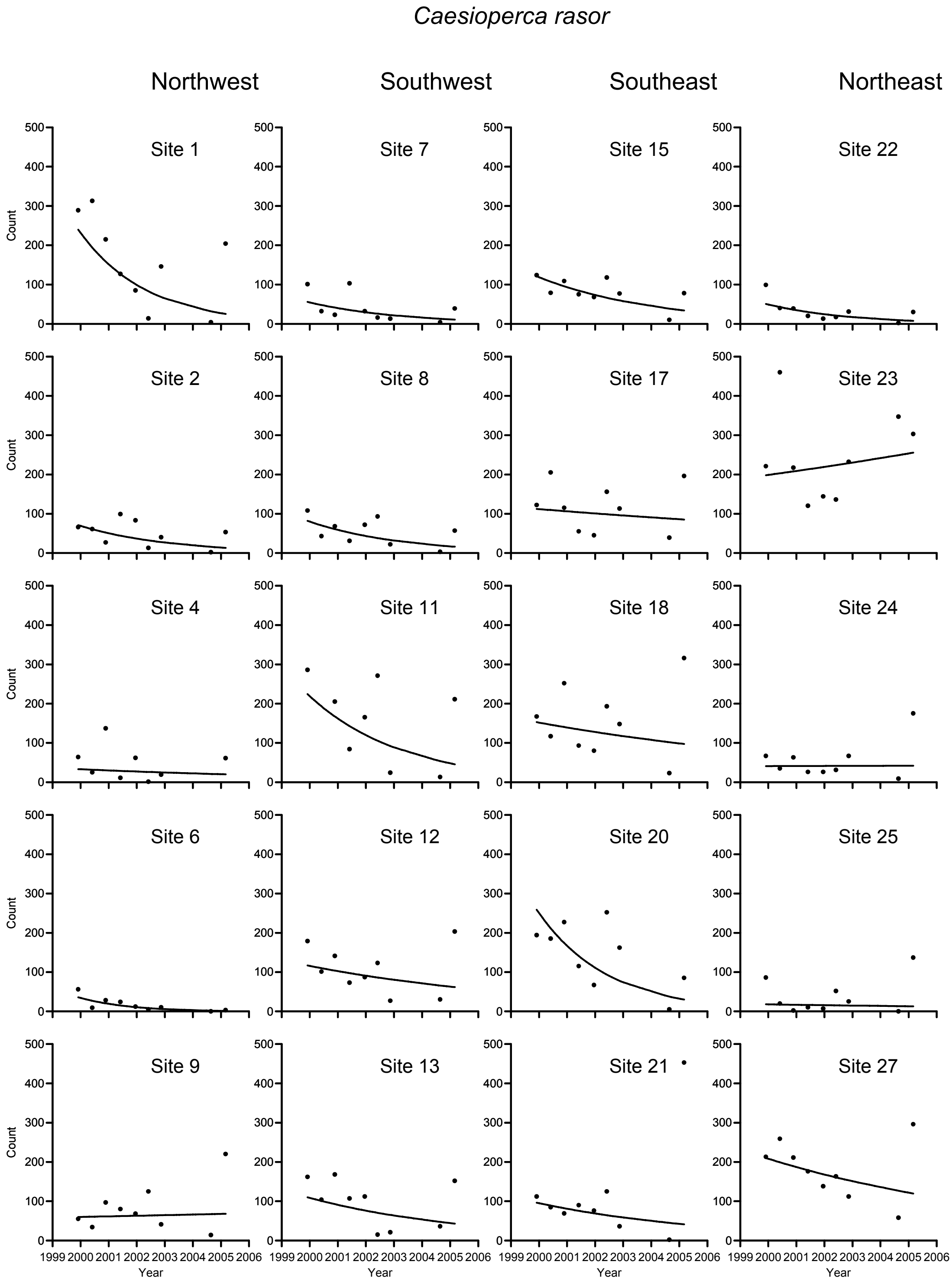


Figure 5.7. Abundances of barber perch *Caesioperca rasor* at Wilsons Promontory.

