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## Victorian Subtidal Reef Monitoring Program: The Reef Biota at Bunurong Marine National Park

*K. Pritchard, M. Edmunds, K. Stewart and S. Davis*

*June 2011*

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**Victorian Subtidal Reef Monitoring  
Program:**

**The Reef Biota at Bunurong Marine  
National Park**

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**June 2011**



## EXECUTIVE SUMMARY

Shallow reef habitats cover extensive areas along the Victorian coast and are dominated by seaweeds, mobile invertebrates and fishes. These reefs are known for their high biological complexity, species diversity and productivity. They also have significant economic value through commercial and recreational fishing, diving and other tourism activities. 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 Bunurong Marine National Park (MNP) began in 1999. Since that time between 4 and 12 sites have been surveyed over 10 census events. The monitoring involves standardised underwater visual census methods to a depth of 8 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 pyrifera*).

To date over 300 different species have been observed during the monitoring program in and around Bunurong Marine National Park. The algal community structure at Bunurong is one of the most diverse of Victorian coast. This is partly due to the predominance of large brown algal species including *Seirococcus axillaris*, *Cystophora* species, *Sargassum* species and *Acrocarpia paniculata*. The invertebrate community was largely composed of the blacklip abalone *Haliotis rubra*, the gastropod *Turbo undulatus* and a variety of sea stars, particularly *Meridiastra gunnii* and *Tosia australis*. The common fish species included blue-throated wrasse, purple wrasse, senator wrasse, silver sweep and scalyfin.

**Key observations from the monitoring program were:**

- Seaweed species richness and diversity remained relatively high and was consistently higher within the MNP.
- Fish species richness and diversity was lower in the MNP during 2006 and 2010.
- The seagrass *Amphibolis antarctica* was at maximum abundances in 2010.
- There were no changes in dominant seaweeds inside and outside the MNP from 2006 to 2010.
- The abundances of the dominant invertebrates, particularly blacklip abalone *Haliotis rubra*, warrener *Turbo undulatus*, dogwhelk *Dicathais orbita* and sea urchin *Heliocidaris erythrogramma* peaked during the baseline period (2001/2002) then decreased to lowest abundances in 2006 and 2010. These changes were both inside and outside the MNP.
- The close-interval baseline monitoring identified intra and inter-annual fluctuations in density of reef fishes, particularly blue throated wrasse *Notolabrus tetricus*, purple wrasse *N. fucicola* and senator wrasse *Pictilabrus laticlavus*.
- The densities of blue throated wrasse *N. tetricus* were similar inside and outside the MNP, with densities after MNP declaration varying within a similar range.
- The densities of purple wrasse *N. fucicola* were higher inside the MNP before declaration, but have since dropped to densities similar to the reference areas.
- The density of senator wrasse *P. laticlavus* was generally low inside the MNP following declaration.
- Exceptionally low densities were observed for zebrafish *Girella zebra* in 2005, 2006 and 2010 and for magpie morwong *Cheilodactylus nigripes* in 2010, inside and outside the MNP.
- Seastars were very low in abundance in 2010, inside and outside the MNP.
- There were very low abundances of string kelp *Macrocystis pyrifera* from 2003 onwards, which is a cold-water species.
- There was a substantial decline in sizes of blacklip abalone *Haliotis rubra*. Abundances have been at lowest recorded levels since 2005, both inside and outside the MNP.

There was a distinct decline in fish abundances over 200 mm length, with densities in 2010 being at or below previously recorded levels. This decline was more marked inside the Bunurong MNP.



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# 1 INTRODUCTION

## 1.1 Subtidal Reef Ecosystems of Victoria

Shallow reef habitats cover extensive areas along the Victorian coast. Prominent biological components of Victorian shallow reefs are kelp and other seaweeds (Figure 1.1). Large species, such as the common kelp *Ecklonia radiata* and crayweed *Phyllospora comosa*, are usually present along the open coast in dense stands. The production rates of dense seaweed beds are equivalent to the most productive habitats in the world, including grasslands and seagrass beds, with approximately 2 kg of plant material produced per square metre per year. These stands typically have 10-30 kg or more of plant material per square metre. The biomass of seaweeds is substantially greater where giant species such as string kelp *Macrocystis pyrifera* 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 pyrifera*, which sometimes form a dense layer of fronds floating on the water surface. Other species with large, stalk-like stipes, such as *Ecklonia radiata*, *Phyllospora comosa* and *Durvillaea potatorum*, form a canopy 0.5-2 m above the rocky substratum. Lower layers of structure are formed by: foliose macroalgae typically 10-30 cm high, such as the green *Caulerpa* and red *Plocamium* species; turfs (to 10 cm high) of red algae species, such as *Pterocladia capillacea*; and hard encrusting layers of pink coralline algae. The nature and composition of these structural layers varies considerably within and between reefs, depending on the biogeographical region, depth, exposure to swell and waves, currents, temperature range, water clarity and presence of sand.

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

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

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



Green alga *Caulerpa flexilis*



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



Red coralline alga *Haliptilon roseum*



Thallose red alga *Ballia callitricha*



Crayweed *Phyllospora comosa* canopy



Common kelp *Ecklonia radiata* canopy

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





Southern rock-lobster *Jasus edwardsii*



Red bait crab *Plagusia chabrus*



Blacklip abalone *Haliotis rubra*



Feather star *Comanthus trichoptera*



*Nectria ocellata*



Common sea urchin  
*Heliocidaris erythrogramma*



*Fromia polypora*



Red velvet fish *Gnathanocanthus goetzei*

**Figure 1.2.** 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 *Meuschenia freycineti* (male)



Magpie morwong *Cheilodactylus nigripes*



Old-wife *Enoplosus armatus*

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



## 1.2 Subtidal Reef Monitoring Program

### 1.2.1 Objectives

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

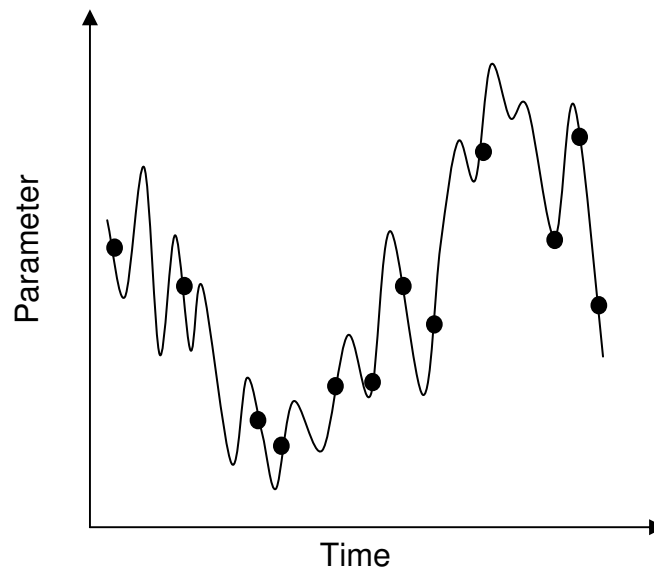
Consequently, the Victorian Government has established a long-term Subtidal Reef Monitoring Program (SRMP). The primary objective of the SRMP is to provide information on the status of Victorian reef flora and fauna (focussing on macroalgae, macroinvertebrates and fish). This includes monitoring the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

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

- Compare changes in the status of species populations and biological communities between highly protected marine national parks and marine sanctuaries and other Victorian reef areas (*e.g.* Edgar and Barrett 1997, 1999);
- Determine associations between species and between species and environmental parameters (*e.g.* depth, exposure, reef topography) and assess how these associations vary through space and time (*e.g.* Edgar *et al.* 1997; Dayton *et al.* 1998; Edmunds, 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. Plots of changes over time are unlikely to match the changes in real populations because changes over shorter time periods and actual minima and maxima may not be adequately sampled (*e.g.* 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, harvesting), years (*e.g.* El Niño), decades (*e.g.* pollution, extreme storm events) or even centuries (*e.g.* tsunamis, global warming). Other studies indicate this monitoring program will begin to adequately reflect average trends and patterns as the surveys continue over longer periods (multiple years to decades). Results of this monitoring need to be interpreted within the context of the monitoring frequency and duration.



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

## **1.2.2 Monitoring Protocols and Locations**

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

The SRMP was initiated in May 1998 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 and 2004, the Subtidal Reef Monitoring Program was expanded to include Marine National Parks and Marine Sanctuaries throughout Victoria.

## **1.3 Subtidal Reef Monitoring at Bunurong**

This report describes the subtidal reef monitoring program in the Bunurong region and results from eleven surveys, incorporating Bunurong Marine National Park and the adjacent conservation areas of the Bunurong Marine and Coastal Park. The objectives of this report were to:

1. Provide an overview of the methods used for SRMP;
2. Provide general descriptions of the biological communities and species populations at each monitoring site up to March 2010;
3. Describe changes and trends that have occurred over the monitoring period;
4. Identify any unusual biological phenomena such as interesting of unique communities or species; and
5. Identify any introduced species at the monitoring locations.



**Figure 1.5.** The Eagles Nest stack rising above intertidal platforms, eastern end of Shack Bay.

## 2 METHODS

### 2.1 Site Selection and Survey Times

Eight long-term monitoring sites were established along the Bunurong coast in June 1999 (Sites 1 to 8, Table 2.1, Figure 2.1) The sites were located in 4 - 6 m depth in three zones: Western Zone (2 sites); the Central Zone (4 sites); and the Eastern Zone (2 sites). Three deep-water reconnaissance sites were surveyed in 16 m depth, with one site in each of the Western, Central and Eastern zones (Sites 9 to 11; Table 2.1, Figure 2.1).

A further four sites were established at 4-6 m depth during the second survey in January/March 2000 (Sites 12 to 15; Figure 2.1). The second Bunurong survey was over three periods because of persistent poor visibility conditions throughout the summer period (Table 2.2).

The third survey commenced in winter 2000. However, persistently bad weather and heavy rainfalls affected diving conditions and underwater visibility for much of winter and spring. Only four sites could be surveyed: Sites 6, 12, 7 and 8.

An analysis of wind and rainfall data indicated the best periods for monitoring at Bunurong were in January/February and in June.

All sites were surveyed in summer 2000/2001 (Survey 4), winter 2001 (Survey 5), summer 2001/2002 (Survey 6), winter 2002 (Survey 7), spring 2003 (Survey 8), summer 2004/2005 (Survey 9), autumn 2006 (Survey 10) and summer 2009/2010 (Survey 11; Table 2.2).

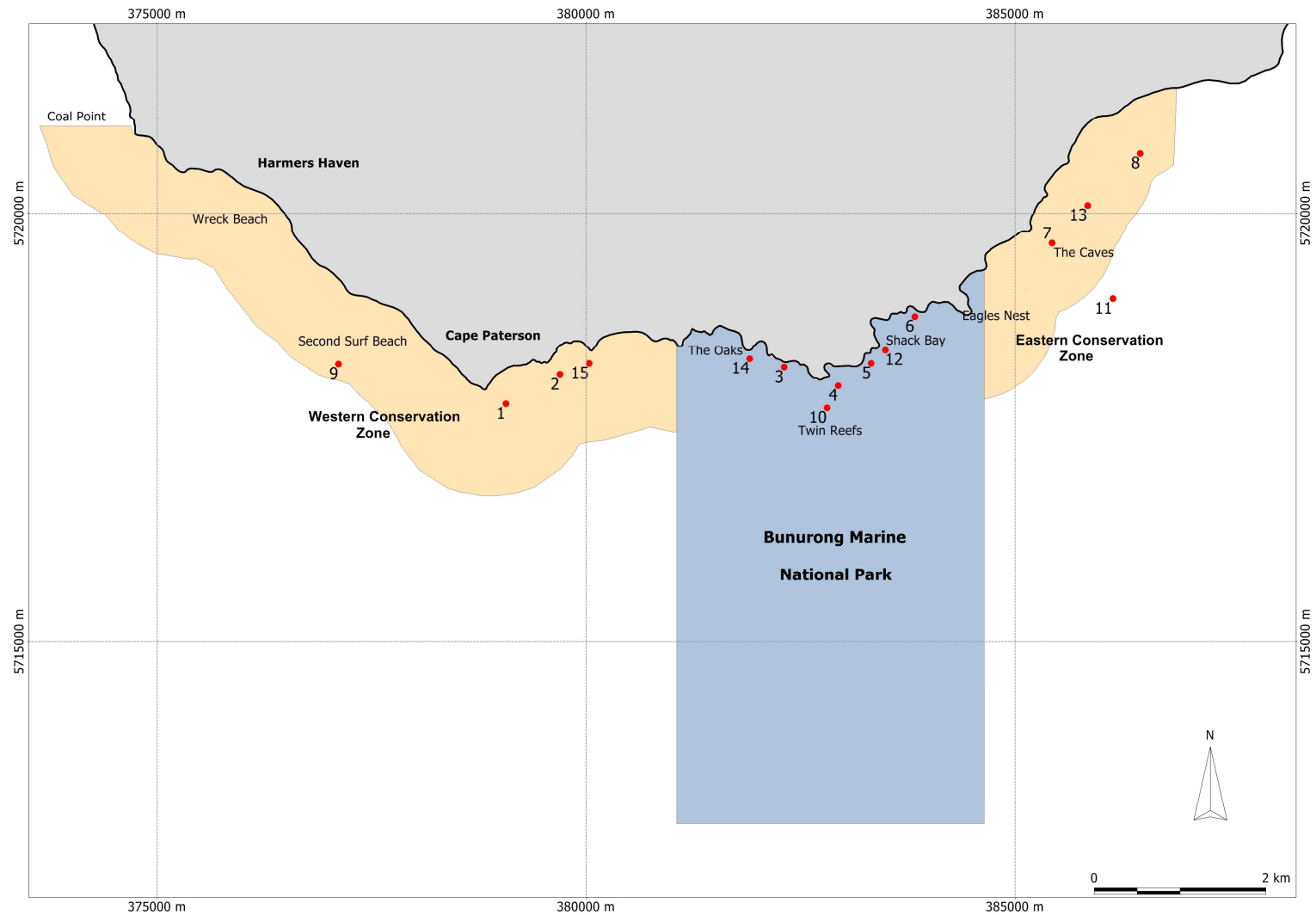
**Table 2.1.** Subtidal reef monitoring sites within zones of the Bunurong Marine and Coastal Park and Bunurong Marine National Park.

Region	No.	Description	Status	Depth
Western Zone	3001	Cape Patterson	Reference	4
	3002	C. Pat. Boat Ramp	Reference	6
	3015	Boat Ramp East	Reference	7
	3009	Patterson West Deep	Reference	15
Marine National Park	3014	The Oaks Beach	MPA	7
	3003	Oaks East	MPA	6
	3004	Twin Reefs	MPA	6
	3005	Shack Bay West	MPA	5
	3012	Shack Bay beach	MPA	7
	3006	Shack Bay Middle	MPA	6
	3010	Twin Reefs Deep	MPA	16
Eastern Zone	3007	The Caves	Reference	6
	3013	Petrel Rock West	Reference	6
	3008	Petrel Rock East	Reference	5
	3011	The Caves Deep	Reference	16

**Table 2.2.** Survey times for monitoring at Bunurong.

Survey Number	Season	Survey Period
1	Winter 1999	8-26 June 1999
2	Summer 1999/2000	9-14 Jan, 17 Feb, 27-28 Mar 2000
3	Winter 2000	30-31 August 2000
4	Summer 2000/2001	18 Dec 2000 to 3 Jan 2001
5	Winter 2001	11-12 May, 4-6 June 2001
6	Summer 2001/2002	14-16 February, 5-7 March 2002
7	Winter 2002	1-3 August, 10-11 August 2002
8	Autumn 2003	28-29 April, 13-15 May 2003
9	Summer 2004/2005	29-30 Nov 2004, 31 Jan to 21 Feb 2005
10	Autumn 2006	2-23 March 2006
11	Summer 2009/2010	21 Dec 2009, 17-18 Feb and 12 Mar 2010





**Figure 2.1.** Location of survey sites associated with the Bunurong Marine National Park and Eastern and Western Conservation Zones of the Bunurong Marine and Coastal Park.

## 2.2 Census Method

### 2.2.1 Underwater Visual Census Approach

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

At most monitoring locations in Victoria, surveying along the 5 m depth contour is considered optimal because diving times are not limited by decompression schedules and these reefs are of interest to natural resource managers. However the actual that can be surveyed varies with reef extent, geomorphology and exposure. Monitoring sites along the central coast of Victoria are between 4 and 7 m deep.

### 2.2.2 Survey Design

Each site was located using differential GPS and marked with a buoy or the boat anchor. A 100 m numbered and weighted transect line is run along the appropriate depth contour either side of the central marker (Figure 2.2). The resulting 200 m of line was divided into four contiguous 50 m sections (T1 to T4). The orientation of transect was the same for each survey, with T1 generally 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 sessile invertebrates; and (4) the density of string-kelp *Macrocystis pynifera* plants (where present). In 2010, a new diver-operated stereo video method (Method 5) was implemented as a trial to assess its efficacy for monitoring fish diversity, abundances and sizes. The stereo video system enables precise measurements of fish lengths and sample volume or area for density estimates

(Harvey *et al.* 2001a, 2001b, 2002a, 2002b; Harmen *et al.* 2003; Westera *et al.* 2003; Watson *et al.* 2010).

The depth, horizontal visibility, sea state and cloud cover are recorded for each site. Horizontal visibility was gauged by the distance along the transect line to detect a 100 mm long fish. All field observations are recorded on underwater paper.



**Figure 2.2.** Biologist-diver with transect line.

### 2.2.3 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 a 50 m section of the transect, and then back along the other side. The predominant fish species observed are listed in Table 2.3. The diver records the number and estimated size-class of fish, within 5 m of each side of the line (50 x 10 m area). The size-classes for fish were 25, 50, 75, 100, 125, 150, 200, 250, 300, 350, 375, 400, 500, 625, 750, 875 and 1000+ mm. Each diver had size-marks on an underwater slate to enable calibration of their size estimates. Four 10 x 50 m sections of the 200 m transect are censused for mobile fish at each site. The data for easily sexed species are recorded separately for males and female/juveniles. Such species include the blue-throated wrasse *Notolabrus tetricus*, herring cale *Odax cyanomelas*, barber perch *Caesioperca rasor*, rosy wrasse *Pseudolabrus rubicundus* and some leatherjackets.

### **2.2.4 Method 2 – Invertebrates and Cryptic Fishes**

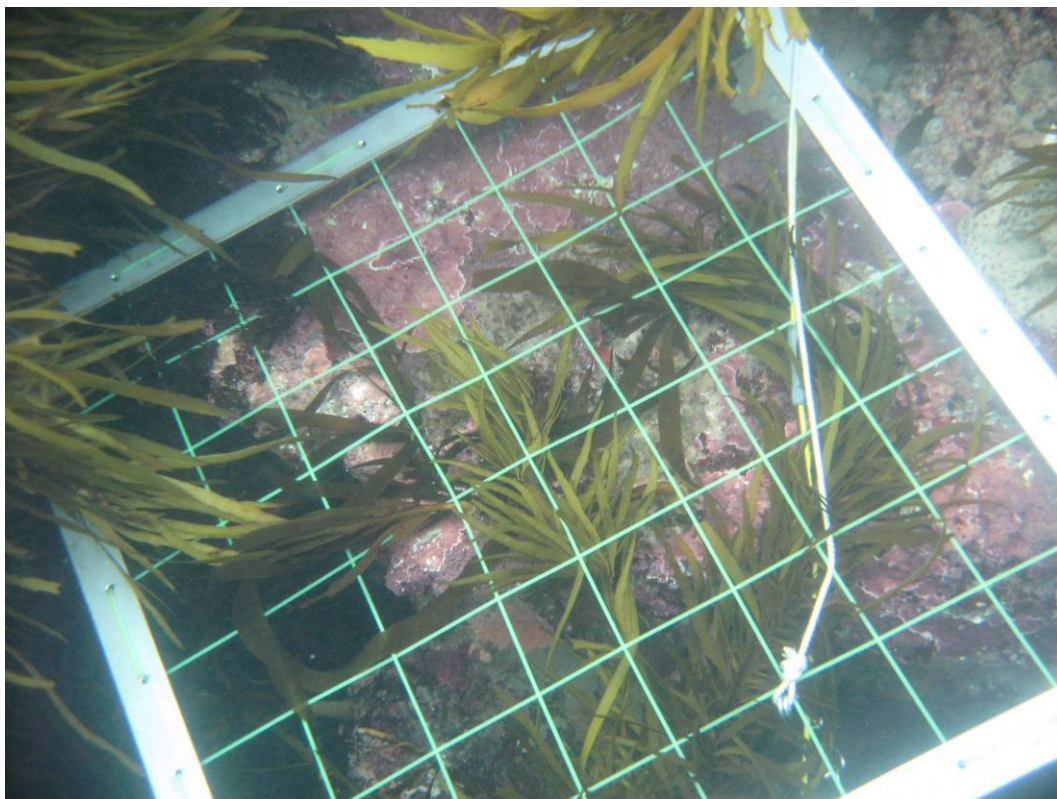
Cryptic fishes and mobile megafaunal invertebrates (*e.g.* large molluscs, echinoderms, crustaceans) are counted along the transect lines used for the fish survey. A diver counts animals within 1 m of one side of the line (a total of four 1 x 50 m sections of the 200 m transect). A known arm span of the diver is used to standardise the 1 m distance. The predominantly observed species are listed in Table 2.4. The maximum length of abalone and the carapace length and sex of rock lobsters were measured *in situ* using vernier callipers whenever possible. Selected specimens are photographed or collected for identification and preservation in a reference collection.

### **2.2.5 Method 3 – Macroalgae**

The area covered by macroalgal and sessile invertebrate species is quantified by placing a 0.25 m<sup>2</sup> quadrat at 10 m intervals along the transect line and determining the percent cover of the all plant species (Figure 2.3). The predominantly observed seaweed species are listed in Table 2.5. 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 points covering a species (1.25 m<sup>2</sup> for each of the 50 m sections of the transect line). Selected specimens are photographed or collected for identification and preservation in a reference collection.

### **2.2.6 Method 4 – *Macrocystis***

Where present, the density of *Macrocystis pyrifera* plants are estimated. While swimming along the transect line between quadrat positions for Method 3, a diver counts all observable plants within 5 m either side of the line. Counts are recorded for each 10 m section of the transect (giving counts for 100 m<sup>2</sup> sections of the transect).



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

### 2.2.7 Method 5 – Fish Stereo Video

A diver operated stereo video system (DOVS; SeaGIS design) was used to supplement the diver UVC fish surveys. The videos were Canon HG21 Handycams recording to SD card in 1080p format. The cameras were calibrated in a pool before and after the excursion using a SeaGIS calibration cube and SeaGIS CAL software for calibration of internal and external camera parameters. The cameras were mounted permanently fixed to a diver frame. A flashing LED mounted on a pole in front of the frame was used for synchronisation of paired images from each camera.

The stereo camera system was used by a single diver who did the UVC fish survey at the same time (Method 1). The camera system was pointed parallel with the transect line with the diver swimming 2.5 m to one side of the transect and then returning on the other side of the transect, 2.5 m from the transect line. The camera unit was tilted vertically (up or down) according to the fish seen to ensure adequate footage for size measurements. Lateral movement of the unit was minimised. The survey speed was 10 m per minute ( $0.16 \text{ m s}^{-1}$ ).

In the laboratory, the stereo video footage was converted from MTS to AVI format. The SeaGIS EventMeasure and PhotoMeasure software were then used for extracting and recording fish density and fish length estimates from the stereo video footage. Measured fish were those without body flexure and orientated transverse to the camera, as well as with the measurement points visible. Standard lengths (SL) were measured (tip of snout to end of caudal fin ray). The original video footage and frames used for fish length measurements were archived. The results of this method were archived for future analysis and were not reported here.



