PARKS VICTORIA TECHNICAL SERIES

Community-Based Monitoring of Victoria's Marine National Parks and Marine Sanctuaries

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March 2005

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EXECUTIVE SUMMARY

This study investigated community-based monitoring in Victoria's Marine National Parks (MNPs) and Sanctuaries (MSs) from January to May 2004. The primary aim of this study was to evaluate the potential for community-based monitoring projects to assist in the collection of data for the management of Victoria's MNPs and MSs. The pilot habitats that were assessed included subtidal reefs at the Merri MS, intertidal reefs at Ricketts Point MS and seagrass beds at Corner Inlet MNP. The three main objectives for this study were to:

- Develop a template for the monitoring of marine habitats by community groups.

- Assess the quality and integrity of data collected by community volunteers.

- Determine a sustainable model for community monitoring of marine habitats.

Three standard operating procedures (SOPs) in the form of a "how to" manual, were developed for each habitat type. The SOPs were adapted from scientifically robust studies and developed in consultation with community volunteer groups by means of field trials. Volunteer feedback assisted in the final SOP design. The SOP will allow Parks Victoria Rangers to develop community-based programs within the parks. The SOPs are accessible as Parks Victoria Technical Series Numbers 16, 17 and 18.

Data collected by volunteers across the three habitat sites were assessed and compared to that collected by scientists. It was found that data quality collected by volunteers was dependent on habitat type and the type of measurement the volunteer was required to assess. Volunteer estimation measurements were highly variable across all three habitat sites, compared to quantitative data collection. Subtidal monitoring had the greatest potential for inconsistency in data collection.

Intertidal monitoring is the most sustainable of the three habitat monitoring procedures. Sustainability of community-based monitoring programs is dependent on continued support and training by the management authority of Victoria's MNPs and MSs. For the expansion of the monitoring programs to other MNPs and MSs, the management authority could expand strong relationships with the community volunteer groups.

CONTENTS

PARKS VICTORIA TECHNICAL SERIES 19

Community - Based Monitoring of Victoria's Marine National Parks and Marine Sanctuaries

INDEX OF FIGURES AND TABLES

Figures

Tables

1 INTRODUCTION

1.1 Community-Based Monitoring In Marine Protected Areas

The newly created system of Marine National Parks (MNPs) and Marine Sanctuaries (MSs) in Victoria, provide the ideal opportunity to develop a community-based monitoring (CBM) project. Given available resources, detailed monitoring of the MNPs and MSs by Parks Victoria is likely to be annual at most. Consequently, any robust and standardised information that can be gathered more frequently will benefit the management of the system. This is particularly true for factors such as exotic pests which can become a threat over a short period of time (Barrett *et al.* 2002) and require ongoing assessments.

Community involvement in the monitoring of marine protected areas (MPAs) is also of value in developing awareness and raising the profile of natural, cultural and social values among the public (Parks Victoria 2003). Meaningful involvement can also build community custodianship and help to communicate findings back to the broader community. Community participation in the investigation and monitoring of Victorian MPAs is therefore valuable to management from both an ecological and social perspective.

There is an increasing realisation of the importance of community or volunteer collected data in management programs. Volunteers can make important contributions towards management programs (Foster-Smith & Evans 2003; Darwall & Dulvy 1996). Indeed, volunteers and community groups have already made significant contributions to scientific knowledge through participation in a range of studies, including involvement in seagrass monitoring through Seagrass–Watch in Queensland (Campbell & McKenzie 2001), Watching the Seagrass Grow in New South Wales (Valk 2003), Reef Check (Hodgson *et al.* 2003), and the Atlas of Australian Birds (Blakers *et al.* 1984).

The advantages of using community volunteers can increase the level of public awareness of ecological problems through active participation in ecological survey work; and the provision of a survey program requiring simple and inexpensive techniques which can be continued in the long term using local expertise and financing (Darwall & Dulvy 1996). Such programs can empower local communities with the ability to actively participate in the preservation of their local environment. Furthermore, CBM projects have the potential to create partnerships between groups that may otherwise not occur (e.g. between researchers, local environment/community groups, and fisheries and management organizations) and to encourage "stewardship" in local communities (Wescott 2002).