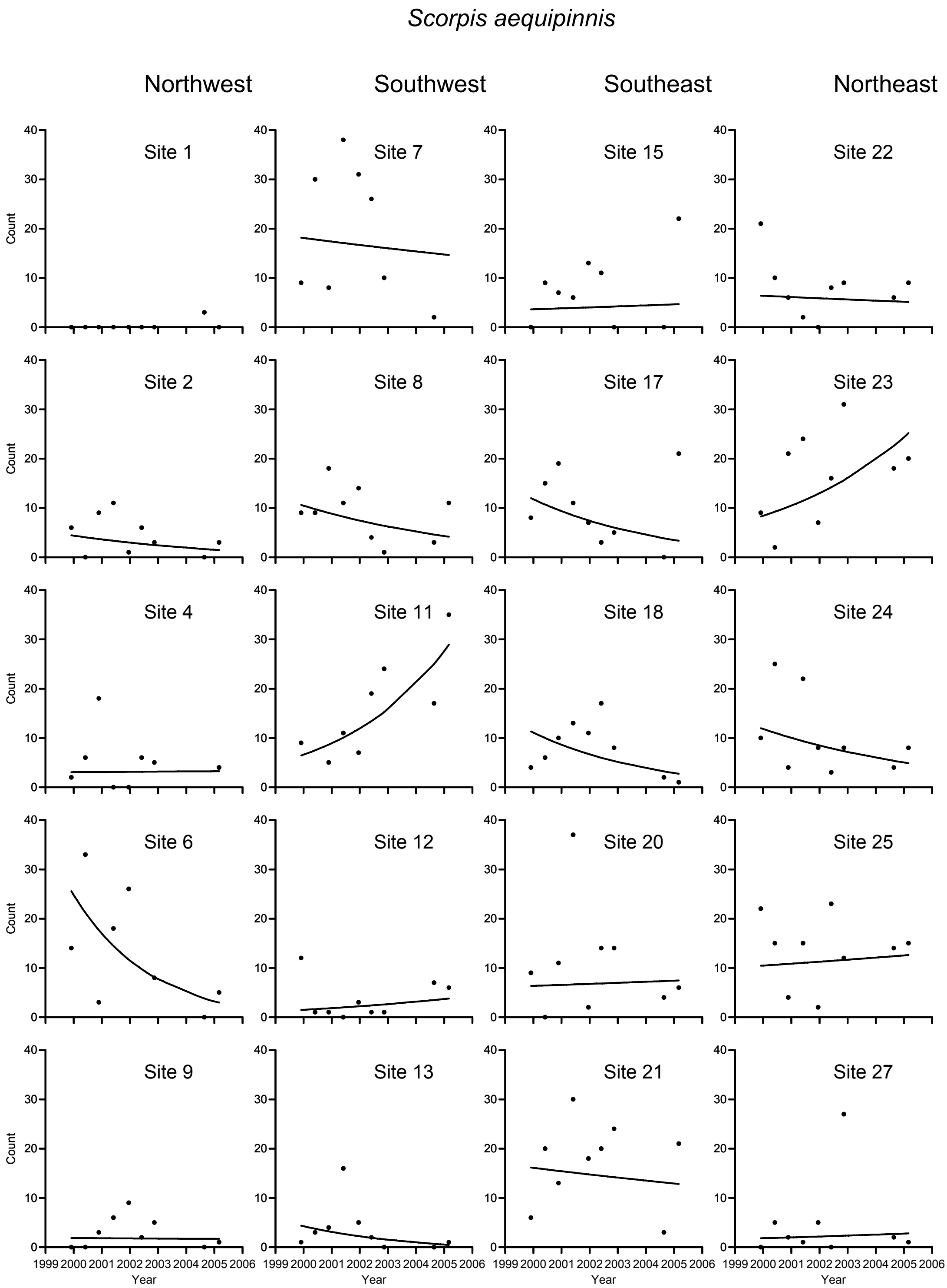


Figure 5.8. Abundances of sea sweep *Scorpis aequipinnis* at Wilsons Promontory.

