NUMBER 68

Victorian Subtidal Reef Monitoring Program: The Reef Biota within the Twofold Shelf Bioregion

M. Edmunds, K. Pritchard and K. Stewart

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. To effectively manage and conserve these important and biologically rich habitats, the Victorian Government has established a long-term Subtidal Reef Monitoring Program (SRMP). Over time the SRMP will provide information on the status of Victorian reef flora and fauna and determine the nature and magnitude of trends in species populations and species diversity through time.

The Subtidal Reef Monitoring Program is established throughout Victoria for all relevant marine protected areas. This report describes the 2009 survey of the Twofold Shelf Bioregion sites associated with the Beware Reef Marine Sanctuary, Point Hicks Marine National Park and Cape Howe Marine National Park.

The Subtidal Reef Monitoring Program uses standardised underwater visual census methods to survey algae, macro-invertebrates and fish. This report aims to:

- Provide general descriptions of the biological communities and species populations at each monitoring site in February - March 2010;
- Identify any unusual biological phenomena such as interesting communities and species;
- Ecologically significant temporal changes in comparison with reference areas; and
- Identify any introduced species at the monitoring locations.

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

- Abundance and size structure of large fishes;
- Abundance of cryptic fishes and benthic invertebrates;
- Percentage cover of macroalgae; and
- Density of string kelp species.

There have been five surveys in the Twofold Shelf Bioregion Marine Sanctuaries over the past ten years: February 2001; March 2004; February 2006; March 2009; and February 2010.
Cape Howe Marine National Park

Cape Howe Marine National Park (MNP) is located adjacent to the NSW border. The four MNP sites are situated on low to moderate relief reef in the northern corner of the MNP. Two reference sites are located at Iron Prince Reef, in a 3 km² excision from the park. The other reference sites are located on granite reefs on the eastern side of Gabo Island. Key findings for the Cape Howe region during the monitoring program are:

- There was some confounding of interpretation of temporal trends through changes in the site locations inside and outside the Marine National Park in 2009.
- The macroalgal community composition had changed inside the MNP, particularly at Howe West and Howe Central, however the deviations were not beyond the 90 % confidence intervals. This included a substantial decrease in the cover of crayweed *Phyllospora comosa*.
- For invertebrate community composition significant deviations were observed at Howe West inside the MNP and at Iron Prince outside the MNP.
- There was significant deviation in fish community structure at Howe West inside the MNP.
- There was increasing trend in algal species richness and species diversity within the Cape Howe MNP.
- There were increase in fish species richness and diversity inside Cape Howe MNP.
- There was a substantial decline in *Phyllospora comosa* over the monitoring period from approximately 75 % to 45 % cover.
- The long-spined sea urchin *Centrostephanus rodgersii* did not change substantially in abundance.
- The blacklip abalone *Haliotis rubra* declined in abundance from 2001 to 2006 with an increase back to baseline abundances in 2010.
- The abundances of both the blue throated wrasse *Notolabrus tetricus* and the purple wrasse *N. fucicola* have increased considerably inside the MNP between 2006 and 2009.
- Banded morwong *Cheilodactylus spectabilis* abundances steadily increased from baseline levels to triple the abundances by 2009, after which there was a substantial decrease to 2010.
- For seaweed functional groups there was a halving of canopy formers over the monitoring period, with a coincident increase in smaller browns, coralline algae and thallose red algae. There were no trends in crustose coralline algae cover.
- There were no temporal patterns for invertebrate functional groups.
- Both fish foragers and fish hunters increase from baseline levels until 2009 with a rapid decline to below baseline levels in 2010. The fish planktivore abundances increased to markedly higher levels in 2009 and 2010.
- There was a decrease in cold water algal abundance consistent with the decline in *P. comosa*. There was an increase in cold water fish species richness and abundance throughout the monitoring period.
- Eastern invertebrate species doubled in abundance to 2009. There was a general increasing trend in eastern fish species richness. Eastern fish species abundance also increased to 2009 but declined in 2010.
- The mean size and proportion of legal sized blacklip abalone *Haliotis rubra* was consistently lower inside the Park.
- The density of fished species was considerably higher inside the Park in 2009 and 2010.
Point Hicks Marine National Park

For Point Hicks Marine National Park (MNP), the four MNP sites and two of the reference sites are situated on the granite slopes, boulders and outcrops around the Point Hicks headland. Two other reference sites are located several kilometres to the east on moderate relief reefs at Müller’s Reef and Petrel Point. Key findings for Point Hicks region during the monitoring program are:

- A change in seaweed community structure at Krafts Garden from both baseline conditions and recent survey conditions.
- Changes in invertebrate community structure at Krafts Garden, Durvillaea Flats, Old Jetty Bay and Point Hicks Joggle.
- Changes in fish community structure at Old Jetty Bay, Point Hicks Southwest, Müller Reef and Durvillaea Flats. There were overall changes inside the Park from baseline conditions and prior conditions.
- Seaweed species richness is higher than baseline conditions both inside and outside the MNP. There were no changes in invertebrate and fish indices.
- The cover of the canopy forming crayweed *Phyllospora comosa* and common kelp *Ecklonia radiata* was constant over time.
- There was a decline in the brown *Cystophora moniliformis* in the reference area.
- Blacklip abalone *Haliotis rubra* rapidly increased in density from 2009 to 2010 inside the MNP, from below reference densities to well above.
- The sea urchins *Heliocidaris erythrogramma* and *Centrostephanus rodgersii* were very low in abundance inside the Park at all times. Densities outside the park were relatively consistent except for a slight dip in 2009.
- There was a decline in density of the red bait crab *Plagusia chabrus* both inside and outside the MNP from 2006 to 2010.
- There was a slight decrease in blue throated wrasse *Notolabrus tetricus* inside the park between 2009 and 2010.
- Densities of purple wrasse *N. fucicola* declined considerably between 2004 and 2006, both inside and outside the MNP.
- Herring cale *Odax cyanomelas* had a considerable increasing trend inside and outside the Park to 2006, with a reverse trend to 2010.
- The banded morwong *Cheilodactylus spectabilis* did not have clear patterns, although there was a potential decrease inside the Park.
- Canopy browns changed little in cover over the monitoring period. There was an increasing trend of sediment cover.
- There were no major trend in cold water species richness and total abundance.
- The string kelp *Macrocystis pyrifera* was present in Old Jetty Bay in 2001 and 2004, providing significant habitat structure. This species was not observed subsequently. There was no apparent change in bull kelp *Durvillaea potatorum* abundance.
- There was a substantial decline in biomass of fished species over 200 mm in length, decreasing by approximately 75 %, both inside and outside the MNP.
- No marked changes were observed in mean fish size over the monitoring period.
- The mean size of black lip abalone *Haliotis rubra* was consistently higher inside the park, by at least 10 mm. There is also a 20 % higher proportion of legal sized abalone within the park.
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1 INTRODUCTION

1.1 Subtidal Reef Ecosystems of the Twofold Bioregion

The Twofold Shelf Bioregion extends from east of Wilsons Promontory to Tathra in southern New South Wales. The western portion of the Twofold Shelf bioregion is largely comprised of long sandy beaches (Ninety Mile Beach) with extensive areas of inshore and offshore sandy beds with some small offshore reefs. The sandy habitats of the far eastern coastline are punctuated by rocky headlands and localised outcrops of granite and metamorphic rocks, such as at Cape Conran, Point Hicks, Rame Head, Gabo Island and Iron Prince at Cape Howe. Sea temperatures are warmer in the Twofold Shelf region compared to elsewhere in Victoria because of incursions of the East Australia current bringing warmer water down the east coast of the continent. The continental slope is quite close to the far eastern Victorian shore and cold-water upwellings are frequent. These upwellings provide nutrients to the inshore ecosystems, contributing to high productivity. The biota of this region has a high component of eastern temperate species, in addition to many southern temperate and cosmopolitan species.

A prominent biological component of all Victorian shallow reefs is kelps and other seaweeds (Figure 1.1). Large species of brown algae, 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 seagrass beds and terrestrial grasslands, with approximately 2 kg of plant material produced per square metre per year. These stands may have 10-30 kg of plant material per square metre. The biomass of seaweeds is greater where giant species such as string kelp *Macroystis 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 *Macroystis angustifolia*, which sometimes forms 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.
Figure 1.1. Examples of macroalgae, sessile invertebrates and substratum types present on subtidal reefs in the Twofold Shelf bioregion.
Grazing and predatory mobile invertebrates are prominent animal inhabitants of the reef (Figure 1.2). An important invertebrate of the eastern Twofold Shelf bioregion is the long-spined sea urchin *Centrostephanus rodgersii*. *Centrostephanus* forms large grazing aggregations which denude the reef of erect algal species, forming ‘sea urchin barrens’. Removal of large seaweeds by *Centrostephanus* causes substantial changes to subtidal reef community structure on reefs in eastern temperate Australia.