This project evaluated the potential of community-based monitoring projects to assist in the management of Victorian MPAs. The project developed a template for the monitoring of marine habitats by community groups that will act as a standard, allowing comparability

across sites and different habitats. It assessed the data collected by volunteers and compared it to that collected by scientists to understand relative data quality. This project also investigated participant attitudes to identify a monitoring regime that may act as a model to encourage sustainability of CBM projects in Victoria's MPAs.

1.2 Project Objectives

The primary aim of this study was to evaluate the potential of CBM projects to assist in collection of data for the management of MPAs. The habitats (and sites) assessed were subtidal rocky reefs (Merri MS), intertidal rocky reefs (Ricketts Point MS), and seagrass beds (Corner Inlet MNP). The major objectives of this study were to:

1. Develop a template for the monitoring of marine habitats by community groups

A template for the monitoring of marine habitats in Victoria's MPAs by community groups was developed from the Parks Victoria standard operating procedures for subtidal and intertidal reef monitoring and existing protocols for monitoring of seagrass habitats. These operating procedures were modified for ease of use and execution by community group members and produced in consultation with them. The development of the templates produced a standard method to allow comparability between sites and to ensure that there was a scientifically robust approach for all community monitoring projects. The development of the template incorporated four main aspects:

- Development of appropriate methods for the capacity of community groups to undertake a monitoring program.

- Identify species/taxonomic groups that can be easily monitored by community groups.

- Production of training resources to assist in improving species identification and understanding of monitoring protocol.

- Needs and capacity of community groups to undertake data management.

2. Assessment of quality and integrity of data collected by community volunteers

The data collected by community groups during an actual monitoring program was tested. Community groups were trained in monitoring techniques and species identification through presentations and field exercises. Volunteer data was compared with that collected by trained scientists to evaluate its quality and integrity. Improvements were made to the monitoring protocol where necessary. The following aspects were addressed:

- Species identification capacity of community groups.

- Ability of volunteers to accurately assess species distribution and abundance.

- Comparability of data collected by community group volunteers with that collected by trained scientists.

3. Determining a sustainable model for community monitoring of marine habitats

Community group volunteer attitudes were assessed to assist in the development of a sustainable model for CBM of marine habitats in Victoria's MPAs. It assessed the best practices to maintain energy, interest and involvement of community groups in a marine habitat. The following aspects were addressed:

- The motivation for participants in CBM programs.

- The suitability of the CBM template.

- The applicability of the CBM template across different habitats and sites.

1.3 Project summary

The CBM project was based upon the input and feedback from volunteers to create a user-friendly monitoring method, for a particular habitat. In conjunction with a Parks Victoria Ranger, community groups will be able to use the designed monitoring methods in any of Victoria's MNPs and MSs. Despite the obvious advantages, the use of volunteers is often criticised on the grounds that information collected will be unreliable (Darwall & Dulvy 1996). This study assessed the ability of community volunteers to accurately monitor the three habitat types.

2 METHODS

CBM proceedures were developed and adapted from existing scientific methodologies. Volunteers from four community groups participated in training sessions and trials of the templates. These groups were associated with specific MPAs: the Deakin University Underwater Club monitored subtidal rocky reefs at Merri MS, Marine Care – Ricketts Point Friends Group monitored intertidal rock platforms at Ricketts Point MS, and Friends of The Prom and S.E.A.L. Diving Services monitored seagrass beds at Corner Inlet MNP. These MPAs and associated groups were chosen as a representative system of monitoring to be undertaken by community groups in regional, urban and rural areas, respectively, across Victoria. Data collected by scientists were compared to that collected by volunteers to assess volunteer-collected data accuracy and integrity. The scientists involved in data collection had postgraduate experience in marine science research. It was imperative for the integrity of results to have scientists who were familiar with undertaking scientific procedures employed for statistically sound monitoring. A volunteer was a person of the general public involved in a community group associated with the MPA who may or may not have experience in marine monitoring. Feedback on template suitability, training and sustainability of the monitoring program was gathered through volunteer surveys.

2.1 Community Participation In Habitat Monitoring

2.1.1 MERRI MARINE SANCTUARY - SUBTIDAL ROCKY REEF MONITORING

The Merri MS is located in Warrnambool, situated in western Victoria. The mouth of the Hopkins River enters the MS. The 'Deakin University Underwater Club' participated in the subtidal rocky reef monitoring. This is an active recreational dive group with approximately 100 members, consisting mainly of undergraduate and postgraduate students of Deakin University, Warrnambool. The president of the group trained 25 members in an accredited PADI scientific dive course to assist with this study's monitoring.