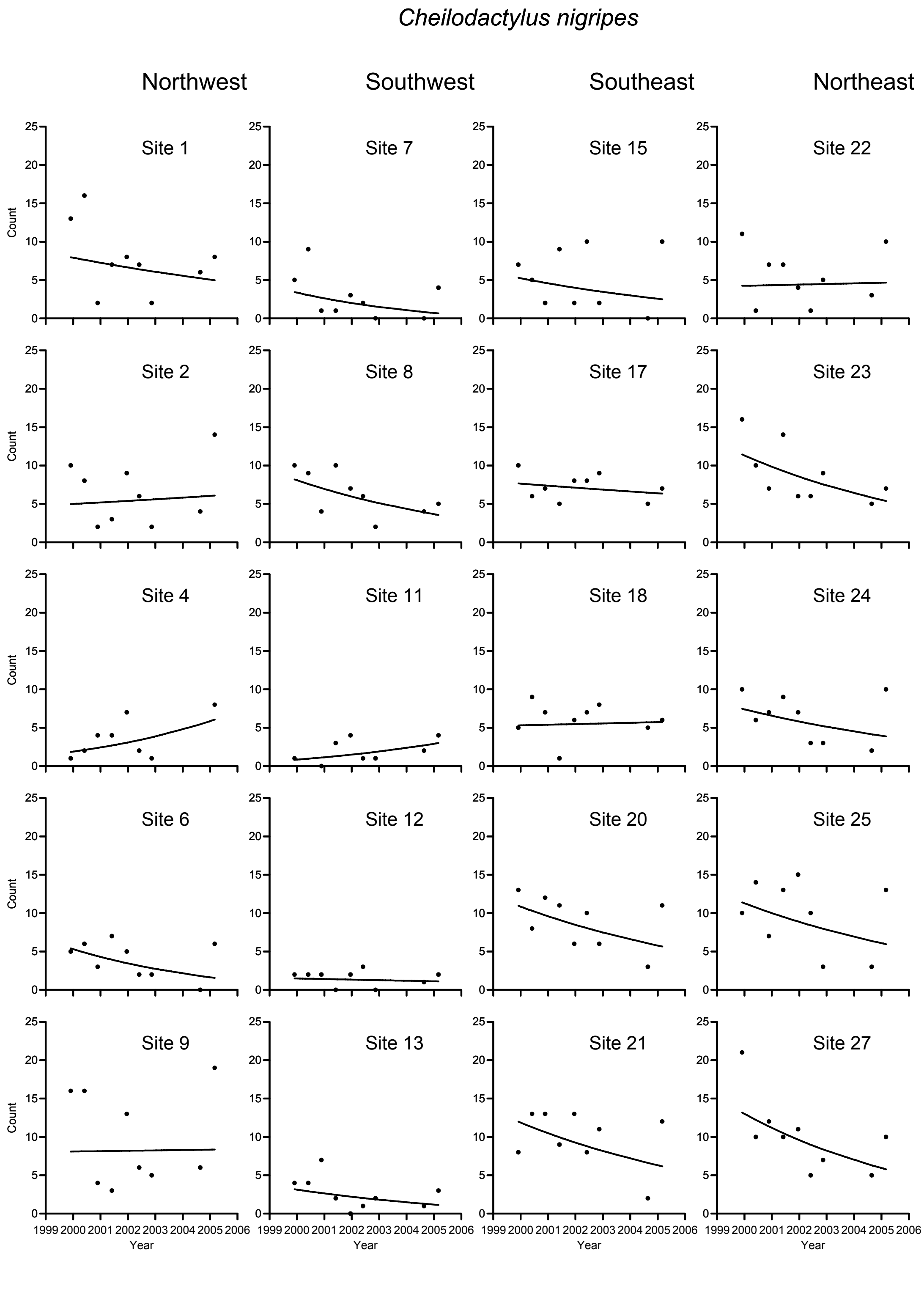


Figure 5.9. Abundances of magpie morwong *Cheilodactylus nigripes* at Wilsons Promontory.