Other common invertebrate grazers found at Twofold Shelf reefs include blacklip abalone *Haliotis rubra*, the eastern temperate gastropod *Astralium tentoriformis*, warrener *Turbo undulatus* and sea urchin *Heliocidaris erythrogramma*. Predatory invertebrates include dogwhelks *Dicathais orbita*, eastern rock lobster *Jasus verreauxi*, octopus *Octopus moarum* 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.

Fish 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 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, breeding aggregations of herring cale *Odax cyanomelas* at certain times of the year can increase patchiness in algal assemblages by concentrating herbivory on kelps in small areas for short periods of time.

Although shallow reef ecosystems in Victoria are dominated by seaweeds, mobile invertebrates and fishes, in terms of biomass and production, 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, occupying various niches as grazers, predators or foragers. At the microscopic level, films of microalgae and bacteria on the reef surface are also very important.
Figure 1.2. Examples of invertebrate species present on subtidal reefs in the Twofold Shelf Bioregion.
a. Six-spined Leatherjacket *Meuschenia freycineti*.

b. White-ear *Parma microlepis*.

c. Maori wrasse *Ophthalmolepis lineolatus*, Blue-throat wrasse *Notolabrus tetricus* (rear).

d. Purple wrasse *Notolabrus fucicola* (left), Banded morwong *Cheilodactylus spectabilis* (right).

e. Eastern hulafish *Trachinops taeniatus*.

f. Trevally *Pseudocaranx georgianus*.

**Figure 1.3.** Examples of fish species present on subtidal reefs in the Twofold Shelf Bioregion.
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 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.

1.2.3 Monitoring in the Twofold Shelf Bioregion

This report describes the Subtidal Reef Monitoring Program and results from the five surveys of subtidal reefs in the Twofold Shelf bioregion, including at Point Hicks and Cape Howe Marine National Parks and Beware Reef Marine Sanctuary. The objectives of this report were to:

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

2.1 Site Selection and Survey Times

Subtidal reefs were quantitatively surveyed in the Cape Howe and Point Hicks regions in 2001, before the current marine protected areas were gazetted (Edmunds et al. 2001). These sites were located on available subtidal reefs inside and outside the current marine protected area boundaries. Consequently, it was considered appropriate to incorporate some of these surveyed sites into the formal Subtidal Reef Monitoring Program that commenced in 2004 (data courtesy of Australian Marine Ecology).

In 2001, seven sites were surveyed at the Point Hicks region and eight sites in the Cape Howe region (Edmunds et al. 2001). Although the objectives of the earlier study were different to this one, the same survey method was used and many of these sites were appropriate for the Parks Victoria long-term monitoring program. Some of the sites were unsuitable for the SRMP because of their depth or representativeness. Nine of these sites were initially selected as part of the long-term Subtidal Reef Monitoring Program. Some of these sites were subsequently removed from the program.

Since the commencement of the SRMP, eight sites at Point Hicks Marine National Park and at least eight sites at Cape Howe Marine National Park have been surveyed on five occasions:

1. March 2004;
2. February 2006;
3. March-May 2009 and
4. March 2010 (Figure 2.1; Table 2.1).

At Cape Howe, four sites inside and four sites outside the marine national park were surveyed in 2004 and 2006. In 2009, three of these sites were discontinued and three new sites were established. Under the direction of Parks Victoria, two reference sites dominated by sea urchin barrens were substituted for two sites with seaweeds. One site in the MNP, Site 3220, was deemed too close to the others so this was replaced by a more distant, but deeper site, Site 3227. A non-SRMP site, Site 11 Gabo Harbour, was resurveyed opportunistically during the 2009 survey, being previously surveyed in 2001.

At Point Hicks, the same four sites inside and four sites the marine national park have been surveyed on all four occasions (Figure 2.1; Table 2.1).
Descriptions of the monitoring sites are presented in the following sections for each marine protected area.

During the 2010 survey, the western Point Hicks sites at Southwest and Old Jetty Bay were visited on 18 March 2010 but were affected by a plankton bloom, producing very low underwater visibility. This low visibility was also present on 20 March 2010 and this bloom was worsening and affecting the whole of the Twofold coast so surveys of these sites was postponed for another excursion. Suitable conditions were limited in the following months and the sites were not surveyed until 21 June 2010.

Table 2.1. Subtidal reef monitoring sites and survey times in the Twofold Shelf bioregion.
Notes: (1) discontinued as deemed too close to other sites; (2) replacement MPA site offshore and deeper than other sites; (3) discontinued as sea urchin barrens deemed not representative enough for statistical analysis purposes; (4) not part of the SRMP but opportunistically resurveyed because of high conservation values; and (5) new reference sites with seaweed rather than urchin barren communities.

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Site Name</th>
<th>MPA/Reference</th>
<th>Depth (m)</th>
<th>Survey 1</th>
<th>Survey 2</th>
<th>Survey 3</th>
<th>Survey 4</th>
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</tbody>
</table>

**Figure 2.1.** Location of sites for the Subtidal Reef Monitoring Program in the Twofold Shelf bioregion. Coordinate system is Map Grid of Australia 1996 (MGA).
2.2 Census Method

2.2.1 Transect Layout

The visual census methods of Edgar and Barrett (Edgar and Barrett 1997, 1999; Edgar et al. 1997) are used for this monitoring program. These are non-destructive and provide quantitative data on a large number of species and the structure of the reef communities. The Edgar-Barrett method is also used in Tasmania, New South Wales, South Australia and Western Australia. The adoption of this method in Victoria provides a systematic and comparable approach to monitoring reefs in southern Australia. The survey methods include 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 depth that can be surveyed varies with reef extent, geomorphology and exposure. Monitoring sites in the Twofold Shelf Bioregion vary between 4 and 14 metres. Monitoring sites were established in deeper water in this area because many sites were exposed to large swells and turbulent conditions.

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 angustifolia plants (where present). In 2010, a new diver-operated stereo video method (Method 6) 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.

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.
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 censured 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 and Sessile Invertebrates
The area covered by macroalgal and sessile invertebrate species is quantified by placing a 0.25 m² quadrate 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 m² 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 densities of Macrocystis pyrifera plants are estimated. While swimming along the transect line between quadrate 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 m² 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 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 2.2. Mobile fish (Method 1) surveyed in the Twofold bioregion.

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<tr>
<th>Method 1</th>
<th>Mobile Bony Fishes</th>
<th>Mobile Bony Fishes</th>
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<td>Sharks and Rays</td>
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Table 2.3. Invertebrates and cryptic fish (Method 2) surveyed on the in the Twofold Shelf bioregion.

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Table 2.4. Macroalgae (Method 3) surveyed on the in the Twofold Shelf bioregion.

<table>
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<th>Method 3</th>
<th>Chlorophyta (green algae)</th>
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<th>Rhodophyta (red algae)</th>
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<td>Durvillaea potatorum</td>
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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. 1995).

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 functions; 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 90th percentile statistic was calculated from 10 000 bootstrap samples as a provisional limit or trigger line. The 50th 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, Hills $N_2$ gives an indication of the number of dominant species within a community. Hills $N_2$ provides more weighting for common species, in contrast to indices such as the Shannon-Weiner Index (Krebs 1999), which weights the rarer species.

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

Abundances of Selected Species

Mean abundance of selected species was 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*, *Macroystis 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 *Meridiaster 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 the data is 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 ‘Maugean’ 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 ≥ 300 mm. Lengths were converted to weights using published conversion factors for the power relationship: weight(grams) = $a \times$ 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 CAPE HOWE MARINE NATIONAL PARK

3.1 Site Descriptions

Three sites, Sites 13, 14 and 15, were positioned over the main shallow reef area within the Cape Howe Marine National Park, which is present only in the north eastern region of the park (Figure 3.1). These sites were varied slightly in substratum structure, with lower relief reef present in the western area (Howe West) and larger bombies, holes and drop-offs present at Howe Border. The monitoring program stipulated four sites within the MNP, however the limited reef area within shallow waters meant any fourth site could not be well separated from the others. For 2004 and 2006, Site 20 was established perpendicular to, and crossing the Howe West Site. This was later deemed statistically inappropriate so, in 2009, this site was replaced by Site 27, set parallel to Howe Central, 75 m apart. This new site was considerably deeper (10-12 m) and has a different seaweed community.