Training Structure

Training of volunteers comprised of two components: a PADI scientific dive training course, and a macroalgae identification course.

The PADI scientific course was run over one weekend by Phillip Kerr, PADI dive instructor of Aqua Agri Enterprises and President of the Deakin University Underwater Club. All divers had internationally recognised 'open water' qualifications as a minimum however, the scientific dive course was necessary to ensure volunteer competency and safety. The scientific dive course trained and assessed volunteers in underwater identification, size estimation of fish and invertebrates, and point-count estimation of macroalgae cover. On the first day divers were trained and tested in a pool, whilst the second day saw divers

undertaking two practice monitoring dives on subtidal reefs at different locations. On completion of this course volunteers undertook subtidal monitoring in the Merri MS for this study.

The subtidal habitat has a great diversity of macroalgae species, many being difficult to identify. The macroalgae identification course gave volunteers an introduction on identification of the broad range of algal species found in the Merri MS. This course was presented by Dr. Alecia Bellgrove, lecturer at Deakin University, Warrnambool Campus. Volunteers were initially trained in the laboratory using herbarium pressings before developing their skills further in a field excursion to the Merri MS.

Each volunteer was provided with a Victorian 'Reef Watch' field guide comprising a set of laminated photo identification sheets. Volunteers referred to this guide throughout the PADI scientific dive course, macroalgae identification course and during monitoring. Other reference books were on hand for identification of unknown fish and macroalgae species (*See References*).

Site Selection

Within the Merri MS, two rocky subtidal reefs were selected. A subtidal rocky reef adjacent to the sanctuary (outside of the MS) was selected as a reference site. Site selection was based upon criteria outlined in the Parks Victoria Subtidal Monitoring (Technical Series Number 18) and was chosen based upon the likelihood of potentially threatening process of illegal harvesting and collection of animals.

Subtidal Rocky Reef Monitoring

Scientists and volunteer divers from the Deakin University Underwater Club monitored two transects within the Merri MS and one transect at the reference site adjacent to the MS. The standard monitoring methods below are summarised from the manual (Koss *et al.* 2005). These methods were adapted from the Standard Operational Procedure for Subtidal Reef Monitoring (Edmunds & Hart 2003) commissioned for Parks Victoria.

A 100m transect line was surveyed by four divers, working in 'buddy pairs'. Buddy dive pairs consisted of one scientist and one volunteer. The volunteer collected data independently of the scientist along the same transect line and quadrat placements allowing for comparison and analysis of the data collected.

Four sets of data were collected for each 100m transect line.

1. Large fish and cephalopods. All fish and cephalopods in the water column, 2m either side of the transect line, were counted. The size of individual fish was estimated to the nearest 10cm.

2. Cryptic fish and large invertebrates. All cryptic fish and large invertebrates within and below the macroalgae canopy and under ledges were counted 1m either side of the transect line. This included under ledges and within crevices. Sizes were estimated to the nearest 2.5cm.

3. Algae. Algal cover was sub-sampled at 10m intervals along the transect using 0.5m x 0.5m quadrats. Quadrats had a 7 x 7 string grid which was used for estimating the cover of algal species. Within each quadrat the percentage cover of each species of macroalgae was estimated by counting the number of intersecting grid points falling directly above them.

4. Invertebrates. Invertebrates were sub-sampled at 10m intervals along the transect using 0.5m x 0.5m quadrats. All visible invertebrates were counted within each quadrat.

Each 'buddy pair' was solely responsible for recording either large fish/cephalopods and algae (1 & 3), or cryptic fish and invertebrates (2 & 4). This reduced the workload on individual divers to a manageable level. Data was used to calculate parameters such as diversity, species richness and species abundances. This was compared between volunteers and scientists to determine the accuracy of volunteers' results.

2.1.2 RICKETTS POINT MARINE SANCTUARY - INTERTIDAL ROCKY REEF MONITORING

Ricketts Point MS is situated in Port Phillip Bay, Victoria. 'Marine Care – Ricketts Point Friends (MCRP) Group' participated in intertidal rocky reef monitoring. This group has approximately 50 members and was formed during the establishment of the Ricketts Point MS in 2002. MCRP is an active community group in the MS, initiating their own rocky shore studies and other educational and awareness building activities.