**Table 2.3.** Mobile fish (Method 1) species censused at Bunurong.

Method 1	Method 1	Method 1	Method 1
<b>Cephalopoda</b>	<b>Mobile Fishes (cont.)</b>	<b>Mobile Fishes (cont.)</b>	<b>Mobile Fishes (cont.)</b>
<i>Sepia apama</i>	<i>Arripis georgianus</i>	<i>Dactylophora nigricans</i>	<i>Meuschenia australis</i>
	<i>Parequula melbournensis</i>	<i>Sphyraena novaehollandiae</i>	<i>Meuschenia flavolineata</i>
<b>Mobile Sharks and Rays</b>	<i>Pagrus auratus</i>	<i>Achoerodus gouldii</i>	<i>Meuschenia freycineti</i>
<i>Heterodontus portusjacksoni</i>	<i>Upeneichthys vlaminghii</i>	<i>Ophthalmolepis lineolata</i>	<i>Meuschenia galii</i>
<i>Parascyllium variolatum</i>	<i>Pempheris multiradiata</i>	<i>Dotalabrus aurantiacus</i>	<i>Meuschenia hippocrepis</i>
<i>Cephaloscyllium laticeps</i>	<i>Kyphosus sydneyanus</i>	<i>Eupetrichthys angustipes</i>	<i>Meuschenia venusta</i>
<i>Orectolobus halei</i>	<i>Girella tricuspidata</i>	<i>Notolabrus tetricus</i>	<i>Meuschenia scaber</i>
<i>Dasyatis brevicaudata</i>	<i>Girella zebra</i>	<i>Notolabrus fucicola</i>	<i>Eubalichthys gunnii</i>
<i>Myliobatis australis</i>	<i>Scorpis aequipinnis</i>	<i>Pseudolabrus rubicundus</i>	<i>Aracana aurita</i>
<i>Urolophus paucimaculatus</i>	<i>Scorpis lineolata</i>	<i>Pictilabrus laticlavus</i>	<i>Aracana ornata</i>
<i>Urolophus gigas</i>	<i>Atypichthys strigatus</i>	<i>Odax acroptilus</i>	<i>Tetractenos glaber</i>
<b>Mobile Bony Fishes</b>	<i>Tilodon sexfasciatus</i>	<i>Odax cyanomelas</i>	<i>Diodon nichthemerus</i>
<i>Pseudophycis barbata</i>	<i>Enoplosus armatus</i>	<i>Siphonognathus attenuatus</i>	<i>Unidentified fish</i>
<i>Siphamia cephalotes</i>	<i>Pentaceropsis recurvirostris</i>	<i>Neoodax balteatus</i>	
<i>Dinolestes lewini</i>	<i>Parma victoriae</i>	<i>Thyristes atun</i>	
<i>Sillaginodes punctata</i>	<i>Parma microlepis</i>	<i>Seriolella brama</i>	
<i>Pseudocaranx georgianus</i>	<i>Aplodactylus arctidens</i>	<i>Acanthaluteres vittiger</i>	
<i>Trachurus declivis</i>	<i>Cheilodactylus nigripes</i>	<i>Scobinichthys granulatus</i>	
	<i>Cheilodactylus spectabilis</i>		

**Table 2.4.** Invertebrate and cryptic fish (Method 2) species censused at Bunurong.

Method 2	Method 2	Method 2	Method 2
<b>Cnidaria</b>	<b>Mollusca (cont.)</b>	<b>Echinodermata (cont.)</b>	<b>Cryptic Fishes</b>
<i>Phlyctenactis tuberculosa</i>	<i>Turbo undulatus</i>	<i>Nectria multispina</i>	<i>Neosebastes scorpaenoides</i>
Unidentified anemone	<i>Astraliu tentoriformis</i>	<i>Nectria saoria</i>	<i>Helicolenus percoides</i>
	<i>Cypraea angustata</i>	<i>Petricia vernicina</i>	<i>Aetapcus maculatus</i>
<b>Crustacea</b>	<i>Cypraea comptoni</i>	<i>Fromia polypora</i>	<i>Gnathanacanthus goetzii</i>
<i>Jasus edwardsii</i>	<i>Cabestana spengleri</i>	<i>Plectaster decanus</i>	<i>Pempheris multiradiata</i>
<i>Paguristes frontalis</i>	<i>Sassia subdistorta</i>	<i>Echinaster arcystatus</i>	<i>Girella elevata</i>
<i>Strigopagurus strigimanus</i>	<i>Dicathais orbita</i>	<i>Pseudonepanthia trougtoni</i>	<i>Parma victoriae</i> (juv.)
<i>Pagurid unidentified</i>	<i>Pleuroploca australasia</i>	<i>Meridiastra gunnii</i>	<i>Parma microlepis</i> (juv.)
<i>Nectocarcinus tuberculatus</i>	<i>Penion mandarinus</i>	<i>Coscinasterias muricata</i>	<i>Bovichtus angustifrons</i>
<i>Plagusia chabrus</i>	<i>Cominella lineolata</i>	<i>Uniophora granifera</i>	<i>Trinorfolkia clarkei</i>
<i>Unidentified chiton</i>	<i>Conus anemone</i>	<i>Amblypneustes spp.</i>	<i>Heteroclinus tristis</i>
<b>Mollusca</b>	<i>Mitra glabra</i>	<i>Holopneustes porosissimus</i>	<i>Heteroclinus johnstoni</i>
<i>Haliotis rubra</i>	<i>Sagaminopteron ornatum</i>	<i>Holopneustes inflatus</i>	Unidentified heteroclinid
<i>Haliotis laevigata</i>		<i>Holopneustes purpurascens</i>	
<i>Haliotis scalaris</i>	<b>Cephalopoda</b>	<i>Heliocidaris erythrogramma</i>	
<i>Scutus antipodes</i>	<i>Sepia apama</i>		
<i>Calliostoma armillata</i>		<b>Cryptic Fishes</b>	
<i>Austrocochlea odontis</i>	<b>Echinodermata</b>	<i>Parascyllium variolatum</i>	
<i>Phasianotrochus rutilus</i>	<i>Comanthus tricoptera</i>	<i>Scorpaena papillosa</i>	
<i>Phasianotrochus eximius</i>	<i>Comanthus tasmaniae</i>	<i>Glyptauchen panduratus</i>	
<i>Phasianella australis</i>	<i>Tosia australis</i>		
<i>Phasianella ventricosa</i>	<i>Nectria ocellata</i>		
	<i>Nectria macrobrachia</i>		

**Table 2.5.** Macroalgae (Method 3) species censused at Bunurong.

Method 3	Method 3	Method 3	Method 3
<b>Chlorophyta (green algae)</b>	<b>Phaeophyta (cont.)</b>	<b>Rhodophyta (red algae)</b>	<b>Rhodophyta (cont.)</b>
<i>Ulva spp</i>	<i>Zonaria spiralis</i>	<i>Gelidium asperum</i>	<i>Polyopes constrictus</i>
<i>Chaetomorpha sp</i>	<i>Zonaria turneriana</i>	<i>Gelidium australe</i>	<i>Halymenia sp. nov.</i>
<i>Abjohnia laetevirens</i>	<i>Zonaria sp</i>	<i>Gelidium spp</i>	<i>Thamnoclonium dichotomum</i>
<i>Cladophora spp</i>	<i>Lobophora variegata</i>	<i>Pterocladia lucida</i>	<i>Plocamium angustum</i>
<i>Dictyosphaeria serica</i>	<i>Carpomitra costata</i>	<i>Pterocladia capillacea</i>	<i>Plocamium costatum</i>
<i>Caulerpa scalpelliformis</i>	<i>Perithalia caudata</i>	<i>Asparagopsis armata</i>	<i>Plocamium mertensii</i>
<i>Caulerpa longifolia</i>	<i>Bellotia eriophorum</i>	<i>Delisea hypneoides</i>	<i>Plocamium dilatatum</i>
<i>Caulerpa brownii</i>	<i>Ecklonia radiata</i>	<i>Delisea pulchra</i>	<i>Plocamium preissianum</i>
<i>Caulerpa cf browni (v. fine ramuli)</i>	<i>Macrocystis pyrifera</i>	<i>Ptilonia australasiae</i>	<i>Plocamium cartilagineum</i>
<i>Caulerpa obscura</i>	<i>Xiphophora chondrophylla</i>	<i>Asparagopsis spp.</i>	<i>Plocamium leptophyllum</i>
<i>Caulerpa flexilis</i>	<i>Seirococcus axillaris</i>	<i>Mastophoropsis canaliculata</i>	<i>Champia viridis</i>
<i>C. flexilis var. muelleri</i>	<i>Scaberia agardhii</i>	<i>Metamastophora flabellata</i>	<i>Champia sp.</i>
<i>Caulerpa geminata</i>	<i>Caulocystis cephalornithos</i>	<i>Amphiroa gracilis</i>	<i>Botryocladia sonderi</i>
<i>Caulerpa hodgkinsoniae</i>	<i>Acrocarpia paniculata</i>	<i>Amphiroa anceps</i>	<i>Rhodymenia australis</i>
<i>Caulerpa cactoides</i>	<i>Cystophora platylobium</i>	<i>Jania spp</i>	<i>Rhodymenia obtusa</i>
<i>Caulerpa simpliciuscula</i>	<i>Cystophora moniliformis</i>	<i>Corallina officinalis</i>	<i>Rhodymenia prolificans</i>
<i>Codium lucasi</i>	<i>Cystophora pectinata</i>	<i>Arthrocardia wardii</i>	<i>Rhodymenia spp</i>
<i>Codium pomoides</i>	<i>Cystophora monilifera</i>	<i>Haloptilon roseum</i>	<i>Cordylecladia furcellata</i>
<i>Codium mamillosum</i>	<i>Cystophora brownii</i>	<i>Cheilosporum sagittatum</i>	<i>Griffithsia sp</i>
<i>Codium duthieae</i>	<i>Cystophora retorta</i>	<i>Metagoniolithon radiatum</i>	<i>Ballia callitricha</i>
<i>Codium spp</i>	<i>Cystophora siliquosa</i>	<i>Encrusting corallines</i>	<i>Euptilota articulata</i>
<b>Phaeophyta (brown algae)</b>	<i>Cystophora retroflexa</i>	<i>Erect corallines</i>	<i>Hemineura frondosa</i>
<i>Ectocarpus spp</i>	<i>Cystophora subfarcinata</i>	<i>Solieria robusta</i>	<i>Dictymenia harveyana</i>
<i>Halopteris paniculata</i>	<i>Carpoglossum confluens</i>	<i>Hypnea ramentacea</i>	<i>Jeannerettia lobata</i>
<i>Halopteris spp</i>	<i>Myriodesma tuberosum</i>	<i>Callophyllis rangiferina</i>	<i>Lenormandia marginata</i>
<i>Cladostephus spongiosus</i>	<i>Myriodesma sp.</i>	<i>Nizymenia australis</i>	<i>Epiglossum smithiae</i>
<i>Dictyota (fine)</i>	<i>Sargassum heteromorphum</i>	<i>Sonderopelta coriacea</i>	<i>Laurencia filiformis</i>
<i>Dictyota dichotoma</i>	<i>Sargassum decipiens</i>	<i>Peyssonelia novaehollandiae</i>	<i>Laurencia elata</i>
<i>Dilophus marginatus</i>	<i>Sargassum sonderi</i>	<i>Peyssonelia sp.</i>	<i>Laurencia spp</i>
<i>Dilophus gunnianus</i>	<i>Sargassum varians</i>	<i>Sonderopelta/ Peyssonelia</i>	<i>Echinothamnion sp</i>
<i>Dilophus sp</i>	<i>Sargassum verruculosum</i>	<i>Phacelocarpus alatus</i>	<i>Echinothamnion hystrix</i>
<i>Pachydictyon paniculatum</i>	<i>Sargassum fallax</i>	<i>Phacelocarpus peperocarpus</i>	<i>Heterosiphonia gunniana</i>

<b>Phaeophyta (cont.)</b>	<b>Phaeophyta (cont.)</b>	<b>Rhodophyta (cont.)</b>	<b>Rhodophyta (cont.)</b>
<i>Lobospira bicuspidata</i>	<i>Sargassum vestitum</i>	<i>Rhodopeltis australis</i>	<i>Thuretia quercifolia</i>
<i>Dictyopteris acrostichoides</i>	<i>Sargassum spinuligerum</i>	<i>Erythroclonium sonderi</i>	Filamentous red algae
<i>Dictyopteris muelleri</i>	<i>Sargassum</i> spp	<i>Erythroclonium</i> spp	Other thallose red alga
<i>Chlanydophora microphylla</i>	Brown algae unidentified	<i>Callophycus laxus</i>	
<i>Distromium</i> spp	Brown algal turf	<i>Areschougia congesta</i>	<b>Magnoliophyta</b>
<i>Homeostrichus sinclairii</i>		<i>Areschougia</i> spp	<i>Halophila ovalis</i>
<i>Homeostrichus olsenii</i>		<i>Acrotylus australis</i>	<i>Amphibolis antarctica</i>
<i>Zonaria angustata</i>		<i>Melanthalia obtusata</i>	<b>Other</b>
<i>Zonaria crenata</i>		<i>Melanthalia abscissa</i>	Algal turf

## 2.3 Data Analysis - Condition indicators

### 2.3.1 Approach

Reef quality indicators were developed to encompass key features of MPA performance assessment and management interest. The selection of indicators for reef ecosystem management were reviewed by (Turner *et al.* 2006) and further theoretical and field considerations are provided by (Thrush *et al.* 2009). Both reviews suggest a variety of indicators, of both ecosystem structure and function, should be used. (Rapport 1992) noted that it is easier to recognise adverse changes of an ecosystem from stressors than systems in the natural range or in 'good health'. Adverse changes to an ecosystem include:

- A shift to smaller organisms;
- Reduced diversity with loss of sensitive species;
- Increased dominance by weedy and exotic species;
- Shortened food chain lengths;
- Altered energy flows and nutrient cycling;
- Increased disease prevalence; and
- Reduced stability/increased variability (Rapport *et al.* 1992).

A suite of indicators was developed for the Tasmanian reef monitoring program, which uses the same Edgar-Barrett underwater visual census methods (Stuart-Smith *et al.* 2008). The indicators are grouped into the general categories: biodiversity; ecosystem function; introduced pests, climate change and fishing. The Stuart-Smith indicators were followed and adapted for the Victorian SRMP. These indices are consistent with the reviews mentioned above. Key adaptations were the use of absolute values rather than proportions, as the Victorian data had considerable concurrent variation in the numerator and denominator of many indices, making proportional indices difficult to interpret. The Stewart-Smith approach for examining community changes was extended by using the multivariate control charting method of Anderson and Thompson (2004).

The indicators were calculated separately for the three survey components, fishes, invertebrates and algae.

The indicators presented in this report provide a basis for assessment and further refinement of indicators for marine protected area performance assessment and management.

## **2.3.2 Biodiversity**

### **Community Structure**

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.

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

### **Trends in Community Structure**

Multivariate control charting was used to examine the degree of changes in community structure over time. Two criteria were assessed, the first being the deviation in community structure at a time  $t$  from the centroid of baseline community structures. This criterion is more sensitive to the detection of gradual changes over time away from the baseline conditions. In this case, the first 5 surveys were used for the baseline centroid (recognising there were 6 baseline surveys for 8 sites and 5 baseline surveys for 4 sites). The second criterion was the deviation in community structure at time  $t$  to the centroid of all previous times ( $t-1$ ). This criterion is more sensitive at detecting abrupt or pulse changes.

Control charts were prepared for each site as well as on a regional basis for combined sites inside the marine protected area and for reference sites. The regional analysis used average species abundances across sites within each region. The analysis used the methods of Anderson and Thompson (2004) and calculations were done using the software ControlChart.exe (Anderson 2008). The analysis used the Bray-Curtis dissimilarity coefficient and the same data transformations described above. Bootstrapping was used to provide control-chart limits for identifying changes that are 'out of the ordinary'. In this case, a 90<sup>th</sup> percentile statistic was calculated from 10 000 bootstrap samples as a provisional limit or trigger line. The 50<sup>th</sup> percentile was also presented to assist in interpreting the control charts.

### **Species Diversity**

The total number of individuals,  $N$ , was calculated as the sum of the abundance of all individuals across species. This index is used to show any simultaneous depression of abundances across all species.

Species richness,  $S$ , is given as the number of species observed at each site. Cryptic, pelagic and non-resident reef fishes were not included.

Species diversity, as a measure of the distribution of individuals among the species, was indicated using Hill's  $N_2$  statistic (which is equivalent to the reciprocal of Simpson's index). The value varies between 1 and  $S$  (*i.e.* the total number of species in the sample) with higher values indicating higher diversity. In general, Hill's  $N_2$  gives an indication of the number of dominant species within a community. Hill's  $N_2$  provides more weighting for common species, in contrast to indices such as the Shannon-Weiner Index (Krebs 1999), which weights the rarer species.

The diversity statistics were averaged across sites to for the marine protected area and reference regions.

### **Abundances of Selected Species**

Mean abundance of selected species were plotted over time for the marine protected area and reference regions. The species presented included abundant or common species as well as any with unusual changes over time.

## **2.3.3 Ecosystem Functional Components**

### **Plant Habitat and Production**

Biogenic habitat and standing stocks of primary producers was indicated by the pooled abundances of macrophyte groups:

- Crustose coralline algae;
- Canopy browns – defined here as *Ecklonia radiata*, *Undaria pinnatifida*, *Lessonia corrugata*, *Macrocystis pyrifera* (which includes the *M. “angustifolia”* ecomorph), *Durvillaea potatorum*, *Phyllospora comosa*, *Seirococcus axillaris*, *Acrocarpia paniculata*, *Cystophora platylobium*, *C. moniliformis*, *C. pectinata*, *C. monilifera*, *C. retorta* and *C. retroflexa*;
- Smaller browns (all other brown species except Ectocarpales);
- Erect coralline algae;
- Thallose red algae (except filamentous species);
- Green algae; and
- Seagrass *Amphibolis Antarctica*.

The index of summed species points-cover does not equate to a total cover estimate in some cases as using species cover can be overlapping with other species at different heights.

### **Invertebrate Groups**

The abundance of invertebrates was pooled into the functional groups:

- Grazers and habitat modifiers, including gastropods and sea urchins;
- Filter feeders, including fanworms and feather stars;
- Predators, including gastropods, crabs and lobsters but excluding seastars; and
- Seastars, which are mostly predators, although *Meridiastra gunnii* may also be a detritus feeder.

### **Fish Groups**

The abundance of fishes was also pooled into trophic groups:

- Herbivores and omnivorous grazers;
- Foraging predators, including pickers and foragers of stationary, benthic prey such as amphipods, crabs and gastropods;
- Hunter predators, including fishes that hunt mobile prey, particularly other fishes, as chasers and ambushers; and
- Planktivores, including feeders of zooplankton and small fish in the water column.



## **Sediment Cover**

The percentage cover of sand and sediment on the survey transect (using Method 3) is the only relevant abiotic parameter measured for the SRMP. This index may indicate changes in hydrodynamic or coastal processes.

### **2.3.4 Introduced species**

The status of introduced species is initially reported as presence-absence of species. Where a species is established and the SRMP measures the abundance of that species, indicators of status are:

- Number of introduced species;
- Total abundance of introduced species; and
- Where data are suitable, time series of abundance of selected introduced species – noting the timing of surveys may influence the time series.

### **2.3.5 Climate change**

#### **Species Composition**

Climate change is likely to cause changes to current strengths and circulation patterns which affect both the ambient temperature regime and the dispersion and recruitment of propagules or larvae. In Victoria, there may be increased incursions of the East Australia Current into eastern Victoria and the South Australia Current into western Victoria and Bass Strait. Biological responses to such changes are potentially indicated by biogeographical changes in the species composition, toward that of adjacent, warmer bioregions. For this analysis, each species was assigned a nominal geographical range:

- Coldwater species, reflecting the 'Maugéan' province, from approximately Kangaroo Island in South Australia, around Tasmania and into southern New South Wales;
- Western species, reflecting the 'Flindersian' province, from southern Western Australia, along the Great Australian Bight and South Australia to western Victoria;
- Eastern species, reflecting the 'Peronian' province, encompassing New South Wales and into eastern Victoria;
- Southern species, including species ranging widely along the southern Australian coast; and

- Northern species, including warm temperate and tropical species in Western Australia and New South Wales and northward.

The number of species and total number of individuals was calculated for the coldwater, western and eastern groups.

### ***Macrocystis pyrifera***

The string kelp *Macrocystis pyrifera* (which includes the former species *M. angustifolia*, Macaya and Zuccarello 2010) is considered potentially vulnerable to climate change through reduced nutrient supply from drought and nutrient poorer warmer waters (Edyvane 2003). The mean abundance of string kelp *Macrocystis pyrifera* was plotted using densities from Method 4, or cover estimates from Method 4 where density data were unavailable. *Macrocystis* provides considerable vertical structure to reef habitats and can also attenuate water currents and wave motion. The loss of *Macrocystis* habitats are likely to reflect ecosystem functional changes.

### ***Centrostephanus rodgersii***

The long-spined sea urchin *Centrostephanus rodgersii* has been increasing its range conspicuously over the past decades (Johnson *et al.* 2005). This grazing species can cause considerable habitat modification, decreasing seaweed canopy cover and increasing area of 'urchin barrens'. Abundances are determined using Method 2 and average abundances are plotted through time. The abundances of *C. rodgersii* are also influenced by interactions with abalone as competitors for crevice space, abalone divers, who may periodically 'cull' urchins within a reef patch and by sea urchin harvesters.

### ***Durvillaea potatorum***

The bull kelp *Durvillaea potatorum* is a coldwater species that is likely to be vulnerable to increased ambient temperatures. There is anecdotal evidence of a decline in range down the New South Wales coast by approximately 80 km. Most of the SRMP sites specifically avoid *Durvillaea* habitats as these occur on highly wave-affected and turbulent reefs. Some sites contain *Durvillaea* stands, providing limited data on population status. *Durvillaea potatorum* is potentially two species, having genetically and morphologically distinct eastern and western forms (Fraser *et al.* 2009).

## 2.3.6 Fishing

### Abalone

Indicators of changed population structure from harvesting pressure on abalone were mean density and the proportion of legal sized individuals. The size-frequency histograms were also examined. The indicators were calculated for the blacklip abalone *Haliotis rubra* in most regions and for the greenlip abalone *H. laevigata* where present in suitable densities (in central and western Victoria).

### Rock Lobster

The southern rock lobster *Jasus edwardsii* is present throughout Victoria and the packhorse lobster *Jasus verreauxi* is present in the Twofold Shelf region. The SRMP transects generally did not traverse rock lobster microhabitats, however abundances and sizes are reported for suitable data.

### Fishes

Potential fishing impacts or recovery of fishing impacts within marine protected areas were indicated by:

- Abundances of selected fished species;
- Mean size and size-frequency histograms of selected fished species;
- Total abundance of fishes > 200 mm length, this being the approximate legal minimum size for most fished species;
- Biomass of fishes > 200 mm length, calculated using length-weight relationships; and
- Parameters of the size-spectra of all fishes.

The size spectrum of all fishes at a site was first centred and linearised. Size frequencies for each field size class were aggregated into classes centred on 87.5 mm (classes 1-6), 200 mm (class 7); 275 mm (classes 8-9); 356.25 mm (classes 10-11); 400 mm (class 12); 500 mm (class 13); 625 mm (class 14); and 750+ mm (class 15). The frequencies and size classes were  $\log_e(x + 1)$  and the size classes are centred by subtracting the mean. Linear regression was used to estimate the slope and intercept (which is also the half-height of the slope) of the log-transformed spectrum.

Biomass was calculated for selected species  $\geq 300$  mm. Lengths were converted to weights using published conversion factors for the power relationship:  $\text{weight(grams)} = a \times \text{Length(cm)}^b$ . The weight estimations used the coefficients

compiled by Lyle and Campbell (1999). The selected species were the most common species under heaviest fishing pressure (where present):

- Banded morwong *Cheilodactylus spectabilis* ( $a = 0.0629$ ,  $b = 2.881$ );
- Bastard trumpeter *Latridopsis forsteri* ( $a = 0.0487$ ,  $b = 3.14$ );
- Blue throated wrasse *Notolabrus tetricus* ( $a = 0.0539$ ,  $b = 2.17$ );
- Purple wrasse *Notolabrus fucicola* ( $a = 0.0539$ ,  $b = 2.17$ );
- Crimson banded wrasse *Notolabrus gymnogenis* ( $a = 0.0539$ ,  $b = 2.17$ ); and
- Eastern blue groper *Achoerodus viridis* ( $a = 0.0539$ ,  $b = 2.17$ ).

## 3 BUNURONG MARINE NATIONAL PARK

### 3.1 Biodiversity

#### 3.1.1 Community Structure

##### Macroalgae

The algal assemblages at Bunurong were generally characterised by a diverse range of medium-sized brown algal species. The predominant brown algal species included *Seirococcus axillaris*, *Cystophora platylobium*, *C. moniliformis*, *C. retorta*, *C. retroflexa*, *Acrocarpia paniculata* and *Sargassum fallax*. Other larger brown species such as *Ecklonia radiata* and *Phyllospora comosa* were generally absent or in very low abundances. The predominant green algae were *Caulerpa brownii* and *Caulerpa flexilis*; however these species were relatively low in abundance. Other predominant components of the algal assemblages included the seagrass *Amphibolis antarctica*, coralline algae such as *Haliptilon roseum* and *Metagoniolithon radiatum*, as well as the red algae *Areschougia congesta*, *Plocamium angustum* and *Phacelocarpus peperocarpos*.