Two of the original reference sites for the Cape Howe Marine National Park were located on sea urchin barrens on the west coasts of Tullaberga and Gabo Islands. These sites were selected as they represent an alternative state of reef habitat within the region, as opposed to kelp bed habitat. The Gabo Island site was also recognised as having conservation value in terms of the fish assemblages.

The two urchin barren reference sites on Tullaberga and Gabo Islands were later deemed inappropriate for statistical purposes, with a preference for reference sites with similar habitat types to those present at the sites inside the Marine National Park. In 2009, these sites were substituted by two sites on the eastern side of Gabo Island. Representative *Phyllospora* habitat was not found, with the two new reference sites being dominated by a mixture of *Phyllospora comosa*, *Acrocarpia paniculata*, smaller brown algae such as *Halopteris* and *Zonaria* spp, erect coralline algae and crustose coralline algae. The substratum at these sites consisted of steep drop-offs from the shore to 7 m depth with boulder fields, rocky outcrops and steps at the base.

Two other reference sites were positioned on Iron Prince Reef. These two sites have similar reef substrata to that observed at sites within the Cape Howe Marine National Park: having larger boulders of moderate relief (1-2 m) with patches of relatively flat, slab reef. Occasional steps/ledges, drop-offs/wall and cavern habitat are also present. The Iron Prince and Cape Howe sites were dominated by a tall canopy of *Phyllospora comosa* on the higher reef patches.
Figure 3.1. Location of monitoring sites inside and outside Cape Howe Marine National Park (shaded area).
3.2 Biodiversity

3.2.1 Community Structure

Macroalgae

The algal composition at Cape Howe was dominated by monospecific stands of the crayweed *Phyllospora comosa*. Other dominant species were the brown algae *Halopteris* spp., crustose coralline algae, and the coralline red *Halipitlon roseum*.

The non-metric MDS plot indicated algal assemblage structure had a similar level of variability between times at each site. The Iron Prince and Cape Howe sites overlapping in community structure between times. The two new eastern Gabo Island sites were moderately distinct from the mainland sites (Figure 3.2).

The multivariate control charts indicated slight deviations of algal assemblages at Howe Central to be at or above the 90th percentile confidence limit, in terms of deviation from centroids of both the baseline period and all previous times (Figure 3.3). The control charts indicated substantial deviations of the mean reference condition for the past two surveys. This is likely to be driven by the change of reference sites in 2009 (Figure 3.3).

Invertebrates

There were typically higher abundances of large herbivorous invertebrates at Cape Howe. These included the sea urchin *Centrostephanus rodgersii*, blacklip abalone *Haliotis rubra*, and the periwinkle *Turbo undulatus*.

The nMDS plot indicated relative stability in invertebrate assemblages within each site, with relative differences between being maintained through time (Figure 3.4).

The multivariate control charts indicated two sites had deviated significantly in 2010: Site 12 Iron Prince and Site 15 Howe Border (Figure 3.5). The control charts indicated substantial deviations of the mean reference condition for the past two surveys. This is likely to be driven by the change of reference sites in 2009 (Figure 3.5).

Fish

The predominant fish species at Cape Howe were the blue throat wrasse *Notolabrus tetricus*, the purple wrasse *Notolabrus fucicola*. The overall abundance of wrasses was lower at Cape Howe than at Point Hicks, however there was a greater variety of wrasse species present, including the Maori wrasse *Ophthalmolepis lineolata*. Fish that were more abundant in the Cape Howe region included herring cale *Odax cyanomelas*, banded morwong *Cheilodactylus spectabilis*, kelpfish *Aplodactylus lophodon*, striped mado *Atypichthys strigatus* and the damselfishes *Parma microlepis* and *Chromis hypsilepis*. 
The nMDS plot indicated distinction in fish assemblages between sites, although there was some overlap in assemblage structure for some sites and times (Figure 3.6). The time trend for Site 13 Howe West followed a consistent trajectory between each of the surveys. The assemblage during the 2010 survey was outside the 90th percentile confidence limit for deviation from both the baseline centroid and the prior surveys centroid (Figure 3.7). The average regional assemblage structure for the marine protected area and references were within the control chart limits (Figure 3.7).

**Figure 3.2.** MDS plot of algal assemblage structure inside and outside the Cape Howe Marine National Park in March 2010. Kruskal stress = 12.30.
Control Chart - Algae

Figure 3.3. Control chart of algal assemblage structure inside and outside the Cape Howe Marine National Park.
**Figure 3.4.** MDS plot of invertebrate assemblage structure inside and outside the Cape Howe Marine National Park in March 2010. Kruskal stress = 12.53.
Figure 3.5. Control chart of invertebrate assemblage structure inside and outside the Cape Howe Marine National Park.
**Figure 3.6.** MDS plot of fish assemblage structure inside and outside the Cape Howe Marine National Park in March 2010. Kruskal stress = 12.35.
Figure 3.7. Control chart of fish assemblage structure inside and outside the Cape Howe Marine National Park.
3.2.2 Species Richness and Diversity

**Macroalgae**

The total algal abundance was relatively stable over time for both the marine protected area and reference regions (Figure 3.8a). There was a slight increasing trend in algal species richness within the Cape Howe Marine National Park. The change in reference sites in 2009 resulted in a large increase in species richness, reflecting the high diversity on eastern Gabo Island (Figure 3.8b). The Hill’s $N_2$ diversity index showed a clearer increasing trend within the Cape Howe Marine National Park (Figure 3.9c).

**Invertebrates**

Invertebrate total abundances have generally declined both inside and outside the Cape Howe Marine National Park to approximately half the levels of the baseline survey (Figure 3.9a). There have been fluctuations in both species richness and species diversity over the monitoring period with levels of both regions in 2010 being similar to baseline levels (Figures 3.9b and 3.9c).

**Fish**

Total fish abundance has not changed markedly within the Cape Howe Marine National Park, although there was a slight decline between 2009 and 2010 (Figure 3.10a). There was a considerable peak in fish abundance at the reference sites in 2004 (Figure 3.10a). Fish species richness and fish diversity increased considerably between 2001 and 2004 and again between 2006 and 2009. These levels were sustained to 2010 (Figures 3.10b and 3.10c).

Total abundance of fish at the reference areas peaked in 2004, decreasing in subsequent surveys. During 2010 survey abundances were the lowest recorded (Figure 3.10a). Abundances at the MNP area were variable over time.

Fish species richness and species diversity followed similar patterns at both the MNP and the reference areas. There had been slight increasing trend in species richness over time (Figure 3.10b). During 2009 there was a peak in species diversity reaching the highest levels recorded. During 2010 the MNP areas remained high and the reference areas dropped to original levels (Figure 3.10c). Increases in diversity were also apparent at the reference sites during recent surveys, with this likely to be influenced by the change in monitoring sites (Figure 3.10c).
Figure 3.8. Algal species diversity inside and outside the Cape Howe Marine National Park.
Figure 3.9. Invertebrate species diversity inside and outside the Cape Howe Marine National Park.
Figure 3.10. Fish species diversity inside and outside the Cape Howe Marine National Park.
3.2.3 Abundances of Selected Species

Preface

The reference sites were changed in 2009 so trends in overall means need to be interpreted carefully alongside site abundances, which are not presented here. The following reporting focuses on trends within the marine protected area. One site within the Marine National Park was changed from Howe Perpendicular to Howe Deep in 2009. This is likely to affect some of the apparent temporal trends with habitat differences occurring with depth.

Macroalgae

Within the Cape Howe Marine National Park, the abundance of crayweed *Phyllospora comosa* declined by approximately 25% cover between 2004 and 2009 (Figure 3.11a). Over the same period, there was an apparent increase in the abundances of the small brown algae *Halopteris* spp and the erect coralline alga *Haliptilon roseum* (Figure 3.11b and 3.11d). There was no apparent trend in the abundance of crustose coralline algae (Figure 3.11c – note this group was not measured during the first survey).

Invertebrates

Over the monitoring period there was a slight, but statistically insignificant, increase in the abundance of the long-spined urchin *Centrostephanus rodgersii* within the Cape Howe Marine National Park (Figure 3.12a). There was a relatively large decline in abundances of the periwinkle *Turbo undulatus* and blacklip abalone *Haliotis rubra* to 2006 remained low while there was increase of *H. rubra* to back to baseline abundance level by 2010 (Figure 3.12b and 3.12c). There was a consistent decline in abundance of the common sea urchin *Heliocidaris erythrogramma* over the monitoring period in the Cape Howe Marine National Park (Figure 3.12d). This decline was contrary to abundances in the reference areas, with a peak in abundance occurring in 2006. The abundance of the whelk *Cabestana spengleri* was generally low within the Cape Howe Marine National Park compared with the reference areas (Figure 3.12e).