Training Structure

Volunteers attended a presentation outlining the monitoring methods, their implementation and identification of locally common intertidal species presented by Associate Professor Geoff Wescott of Deakin University. The presentation was followed up by a quick familiarisation of some of the species in the field.

 Each volunteer was provided with the field guide, *Life on the Rocky Shores of South-Eastern Australia* (Quinn *et al.* 1992) to aid identification. Other reference books were present for assisting with identification of unknown species (*See References*).

Site Selection

Within Ricketts Point MS, two rocky intertidal reefs were selected for this study. These intertidal sites included Teahouse Reef and Triangle Reef (situated in front of the Beaumauris Life Saving Club). The intertidal rocky reef at Black Rock (outside of the MS) was selected as a reference site (situated over the breakwater wall adjacent to the pier). Site selection was based upon criteria outlined in the Parks Victoria Technical Series No. 17 (Koss *et al.* 2005) and were chosen based upon the likelihood of threatening processes occurring; such as trampling, caused by foot traffic from school groups and recreational users, illegal collection and harvesting, and freshwater influxes from stormwater drains.

Intertidal Rocky Shore Monitoring

Monitoring took place at each site on a single low tide. The methods call for five transects per site, though due to logistical constraints, only four were completed at Triangle Reef, and three at Black Rock. The monitoring methods were derived from the Standard Operational Procedure for Intertidal Reef Monitoring (Hart *et al.* 2005) commissioned for Parks Victoria.

Transect baselines were established at each site. Five transects were positioned evenly between these baselines, running along the gradient of the shore. Each transect was partitioned into five evenly spaced 2m x 2m sampling locations. A 0.5m x 0.5m quadrat was randomly placed within each sampling location.

Four sets of data were collected for each quadrat at the five sampling locations along the transect line.

1. Invertebrate counts. Individuals of each species of invertebrate present were counted to give a measure of abundance/density.

2. Gastropod shell length. The shell lengths of five individuals from each of five common gastropod species were measured to identify the size structure of their population.

3. Macroalgae and aggregated invertebrate cover. Quadrats had a 7 x 7 string grid which was used for estimating percentage cover of algal and highly aggregated species. The abundance/density of algae and highly aggregated invertebrates (e.g. tube worms) were measured by counting the number of intersecting grid points on the quadrat that fell directly above each species.

4. Microhabitat description. The microhabitats (horizontal/flat, vertical/crevice, rock pool, boulders or sand) present in each quadrat were recorded.

Each transect was surveyed by one or more volunteers and a scientist. Data was collected independently and used to calculate information such as diversity, species richness, species

abundances, and mean shell size.   This data was compared between volunteers and scientists to determine the accuracy of volunteers' results.

2.1.3 CORNER INLET MARINE NATIONAL PARK - SEAGRASS MONITORING

Corner Inlet MNP is located in South Gippsland, Eastern Victoria. The inlet is surrounded by agriculture, hobby farms and Wilsons Promontory National Park. Two community groups, 'Friends of the Prom' and 'S.E.A.L. Diving Services', participated in the monitoring of seagrass beds in Corner Inlet MNP. Friends of the Prom (FOP), was established in 1979 and have approximately 250 members. This group has working bee weekends throughout the year at Wilsons Promontory National Park with most members travelling from Melbourne.

S.E.A.L. Diving Services is a recreational dive group based in Traralgon, South Gippsland and have approximately 70 members. This group became involved during the later part of the study. Two members participated in the monitoring during the winter, despite the lower temperature. The group's active participation in marine monitoring led to the possible eradication of the introduced Northern Pacific Seastar in Anderson Inlet, Victoria.

Training Structure

Volunteers attended a presentation outlining the aims of the monitoring, monitoring methodologies, and their implementation. This was followed by practise of the monitoring methods on a grass field and an intertidal seagrass bed. Volunteers were provided with laminated field summary sheets and percentage cover visual assessment guides as aids in the field.

Site Selection

Corner Inlet MNP was selected due to the unique beds of *Posidonia australis,* the largest stand in Victoria (O'Hara *et al.* 2002).   Nineteen subtidal sites were selected by visual assessment from a boat for possible monitoring. These sites ranged from dense to sparse *P. australis* beds, to shallow patches of mixed seagrass beds with *Heterozoestera tasmanica*. Reference sites were *P. australis* seagrass beds within Corner Inlet, adjacent to the MNP. Threats associated with these sites included catchment runoff, boat anchor and propeller damage, and at the time of sampling, recreational and commercial fishing.