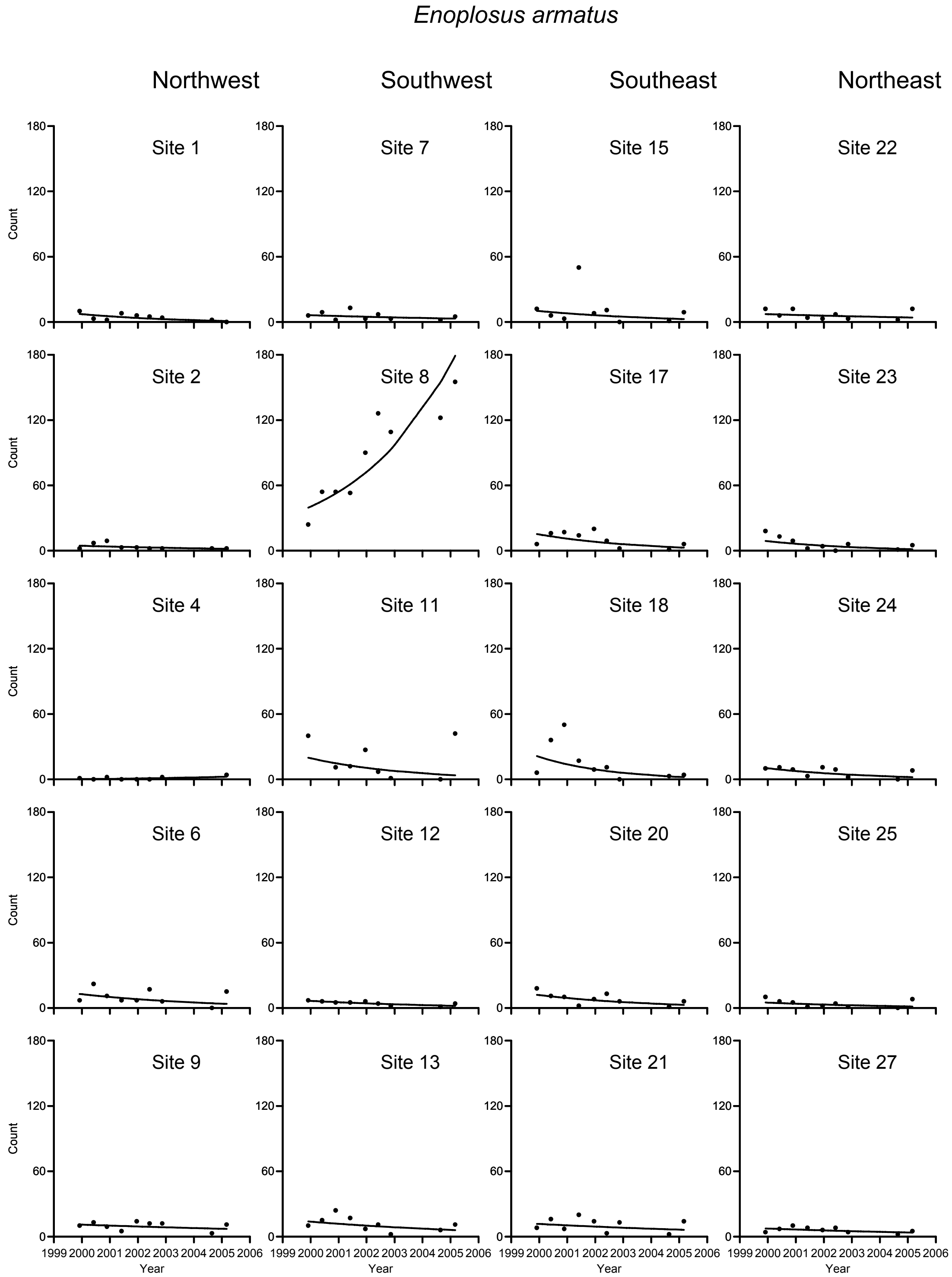


Figure 5.10. Abundances of old wife *Enoplosus armatus* at Wilsons Promontory.

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7.0 ACKNOWLEDGEMENTS

This project was initially funded by the Department of Sustainability and Environment (formerly Department of Natural Resources and Environment) and subsequently by Parks Victoria and supervised by Mr Laurie Ferns and Dr Anthony Boxshall respectively. Field support was kindly provided by Mr Grant Bradbury (Master) and Mr Euan Pennington (Operations Manager and Divers' Attendant). We also wish to acknowledge the logistical contribution by Mr David Wailes and Jan Taylor, Masters and Owners of *MV Kalinda* and *MV Orca*.