Fish

The abundances of both the blue throated wrasse *Notolabrus tetricus* and the purple wrasse *Notolabrus fucicola* have increased considerably inside the Cape Howe Marine National Park between 2006 and 2009 (Figures 3.13a and 3.13b).

The abundance of herring cale *Odax cyanomelas* oscillated between surveys with the abundance during the 2010 survey appearing to be at the lower levels as observed previously (Figure 3.13c).
For the banded morwong *Cheilodactylus spectabilis*, abundances steadily increased from baseline levels of 5 per 2000 m$^2$ up to 15 per 2000 m$^2$ in 2009 inside Cape Howe Marine National Park. There was a subsequent decrease in 2010 (Figure 3.13d).

The eastern kelp fish *Aplodactylus lopodon* was similar in abundance from the baseline surveys until 2006. There was a spike in abundance during 2009, with a subsequent decline to less than baseline levels in 2010 (Figure 3.13e).
Figure 3.11. Percent cover of predominant algal species inside and outside the Cape Howe Marine National Park. Note: crustose coralline algae were not surveyed in 2001.
Figure 3.11 (continued). Percent cover of predominant algal species inside and outside the Cape Howe Marine National Park.
Figure 3.12. Site abundance (per 200 m²) of predominant invertebrate species inside and outside the Cape Howe Marine National Park.
Figure 3.12 (continued). Site abundance (per 200 m²) of predominant invertebrate species inside and outside the Cape Howe Marine National Park.
Figure 3.13. Site abundance (number per 2000 m$^2$) of predominant fish species inside and outside the Cape Howe Marine National Park.
Figure 3.13 (continued). Site abundance (number per 2000 m²) of predominant fish species inside and outside the Cape Howe Marine National Park.
3.3 Ecosystem Components

Preface
The reference sites were changed in 2009 so trends in overall means need to be interpreted carefully alongside site abundances, which are not presented here. The following reporting focuses on trends within the marine protected area. One site within the Marine National Park was changed from Howe Perpendicular to Howe Deep in 2009. This is likely to affect some of the apparent temporal trends with habitat differences occurring with depth.

Habitat and Production
As described previously, there were no apparent trends in cover of crustose coralline algae (Figure 3.14a).

There was an apparent decline in canopy brown algae from 2002 to 2006, which continued through 2009 and 2010, with a decline from approximately 80% to 40% cover (Figure 3.14b). Some of the decline in 2009 and 2010 is likely to be an artefact from the change in site location from Howe Central to Howe Deep.

The seaweed microhabitat of smaller brown algae, erect coralline algae and thallose red algae have similar trends with increases post park declaration to highest abundances occurring in 2009 and 2010 (Figures 3.14b to 3.14e).

Green algae remained low in abundance throughout the monitoring period (Figure 3.14f).

Invertebrate Groups
The invertebrate grazers within the Cape Howe MNP followed the same trend as blacklip abalone *Haliotis rubra*, having a decline to 2006 with a subsequent increase to 2010 (Figure 3.15a). The densities of invertebrate filter feeders and seastars were generally low with no apparent trends (Figures 3.15b and 3.15d). There were no apparent trends in invertebrate predators during the monitoring period (Figure 3.15c).

Fish Groups
The fish grazers followed the variable pattern of herring cale *Odax cyanomelas* (Figure 3.16a). Fish foragers, such as morwong and wrasses, increased steadily from the baseline abundance until 2009. There was a decline to below baseline abundance in 2010 (Figure 3.16b). The same pattern occurred for fish hunters, including fishes such as long finned pike *Dinolestes lewini* (Figure 3.16c).

The abundance of fish planktivores, such as sweep, was relatively constant from the baseline to 2006, after which there were considerably higher densities (Figure 3.16d).
Sediment Cover

Sediment cover was not recorded during the first survey in 2001. Sediment cover remained relatively low at Cape Howe over the surveys (Figure 3.17).
Figure 3.14. Seaweed functional groups inside and outside the Cape Howe Marine National Park.
Figure 3.14 (continued). Seaweed functional groups inside and outside the Cape Howe Marine National Park.
Figure 3.15. Mean abundance of invertebrate functional groups inside and outside the Cape Howe Marine National Park.
Figure 3.15 (continued). Mean abundance of invertebrate functional groups inside and outside the Cape Howe Marine National Park.
Figure 3.16. Mean abundance of fish functional groups inside and outside the Cape Howe Marine National Park.
Figure 3.16 (continued). Mean abundance of fish functional groups inside and outside the Cape Howe Marine National Park.

Figure 3.17. Mean cover (± Standard Error) of sediment inside and outside the Cape Howe Marine National Park.
3.4 Introduced Species
There were no introduced species detected for these sites.

3.5 Climate Change
There was only a low number of, colder water, Maugean algal species within the Cape Howe region; the most conspicuous of these being crayweed *Phyllospora comosa*. There were no marked trends over the monitoring period apart from the decline in *P. comosa* (Figure 3.18).

The cold water, Maugean invertebrate species in the Cape Howe region were no well represented at any one time (Figure 3.19). There was an increase in Maugean-classified fish species and abundance over the monitoring period (Figure 3.20).

Eastern algal species were not well represented in the Cape Howe region (Figure 3.21). There were no apparent trends in eastern invertebrate species richness throughout the monitoring period (Figure 3.22a). Abundance of eastern invertebrates increased considerably, almost doubling, from baseline to 2009 (Figure 3.22b).

The eastern fish species richness was relatively stable from 2001 to 2006, after which there was a marked increase to 2009, persisting to 2010 (Figure 3.23a). There was also an increase in eastern fish abundances to 2009, however there was a large decline to below baseline levels in 2010 (Figure 3.23b).
Figure 3.18. Abundance of Maugean algal species inside and outside the Cape Howe Marine National Park.
Figure 3.19. Abundance of Maugean invertebrate species inside and outside the Cape Howe Marine National Park.
Figure 3.20. Abundance of Maugean fish species inside and outside the Cape Howe Marine National Park.
Figure 3.21. Abundance of Eastern algal species inside and outside the Cape Howe Marine National Park.
Figure 3.22. Abundance of Eastern invertebrate species inside and outside the Cape Howe Marine National Park.
Figure 3.23. Abundance of Eastern fish species inside and outside the Cape Howe Marine National Park.
## 3.6 Fishing

### 3.6.1 Abalone

Both the mean size and proportion of legal sized blacklip abalone *Haliotis rubra* were lower inside the park, throughout the monitoring period (Figure 3.24).

### 3.6.2 Rock Lobster

Abundances of both southern rock lobster *Jasus edwardsii* and packhorse lobster *Jasus verreauxi* were low and sporadically observed during the monitoring period (Figures 3.25 and 3.26).

### 3.6.3 Fishes

With respect to the total size spectrum of fishes, there was a trend of increasing dominance of smaller fish and decreasing dominance of larger fishes from 2001 to 2009. This trend was largely reversed between 2009 and 2010 (Figure 3.27).

Variations in biomass of fished species on the survey transects was largely driven by fishes over 200 mm in length. There were no apparent trends over the monitoring period (Figure 3.28). The density of fished species over 200 mm spiked in 2009 but did not persist to 2010 (Figure 3.29).

At this stage of the monitoring program, there are no discernable changes in the size structure of fished reef species (Figures 3.30 to 3.33).
Figure 3.24. Size of blacklip abalone *Haliotis rubra* inside and outside the Cape Howe Marine National Park.
Figure 3.25. Density of southern rock lobster *Jasus edwardsii* inside and outside the Cape Howe Marine National Park.

Figure 3.26. Density of packhorse lobster *Jasus verreauxi* inside and outside the Cape Howe Marine National Park.
Figure 3.27. Fish size spectra inside and outside the Cape Howe Marine National Park.
Figure 3.28. Biomass of fished species inside and outside the Cape Howe Marine National Park.
Figure 3.29. Density of all fished species inside and outside the Cape Howe Marine National Park.
Figure 3.30. Size of blue throat wrasse *Notolabrus tetricus* inside and outside the Cape Howe Marine National Park.
Figure 3.31. Size of purple wrasse *Notolabrus fucicola* inside and outside the Cape Howe Marine National Park.
Figure 3.32. Size of senator wrasse *Pictilabrus laticlavius* inside and outside the Cape Howe Marine National Park.
Figure 3.33. Size of banded morwong *Cheilodactylus spectabilis* inside and outside the Cape Howe Marine National Park.
4 POINT HICKS MARINE NATIONAL PARK

4.1 Site Descriptions

The reef substratum within the Point Hicks Marine National Park consisted of granite slopes, boulders and outcrops. There are four sites within the Point Hicks Marine National Park: Old Jetty Bay (Site 4), Hicks Southwest (Site 21), Hicks Joggle (Site 22) and Hicks Lighthouse (Site 6).