Seagrass Monitoring

The standard monitoring methods below are summarised in the Parks Victoria Technical Series No. 16 (Koss *et al.* 2005). The methods were derived from baseline monitoring of *P. australis* seagrass beds in Corner Inlet (O'Hara *et al.* 2002), and Queensland Seagrass-Watch (McKenzie and Campbell 2001) and adapted for use by community groups. Feedback from community group volunteers resulted in fine tuning these methods to create a more user friendly approach to monitoring.

Monitoring at each site required three transects, each 50m in length and 25m apart. A 1m x 1m quadrat, divided into 8 sub-quadrats (0.5m x 0.25m), was sampled every 5m along the transect line.

Five sets of data were collected every 5m for each quadrat.

1. Substrate type. A description of substrate type that the seagrass was growing in was noted. Substrate type was defined as: Fine Sand (F), Coarse Sand (C), Mud (M), Fine Silt (S), Shell Grit (SG) and Gravel (G).

2. Percentage seagrass cover was estimated for the whole quadrat. The percentage cover visual assessment guides were used to class the seagrass as Sparse, Medium, Dense or Very Dense.

3. Epiphyte percentage cover. Three random sub-quadrats were chosen to measure epiphyte growth. In each of these sub-quadrats epiphyte cover was estimated in two steps; a) the percentage cover on a random leaf was estimated; b) epiphyte percentage cover was estimated for the entire sub-quadrat.

4. Seagrass shoot length. For each sub-quadrat, three random shoots were measured from base to tip to the nearest 1 cm using a measuring tape.

5. Seagrass shoot density. For each sub-quadrat, three plants were chosen randomly and the number of shoots for each plant was recorded.

Each transect was surveyed by one volunteer and one scientist. Data was collected independently and used to calculate parameters such as mean shoot length, shoot density and epiphyte cover. These values were compared between volunteers and scientists to determine the accuracy of volunteers' results.

2.2 Community - Based Monitoring Evaluation Survey

This aspect of the project investigated the attitudes of CBM of MPAs. This assisted in developing a suitable model for CBM of marine habitats in Victoria's MPAs. If community groups are to adopt the monitoring techniques, it is important to identify and assess levels of motivation, interest and involvement for volunteers. Two separate groups were distinguished within the community groups; volunteers from the community groups who participated in the monitoring, and volunteers who did not participate specifically in this study but are active in other activites within their community group.

2.2.1 Survey Design

Input and feedback relating to CBM in MPAs by community group volunteers were collected with two written surveys; one directed at volunteers who participated in the monitoring

exercises, and one for the remaining members of the community groups who did not participate.

Two key issues were addressed:

1. The motivation for participants in CBM.

2. Suitability and sustainability of CBM in Victoria's MPAs.

A cover letter, consent form and a reply paid envelope were included with each survey. The covering letter outlined the purpose of the study, use of the consent form, issues of confidentiality and the required return date of the survey. A book prize was offered to encourage volunteers to return the survey. A reminder letter was distributed by mail 3 – 4 weeks after community members received the surveys to encourage volunteers to complete and return the survey.

2.2.2 Data Collection

Community Group Participant Volunteers

This group consisted of volunteers who participated in the monitoring of their respective habitat. It was important to identify if the training was adequate and if the monitoring was easy to undertake and sustainable in the long term. Volunteer participants received the survey following the first monitoring session. The 7 page survey consisted of three sections designed to explore the issues associated with community-based monitoring.

1. Member Profile. A range of information on participants was collated including, demographic data, level of education, occupation and income. Participants were surveyed in relation to their reasons for participating in the project, time commitment and involvement in other community activities.

2. Training. Participants were questioned on the quality of the training as an introduction for monitoring. Information collected included, time length, clarity and ease of understanding the training.

3. Monitoring. Topics ranged from ease of monitoring methods, length of time to undertake monitoring, replication of the monitoring procedures, participant enjoyment of monitoring and broader values of the monitoring. The volunteer could only complete this section after participation in at least one monitoring session.

Community Group Non-Participant Volunteers

This group consisted of members of the community groups who did not participate in the specific monitoring themselves on these occasions. Non-participant volunteers received the

survey by mail. The survey consisted of two sections designed to explore key issues for non-participation:

1. Member Profile: A range of information on participants was collated including demographic data, level of education, occupation and income.