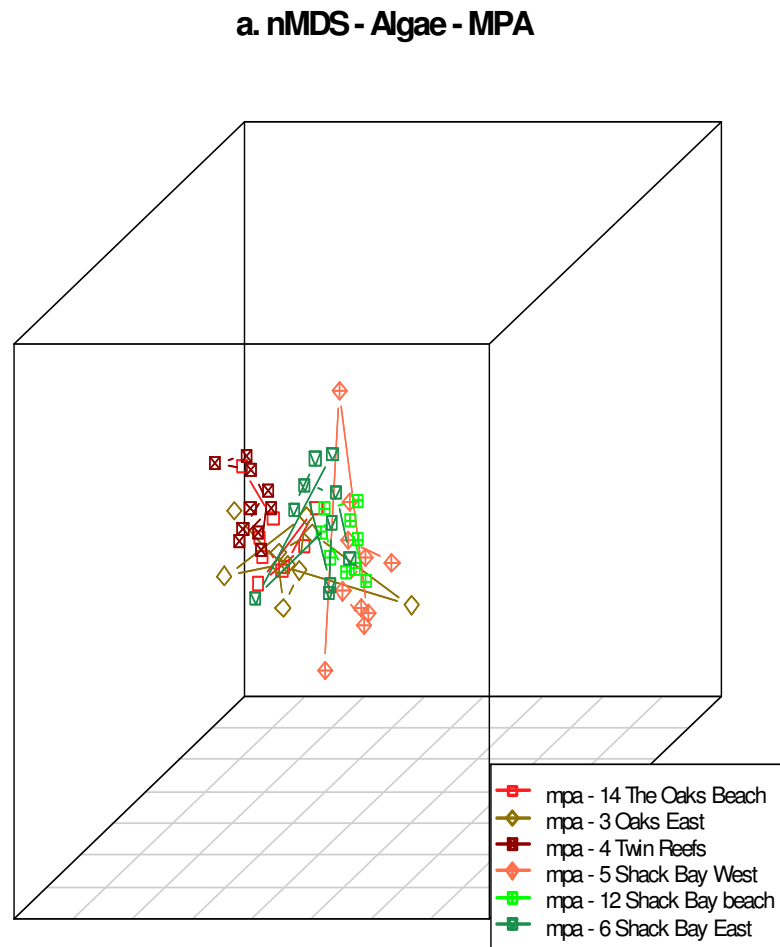
The MDS plots indicated there was an overall east-west gradient in changes in algal assemblage structure (Figures 3.1a and 3.1b). This change in site algal assemblage can be largely attributed to an increasing predominance of the seagrass *Amphibolis antarctica*, as well as the brown algae *Seirococcus axillaris* and *Cystophora pectinata* in the far eastern sites. The eastern sites also had much lower abundances of *Acrocarpia paniculata* and *Phacelocarpus peperocarpos* than the western sites.

The sites within the Bunurong Marine National Park (MNP) were relatively similar in structure; although the structure at each site was still distinguishable from other sites during each survey time (Figure 3.1a).

Amongst the western reference sites, Site 3001 (Cape Paterson) was quite different in assemblage structure and was reasonably isolated at the lower left of the MDS plot (Figure 3.1b). This was largely because Site 1 had a higher abundance of *Amphibolis antarctica*, *Cystophora retorta* and *C. retroflexa*, lower abundance of *Phacelocarpus peperocarpos* and an absence of *Seirococcus axillaris*. This algal assemblage is more similar to the far eastern sites (Sites 3007, 3013 and 3008) and this is reflected in its relative position in the MDS plot. There was considerable overlap in assemblage structure for the three eastern reference sites (Figure 3.1b).

The algal assemblage control charts indicated a few sites with significant deviation from the baseline or prior times centroid during 2005, however only Cape Paterson (Site 1) was

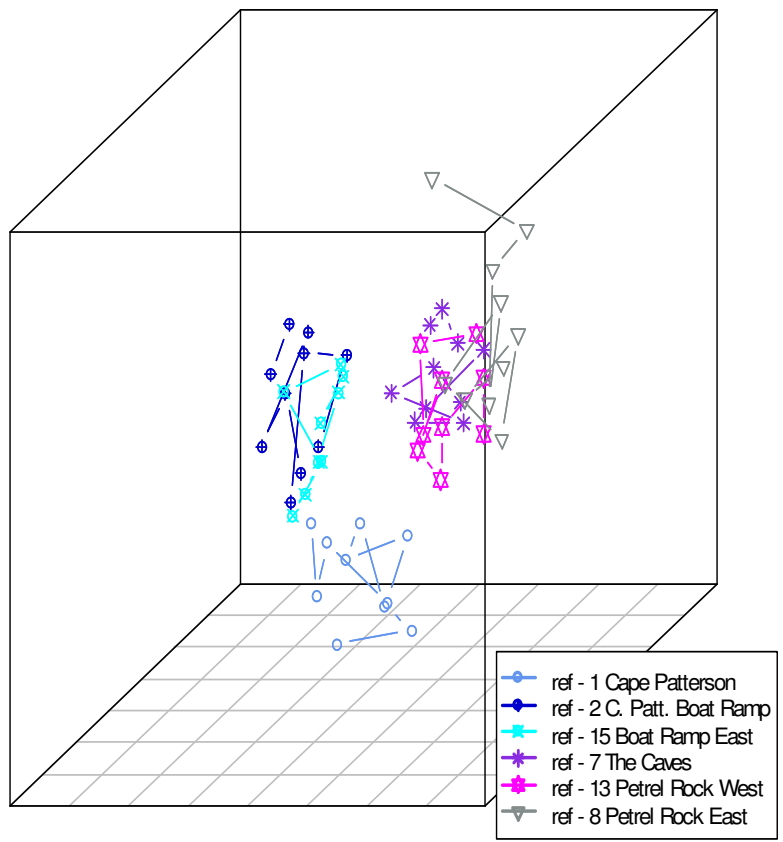
outside the 90th percentile limit in 2010. This site had significant deviation from both the baseline centroid and the prior times centroid (Figures 3.2c and 3.2d). This was reflected in the regional data, with the reference control chart just outside the 90th percentile limit (Figures 3.2e and 3.2f).



**Figure 3.1.** Three-dimensional MDS plot of algal assemblage structure at Bunurong for each site: (a) MNP sites (b) reference sites. Kruskal stress value = 15.78.

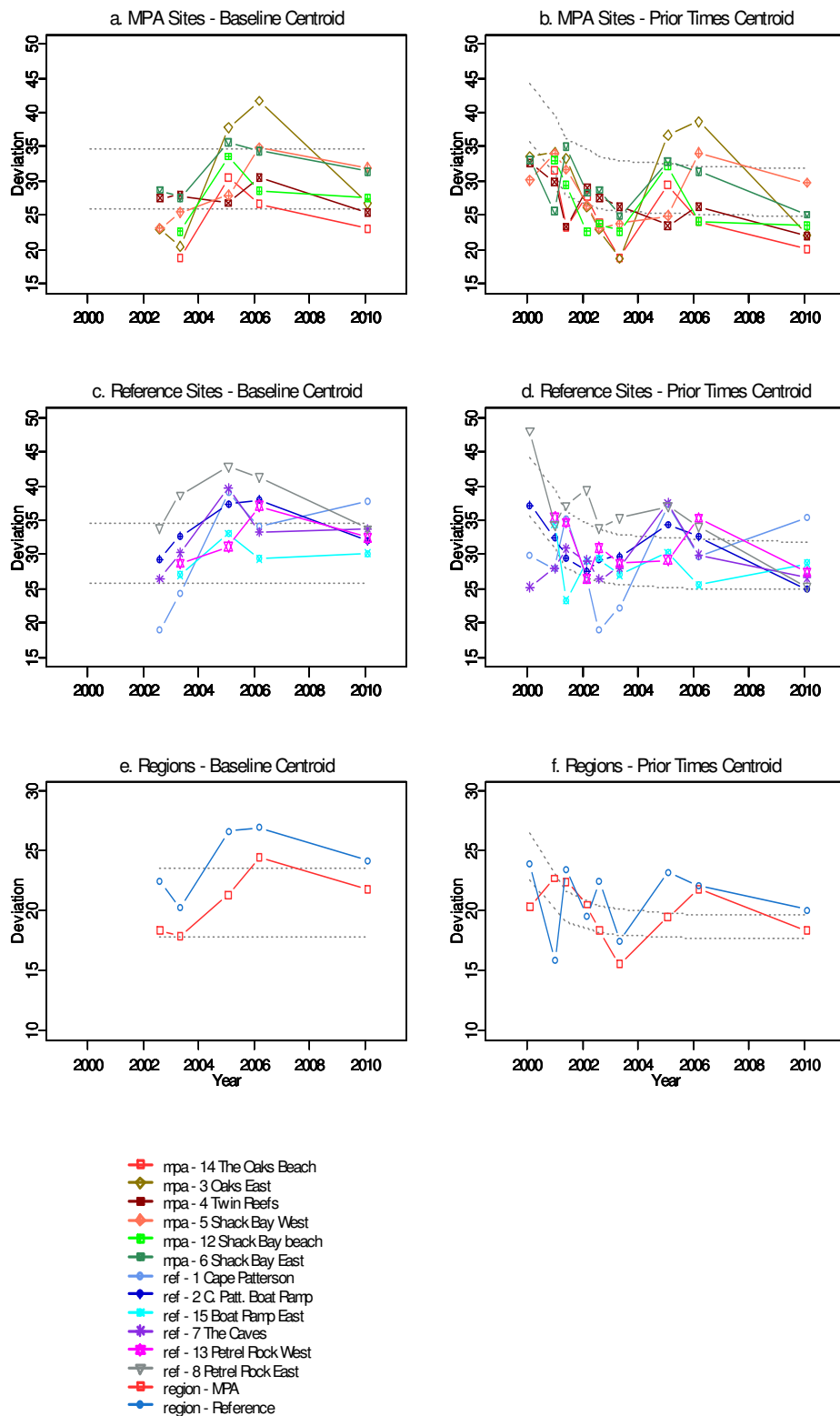


**b. nMDS - Algae - Reference**



**Figure 3.1 (continued).** Three-dimensional MDS plot of algal assemblage structure at Bunurong for each site: (a) MNP sites (b) reference sites. Kruskal stress value = 15.78.

### Control Chart - Algae



**Figure 3.2.** Control charts of algal assemblage structure inside and outside Bunurong Marine National Parl.

## Invertebrates

The invertebrate fauna was largely composed of the blacklip abalone *Haliotis rubra*, the gastropod *Turbo undulatus* and a variety of sea stars, particularly *Meridiastra gunnii* and *Tosia australis*. Other commonly encountered species included greenlip abalone *H. laevigata*, the dogwhelk *Dicathais orbita* and seastar *Nectria ocellata*.

The MDS analysis showed similar variation throughout time for most sites, with considerable overlap in structure between sites (Figures 3.3a and 3.3b). Petrel Rock East (Site 8) was the most different from other sites, having relatively low abundances of *H. rubra* and *T. undulatus* and relatively high abundances of the seastar *M. gunnii* and sea urchin *H. erythrogramma*.

The control charts detected significant departures in invertebrate assemblage structure from both the baseline centroid and prior times centroid. Within the MNP, these were at Twin Reefs (Site 4), Oaks Beach (Site 14) and Shack Bay Beach (Site 12; Figures 3.4a and 3.4b). All but two reference sites, Boat Ramp East (Site 15) and Cape Paterson (Site 1), were outside the 90th percentile limit for the reference sites during 2010 (Figures 3.4c and 3.4d). This was reflected in the regional plot, with the reference region outside the limit for deviation from both the baseline centroid and the prior times centroid (Figures 3.4e and 3.4f).

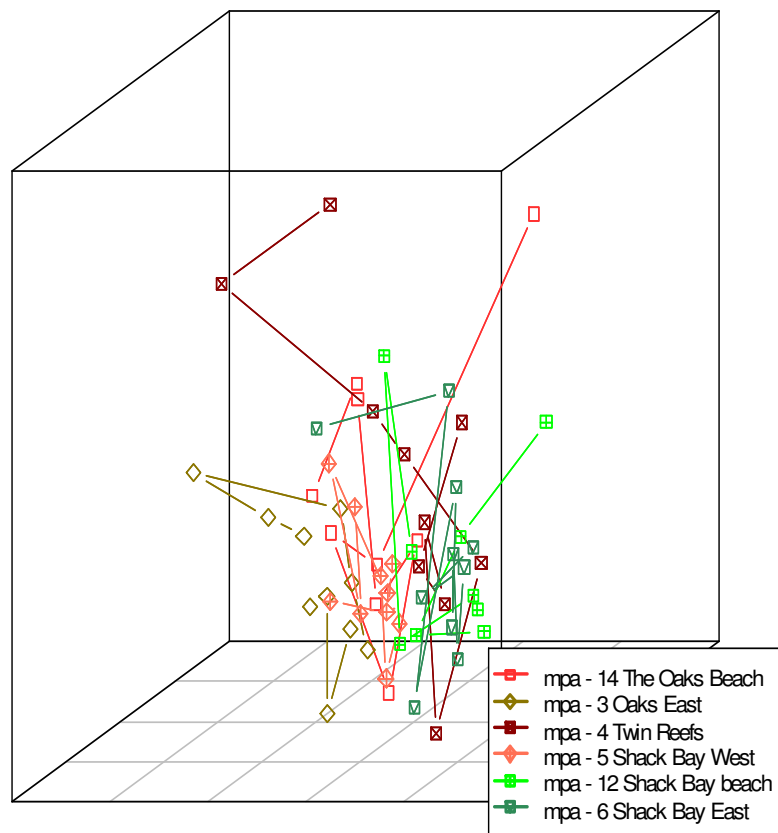
## Fishes

The fish assemblages primarily consisted of blue throated wrasse *Notolabrus tetricus*, purple wrasse *Notolabrus fucicola*, senator wrasse *Pictilabrus laticlavius* and sea sweep *Scorpius aequipinnis*. Other common species included the scaly fin *Parma victoriae*, magpie perch *Cheilodactylus nigripes*, herring cale *Odax cyanomelas*, zebra fish *Girella zebra* and a variety of monacanthids (leatherjackets).

The MDS analysis indicated there were no marked differences in assemblage structure between sites, with considerable overlap of trajectories through time (Figures 3.5a and 3.5b). At many of the sites, the trajectories of shift in community structure oscillated in similarity between summer and winter surveys, indicating seasonal processes may be occurring (Figure 5.5).

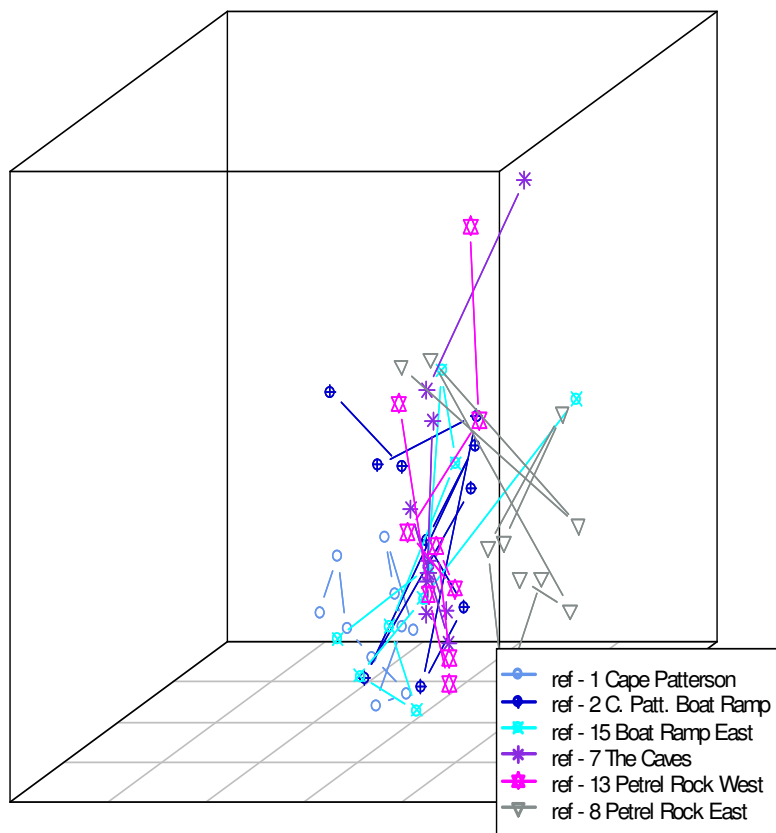
The control charts indicated substantial departure from average conditions at Shack Bay Beach (Site 12) and The Oaks Beach (Site 14) from both baseline and prior times centroids in 2010 (Figures 3.6a and 3.6b). This was reflected in the regional trends, with the MNP average outside the 90th percentile limits for distance to baseline centroid and distance to prior times centroid (Figures 3.6e and 3.6f). For the reference sites, Boat Ramp East (Site 15) was outside the 90th percentile distance from both baseline and prior times centroids (Figures 3.6c and 3.6d).

**a. nMDS - Invertebrates - MPA**



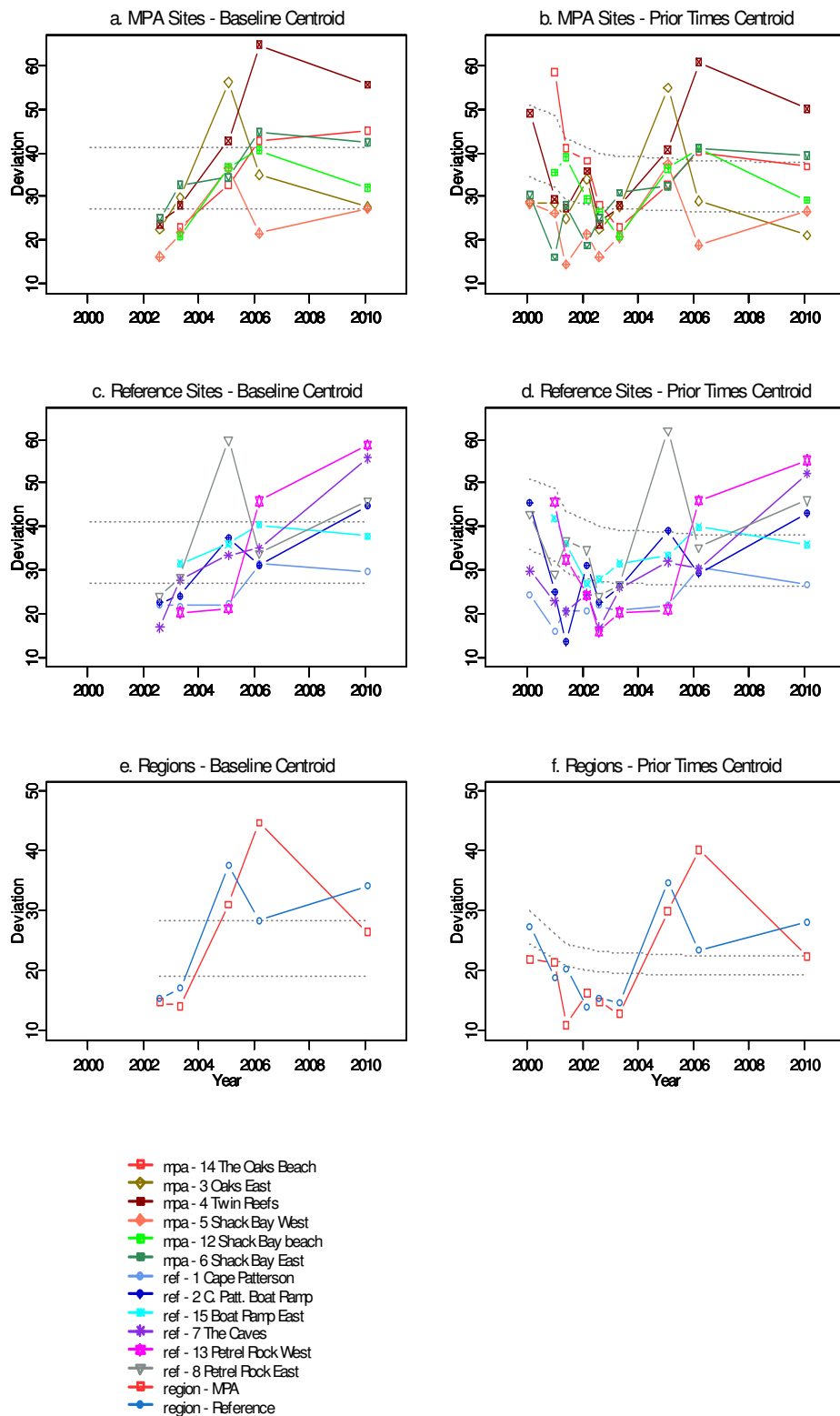
**Figure 3.3.** Three-dimensional MDS plot of invertebrate assemblage structure at Bunurong for each site: (a) MNP sites; and (b) reference sites. Kruskal Stress value= 16.86.

**b. nMDS - Invertebrates - Reference**

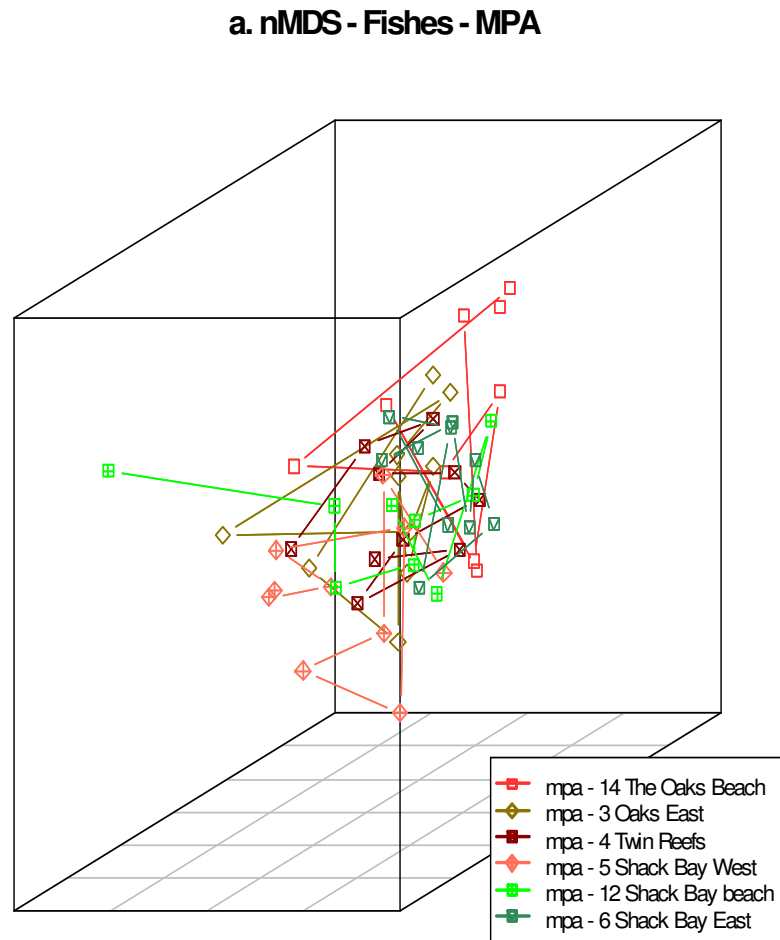


**Figure 3.3 (continued).** Three-dimensional MDS plot of invertebrate assemblage structure at Bunurong for each site: (a) MNP sites; and (b) reference sites. Kruskal Stress value= 16.86.

### Control Chart - Invertebrates

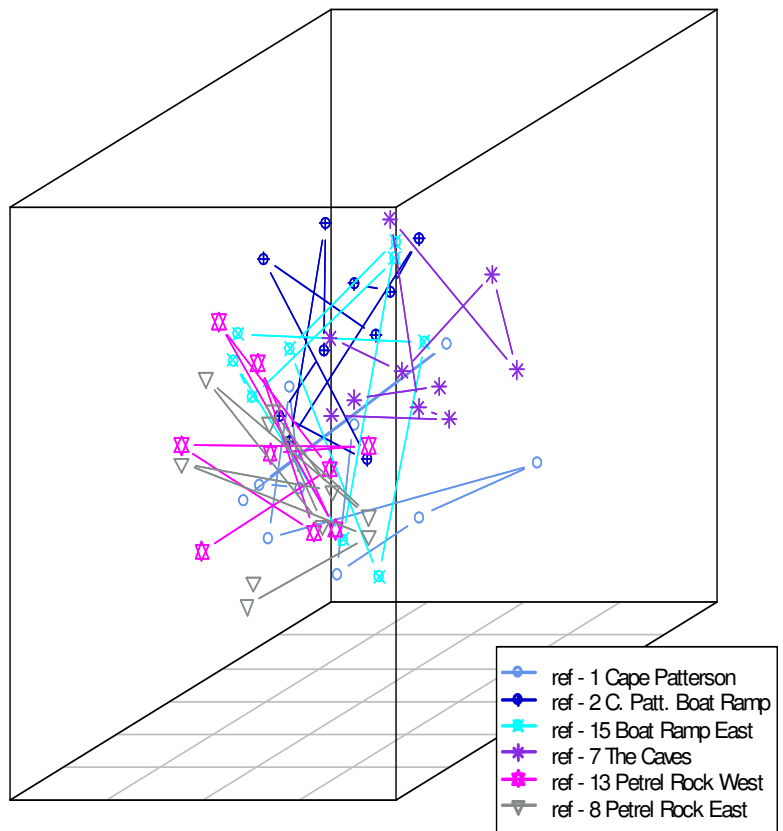


**Figure 3.4.** Control chart of invertebrate assemblage structure inside and outside Bunurong Marine National Park.



**Figure 3.5.** Three-dimensional MDS plot of fish assemblage structure at Bunurong for each site: (a) MNP sites; and (b) reference sites. Kruskal Stress value = 19.93.