Old Jetty Bay (Site 4; Figure 4.1) is located on the western side of the point where it is relatively sheltered and shallow and consists of flat rock slabs with low boulders with occasional bombies. Some areas of boulders and cobble were interspersed with sand.

The three other sites within the Marine National Park were highly exposed to swell and seas. Hicks Southwest (Site 21) has both low and moderate relief (1-1.5 m), with steps, bombies and reef flats. There are patches of sand in the rock gullies and over rock flats.

Hicks Joggle (Site 22) is situated beneath the lighthouse and is highly exposed, but has a small barrier reef in front of it which breaks up smaller swell waves. Larger waves continue over this reef and break on the steep shore. While the barrier reef protects the inner reef to some extent, a current frequently flows along the coast, between the barrier reef and the shore. This interacts with swells and backwash from the shore to make it a turbulent area (hence the name). The site is characterised by moderate to high granite boulders and outcrops (1.5-2 m) with low relief boulder habitat in the western end, where there are also large sand patches.

Hicks Lighthouse (Site 6) is situated on the eastern side of the point and is fully exposed to easterly swells. Although the aspect of this site is sheltered from westerly swells, the waves refract around the point and break over the site.

The reference sites for Point Hicks Marine National Park are all situated to the east, where the closest suitable reefs were present. Krafts Garden and Durvillaea Flats (Sites 7 and 16) are close together along a rocky reef outcrop immediately to the east of Point Hicks. Both sites consisted of gently sloping low-profile reef punctuated by bombies and outcrops 1-2 m high and interspersed with sandy patches. Ground swell surge is particularly strong at these sites, with sand continually being resuspended in the water column, reducing visibility.

The habitats at Müllers Reef and Petrel Point (Sites 17 and 18) consisted of reef with 1-2 m high ridges with gullies in between. Some areas of low-profile reef were also observed. Both of these sites are prone to strong ground surge and high wave action.
Figure 4.1. Location of monitoring sites associated with Point Hicks Marine National Park. The park area is shaded blue. Coordinate system is Map Grid of Australia 1996 (MGA).
4.2 Biodiversity

4.2.1 Community Structure

**Macroalgae**

The algal composition at Point Hicks had a mixed algal canopy of *Phyllospora comosa* and common kelp *Ecklonia radiata*. Other dominant species were fucalean species, such as *Cystophora* spp and *Sargassum* spp, and fleshy thallose red algae.

The non-metric MDS plot indicated algal assemblage structure had a similar level of variability between times at each site. Exceptions were Hicks Light (Site 6) inside Point Hicks Marine National Park and Krafts Garden (Site 7) outside the Park (Figure 4.2).

The multivariate control charts indicate a significant deviation at Krafts Garden (Site 7) from both the baseline centroid and prior times centroid conditions during 2010. There were no significant regional deviations from baseline and prior time centroids during the monitoring period (Figure 4.3).

**Invertebrates**

In general, sites at Point Hicks were characterised by high abundances of the featherstar *Comanthus trichoptera*, the seastar *Meridiastra calcar* and moderate abundances of the predatory gastropod *Cabestana spengleri*, blacklip abalone *Haliotis rubra* and the common sea urchin *Heliocidaris erythrogramma*.

The nMDS plot indicated considerable overlap between sites and times in invertebrate assemblage structure for Point Hicks Joggle (Site 22), Krafts Garden (Site 7), Petrel Point (Site 18) and Meullers Reef (Site 17). There was also overlap between sites and times for structure between Hicks Light (Site 6), Point Hicks Southwest (Site 21) and Old Jetty Bay (Site 4). The Durvillaea Flats (Site 16) community had elements of similarity between both groups (Figure 4.4).

The multivariate control charts indicated significant deviations from the baseline centroid for Krafts Garden (Site 7), Durvillaea Flats (Site 16) and Old Jetty Bay (Site 4) in 2010. These sites were also significantly deviant from the prior time centroid, along with Point Hicks Joggle (Site 22; Figure 4.5). The combined regional data remained within the control chart limits.

**Fish**

The predominant fish species at Point Hicks were blue throated wrasse *Notolabrus tetricus* and purple wrasse *Notolabrus fucicola*. Other abundant species were the banded morwong
Cheilodactylus spectabilis, herring cale Odax cyanomelas, and the eastern kelpfish Aplodactylus lophodon.

The nMDS plot indicated fish assemblage structure had a similar level of variability between times at each site. Sites were overlapping in community structure between times (Figures 4.6).

There was a deviation in fish community structure from the baseline centroid at Old Jetty Bay (Site 4), Point Hicks Southwest (Site 21) and Meullers Reef (Site 17). Old Jetty Bay and Durvillaea Flats (Site 16) were significantly deviant from the prior times centroid, indicating an abrupt change from the previous survey. The Point Hicks Marine National Park regional data had a significant shift from the baseline centroid and the prior times centroid in 2010, indicating overall shift in community structure inside the park (Figure 4.7).

Figure 4.2. MDS plot of algal assemblage structure inside and outside the Point Hicks Marine National Park in March 2010. Kruskal stress = 13.28.
Control Chart - Algae

Figure 4.3. Control chart of algal assemblage structure inside and outside the Point Hicks Marine National Park.
Figure 4.4. MDS plot of invertebrate assemblage structure inside and outside the Point Hicks Marine National Park in March 2010. Kruskal stress = 10.24.
Figure 4.5. Control chart of invertebrate assemblage structure inside and outside the Point Hicks Marine National Park.
Figure 4.6. MDS plot of fish assemblage structure inside and outside the Point Hicks Marine National Park in March 2010. Kruskal stress = 15.59.
Figure 4.7. Control chart of fish assemblage structure inside and outside the Point Hicks Marine National Park.
4.2.2 Species Richness and Diversity

**Macrolgae**

Algal species richness was generally higher inside Point Hicks MNP post commissioning. There has been a gradual decline from 2004 to 2010. The reference sites had similar changes over time (Figure 4.8b). Seaweed diversity did not change markedly over time for both the Park and reference areas, with the exception of higher diversity inside the park from 2004 to 2006 (Figure 4.8c).

**Invertebrates**

There have been no marked changes in invertebrate species richness and diversity over time with similar levels inside and outside the Park (Figures 4.9b and 4.9c).

**Fish**

There has been a general decline in fish total abundance both inside and outside the MNP over the monitoring period (Figure 4.10a). There were no trends in fish species richness and fish diversity, except for a minor peak in 2006 (Figures 4.10b and 4.10c).
Figure 4.8. Mean abundance of algal functional groups inside and outside the Point Hicks Marine National Park.
Figure 4.9. Mean abundance of invertebrate functional groups inside and outside the Point Hicks Marine National Park.
Figure 4.10. Mean abundance of fish functional groups inside and outside the Point Hicks Marine National Park.
4.2.3 Abundances of Selected Species

Macroalgae

The crayweed *Phyllospora comosa* and the common kelp *Ecklonia radiata* were the most abundant algal species at Point Hicks. *Phyllospora comosa* did not have any marked trends over the monitoring period both inside and outside Point Hicks MNP (Figure 4.11a). The abundance of *E. Radiata* was exceptionally consistent over time inside and outside the Park. The plots indicate an increase between 2001 and 2004, however this is largely driven by the inclusion of new sites in 2004 (Figure 4.11b).

The strap weed *Cystophora moniliformis* had an apparent decline in abundance in the reference areas however there is considerable variability during this decline (Figure 4.11c). The abundance of the red alga *Rhodymenia linearis* was remarkably consistent through time (note: this was not measured during the first survey; Figure 4.11d). Crustose coralline algae was not measured during the first survey but had similar abundances both inside and outside the Park at most times, with the exception of a peak in 2006 (Figure 4.11e).

Invertebrates

The featherstar *Comanthus trichoptera* had very high abundances in the reference areas during the 2004 and 2006 surveys, with reduced abundances during 2009 and 2010. Featherstar *C. trichoptera* was not abundant inside the Park (Figure 4.12a).