2. Interest in Monitoring Activities: Participants were questioned on their reasons for not participating in the monitoring, and involvement in other community activities. It also explored issues related to non-participation and ways to encourage participation in the future.

2.3 Parks Victoria Ranger Evaluation Survey

Parks Victoria Rangers responsible for the management of Victoria's MPAs participated in a one day seminar focussing on CBM. A total of 19 Parks Victoria Rangers participated in this survey. Rangers were presented with results of the project undertaken by the community groups in the MPAs. This was followed by a session of trial monitoring of the three protocols. At the completion of the seminar, the rangers were asked to complete a survey based on their perceptions of CBM (*See Appendix 1*).

2.4 Data Analysis of Monitoring surveys

Each volunteer-scientist pair (transect) was generally considered a replicate with the majority of tests performed at this scale. As only one transect was completed at each subtidal or seagrass site, these sites were considered replicates. To improve the power of the intertidal tests, transects from all sites were pooled together. This technique was considered appropriate only when no effect of the different sites was detected using ANOVA analysis. Assumptions of normality and homogeneity of variances were checked using box plots and residual plots, respectively (Quinn & Keough 2002). Data were square-root or fourth-root transformed to meet assumptions where necessary. Univariate analyses were performed on SPSS version 11.5.

Univariate comparisons between volunteers and scientists were made for a range of parameters used in ecological monitoring (Barrett *et al.* 2002; Clarke & Warwick 1994; Edmunds *et* al. 2003; O'Hara *et al.* 2002). For subtidal and intertidal monitoring this included:

- species richness (number of species);

- species diversity; and

- abundance of dominant organisms.

Species diversity takes into account the relative abundances of all the species and was measured using the Shannon-Wiener diversity index (Clarke & Warwick 1994). It was

examined separately for groups of organisms recorded with different techniques (eg. point count or abundance count). Dominant species investigated for abundance measurements were *Cystophora* spp., *Halopteris* spp., *Plocamium* spp. and encrusting coralline algae from subtidal surveys and *Enteromorpha* spp., *Hormosira banksii, Corallina* spp., *Galeolaria caespitosa, Austrocochlea constricta, Turbo undulatus, Lepsiella vinosa and Cellana tramoserica* from intertidal surveys. For intertidal results, length measurements of common gastropods were also compared between volunteers and scientists. Parameters investigated for seagrass monitoring included estimates of:

- epiphyte cover;

- shoot density; and

- shoot height.

The mean difference between volunteers' and scientists' measurements was calculated for each subtidal, intertidal and seagrass parameter. The significance of each mean difference was examined with a one-sample t-test, testing the null hypothesis that the difference equalled 0, i.e. no difference between volunteers' measurements and scientists'. Tests were two-tailed in all cases except for abundance and gastropod size. These were tested using the absolute difference between volunteers and scientists, allowing non-directional variation to be detected (the level of accuracy required for examining within site variation). Power analysis of non-significant results was based on detecting a 10% difference between scientists and volunteers.

Where abundance measurements of particular species (as listed above) were tested, a volunteer error margin was also calculated. This error margin is a percentage value indicating the mean discrepancy between volunteers' measurements of abundance and the actual abundance (as measured by scientists):

- Error Margin (%) = (Absolute Difference / Abundance) x 100

Where *Absolute difference* equals *volunteer measurement – scientist measurement*, ignoring direction. *Abundance* is the abundance as measured by scientists. The larger the number, the greater the level of inaccuracy (eg. error margin = 50%, volunteers' measurements are on average 50% smaller or larger than the actual value). Error margins were calculated at two scales. Firstly, error margins were calculated for each individual quadrat before being averaged across all quadrats (in which the species occurred). This gave an estimate of the mean level of error associated with any given quadrat (in which the species occurs). At a broader scale, error margins were calculated from abundance data that had first been averaged across whole sites (for intertidal data) or all sites/transects (for subtidal data). This

gave the level of error associated with the overall abundance of a particular species as measured by volunteers.

A similar measure termed *observer bias* (Campbell and McKenzie, 2001) was calculated for volunteers' estimates of epiphyte cover of seagrass at the Corner Inlet site according to the formula:

- (Volunteer estimate of % cover / Scientist estimate of % cover) x 100.