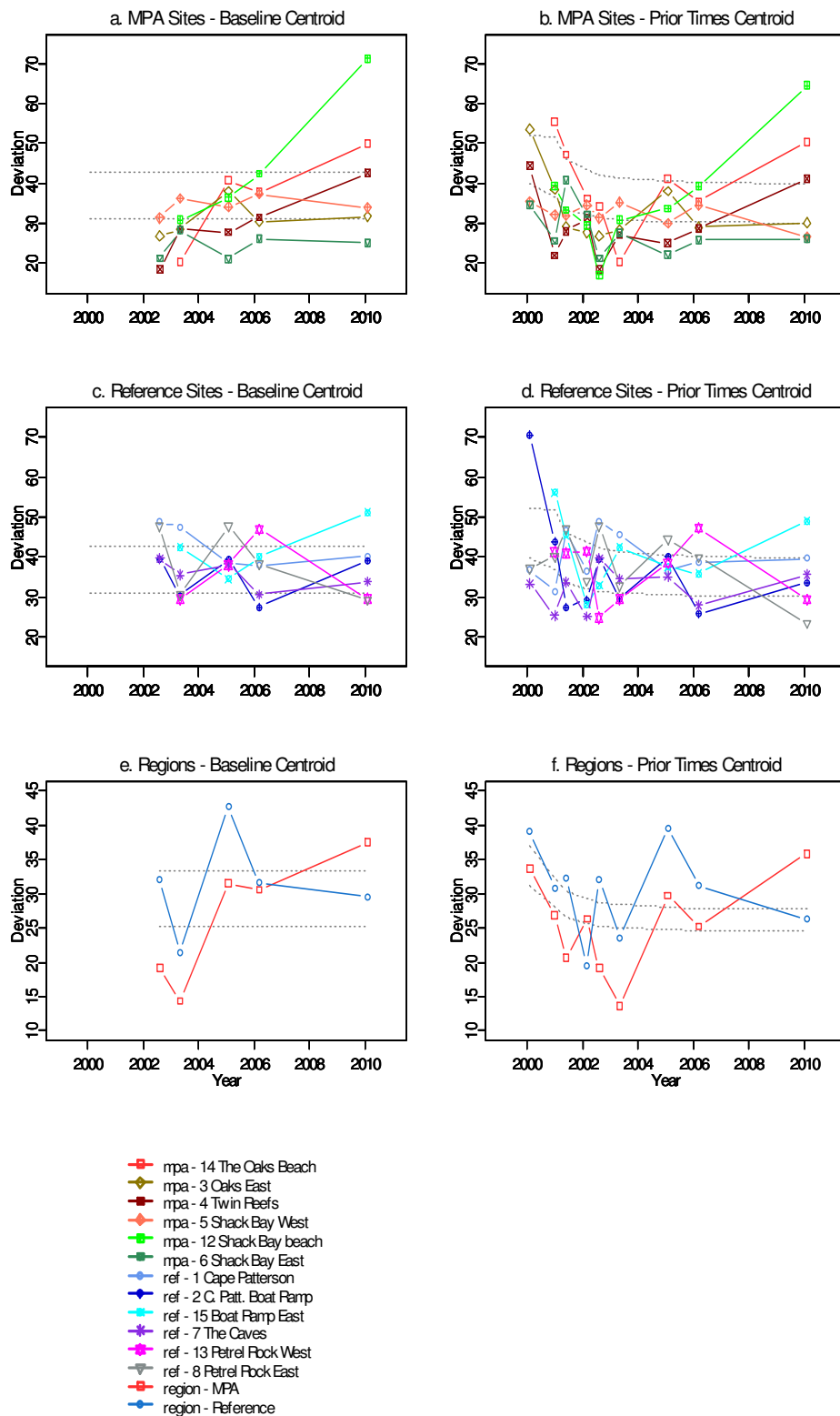
**b. nMDS - Fishes - Reference**



**Figure 3.5 (continued).** Three-dimensional MDS plot of fish assemblage structure at Bunurong for each site: (a) MNP sites; and (b) reference sites. Kruskal Stress value = 19.93.



### Control Chart - Fishes



**Figure 3.6.** Control chart of fish assemblage structure inside and outside Bunurong Marine National Park.

### 3.1.2 Species richness and Diversity

#### Macroalgae

The total algal abundance remained at complete substratum coverage throughout the survey period (Figure 3.7a). Macrophyte species richness was relatively high (30-40 species per site) and stable at most sites over time (Figure 3.7b). Species diversity was consistently greater within the MNP compared to the reference areas (Figure 3.7c). Both species richness and diversity have remained relatively high since declaration of the MNP.

#### Invertebrates

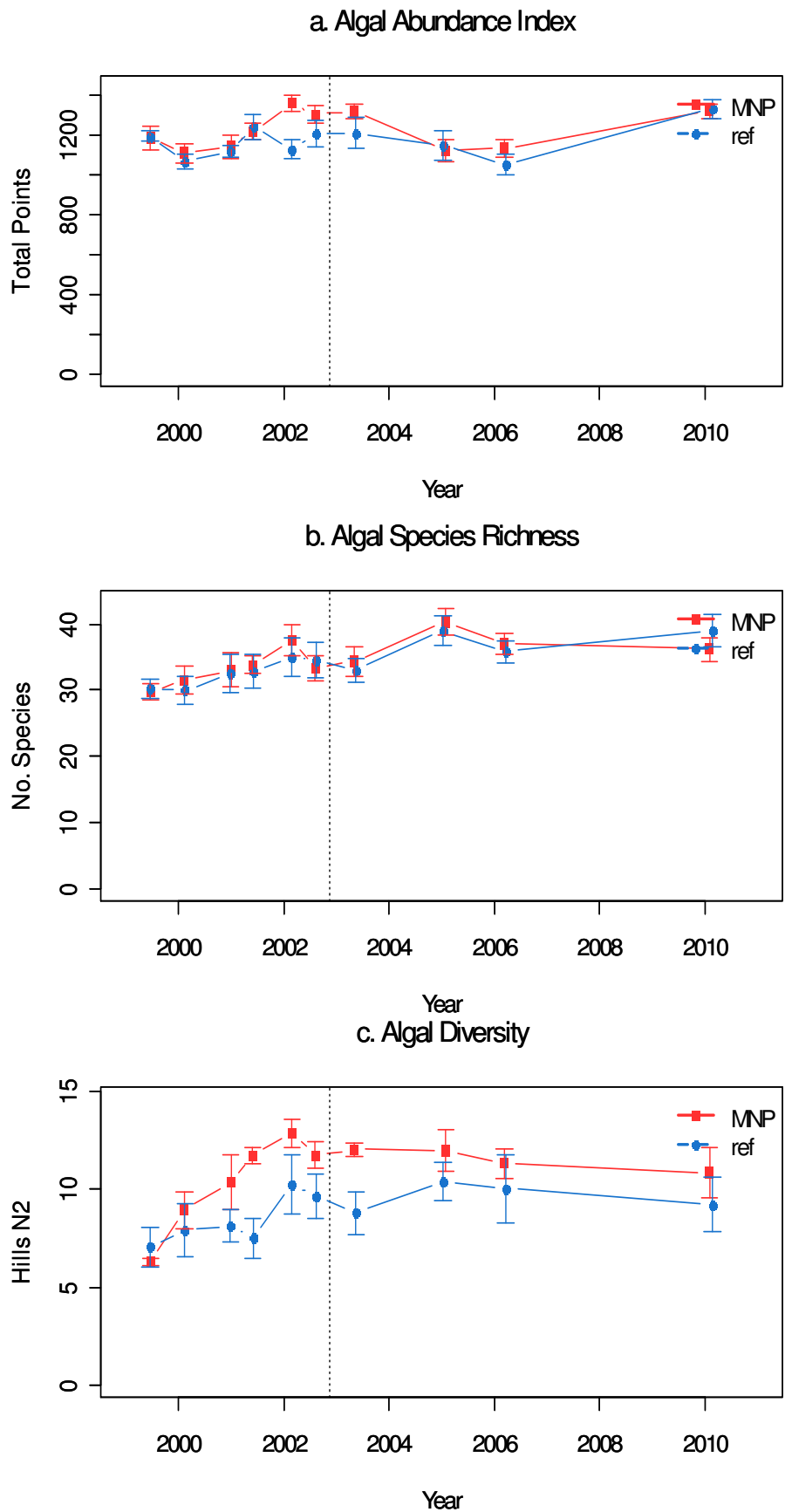
Total invertebrate abundance peaked in 2001, both inside and outside the MNP area, before decreasing to below baseline surveys in 2005 and 2006, with little subsequent change to 2010 (Figure 3.8a). Invertebrate species richness had a similar pattern over time (Figure 3.8b).

Species diversity in terms of Hill's  $N_2$ , was generally confined to between 2 and 3 dominant species in both regions, with no discernable trends over time (Figure 3.8c).

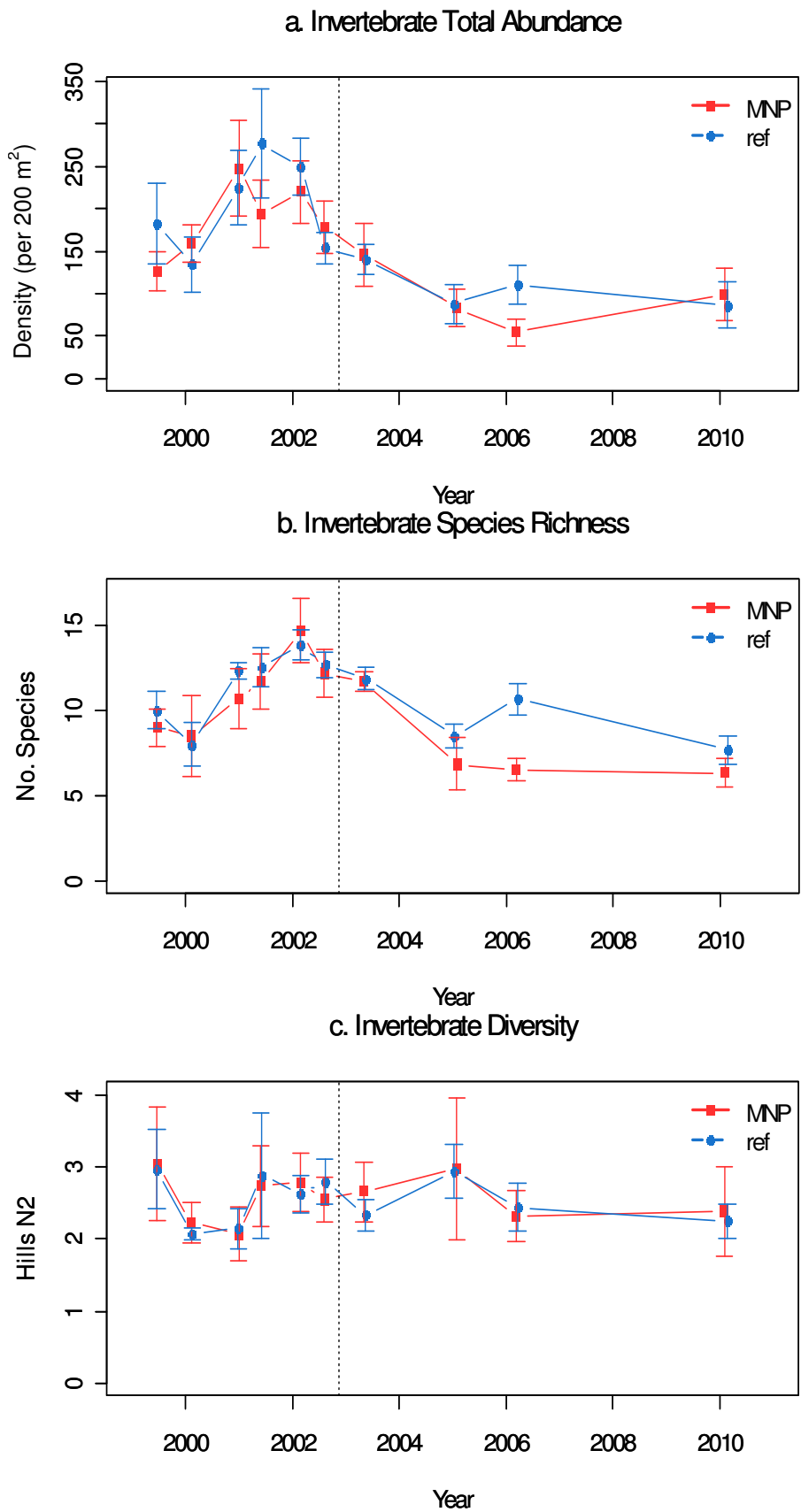
#### Fishes

Total fish abundance fluctuated over time both inside and outside the Bunurong MNP (Figure 3.9). Total abundances inside the MNP largely followed the reference area variations, except for low total abundances in 2006 (Figure 3.9a).

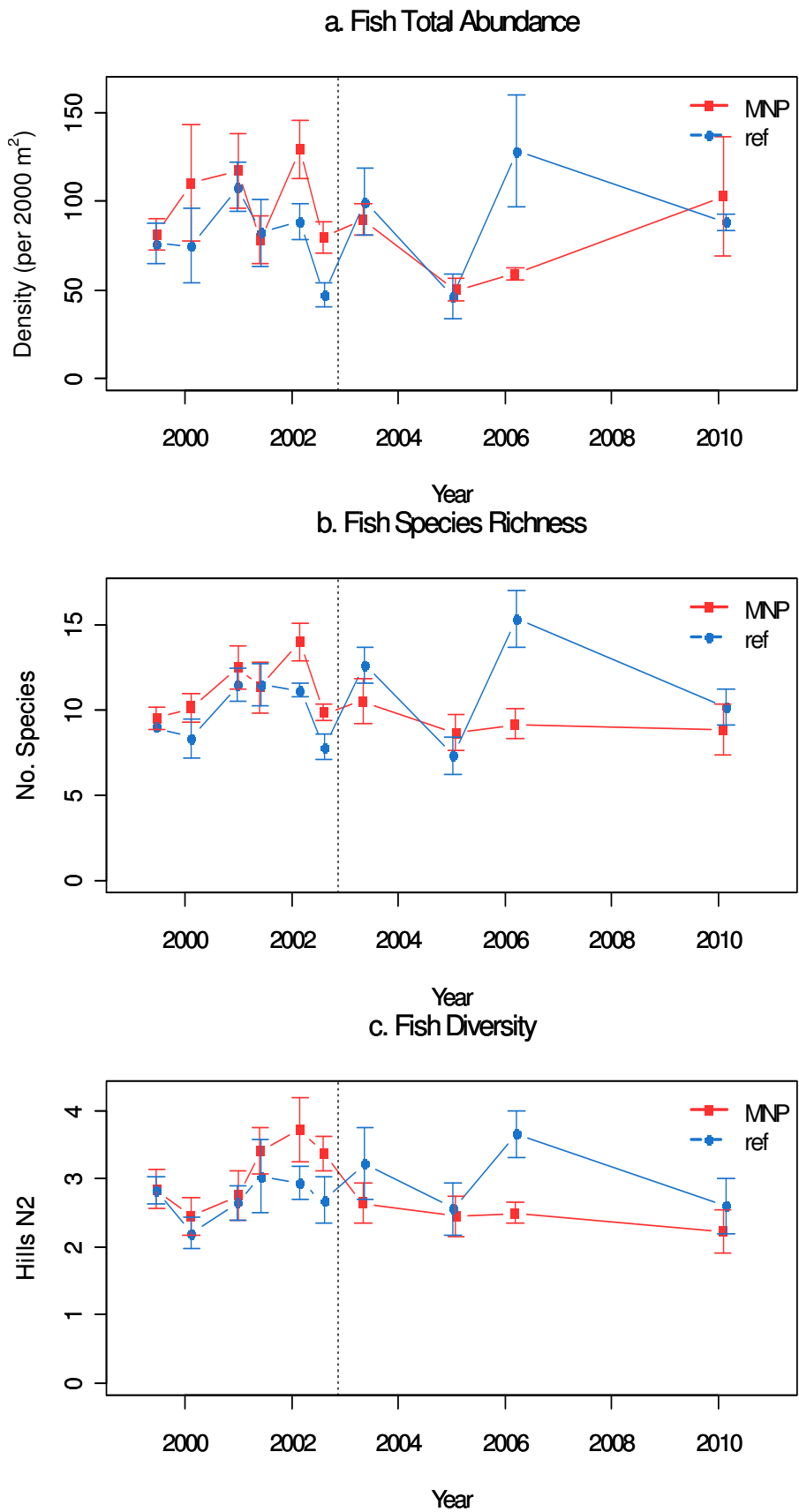
Both species richness and species diversity had similar levels and temporal patterns between the reference and MNP areas prior to the park declaration. This pattern did not continue after 2005, with species richness and diversity being lower within the MNP during 2006 and 2010 (Figures 3.9b and 3.9c).



**Figure 3.7.** Algal species diversity indicators ( $\pm$  Standard Error) inside and outside Bunurong Marine National Park.



**Figure 3.8.** Invertebrate species diversity indicators ( $\pm$  Standard Error) inside and outside Bunurong Marine National Park.



**Figure 3.9.** Fish species diversity indicators ( $\pm$  Standard Error) inside and outside Bunurong Marine National Park.

### 3.1.3 Abundances of Selected Species

#### Macroalgae

The seagrass *Amphibolis antarctica* is found in high abundance in the eastern zone reference sites. Petrel Rock West (Site 13), Petrel Rock East (Site 8) and The Caves (Site 7) have shown an increase since the 2006 survey, which is reflected in the reference area average (Figure 3.10a). Although abundances were much lower inside the MNP, there was a concurrent increase in *A. antarctica* coverage to 2010.

There were no marked changes in abundances of the dominant brown algae *Acrocarpia paniculata*, *Seirococcus axillaris*, *Cystophora retorta* and *Cystophora platylobium* over the monitoring period inside or outside the MNP (Figures 3.10b to 3.10e). Similarly, there were no major changes in abundances of the red algae *Haliptilon roseum* and *Plocamium angustum* inside or outside the MNP (Figures 3.10f and 3.10g). There was a slight increase in coverage of the red alga *Phacelocarpus peperocarpos* inside the MNP between 2006 and 2010 (Figure 3.10h). Although there have not been discernable trends in average regional abundances, there have been moderate fluctuations in abundance within sites.

#### Invertebrates

The average abundance of blacklip abalone *H. rubra* increased considerably from 1999 to peak abundances in 2001, both inside and outside the MNP (Figure 3.11a). There was a subsequent, gradual decline to 2005 for the reference area and 2006 for the MNP, with no appreciable increase by 2010 (Figure 3.11a). A similar pattern was observed for the periwinkle *T. undulatus*, with peak abundances in 2001 and minima in 2006, however there were slight increases in abundances to 2010 (Figure 3.11b). The dogwhelk *D. orbita* also had a distinct peak in abundance, but lagged to 2002, with low abundances in 2010. Abundances were higher inside the MNP than the reference areas during the baseline monitoring period, but were lower than the reference areas during more recent surveys (Figure 3.11c).

Average abundances of the common sea urchin *Heliocidaris erythrogramma* were relatively high during the baseline period compared to the recent survey periods, although low abundances were observed during 2000 (Figure 3.12d). Abundances in 2010 were among the lowest observed levels.

#### Fishes

The frequent baseline surveys detected considerable intra- and interannual fluctuations in blue throated wrasse *N. tetricus*, with subsequent surveys having abundances within the range of baseline variations. The abundances of *N. tetricus* were very similar inside and outside the MNP over time (Figure 3.13a).

The abundances of purple wrasse *N. fucicola* fluctuated considerably during the baseline monitoring, with abundances higher inside the MNP (sanctuary) area. Post declaration, abundances inside the MNP were lower than baseline levels, with densities similar to the reference areas (Figure 3.13b).

A similar, but weaker, decline in abundances inside the MNP was apparent for senator wrasse *P. laticlavus* (Figure 3.13c).

Zebrafish *Girella zebra* were largely absent from both inside and outside the MNP in 2005, 2006 and 2010, which is inconsistent with baseline observations (Figure 3.13d).

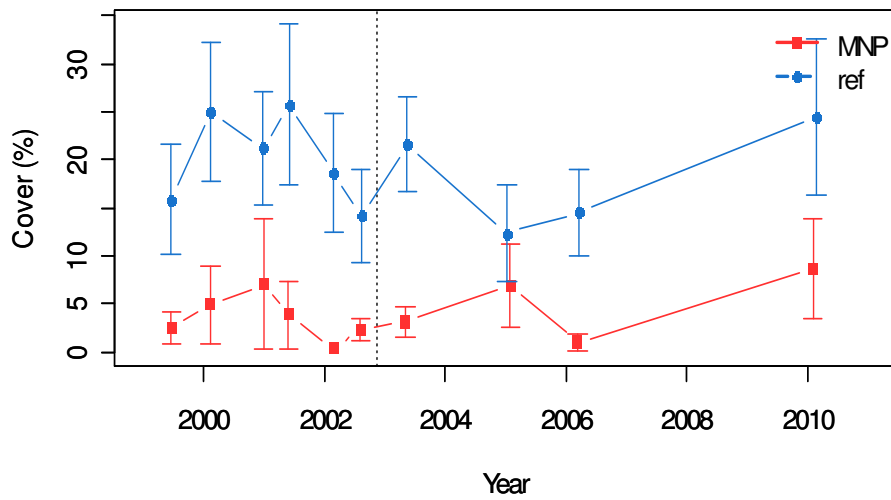
There are no apparent trends in density for sea sweep *Scorpiis aequipinnis* (Figure 3.13e).

The densities of magpie morwong *Cheilodactylus nigripes* were similar inside and outside the MNP at all times and had similar temporal fluctuations. The densities in 2010 were relatively low, however low densities were also observed in 1999 and early 2000 (Figure 3.13f).

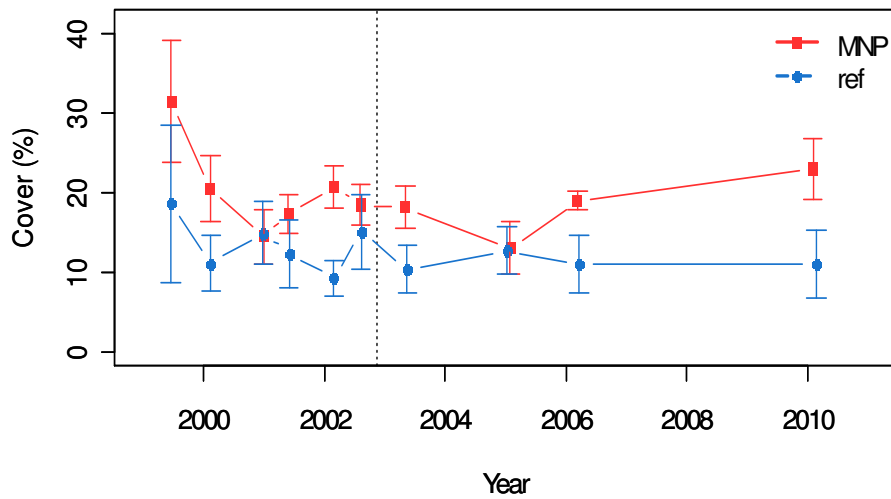
The density of herring cale *Odax cyanomelas* was consistently higher inside the MNP during the baseline period, to 2002, after which average densities were slightly lower and similar to the reference areas (Figure 3.13g).

The densities of scalyfin *Parma victoriae* were similar inside and outside the MNP, with similar fluctuations up to 2005. Densities were notably higher than previously observed in the reference areas in 2006 and 2010 (Figure 3.13h).