The seastar *Meridiastra calcar* had similar temporal patterns both inside and outside the Park, with abundances inside the Park consistently higher than outside. Abundances during the baseline survey were substantially greater than subsequent surveys, both inside and outside the Park (Figure 4.12b). Densities of the trumpet shell *Cabestana spengleri* fluctuated over time with densities inside the Park being similar to densities outside the Park between 2004 and 2010 (Figure 4.12c).

Densities of the blacklip abalone *Haliotis rubra* had remained relatively constant over time outside the Park. Inside the Park, densities declined slightly between 2001 and 2004, then increased above baseline levels during 2006 onwards. There was a marked increase in density between 2009 and 2010, with densities well above baseline surveys (Figure 4.12d).

The abundances of sea urchins *Heliocidaris erythrogramma* and *Centrostephanus rodgersii* remained very low inside the Point Hicks Marine National Park. The abundances of these two species in the reference areas had similar temporal patterns, which consisted of a slight drop in abundances in 2009 (Figures 4.12e and 4.12g; note: abundances appear lower in 2001 due to the different sites).
Abundances of the red bait crab *Plagusia chabrus* followed similar patterns inside and outside the Park, with the exception of the 2004 survey where there was a drop in the reference area. From 2006 to 2010 there has been a decline in densities both inside and outside the MNP (Figure 4.12f). The turban shell *Turbo undulatus* had consistently higher abundances in the reference area. There were no clearly discernable trends inside or outside the Park (Figure 4.12h).

**Fish**

For most of the abundant fish the temporal patterns were similar both inside and outside the MNP (Figure 4.13). The abundances of blue throated wrasse *Notolabrus tetricus* did not have any marked changes over time although there was a slight decrease inside the Park between 2009 and 2010 (Figure 4.13a). There was a considerable decline in purple wrasse *Notolabrus fucicola* abundance between 2004 and 2006, with no major changes there after (Figure 4.13b).

For herring cale *Odax cyanomelas*, there was a consistent increase in density from 2001 to a marked peak in 2006 after which there was an equivalent decline from 2006 to 2010. This pattern was mirrored inside and outside the MNP (Figure 4.13c).

The banded morwong *Cheilodactylus spectabilis* did not have clear pattern of change over time both inside and outside the MNP, although there is potentially a slight decreasing trend in abundance inside the Park (Figure 4.13d). Inside the Park, the abundance of eastern kelpfish *Aplodactylus lophodon* was originally relatively high from 2001 to 2004, after which there was a gradual decline to very low abundances in 2010 (Figure 4.13e).
Figure 4.11. Percent cover of predominant algal species inside and outside the Point Hicks Marine National Park.
Figure 4.11 (continued). Percent cover of predominant algal species inside and outside the Point Hicks Marine National Park.
Figure 4.12. Site abundance (per 200 m$^2$) of predominant invertebrate species inside and outside the Point Hicks Marine National Park.
Figure 4.12. (continued). Site abundance (per 200 m²) of predominant invertebrate species inside and outside the Point Hicks Marine National Park.
**Figure 4.12.** (continued). Site abundance (per 200 m$^2$) of predominant invertebrate species inside and outside the Point Hicks Marine National Park.
Figure 4.13. Site abundance (number per 2000 m$^2$) of predominant fish species inside and outside the Point Hicks Marine National Park.
Figure 4.13 (continued). Site abundance (number per 2000 m$^2$) of predominant fish species inside and outside the Point Hicks Marine National Park.
4.3 Ecosystem Components

Habitat and Production

As described previously, the abundance was very similar inside and outside the Park during most times with the exception of a peak during 2006 (Figure 4.14a).

The cover of canopy browns and thallose red algae were similar inside and outside the Park and changed little over time (Figures 4.14b and 4.14e). The total abundance of smaller brown algae was variable over time inside the MNP. Outside the Park there was a clear decrease in abundance between 2001 and 2006 (Figure 4.14c). The abundances of erect coralline algae were insignificant in the Point Hicks region (less than < 1%; Figure 4.14d). Although green algae were low in abundance at all times (less than 4%), there was a gradual decline both inside and outside the MNP between 2001 and 2010 (Figure 4.14f).

The densities of invertebrate grazers and invertebrate filter feeders were higher outside the Park (Figure 4.15b). Invertebrate predators and seastars are following similar patterns both inside and outside the MNP area (Figure 4.15c and 4.15d).

The fish grazer patterns were driven by a peak in abundance of herring cale *Odax cyanomelas* during 2006 (Figure 4.16a). For fish foragers and fish hunters there were no marked trends over time (Figure 4.16b and 4.16c). Fish planktivores were observed in both reference and park areas in moderate densities during 2001, however densities were very low in both areas during subsequent surveys (Figure 4.15d).

Sediment Cover

For both inside and outside the Park, there was an overall increasing trend between 2004 and 2010 (note: sediment cover was not measured during the first 2001 survey; Figure 4.17).
Figure 4.14. Seaweed functional groups inside and outside the Point Hicks Marine National Park.
Figure 4.14 (continued). Seaweed functional groups inside and outside the Point Hicks Marine National Park.
Figure 4.15. Mean abundance of invertebrate functional groups inside and outside the Point Hicks Marine National Park.
Figure 4.15 (continued). Mean abundance of invertebrate functional groups inside and outside the Point Hicks Marine National Park.
Figure 4.16. Mean abundance of fish functional groups inside and outside the Point Hicks Marine National Park.
Figure 4.16 (continued). Mean abundance of fish functional groups inside and outside the Point Hicks Marine National Park.

Figure 4.17. Percent cover of sediments inside and outside the Point Hicks Marine National Park.
4.4 Introduced Species

There were no introduced species detected for these sites.

4.5 Climate Change

Species composition

There are no major trends in cold water, Maugean algal and fish species richness or total abundance over the monitoring period (Figures 4.18 and 4.20). Cold water invertebrate species were not well represented in the Point Hicks region at any time (Figure 4.19).

Eastern algal species were not well represented at Point Hicks at any time over the monitoring period (Figure 4.21). Eastern invertebrate species richness and abundance did not have any marked trends over time (Figure 4.22). Eastern fish species had richness decreased slightly between 2009 and 2010 (Figure 4.23).

The string kelp *Macrocystis pyrifera* formed beds in Old Jetty Bay (Site 4) in 2001 and 2004, but have not been observed at any sites during subsequent surveys (Figure 4.24a). The bull kelp *Durvillaea potatorum* is predominantly surveyed at Durvillaea Flats (Site 16), there have been no indications of changes over the monitoring period (Figure 4.24b).
Figure 4.18. Abundance of Maugean algal species inside and outside the Point Hicks Marine National Park.
Figure 4.19. Abundance of Maugean invertebrate species inside and outside the Point Hicks Marine National Park.
Figure 4.20. Abundance of Maugean fish species inside and outside the Point Hicks Marine National Park.
Figure 4.21. Abundance of Eastern algal species inside and outside the Point Hicks Marine National Park.
Figure 4.22. Abundance of Eastern invertebrate species inside and outside the Point Hicks Marine National Park.
Figure 4.23. Abundance of Eastern fish species inside and outside the Point Hicks Marine National Park.
Figure 4.24. Percent cover of algal species of interest string kelp *Macrocystis pyrifera* and bull kelp *Durvillaea potatorum* inside and outside the Point Hicks Marine National Park.
4.6 Fishing

4.6.1 Abalone
The length of blacklip abalone *Haliotis rubra* has gradually increased in both inside and outside the Park, with the mean size inside the park being consistently greater than outside (Figure 4.25a). The proportion of legal size abalone followed a similar trend (Figure 4.25b).

4.6.2 Rock Lobster
Observations of the packhorse lobster *Jasus verreauxi* have been low. This species has been more commonly observed inside the MNP over the survey period (Figure 4.26).

4.6.3 Fishes
The fish size spectrum indicated a decline in larger individuals between 2001 and 2006 inside the Park. There was a subsequent decline to baseline levels between 2006 and 2010 (Figure 4.27).

Both inside and outside the Park, there was a gradual decline in biomass of fished species over 200 mm length from 2001 to 2010. The overall decline is approximately 75 % over this period (Figure 4.28). The density of larger fished species followed the same pattern (Figure 4.29).

There are no differences in the mean size of blue throated wrasse *Notolabrus tetricus* and purple wrasse *Notolabrus fucicola* inside and outside the MNP. Sizes have fluctuated little, remaining stable over the survey period (Figure 4.30 and 4.31).