Multivariate analyses of species assemblages using non-metric multidimensional scaling (NMDS) and ANOSIM (Clarke & Warwick 1994) were conducted using Primer version 5.2 software. Limited results from the subtidal habitat restricted multivariate analyses to intertidal data only.   NMDS was based on Bray-Curtis similarity matrices after fourth-root transformation of abundance data to reduce the dominance of very common species (Clarke & Warwick 1994, Quinn & Keough 2002).   NMDS is an ordination technique that plots samples (in this case transects) according to the similarity of the species composition and abundance, such that points closer together are more similar in their assemblages than more distant points. This is a very useful technique for describing patterns between samples (Clarke and Warwick 1994, O'Hara *et al.* 2002) and has the advantage (compared to richness/diversity indices) of taking into account all of the species present and their abundances at the same time.   Statistical analyses of differences between groups were performed using ANOSIM (Analysis of Similarity), a non-parametric equivalent of ANOVA based on Bray-Curtis rank similarities.

Examination of survey data was limited to descriptive statistics and qualitative analysis due to small sample sizes.

3 RESULTS

The accuracy and integrity of volunteer data varied across habitat types. Analysis was limited for the seagrass and subtidal habitats as collection of monitoring data was restricted due to unsuitable weather and difficulty in recruiting volunteers at short notice.

3.1 Merri Marine Sanctuary - Subtidal Rocky Reef Monitoring

Monitoring data was collected on two separate occasions (29 April 2004, 11 May 2004) by 5 volunteer-scientist pairs. Three transects were surveyed though cryptic fish and invertebrate data were not collected on the final transect due to a lack of divers. Two transects were surveyed inside the MS and one adjacent to it, each taking approximately 45-50 minutes to complete. The difference between volunteers and their paired scientist was averaged across all transects and the small sample size should be considered when interpreting the data. Fish length estimates were not compared because of limited data.

3.1.1 Species Richness and Diversity

A total of 43 species or taxa were recorded in and adjacent to the Merri MS (Table 1). Thirty-nine species were recorded by scientists, whilst 36 were recorded by volunteers. There was no significant difference in the mean species richness recorded by volunteers and scientists ($t = 0.866$, d.f. = 2, $P = 0.478$; Figure 1), although the test had low power (0.102).
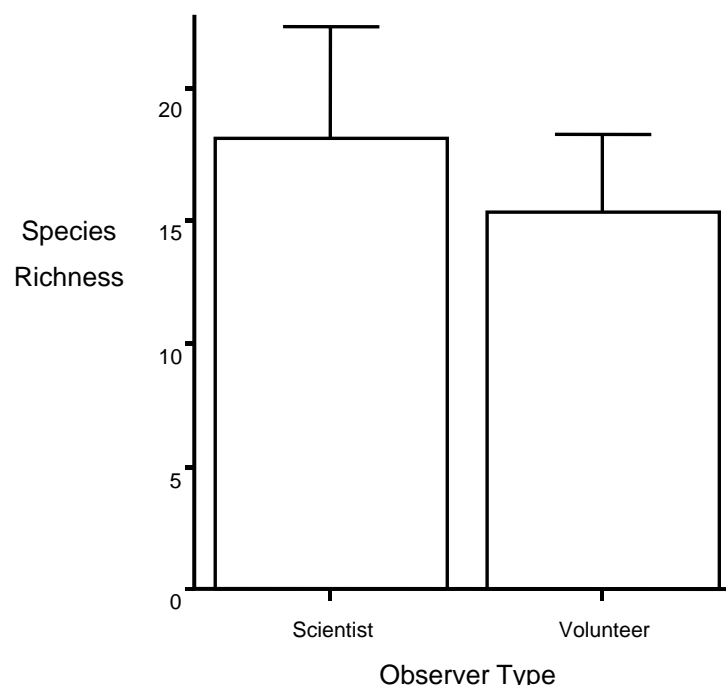
Figure 1 Mean species richness (±1 SE) measured by scientists and volunteers at Merri MS.

Table 1 Taxa recorded in and adjacent to the Merri MS by scientists and volunteers. Common names sourced from Edgar (1997).