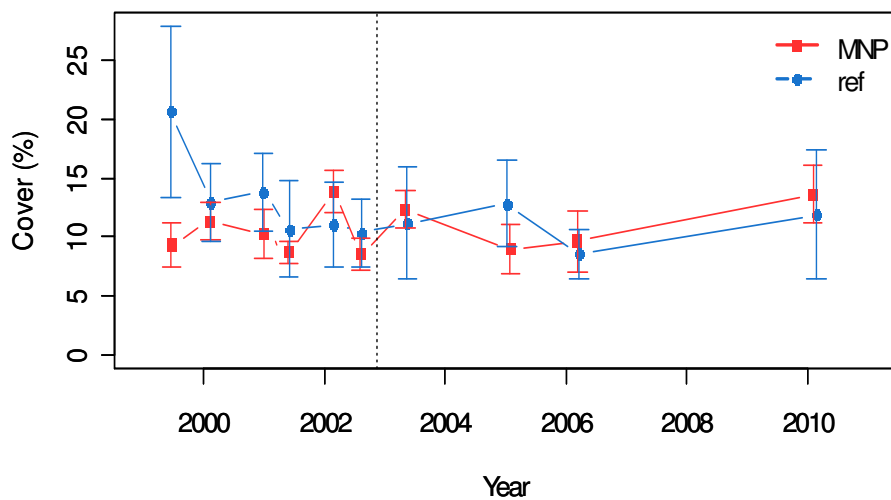
*a. Amphibolis antarctica*



*b. Acrocarpia paniculata*



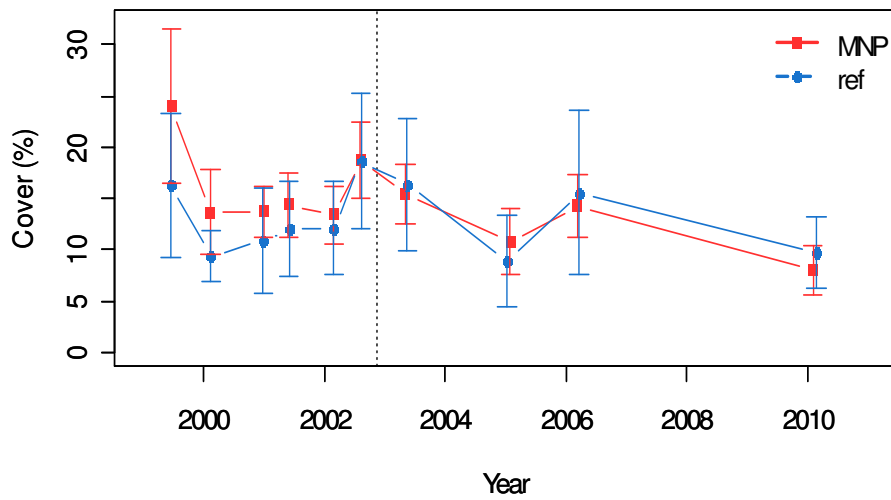
*c. Seirococcus axillaris*



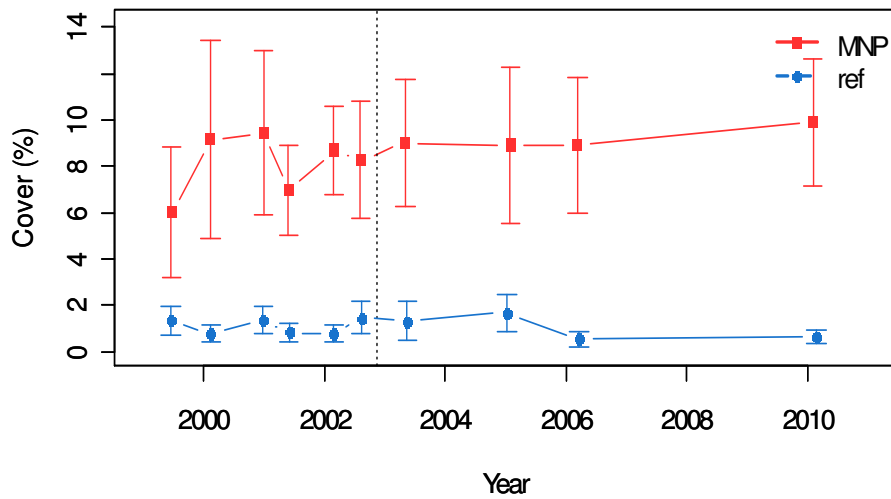
**Figure 3.10.** Percent cover ( $\pm$  Standard Error) of predominant seagrass and algal species inside and outside the Bunurong Marine National Park.



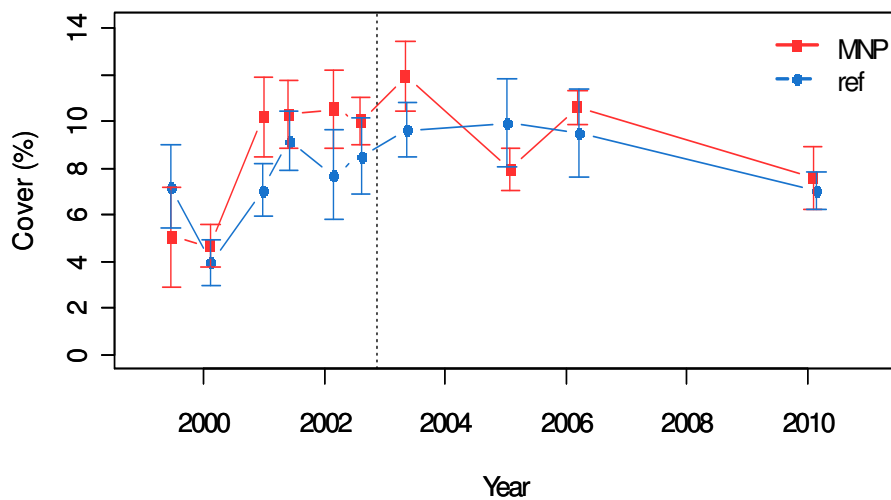
*d. Cystophora retorta*



*e. Cystophora platylobium*

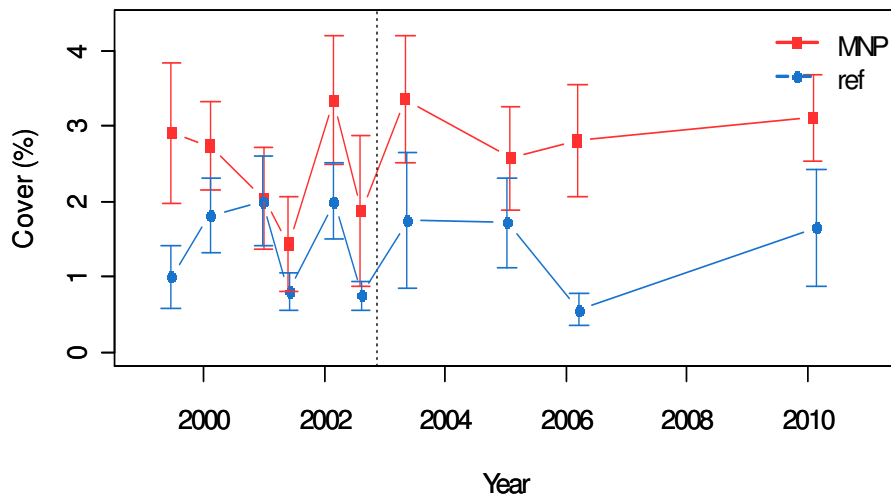


*f. Haliptilon roseum*

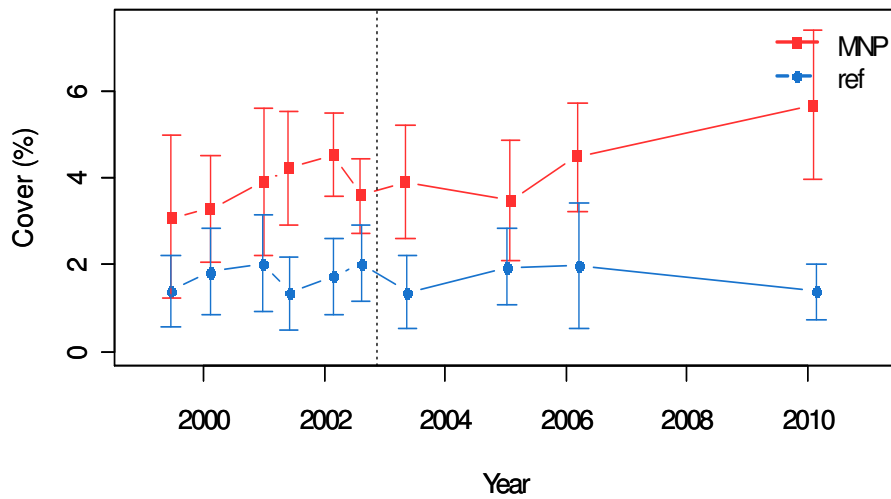


**Figure 3.10 (continued).** Percent cover ( $\pm$  Standard Error) of predominant seagrass and algal species inside and outside the Bunurong Marine National Park.

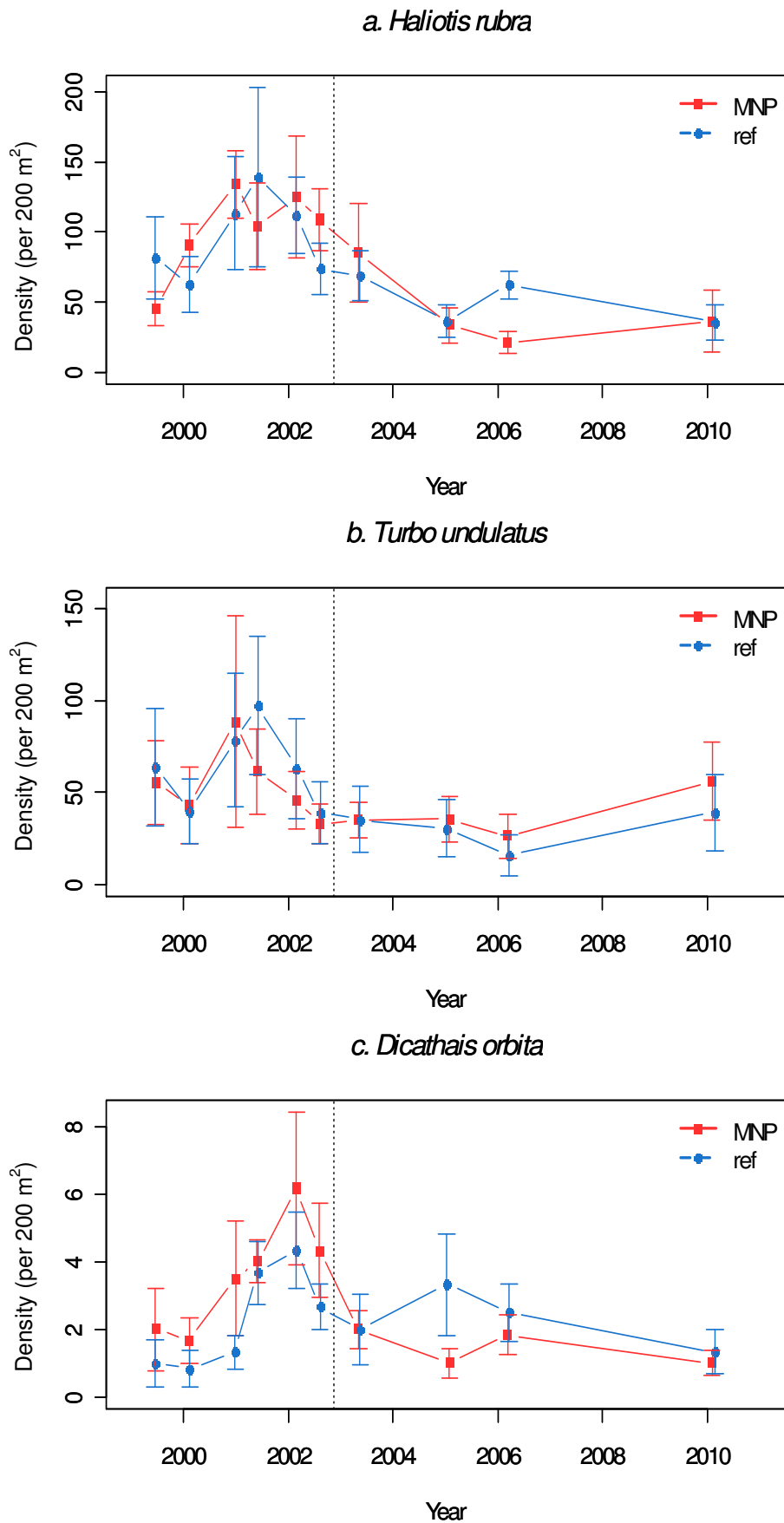
*g. Plocamium angustum*



*h. Phacelocarpus peperocarpus*

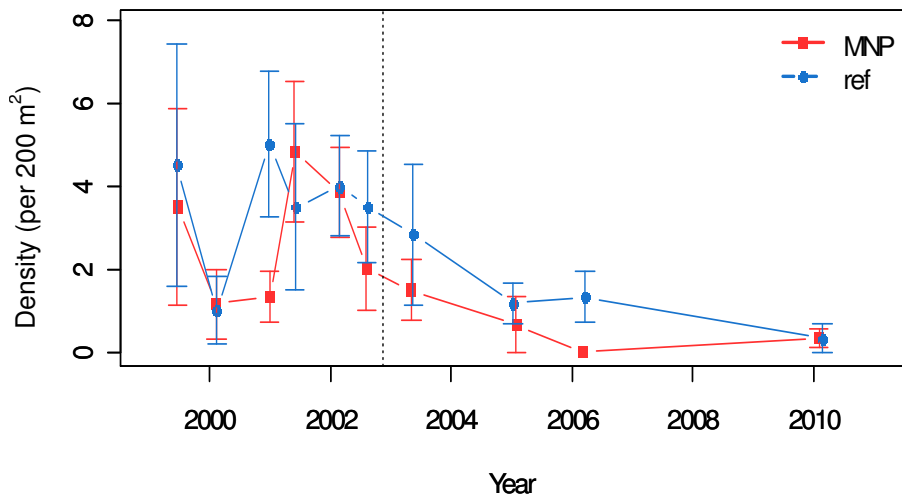


**Figure 3.10 (continued).** Percent cover ( $\pm$  Standard Error) of predominant seagrass and algal species inside and outside the Bunurong Marine National Park.

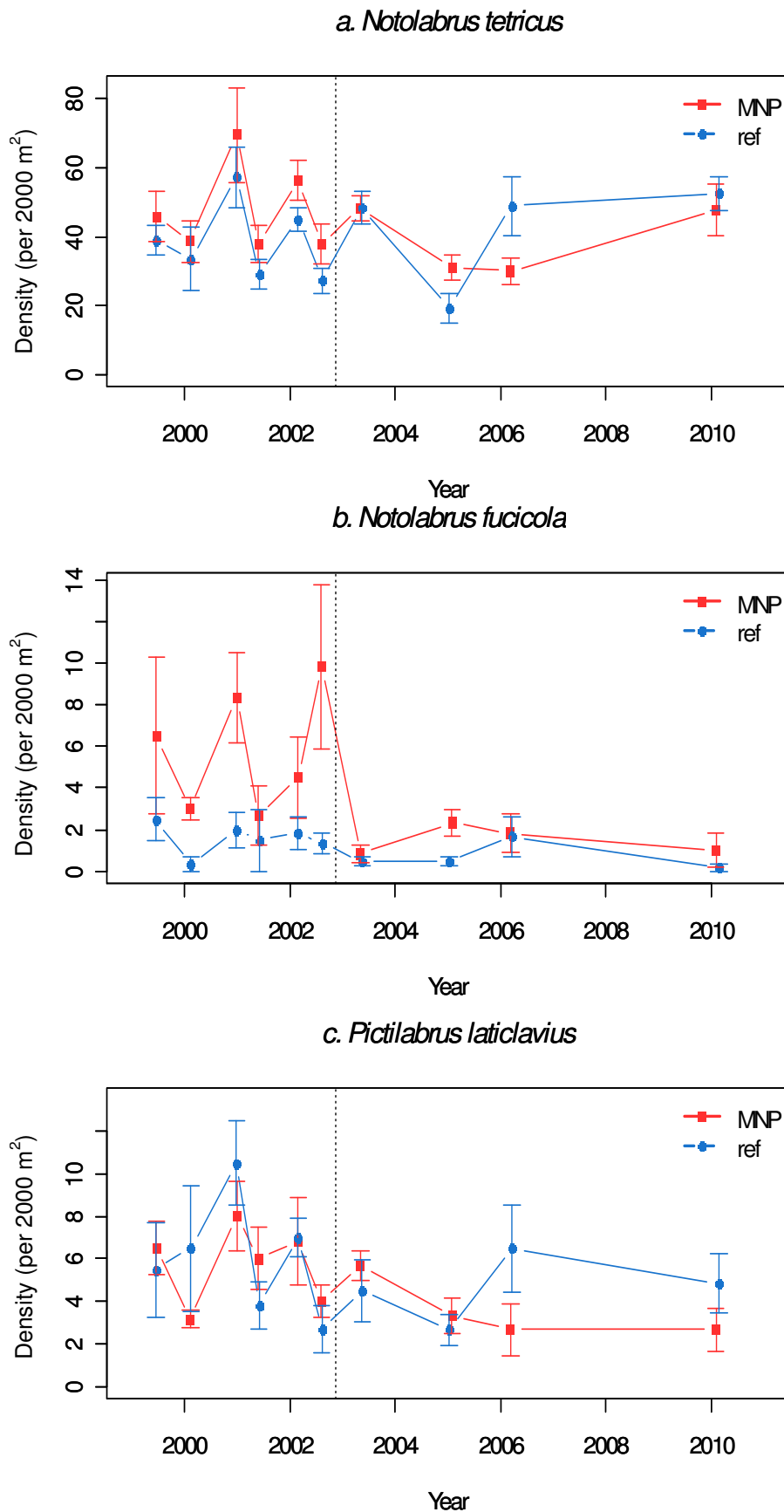


**Figure 3.11.** Mean abundance ( $\pm$  Standard Error) of predominant invertebrate species inside and outside the Bunurong Marine National Park.

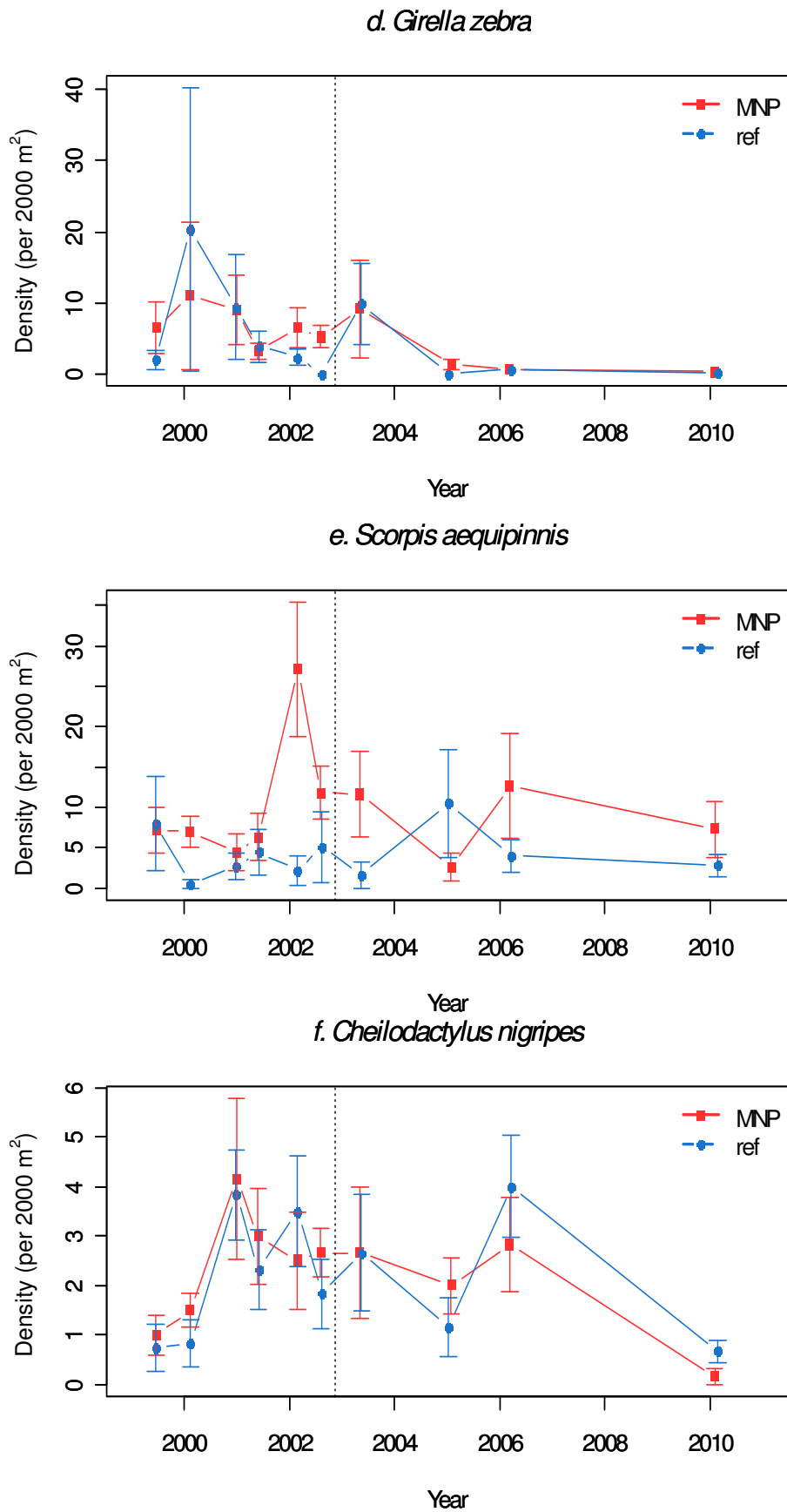
*d. Heliocidaris erythrogramma*



**Figure 3.11. (continued).** Mean abundance ( $\pm$  Standard Error) of predominant invertebrate species inside and outside the Bunurong Marine National Park.

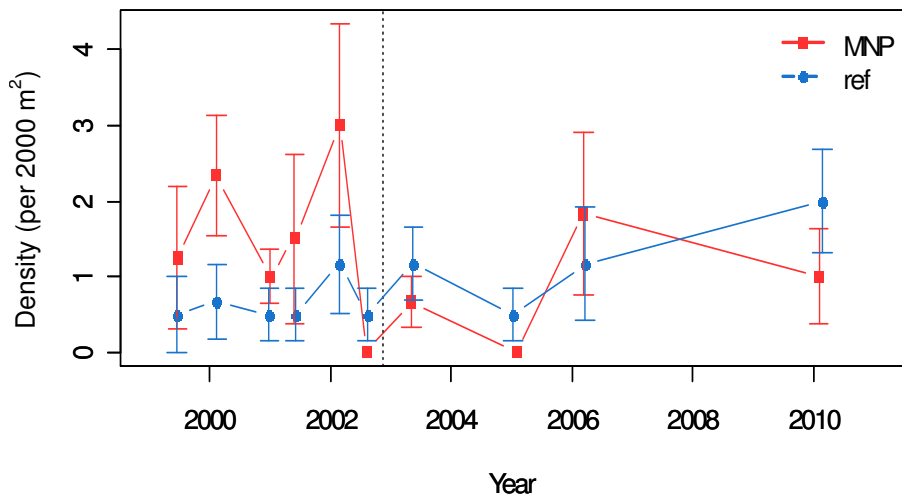


**Figure 3.12.** Mean abundance ( $\pm$  Standard Error) of predominant fish species inside and outside the Bunurong Marine National Park.

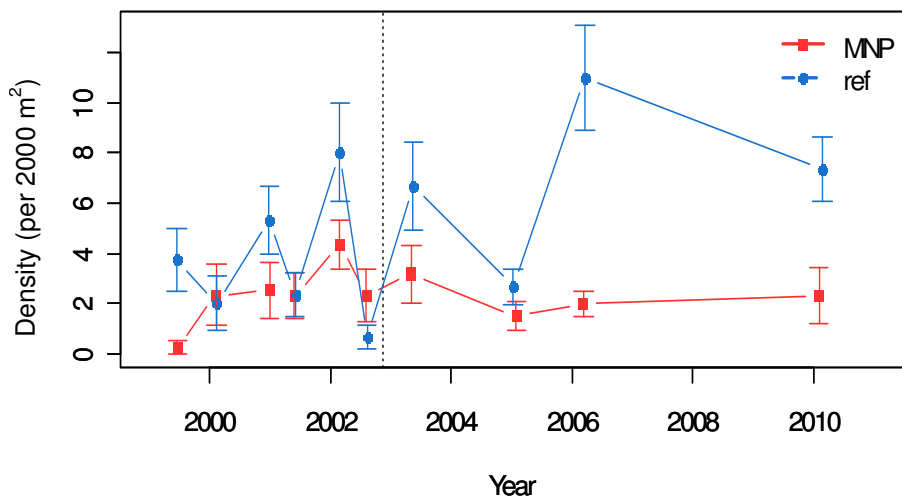


**Figure 3.12 (continued).** Mean abundance ( $\pm$  Standard Error) of predominant fish species inside and outside the Bunurong Marine National Park.

*g. Odax cyanomelas*



*h. Parma victoriae*



**Figure 3.12 (continued).** Mean abundance ( $\pm$  Standard Error) of predominant fish species inside and outside the Bunurong Marine National Park.

## 3.2 Ecosystem Components

### Habitat and Production

Cover of different algae functional groups has remained relatively constant since the previous survey in 2006, with canopy browns being the most dominant group. Over a larger time scale, some patterns are evident with crustose coralline algae cover decreasing by approximately half between 2005 and 2006 (Figure 3.14a). There have been corresponding, but slight, increases in abundance of smaller browns and thallose red algae (Figures 3.14c and 3.14e).

### Invertebrate Groups

Abundance of Invertebrate grazers is by far the largest of the invertebrate functional groups in all surveys (Figure 3.15a). Peaks in the densities of invertebrate grazers and predators occurred prior to the MNP introduction and have since declined and remained relatively constant, with a similar trend occurring in reference sites (Figures 3.15a and 3.15c). No trends were detected in the density of invertebrate filter feeders. Although there was an increase in abundance in the first survey after the MNP declaration, densities were relatively low during most surveys (Figure 3.15b). Seastar densities were very low inside the MPA in 2006 and 2010 and in the reference areas in 2010 (Figure 3.15d).