The size of senator wrasse *Pictilabrus laticlavius* has oscillated throughout the monitoring period, with similar abundances inside and outside the Park (Figure 4.32). Mean size of banded morwong *Cheilodactylus spectabilis* decreased outside the Park between 2001 and 2004. There was a slight increase in mean size inside the Park between 2009 and 2010 (Figure 4.33).
Figure 4.25. Sizes of blacklip abalone *Haliotis rubra* inside and outside the Point Hicks Marine National Park.
Figure 4.26. Proportion of eastern rock lobster *Jasus verreauxi* inside and outside the Point Hicks Marine National Park.
Figure 4.27. Fish size spectra inside and outside the Point Hicks Marine National Park.
Figure 4.28. Biomass of fished species inside and outside the Point Hicks Marine National Park.
Figure 4.29. Density of fished species inside and outside the Point Hicks Marine National Park.
Figure 4.30. Size of blue throat wrasse *Notolabrus tetricus* inside and outside the Point Hicks Marine National Park.
Figure 4.31. Size of purple wrasse *Notolabrus fucicola* inside and outside the Point Hicks Marine National Park.
Figure 4.32. Size of senator wrasse *Pictilabrus laticlavius* inside and outside the Point Hicks Marine National Park.
Figure 4.33. Size of banded morwong *Cheilodactylus spectabilis* inside and outside the Point Hicks Marine National Park.
5 REFERENCES


6 ACKNOWLEDGMENTS

This project was funded by Parks Victoria and supervised by Steffan Howe. We are grateful for the field assistance and technical support of Reinhart Strauss and crew from Wilderness Coast Charters.
7 APPENDIX A – SITE DETAILS

Beware Reef Marine Sanctuary

Beware Reef – Site 3223

Site Description

Beware Reef marine sanctuary is a small isolated reef located approximately 4 km offshore from Cape Conran. The reef profile in the shallower water consists of small gullies, slopes and flats down to the ten meter isobath, where the reef generally drops off steeply into deeper water.

Transect Layout

The Beware Reef monitoring site (Site 23) was positioned along the 8 m isobath over small gullies and flats. The central position is located on the eastern side of an emergent rock, with transects 1 and 2 along the northern side of the island and transects 3 and 4 along the southern side (forming a ‘v’).

Appendix A Figure 1.1. Site dive transects for Beware Reef (site 3223) in Beware Reef Marine Sanctuary.

Appendix A Table 1.1. Site details for Beware Reef (site 3223) in Beware Reef Marine Sanctuary.

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Beware Reef Marine Sanctuary
Pearl Point – Site 3224

Site Description
Pearl Point is a reference site for Beware Reef Marine Sanctuary. The habitat structure at Pearl Point was similar to Müller’s Reef and Petrel Point, consisting of ridges of reef 1-2 m high with gullies in between.

Transect Layout
The Pearl Point reference site is at 7-8 m depth. T2 and T1 head in a straight line to the northeast from the marker, and T3 and T4 in a southwest direction.

Appendix A Figure 1.2. Site dive transects for Pearl Point (site 3224), the reference site for Beware Reef Marine Sanctuary.

Appendix A Table 1.2. Site details for Pearl Point (site 3224), the reference site for Beware Reef Marine Sanctuary.

<table>
<thead>
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</table>
Point Hicks Marine National Park
Old Jetty Bay – Site 3204

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

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

Appendix A Figure 1.3. Site dive transects for Old Jetty Bay (site 3204) in Point Hicks Marine National Park.

Appendix A Table 1.3. Site details for Old Jetty Bay (site 3204) in Point Hicks Marine National Park.

<table>
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Hicks Southwest – Site 3221

Site Description

Hicks Southwest is highly exposed to swell and has both low and moderate relief reef (1-1.5 m), with steps, bombies and reef flats. There are patches of sand in the rock gullies and over rock flats.

Transect Layout

The areas of reef is short, so the transect curves to fit. T2 heads east from the marker, curving south in to T1. T3 heads west and T4 in a south-southwest direction.

Appendix A Figure 1.4. Site dive transects for Hicks Southwest (site 3221) in Point Hicks Marine National Park.

Appendix A Table 1.4. Site details for Hicks Southwest (site 3221) in Point Hicks Marine National Park.

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Point Hicks Marine National Park
Hicks Joggle– Site 3222

Site Description
Hicks Joggle (Site 22) is situated beneath the lighthouse and is highly exposed, but has a small barrier reef in front of it which breaks up smaller swell waves. Larger waves continue over this reef and break on the steep shore. While the barrier reef protects the inner reef to some extent, a current frequently flows along the coast, between the barrier reef and the shore. This interacts with swells and backwash from the shore to make it a turbulent area (hence the name). The site is characterised by moderate to high granite boulders and outcrops (1.5-2 m) with low relief boulder habitat in the western end, where there are also large sand patches.

Transect Layout
The transect follows the curve of the bay. T2 and T1 head southeast from the marker, and T3 and T4 curve from northwest at the marker to southwest at the end of T4.

Appendix A Figure 1.5. Site dive transects for Hicks Joggle (site 3222) in Point Hicks Marine National Park.

Appendix A Table 1.5. Site details for Hicks Joggle (site 3222) in Point Hicks Marine National Park.

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<thead>
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Point Hicks Marine National Park
Hicks Lighthouse – Site 3206

Site Description
Hicks Lighthouse (Site 6) is situated on the eastern side of the point and is fully exposed to easterly swells. Although the aspect of this site is sheltered from westerly swells, the waves refract around the point and break over the site.

Transect Layout
T2 and T1 head northeast from the marker, meandering parallel to the shoreline and offshore from a submerged bombie. T3 and T4 head in a southerly direction, also parallel to shore.

Appendix A Figure 1.6. Site dive transects for Hicks Lighthouse (site 3206) in Point Hicks Marine National Park.

Appendix A Table 1.6. Site details for Hicks Lighthouse (site 3206) in Point Hicks Marine National Park.

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Point Hicks Marine National Park
Krafts Garden – Site 3207

Site Description
Krafts Garden in a reference site for Point Hicks Marine National Park. Situated along a rocky reef outcrop immediately to the east of Point Hicks, Krafts Garden consists of gently sloping low-profile reef punctuated by bombies and outcrops 1-2 m high and interspersed with sandy patches. This site is particularly exposed to ground swell surge and sand continually being resuspended in the water column, reducing visibility.

Transect Layout
The marker is located within a sand patch. T2 and T1 head to the northeast from the marker, curving to the east on T1. T3 and T4 head in a southwest direction.

Appendix A Figure 1.7. Site dive transects for Krafts Garden (site 3207), a reference site for Point Hicks Marine National Park.

Appendix A Table 1.7. Site details for Krafts Garden (site 3207), a reference site for Point Hicks Marine National Park.

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Point Hicks Marine National Park
Durvillaea Flats – Site 3216

Site Description

Durvillaea Flats is a reference site for Point Hicks Marine National Park. The site is on rocky reef outcrop on the eastern side of Point Hicks. The gently sloping low-profile reef is punctuated by bombies and outcrops 1-2 m high and interspersed with sandy patches. There is strong ground swell surge at this site, with sand continually being resuspended in the water column, reducing visibility.

Transect Layout

The transects are situated on the inshore side of the reef following the shape of the reef outcrop. T2 heads north-northeast from the marker and then T1 curves to the west, and T3 and T4 in a west-southwest direction.

Appendix A Figure 1.8. Site dive transects for Durvillaea (site 3216), a reference site for Point Hicks Marine National Park.

Appendix A Table 1.8. Site details for Durvillaea (site 3216), a reference site for Point Hicks Marine National Park.

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Point Hicks Marine National Park
Müller Reef – Site 3217
Site Description
Müller Reef is a reference site for Point Hicks Marine National Park. Müller Reef is rocky reef with 1-2 m high ridges with gullies in between. Some areas of low-profile reef were also observed. This site is prone to strong ground surge and high wave action.

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

Appendix A Figure 1.9. Site dive transects for Müller Reef (site 3217), a reference site for Point Hicks Marine National Park.

Appendix A Table 1.9. Site details for Müller Reef (site 3217), a reference site for Point Hicks Marine National Park.

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Point Hicks Marine National Park
Petrel Point – Site 3218
Site Description
Petrel Point is a reference site for Point Hicks Marine National Park. It is situated on rocky reef with 1-2 m high ridges with gullies in between. Some areas of low-profile reef were also observed. This site is prone to strong ground surge and high wave action.
Transect Layout
T2 and T1 head in a straight line to the north-northeast from the marker, and T3 and T4 in a south-southwest direction.