### Fish Groups

The fish functional group indicators were similar between inside and outside the MNP, with patterns of change through time (Figure 3.16). An exception was a lower density of fish grazers inside the MNP during 2006 and 2010 (Figure 3.16a).

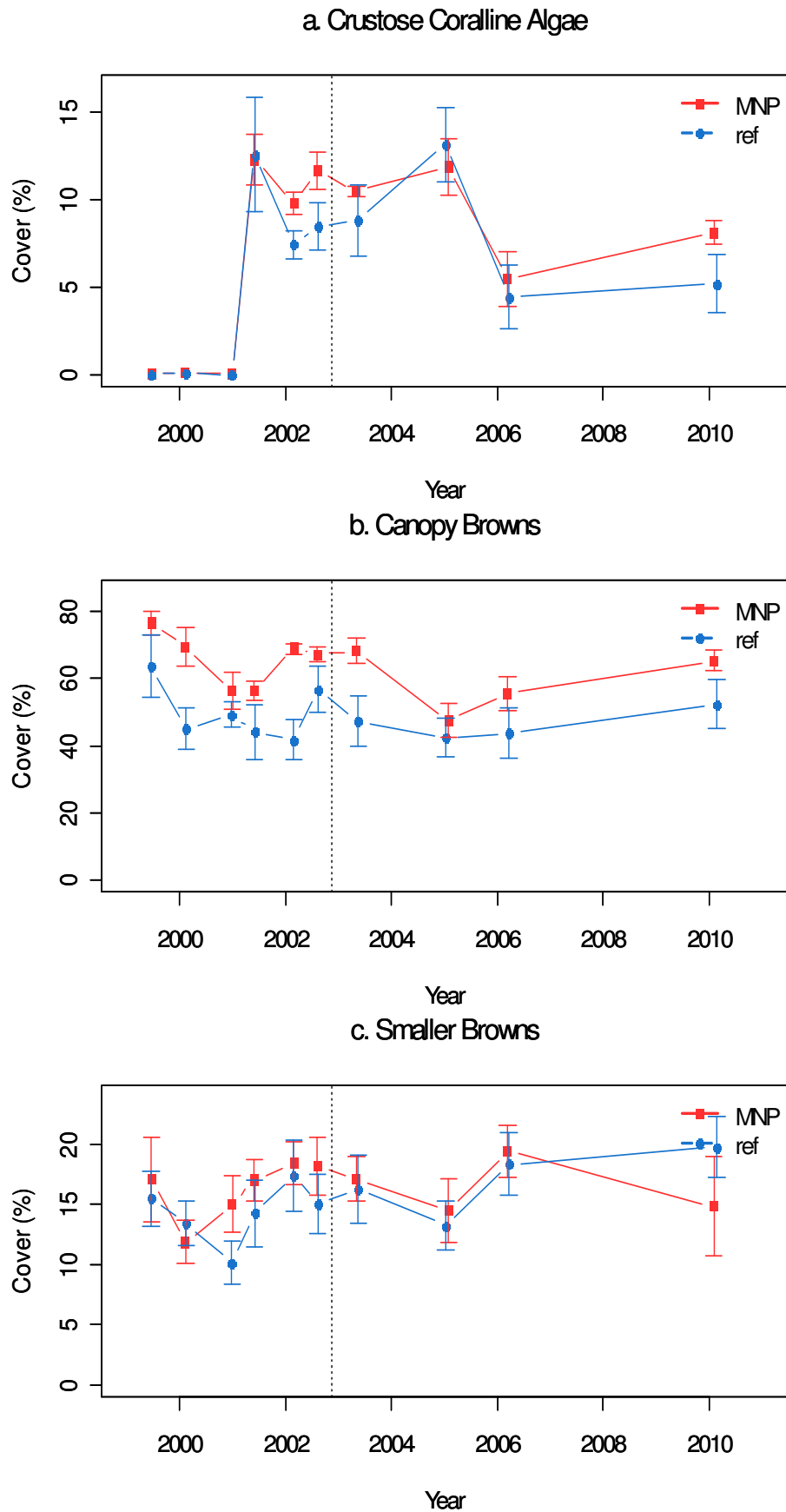
### Sediment Cover

Sediment cover was not recorded during the first two surveys. There were no marked changes from baseline surveys until a peak in 2005, returning to original levels during the subsequent 2006 and 2010 surveys (Figure 3.17).

## 3.3 Introduced Species

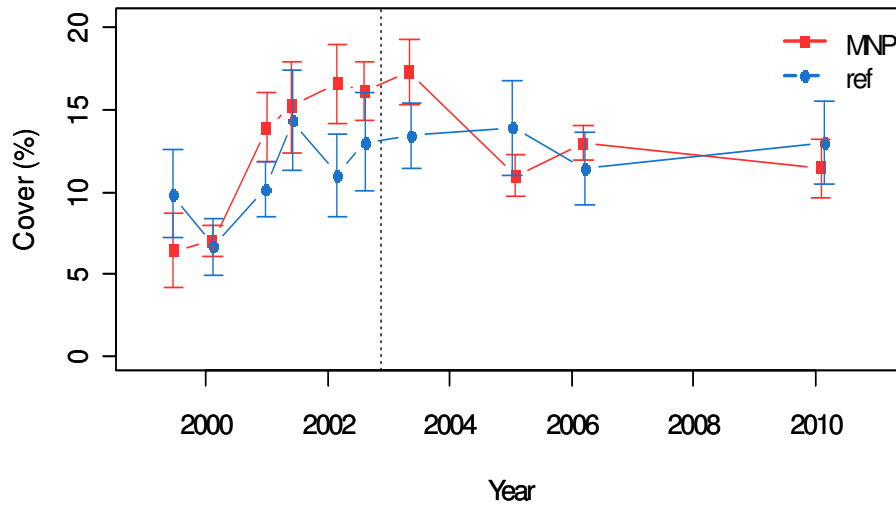
There were no introduced species observed at the Bunurong monitoring sites during any of the survey times.



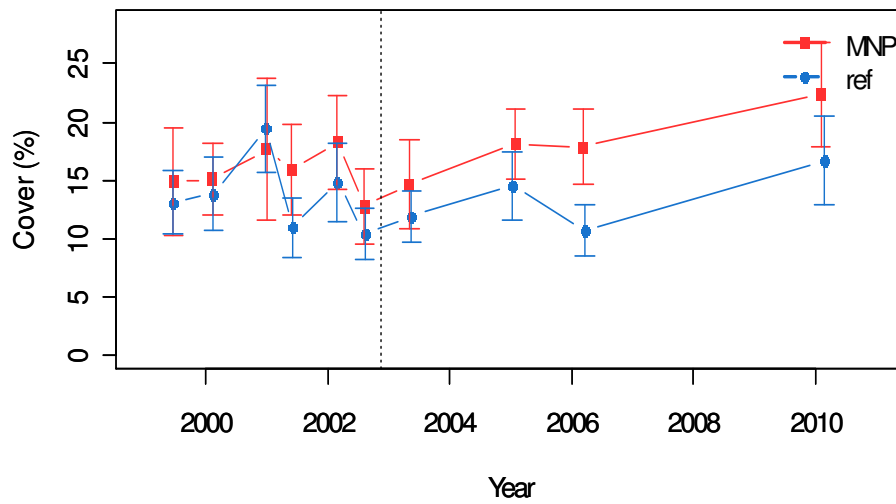


**Figure 3.13.** Seaweed functional groups ( $\pm$  Standard Error) inside and outside the Bunurong Marine National Park.

d. Erect Coralline Algae



e. Thallose Red Algae



f. Green Algae

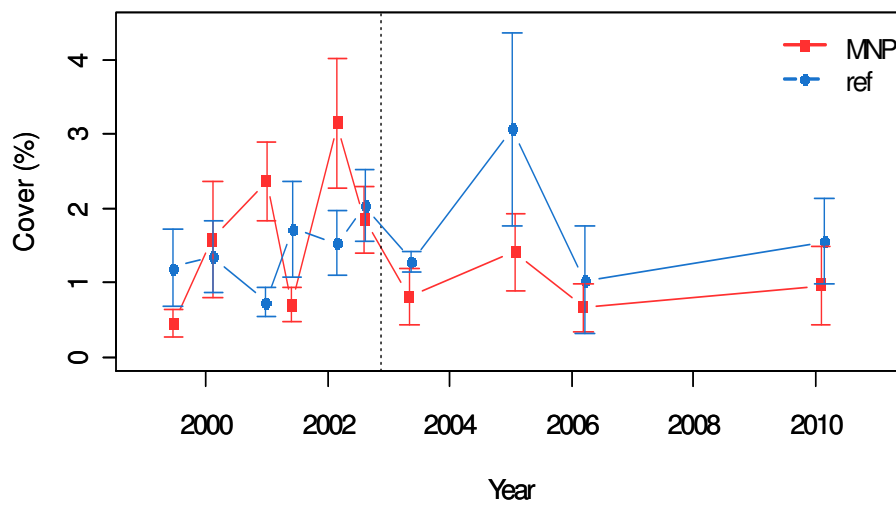
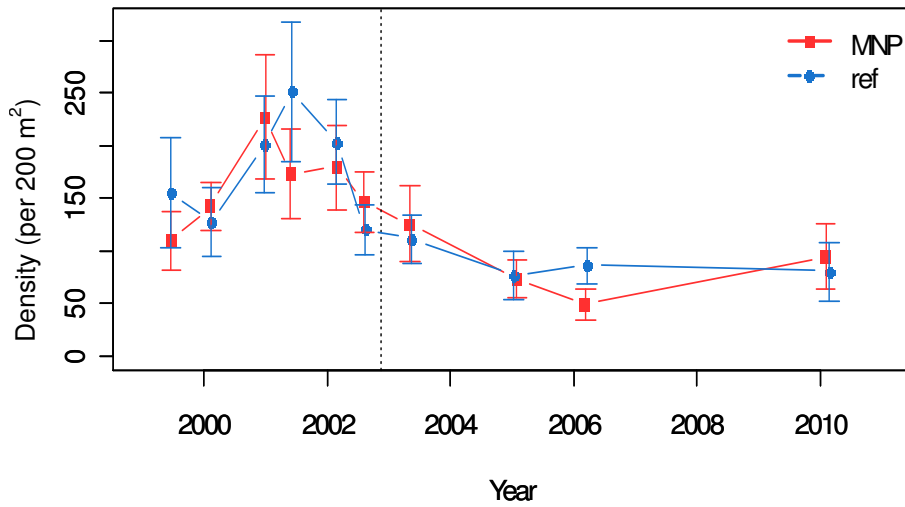
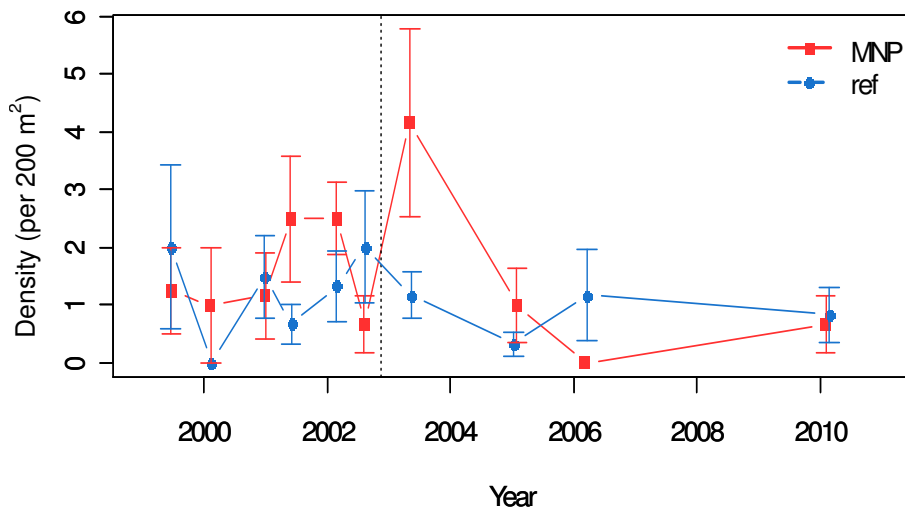


Figure 3.13 (continued). Seaweed functional groups ( $\pm$  Standard Error) inside and outside the Bunurong Marine National Park.

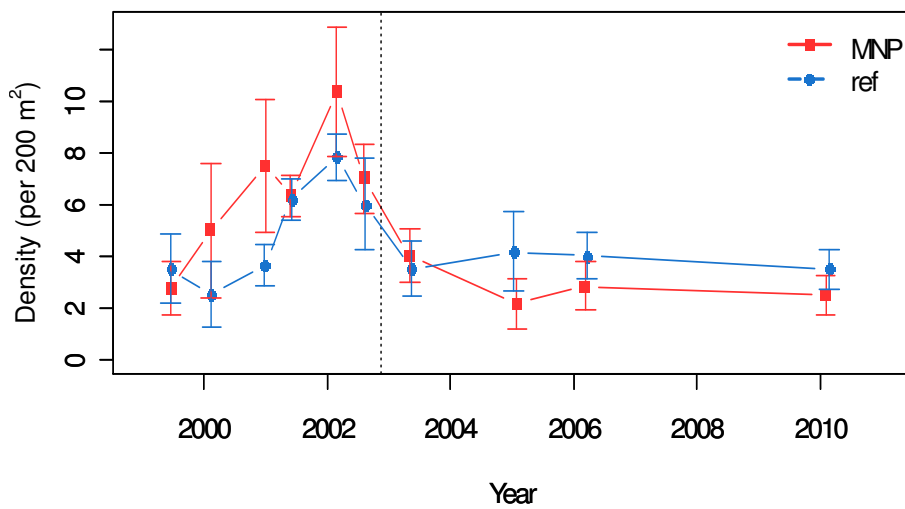
a. Invertebrate Grazers



b. Invertebrate Filter Feeders

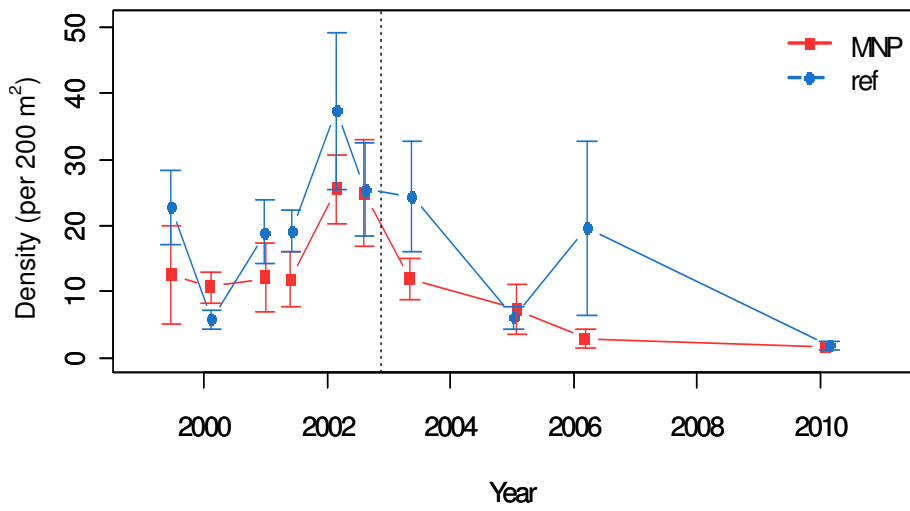


c. Invertebrate Predators

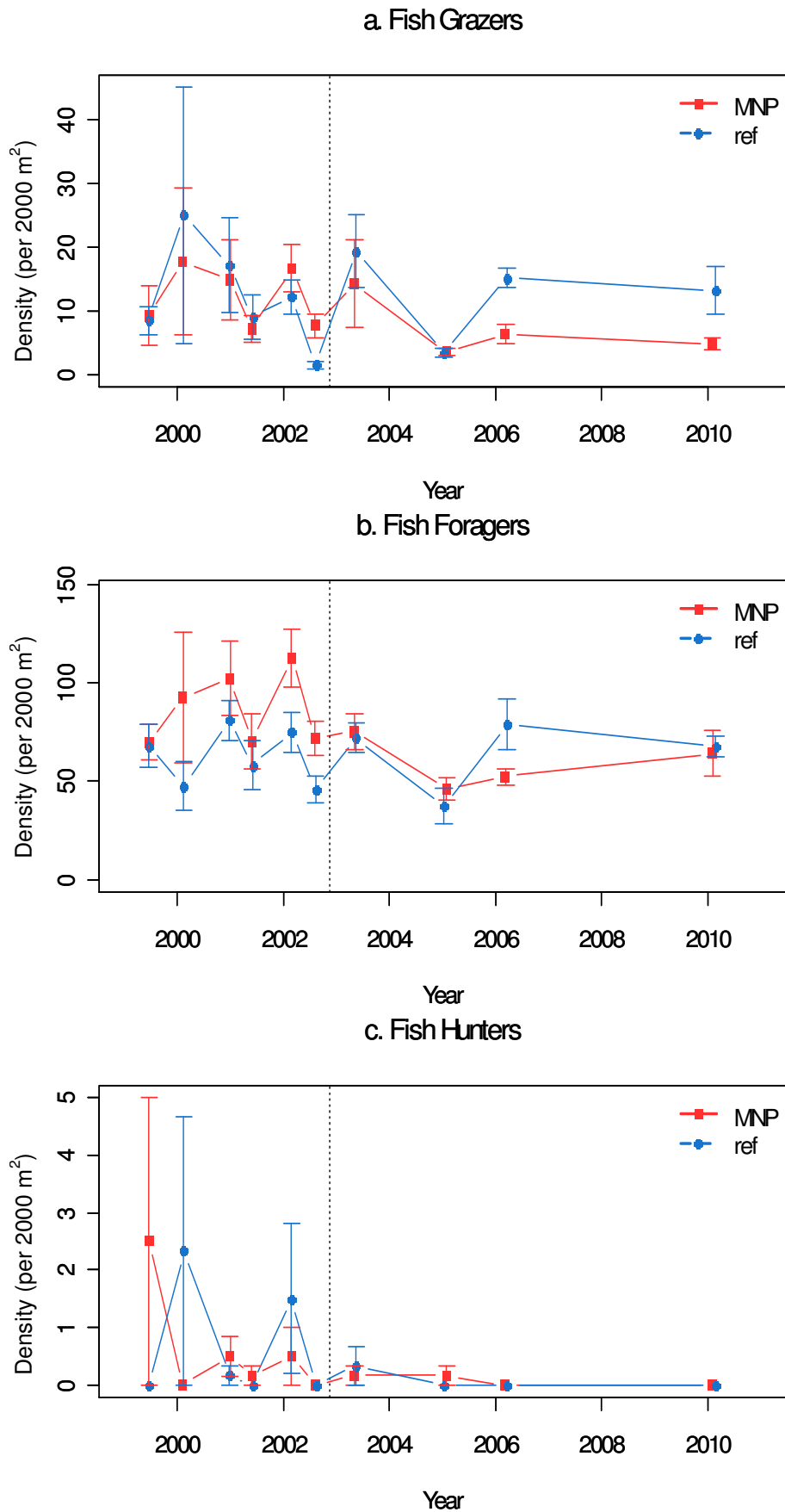


**Figure 3.14.** Mean abundance ( $\pm$  Standard Error) of invertebrate functional groups inside and outside the Bunurong Marine National Park.

d. Seastars

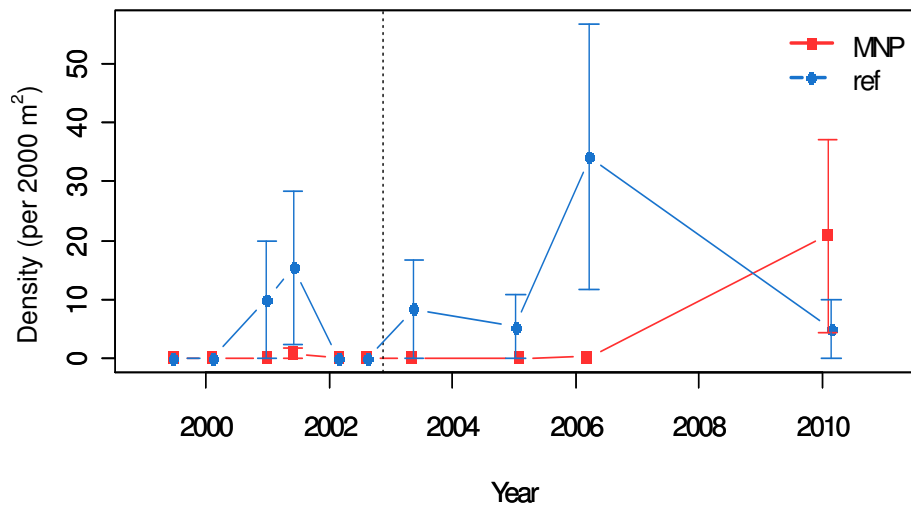


**Figure 3.14 (continued).** Mean abundance ( $\pm$  Standard Error) of invertebrate functional groups inside and outside the Bunurong Marine National Park.



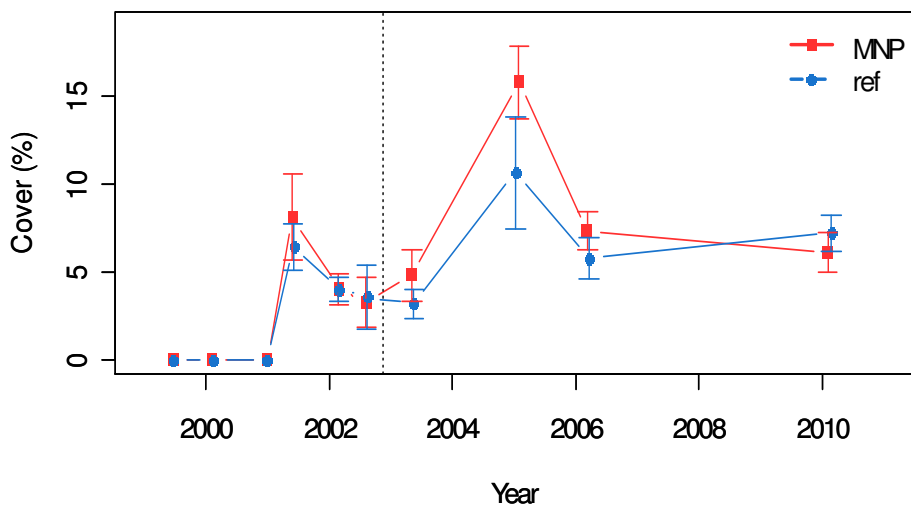
**Figure 3.15.** Mean abundance ( $\pm$  Standard Error) of fish functional groups inside and outside the Bunurong Marine National Park.

d. Fish Planktivores



**Figure 3.15 (continued).** Mean abundance ( $\pm$  Standard Error) of fish functional groups inside and outside the Bunurong Marine National Park.

Sediment Cover



**Figure 3.16.** Mean cover ( $\pm$  Standard Error) of sediment inside and outside the Bunurong Marine National Park

## 3.4 Climate Change

### Species composition

There have not been major declines in cold water, Maugean seaweed species richness or total abundance over the monitoring period. Maugean algal species richness was at the lower range level during 2010 (Figure 3.19). The Maugean fish species richness and total abundance has been at the lower baseline levels since MNP declaration (Figure 3.19).

The occurrence of western algal species was relatively low and sporadic throughout the monitoring period (Figure 3.20). Similar trends in western invertebrate species were recorded both inside and outside the Park, with a decline in species richness following the baseline period (Figure 3.21).

The eastern algal species in the Bunurong region were not well represented at any time (*e.g.* Figure 3.22). Eastern invertebrate species were recorded intermittently in very low densities over the monitoring period.

### *Macrocystis pyrifera*

The string kelp *Macrocystis pyrifera* can grow up to 10 m in height and form dense forests with a thick canopy floating on the surface. Consequently, *M. pyrifera* is a significant habitat forming species. Anecdotal evidence suggests *Macrocystis pyrifera* was once present in relatively high abundance along the Victorian coast, forming large forests in some locations. Abundances of *M. pyrifera* have been reduced considerably for much of this decade. Possible causes of this decline include a rapid succession of El Niño events in the late 1980s and early 1990s (affecting water temperature and nutrient levels), a long-term increase in average sea temperature (1 °C over the last 40 years) and changes to coastal nutrient inputs.

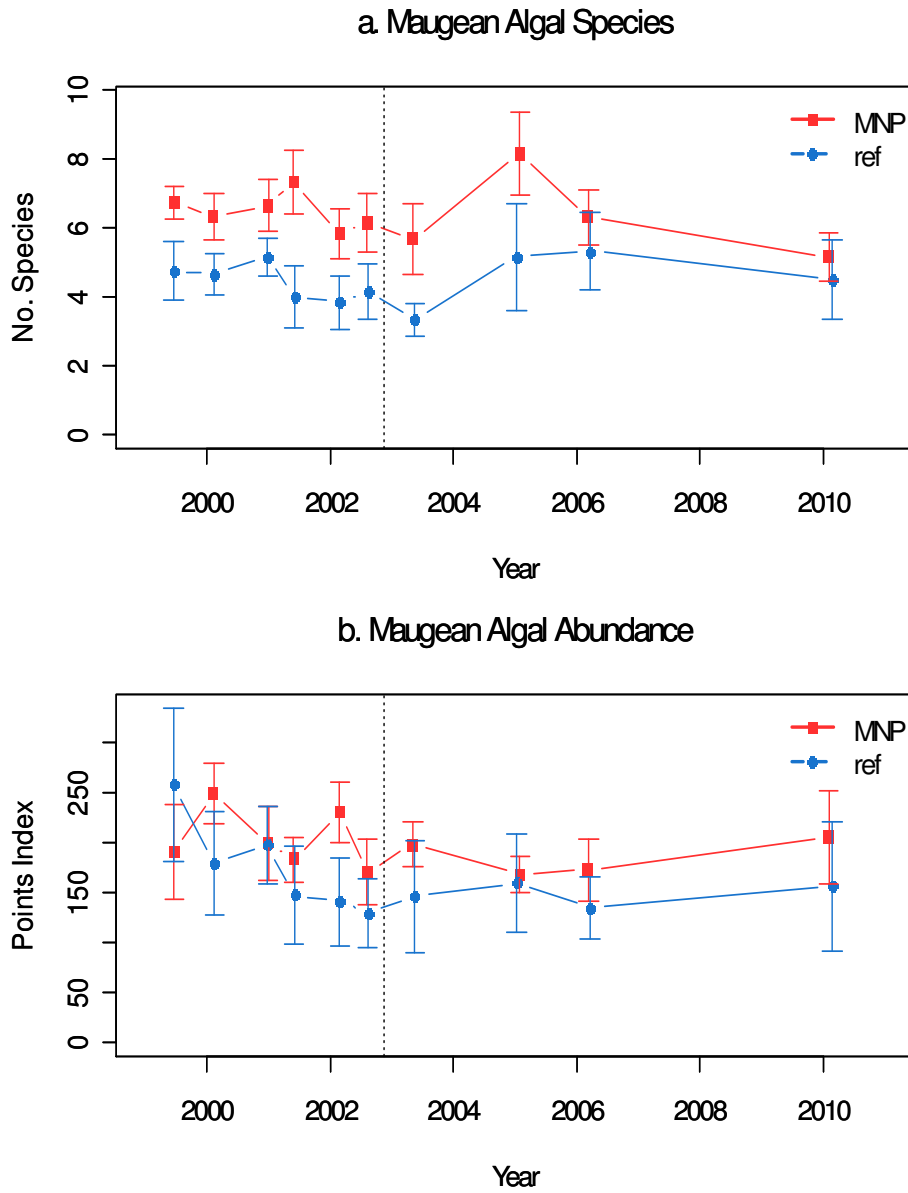
The quadrat-cover measurements detected substantial changes in *Macrocystis* cover between the first two surveys. During June 1999, the highest coverage was at Cape Patterson (Site 1), Oaks East (Site 3), Twin Reefs (Site 4) and Shack Bay West (Site 5) with coverage of 2.5, 1.6, 0.8 and 1.5 percent respectively. By January 2000, this had increased to 15 % at Sites 3003 and 3004, with minor increases or decreases detected at other sites. There was a general decline in abundance to the fourth survey, December 2000, with quadrat coverage of 2.2 and 0.5 % detected only at Cape Patterson (Site 1) and Shack Bay Beach (Site 12). *M. pyrifera* cover has remained low at most sites during subsequent surveys. Exceptions include Oaks East (Site 3), where cover increased to 5.4% at Survey 6 before decreasing to 0.7 % in Survey 7. No *M. pyrifera* was recorded in the quadrat-cover measurements during Surveys 8 and 9. Low percentage cover was recorded during Survey

11 in 2010 at Cape Patterson (Site 1), Shack Bay Beach (Site 12), The Oaks Beach (Site 14) and Boat Ramp East (Site 15), with 0.9, 0.2, 0.3 and 1.4 % cover respectively (Figure 3.23a).

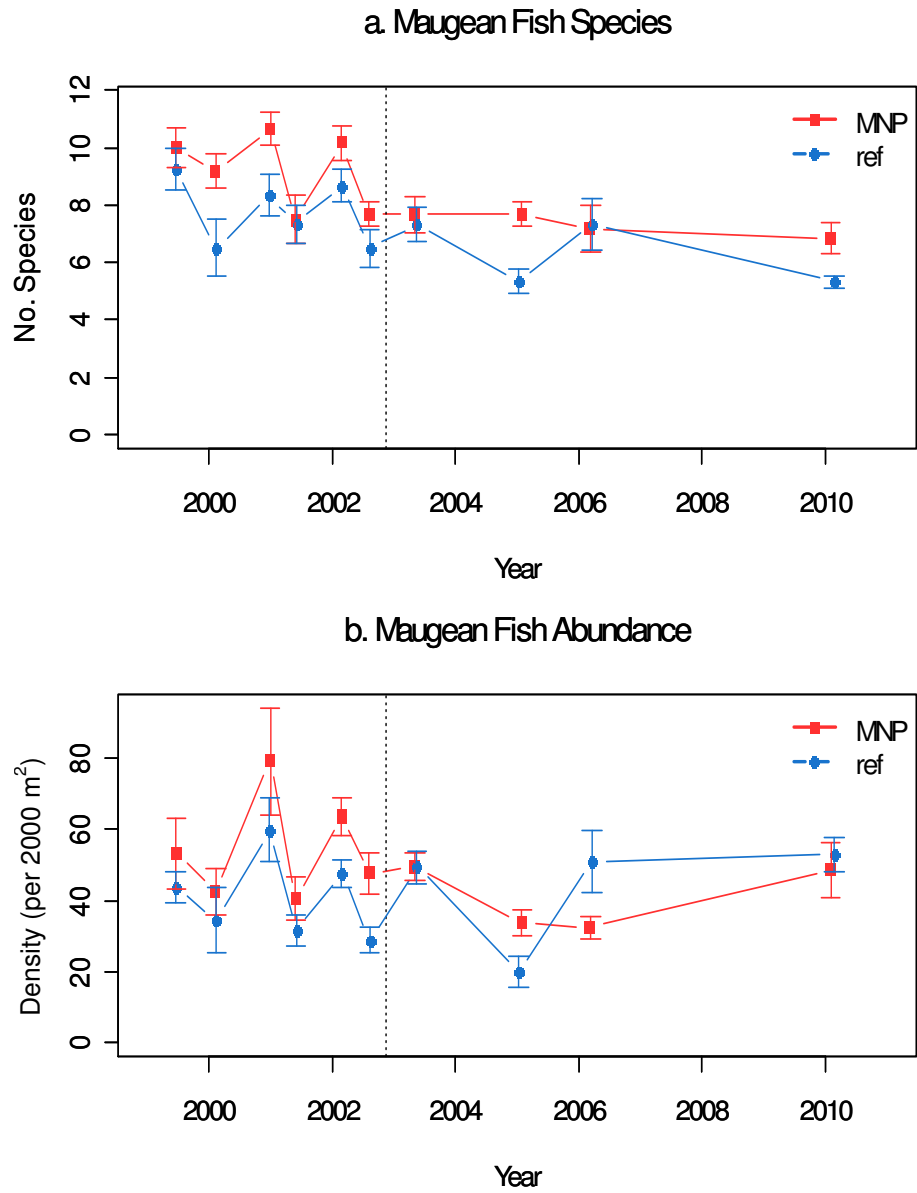
The quadrat-cover method is generally insensitive in detecting small changes in abundances of sparsely distributed individuals such as this species. Therefore, given the importance of this species, a new census technique was introduced during the second survey, summer 2000. As described in Section 2.2.6, this method quantified the number of plants within 10 x 10 m sections of the transects.

The quadrat results were also reflected in the plant density measurements. Densities were highest during the first survey using this method, January 2000 (Figure 3.23b). Abundances have tended to decline or remain low during all subsequent surveys (Figure 3.23b). During Survey 7, only 25 plants were observed, all being at Site 14 (Oaks Beach West). This decline continued with few plants observed during the eighth survey (Autumn 2003) and no plants observed during the ninth survey (Summer 2004/2005). During the tenth survey (Autumn 2006) four to five plants were observed at Sites 1, 2, 4 and 5 during quadrat-cover measurements, however these plants were juveniles and undetectable during plant density measurements. During the eleventh survey plants were recorded at only three sites. One plant was recorded at Oaks East (Site 3) and eleven at both Cape Patterson (Site 1) and The Oaks Beach (Site 14). Over the eleven years surveyed, this represents a major decrease in *M. pyrifera* at the Bunurong Marine National Park and surrounding area, a trend reflected in many other subtidal reefs along the south east Australian coast (Figure 3.23b).

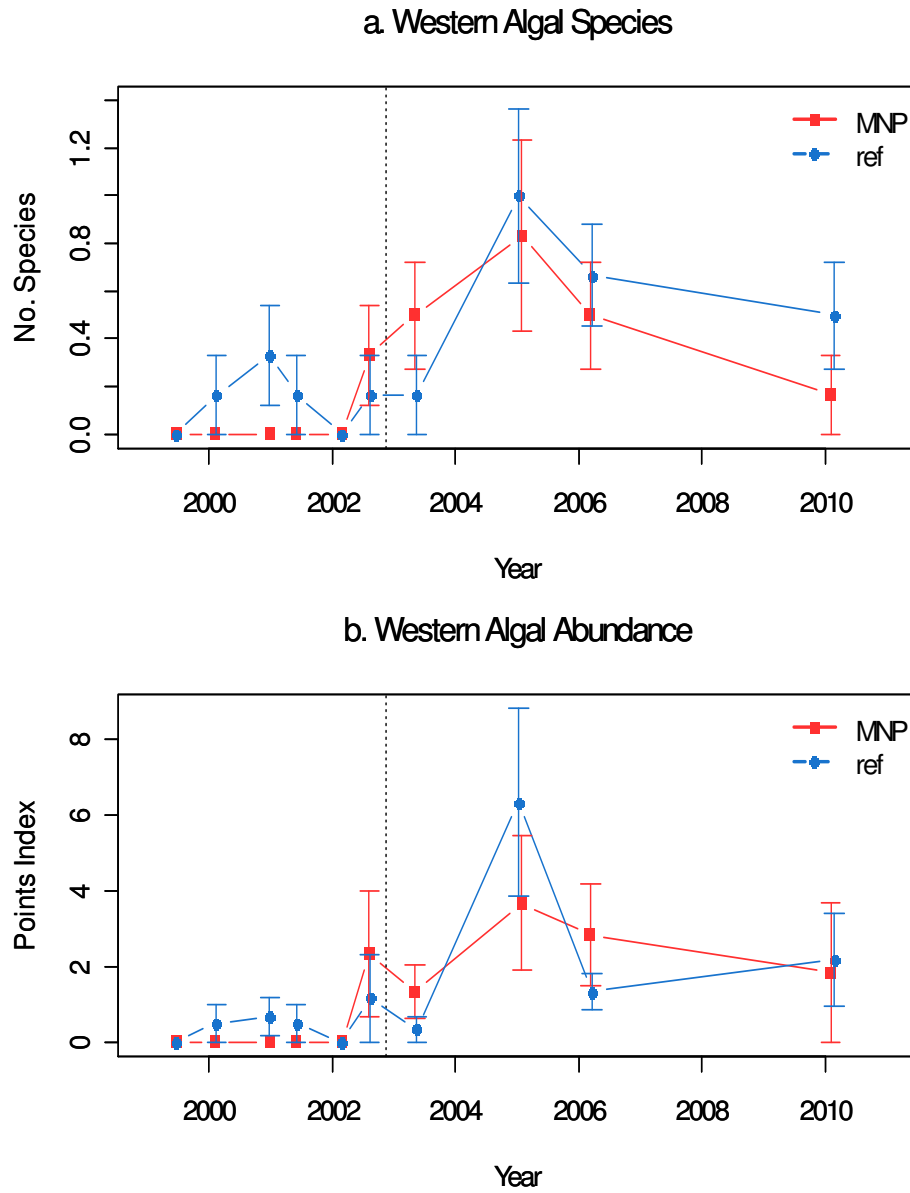




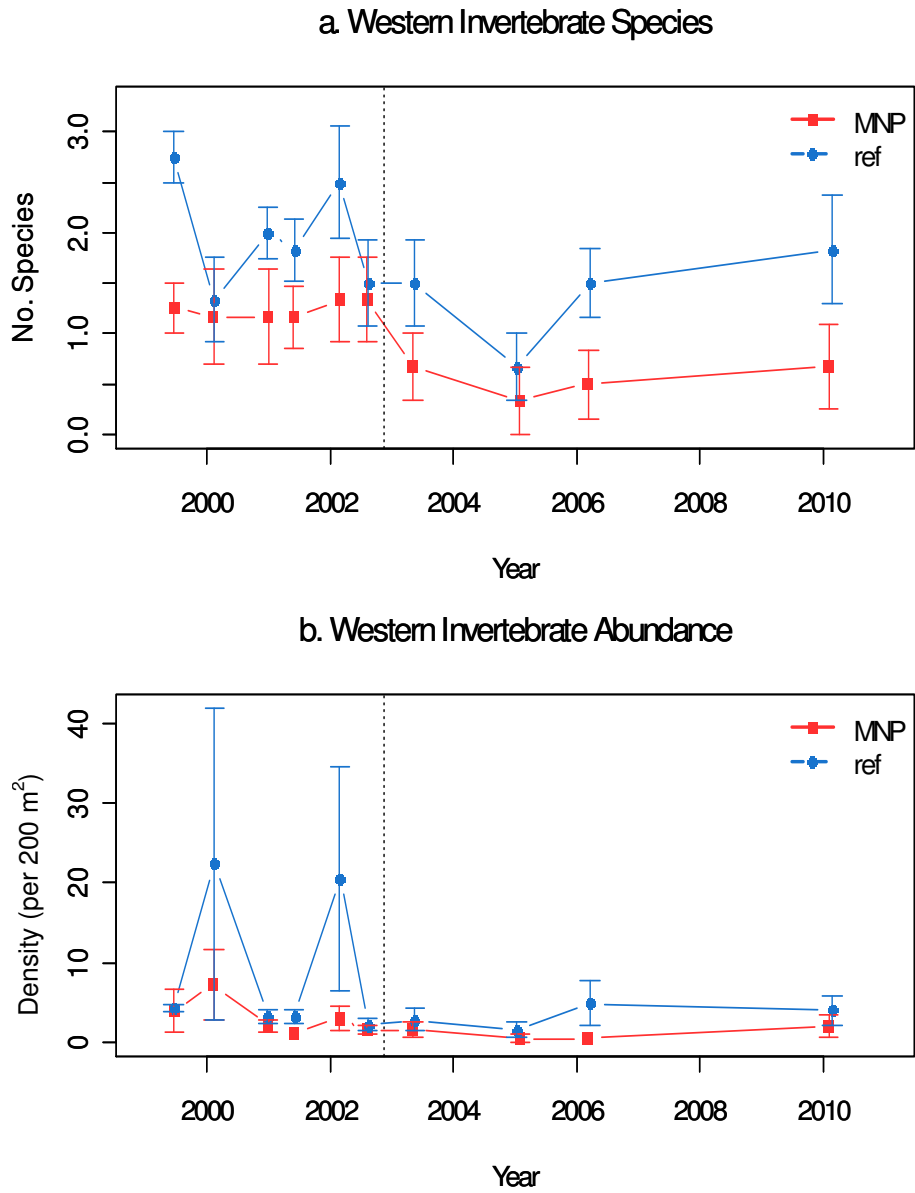
**Figure 3.17.** Abundance ( $\pm$  Standard Error) of Maugean algae species inside and outside the Bunurong Marine National Park.



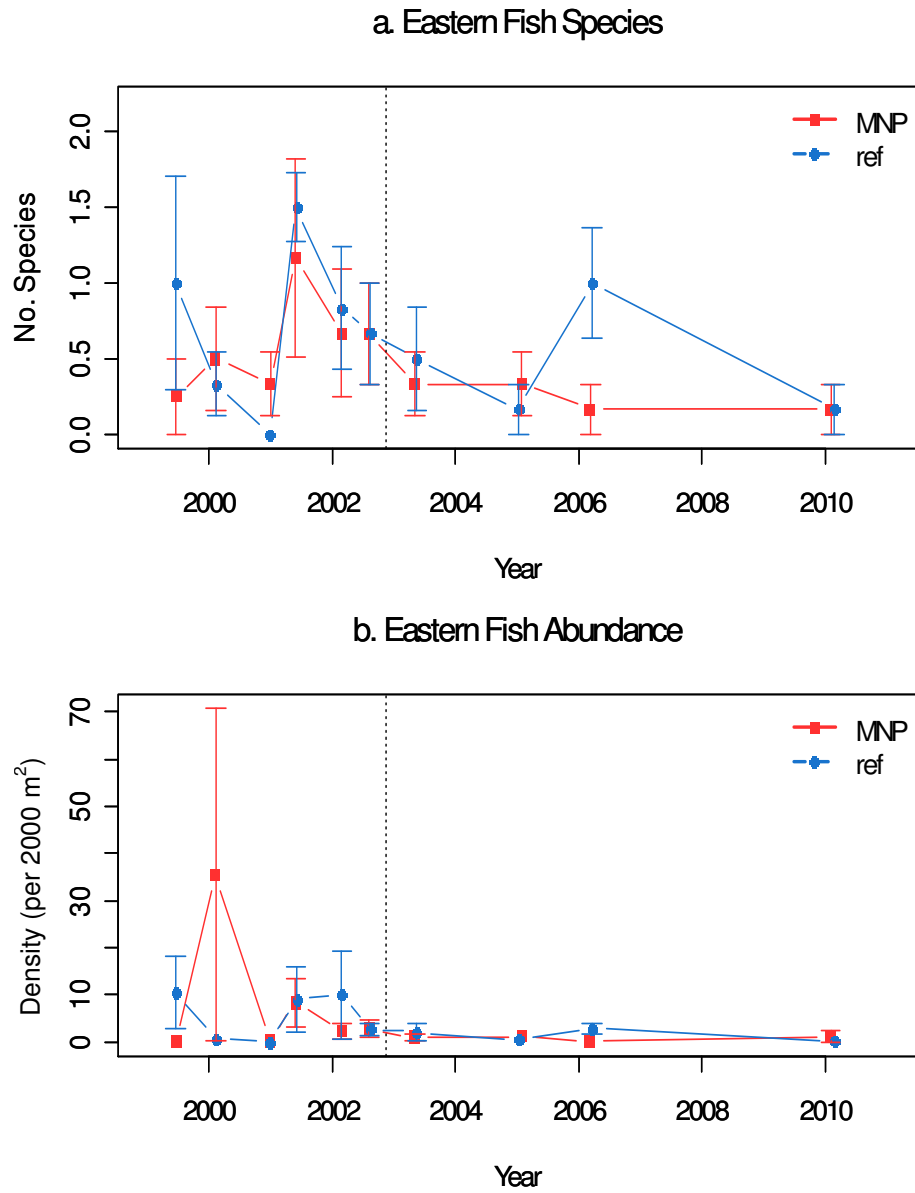
**Figure 3.18.** Abundance ( $\pm$  Standard Error) of Maugean fish species inside and outside the Bunurong Marine National Park.



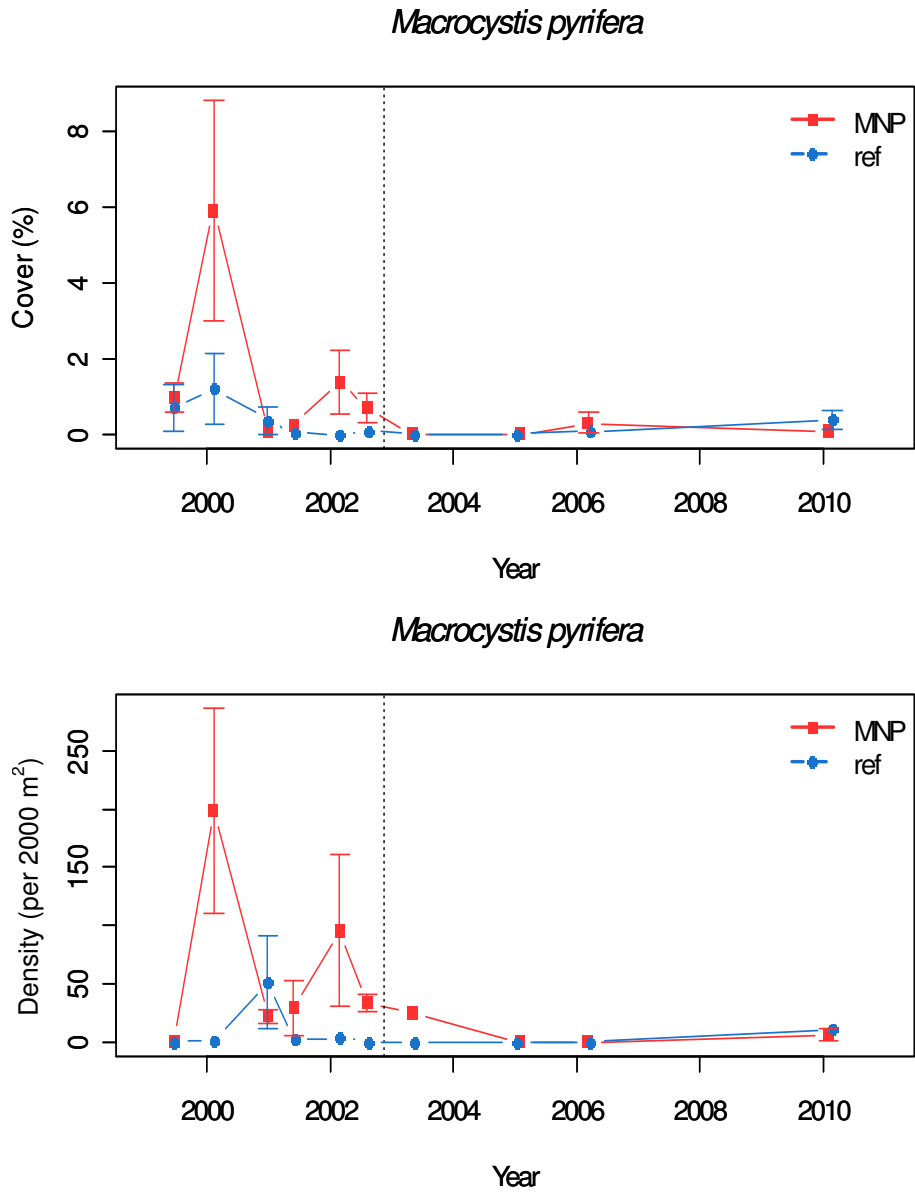
**Figure 3.19.** Abundance ( $\pm$  Standard Error) of Western algae species inside and outside the Bunurong Marine National Park.



**Figure 3.20.** Abundance ( $\pm$  Standard Error) of Western invertebrate species inside and outside the Bunurong Marine National Park.



**Figure 3.21.** Abundance ( $\pm$  Standard Error) of Eastern fish species inside and outside the Bunurong Marine National Park.



**Figure 3.22.** Abundance ( $\pm$  Standard Error) of string kelp *Macrocystis pyrifera* inside and outside the Bunurong Marine National Park.