Appendix A Figure 1.10. Site dive transects for Petrel Point (site 3218), a reference site for Point Hicks Marine National Park.

Appendix A Table 1.10. Site details for Petrel Point (site 3218), a reference site for Point Hicks Marine National Park.

<table>
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Cape Howe Marine National Park
Howe Perpendicular – Site 3220

Site Description
Howe Perpendicular was situated on low relief reef with 0.2 m to 0.5 m steps and ridges. There were areas of flat reef and sand patches. The transect ran perpendicular to shore, consequently depth ranged from 5 m at the near-shore end to 12 m at the offshore end of the transect.

Transect Layout
T2 heads in a straight line to the northwest from the marker, and T1 heads slightly west of north from the end of T2. T3 and T4 head in a southerly direction from the shot.

Survey Notes
This site was not surveyed in 2009 and 2010.

Appendix A Figure 1.11. Site dive transects for Howe Perpendicular (site 3220) in Cape Howe Marine National Park.

Appendix A Table 1.11. Site details for Howe Perpendicular (site 3220) in Cape Howe Marine National Park.

<table>
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Cape Howe Marine National Park
Howe Outer – Site 3227

Site Description
This site was a new site in 2009. Located within the Cape Howe Marine National Park, it is situated parallel to, and further offshore from, Howe Central (site 3214). These two sites are approximately 75 m apart. This new site was considerably deeper (10-12 m).

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

Appendix A Table 1.12. Site details for Howe Outer (site 3227) in Cape Howe Marine National Park.

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Cape Howe Marine National Park
Howe West – Site 3213

Site Description

Howe West was on moderate relief reef with gullies and depressions. Dense beds of *Phyllospora comosa* were present on reef tops and there were patches of urchin barren.

Transect Layout

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

Appendix A Figure 1.12. Site dive transects for Howe West (site 3213) in Cape Howe Marine National Park.

Appendix A Table 1.13. Site details for Howe West (3213) in Cape Howe Marine National Park.

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Cape Howe Marine National Park
Howe Central – Site 3214

Site Description
Howe central was on low to moderate relief reef with some gullies and ridges. Dense beds of *Phylllospora comosa* were present on reef tops and there were several areas of urchin barren.

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

Appendix A Figure 1.13. Site dive transects for Howe Central (site 3214) in Cape Howe Marine National Park.

Appendix A Table 1.14. Site details for Howe Central (3214) in Cape Howe Marine National Park.

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Cape Howe Marine National Park
Howe Border – Site 3215

Site Description
There was moderate relief reef, with some larger bombsies, holes and drop-offs present at Howe Border. This site initially had a high cover of crayweed *Phyllospora comosa*, but in recent surveys the area and number of urchin barren patches has increased.

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

Appendix A Figure 1.14. Site dive transects for Howe Border (site 3215) in Cape Howe Marine National Park.

Appendix A Table 1.15. Site details for Howe Border (site 3215) in Cape Howe Marine National Park.

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Cape Howe Marine National Park
Tullaberga Deep – Site 3208

Site Description
This site was 5-7 m deep and was characterised by moderate to high relief bedrock outcrops at the southern end, with lower relief rock slabs at the northern end. There were occasional patches of boulders and rubble, providing interstitial spaces. Much of the Tullaberga site was sea urchin barren habitat with high abundances of *Centrostephanus rodgersii* and encrusting coralline algae. Crayweed *Phyllospora comosa* was present on occasional boulder tops. 

A predominant feature was the high abundance of white ear damselfish *Parma microlepis* and one spot puller *Chromis hypsilepis*.

Transect Layout
T2 and T1 head south from the marker, and T3 and T4 in a northerly direction.

Survey Notes
This site was not surveyed in 2009 and 2010.

Appendix A Table 1.16. Site details for Tullaberga Deep (site 3208), a reference site for Cape Howe Marine National Park.

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Cape Howe Marine National Park
Gabo Monument – Site 3210

Site Description
Gabo Monument site (near the pump house) was all sea urchin barren on a substratum of large granite boulders with a large amount of interstitial space. Small Phyllospora comosa clumps were present on the tops of occasional large boulders.

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

Survey Notes
This site was not surveyed in 2009 and 2010

Appendix A Figure 1.15. Site dive transects for Gabo Monument (site 3210), a reference site for Cape Howe Marine National Park.

Appendix A Table 1.17. Site details for Gabo Monument (site 3210), a reference site for Cape Howe Marine National Park.

<table>
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Cape Howe Marine National Park
Gabo Harbour – Site 3211

Site Description
A non-SRMP site, Site 11 Gabo Harbour, was resurveyed opportunistically during the 2009 survey, being previously surveyed in 2001. This site was shallow and protected from swell. It was all urchin barren on granite boulder reef.

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

Survey Notes
This site was not surveyed in 2010.

Appendix A Figure 1.16. Site dive transects for Gabo Harbour (site 3211), a reference site for Cape Howe Marine National Park.

Appendix A Table 1.18. Site details for Gabo Harbour (site 3211), a reference site for Cape Howe Marine National Park.

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Cape Howe Marine National Park
Gabo NE Gulch – Site 3225

Site Description
This site was a new site in 2009 and is a reference site for Cape Howe Marine National Park. It is located on the eastern side of Gabo Island.

The substratum at this site consisted of a steep drop-off from the shore to 7 m depth with boulder fields, rocky outcrops and steps at the base. At the end of transect 4 there were patches of urchin barren.

Transect Layout
The transect ran parallel to shore. T2 and T1 headed in a straight line to the northwest from the marker, and T3 and T4 in a southeast direction, finishing just past a steep dropoff.

Survey Notes
This site was established in 2009.

Appendix A Table 1.19. Site details for Gabo NE Gulch (site 3225), a reference site for Cape Howe Marine National Park.

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Cape Howe Marine National Park
Gabo Boulder Bay – Site 3226

Site Description
This site was a new site in 2009 and is a reference site for Cape Howe Marine National Park. It is located on the eastern side of Gabo Island.

Similar to Gabo NE Gulch (site 3225), it is dominated by a mixture of *Phyllospora comosa*, *Acrocarpia paniculata*, smaller brown algae, erect coralline algae and crustose coralline algae. The substratum consisted of steep dropoffs from the shore with boulder fields and rocky outcrops.

Transect Layout
T2 and T1 curved parallel to shore, from north at the marker to northwest at the end of T1, and T3 and T4 headed in a southerly direction.

Survey Notes
This site was established in 2009.

Appendix A Table 1.20. Site details for Gabo Boulder Bay (site 3226), a reference site for Cape Howe Marine National Park.

<table>
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Cape Howe Marine National Park
Iron Prince West – Site 3212
Site Description
Larger boulders of moderate relief (1-2 m) with patches of relatively flat, slab reef. Occasional steps/ledges, dropoffs/wall and cavern habitat are also present. The Iron Prince sites are dominated by a tall canopy of *Phyllospora comosa*.

Transect Layout
T2 heads east from the marker, with T1 curving northeast from the end of T2. T3 and T4 head in a southwest direction.

Appendix A Figure 1.7. Site dive transects for Iron Prince West (site 3212), a reference site for Cape Howe Marine National Park.

Appendix A Table 1.21. Site details for Iron Prince West (site 3212), a reference site for Cape Howe Marine National Park.

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Cape Howe Marine National Park
Prince Wreck – Site 3219

Site Description
Larger boulders of moderate relief (1-2 m) with patches of relatively flat, slab reef. Occasional steps/ledges, dropoffs/wall and cavern habitat are also present. The Iron Prince sites are dominated by a tall canopy of *Phyllospora comosa*.

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

Appendix A Figure 1.8. Site dive transects for Prince Wreck (site 3219), a reference site for Cape Howe Marine National Park.

Appendix A Table 1.22. Site details for Prince Wreck (site 3219), a reference site for Cape Howe Marine National Park.

<table>
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<th>GDA latitude</th>
<th>GDA longitude</th>
<th>Zone</th>
<th>MGA Easting</th>
<th>MGA Northing</th>
<th>Depth (m)</th>
<th>Ab100</th>
<th>MPA/Ref</th>
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<td>5843236</td>
<td>6</td>
<td>N</td>
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Parks Victoria is responsible for managing the Victorian protected area network, which ranges from wilderness areas to metropolitan parks and includes both marine and terrestrial components. Our role is to protect the natural and cultural values of the parks and other assets we manage, while providing a great range of outdoor opportunities for all Victorians and visitors.

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

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