## 3.5 Fishing

### Abalone

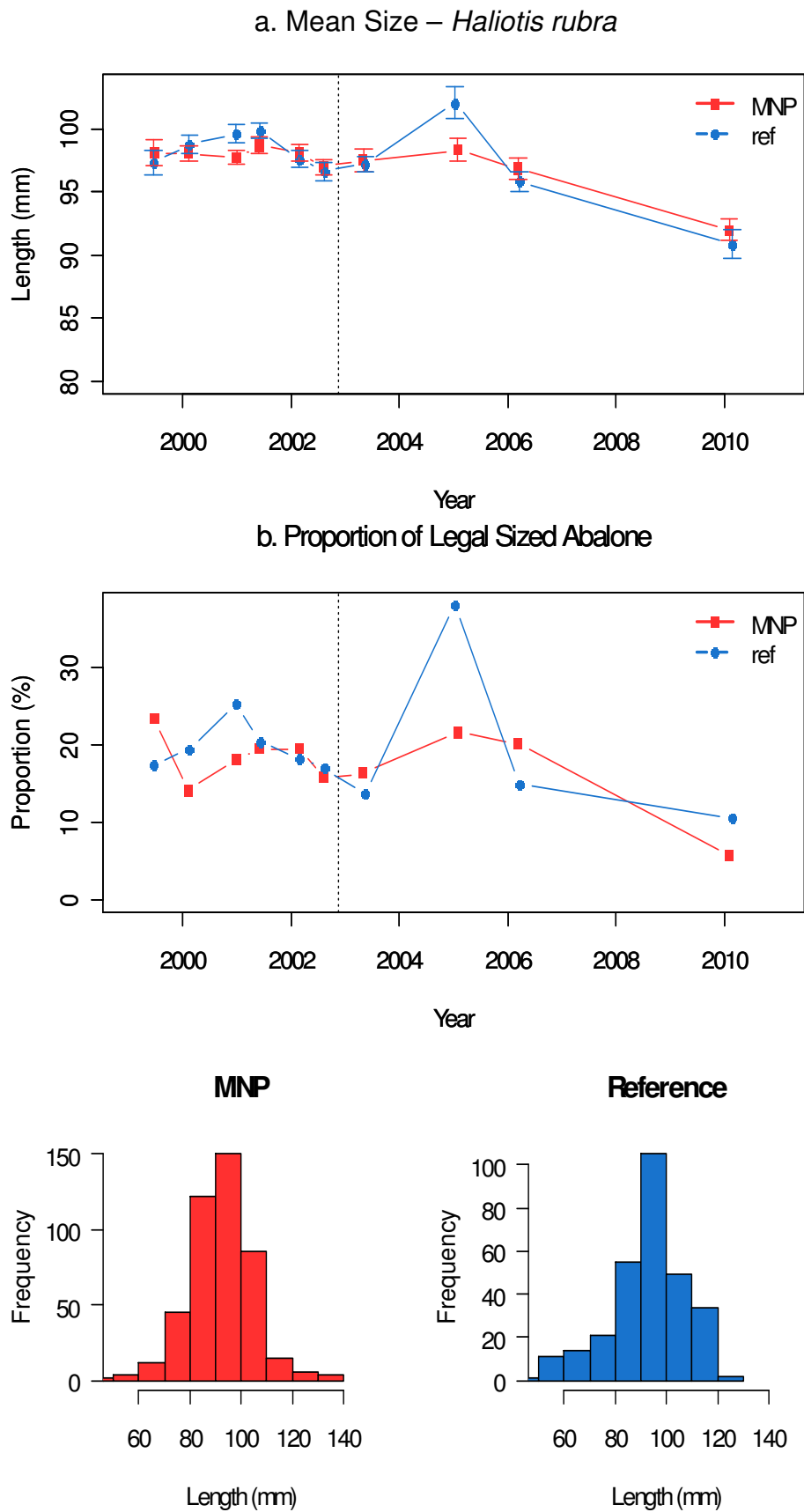
The average size of blacklip abalone *Haliotis rubra* was similar between the Bunurong Marine National Park and the reference areas during most surveys, with variations in mean size generally less than 5 mm length (Figure 3.24a). There was a marked decrease in mean size of abalone *H. rubra* both inside and outside the MNP between 2009 and 2010, to well below previously observed sizes (Figure 3.24a). The proportion of legal sized abalone has also declined during this period to lowest observed levels, both inside and outside the Marine National Park (Figure 3.24b).

### Rock Lobster

The southern rock lobster *Jasus edwardsii* is common inside the MNP, however the survey sites do not encompass their preferred microhabitat and do therefore do not adequately survey their abundances (Figure 3.25).

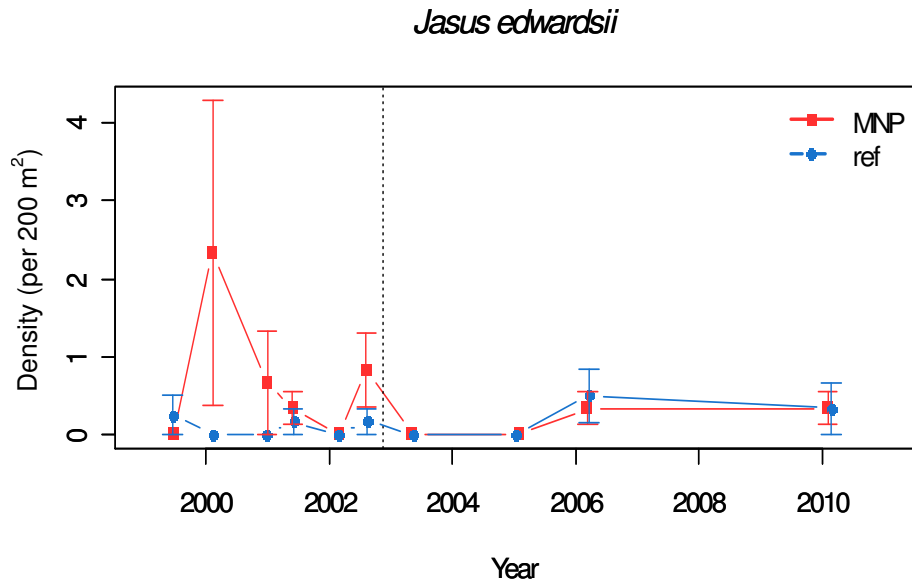
### Fishes

The size spectrum analysis indicated a reduction in abundance of larger fishes outside the MNP from 2006 and inside the MNP during 2010, to levels lower than recorded previously (Figure 3.26). The biomass and density of fishes above 200 mm length was also at a minimum in 2010 (Figures 3.27 and 3.28). There was an apparent decline in size of the larger, fished species, including blue throated wrasse *N. tetricus*, purple wrasse *N. fucicola*, senator wrasse *P. laticlavus* and banded morwong *Cheilodactylus nigripes* (Figures 3.29 to 3.32).

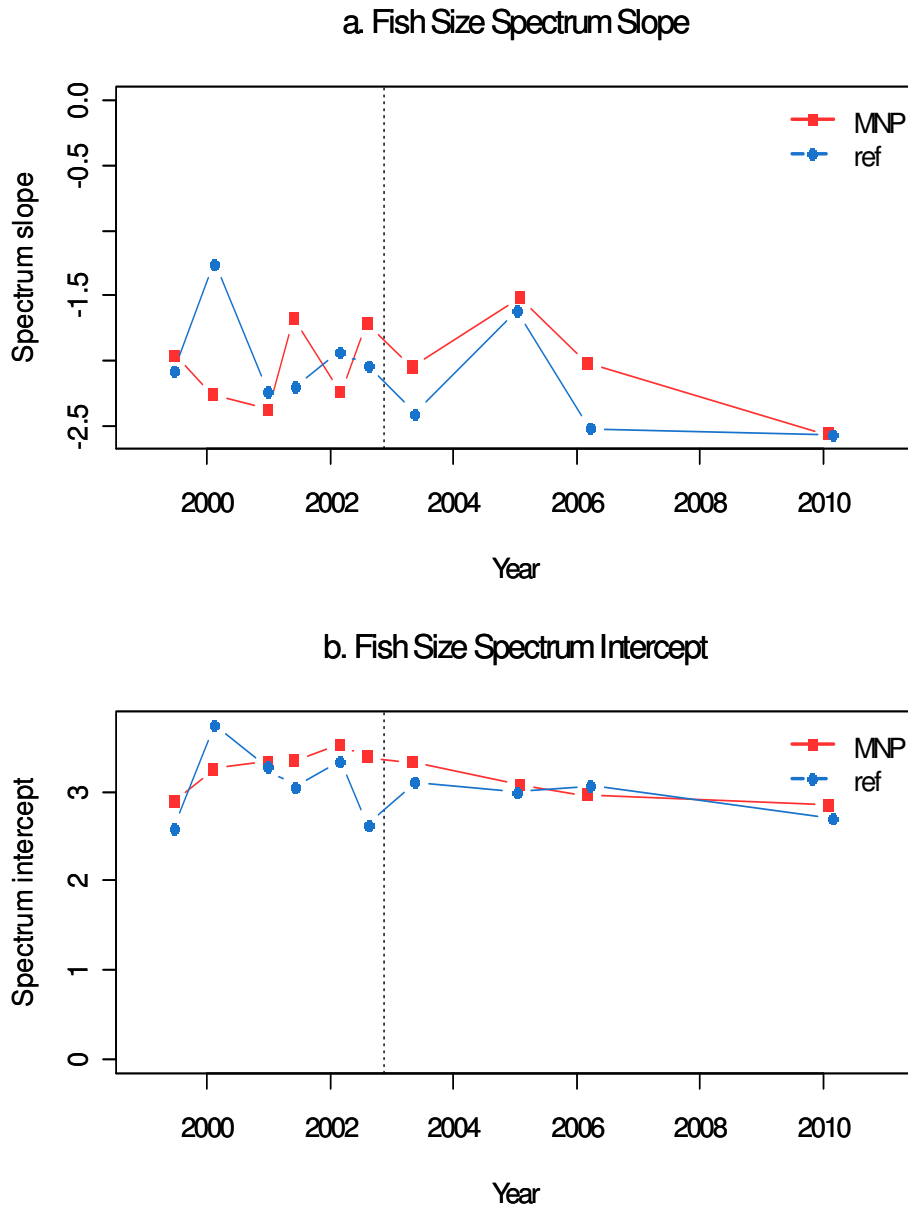


**Figure 3.23.** Abundance ( $\pm$  Standard Error) of different size classes of the Blacklip Abalone *Haliotis rubra* at Bunurong Marine National Park and reference sites.

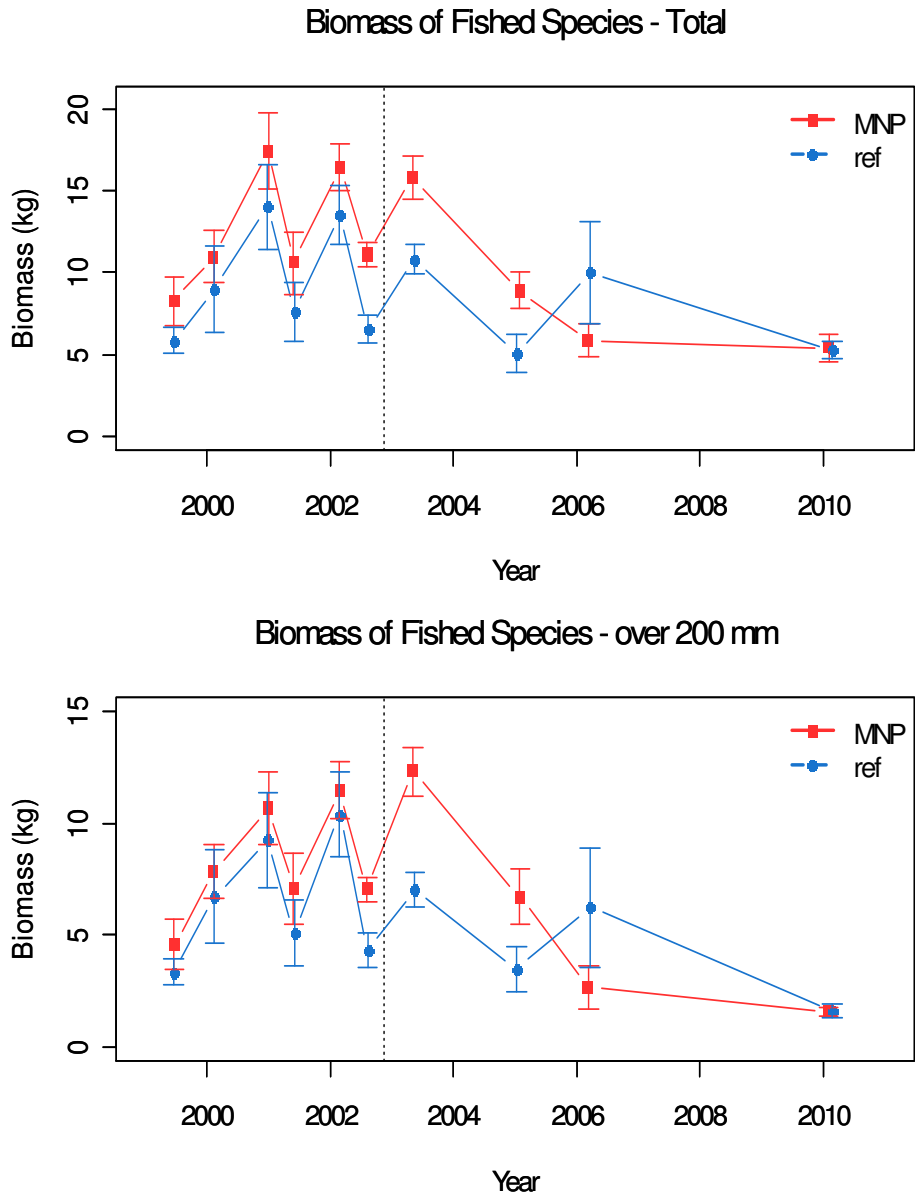




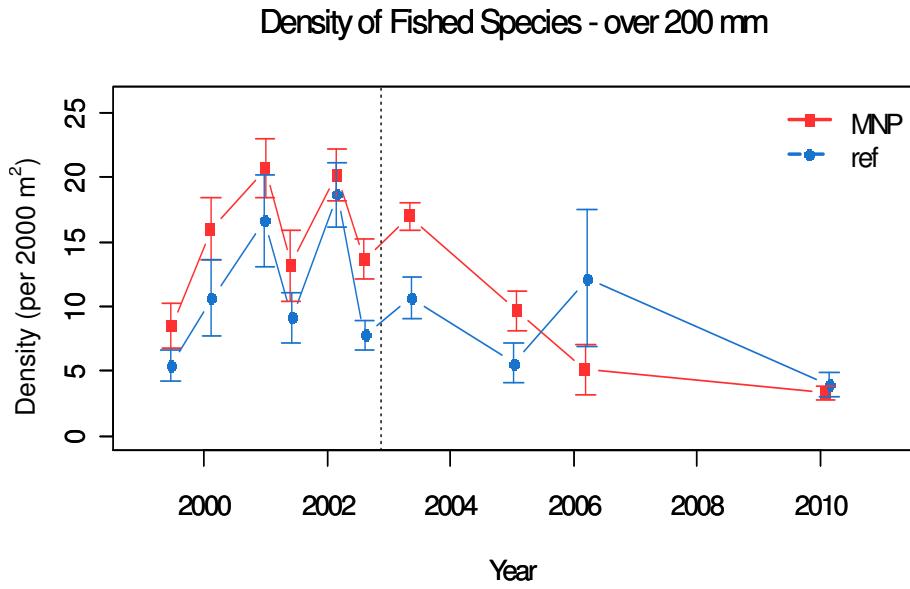
**Figure 3.24.** Density ( $\pm$  Standard Error) of southern rock lobster *Jasus edwardsii* inside and outside the Bunurong Marine National Park.



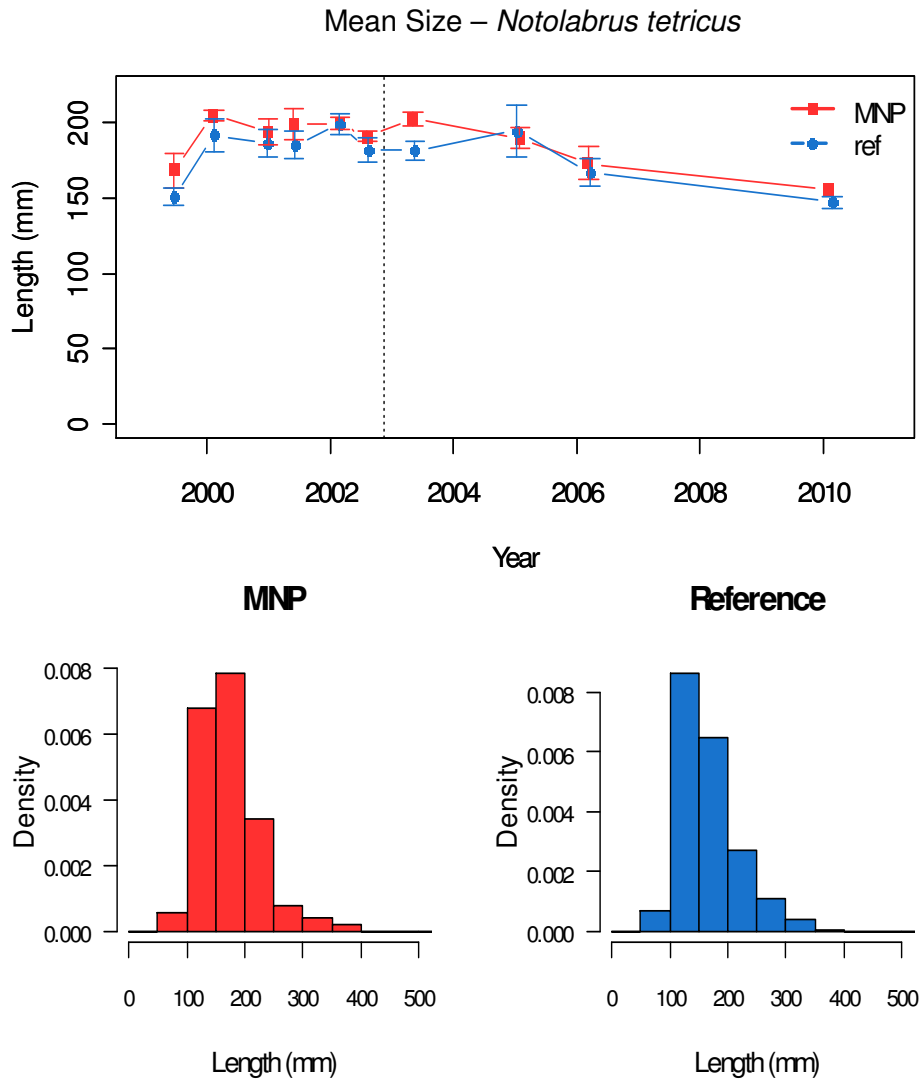
**Figure 3.25.** Fish size ( $\pm$  Standard Error) spectra inside and outside the Bunurong Marine National Park.



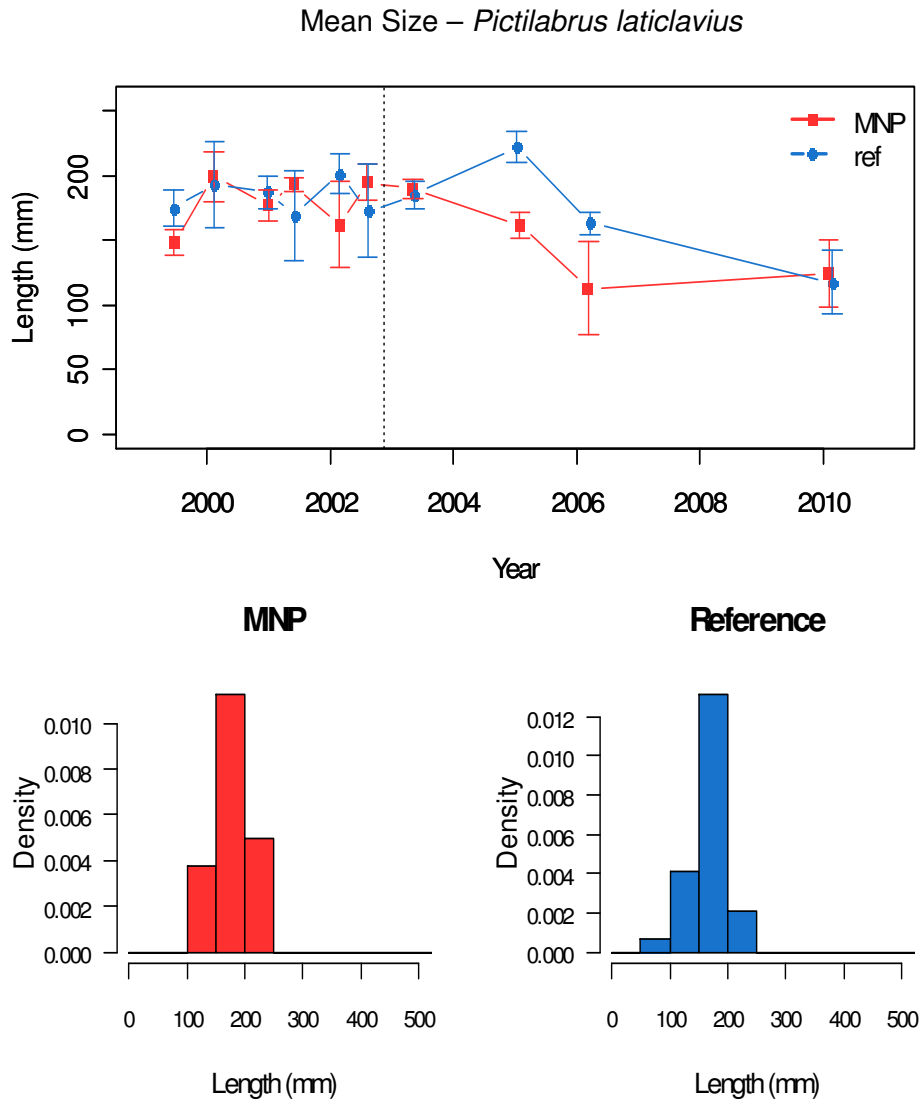
**Figure 3.26.** Biomass ( $\pm$  Standard Error) of fished species inside and outside the Bunurong Marine National Park.



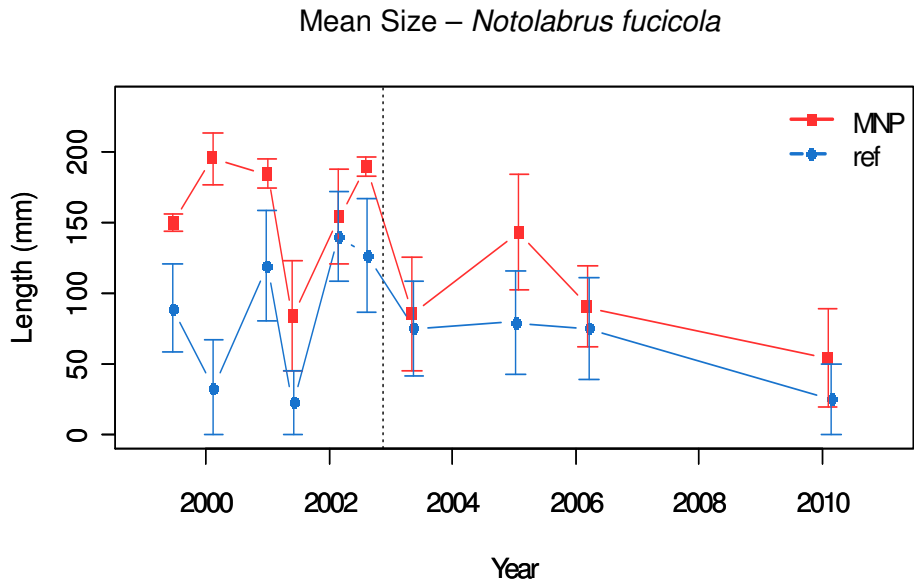
**Figure 3.27.** Density ( $\pm$  Standard Error) of larger fished fish species inside and outside the Bunurong Marine National Park.



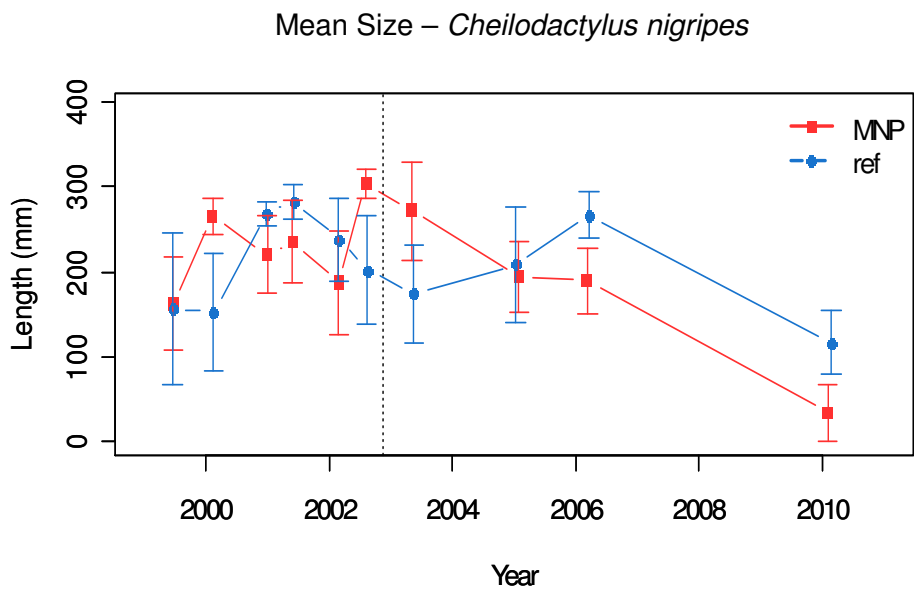
**Figure 3.28.** Abundance ( $\pm$  Standard Error) of different size classes of the Blue throat Wrasse *Notolabrus tetricus* at Bunurong Marine National Park and reference sites.



**Figure 3.29.** Abundance ( $\pm$  Standard Error) of different size classes of the Senator Wrasse *Pictilabrus laticlavius* at Bunurong Marine National Park and reference sites.



**Figure 3.30.** Abundance ( $\pm$  Standard Error) of different size classes of the purple wrasse *Notolabrus fucicola* at Bunurong Marine National Park and reference sites.



**Figure 3.31.** Abundance ( $\pm$  Standard Error) of different size classes of the magpie perch *Cheilodactylus nigripes* at Bunurong Marine National Park and reference sites.

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