Common Name	Scientific Name	Recorded by:	
		Scientists	Volunteers
Blue-throated Wrasse	*Notolabrus tetricus*	✓	✓
Herring Cale	*Odax cyanomelas*	✓	✓
Long-finned Pike	*Dinolestes lewini*	✓	✓
Magpie Perch	*Cheilodactylus nigripes*	✓	✓
Purple Wrasse	*Notolabrus fucicola*	✓	✗
Sandager's Wrasse	*Coris sandageri*	✓	✓
Sea Carp	Aplondactylidae	✓	✓
Sea Sweep	*Scorpis aequipinnis*	✓	✓
Scalyfin	*Parma victoriae*	✓	✓
Senator Wrasse	*Pictilabrus laticlavius*	✓	✗
Smooth Stingray	*Dasyatis brevicaudata*	✓	✓
Zebrafish	*Girella zebra*	✓	✗
Brown Alga	*Colpomenia* spp.	✓	✓
Brown Alga	*Cystophora* spp.	✓	✓
Brown Alga	*Halopteris* spp.	✓	✓
Brown AlgaS	*Padina* spp.	✓	✗
Brown Alga	*Sargassum* spp.	✗	✓
Brown Alga	*Zonaria* spp.	✓	✓
Bull Kelp	*Durvillea potatorum*	✓	✓
Common Kelp	*Ecklonia radiate*	✓	✓
Filamentous Brown	Phaeophyta	✓	✓
Giant Kelp	*Marcrocyctis angustifolia*	✓	✓
Branching Coralline	Corallinaceae	✓	✓
Encrusting Coralline	Corallinaceae	✓	✓
Filamentous Red	Rhodophyta	✓	✓
Red Alga	*Laurencia* spp.	✓	✓
Red Alga	*Plocamium spp*	✓	✓
Green Alga	*Caulerpa brownie*	✓	✗
Green Alga	*Caulerpa longifolia*	✓	✓
Green Alga	*Caulerpa* spp.	✓	✗
Green Alga	*Chaetomorpha darwinii*	✗	✓
Green Alga	*Codium pomoides*	✓	✓
Filamentous Green	Chlorophyta	✓	✓
Abalone	*Halotiotis* spp.	✓	✓
Top Shell	*Austrocochlea* spp.	✓	✓
Warrener	*Turbo undulates*	✓	✓
Encrusting Sponge	Porifera	✓	✓
Golfball Sponge	*Tethya* spp.	✓	✗
Anemone	Actiniaria	✓	✓
Sea Urchin	Echinoidea	✓	✓
Crayfish	*Jasus edwardsii*	✗	✓

When the results are separated into groups based on data set (algae, fish, etc), volunteers seem to underestimate species richness for all groups of organisms (Table 2). In many instances a species was recorded in a quadrat by a scientist, but not by the volunteer. However, there were also several cases where a volunteer recorded a species that the scientists did not. Volunteers' measurements of diversity were also low compared to scientists (Table 3). Although these differences were not statistically significant, the power was too low to confidently accept the null hypothesis (no difference).

Table 2 Mean species richness recorded by volunteers and scientists in the Merri MS, categorized by data set. † Unreplicated group

Data Set	Mean Richness (SE)	
	Volunteer	Scientist
Algae	8.7 (2.9)	10.0 (2.1)
Large Fish & Cephalopods	4.5 (0.5)	5.5 (0.5)
Invertebrates †	3.0	3.5
Cryptic Fish & Large Invertebrates	4.0 (1.0)	5.0 (0.0)

Table 3 Measurements of species diversity in the Merri MS, separated by data set and tested for differences between volunteers and scientists. † Insufficient replicates to test.

Data Set	Mean Diversity (SE)		t-test Statistics			
	Volunteer	Scientist	t-value	d.f.	P-value	Power
Algae	1.61 (0.27)	1.73 (0.17)	1.08	2	0.395	0.164
Large Fish & Cephalopods	1.19 (0.04)	1.47 (0.10)	1.96	1	0.301	0.051
Invertebrates†	0.60	0.68				
Cryptic Fish & Large Invertebrates	1.02 (0.20)	1.30 (0.13)	0.85	1	0.551	0.039

3.1.2 Accuracy of Species Abundances

Four species of algae were recorded in a sufficient number of transects to allow comparison of volunteers' measurements of percentage cover to those of scientists (Figure 2). Only quadrats in which the species was recorded were used in analysis. Those in which the species was not present were not relevant in investigating the ability of volunteers to record abundance. The difference between percentage cover estimates of volunteers and scientists was significant for all four species of algae (Table 4).
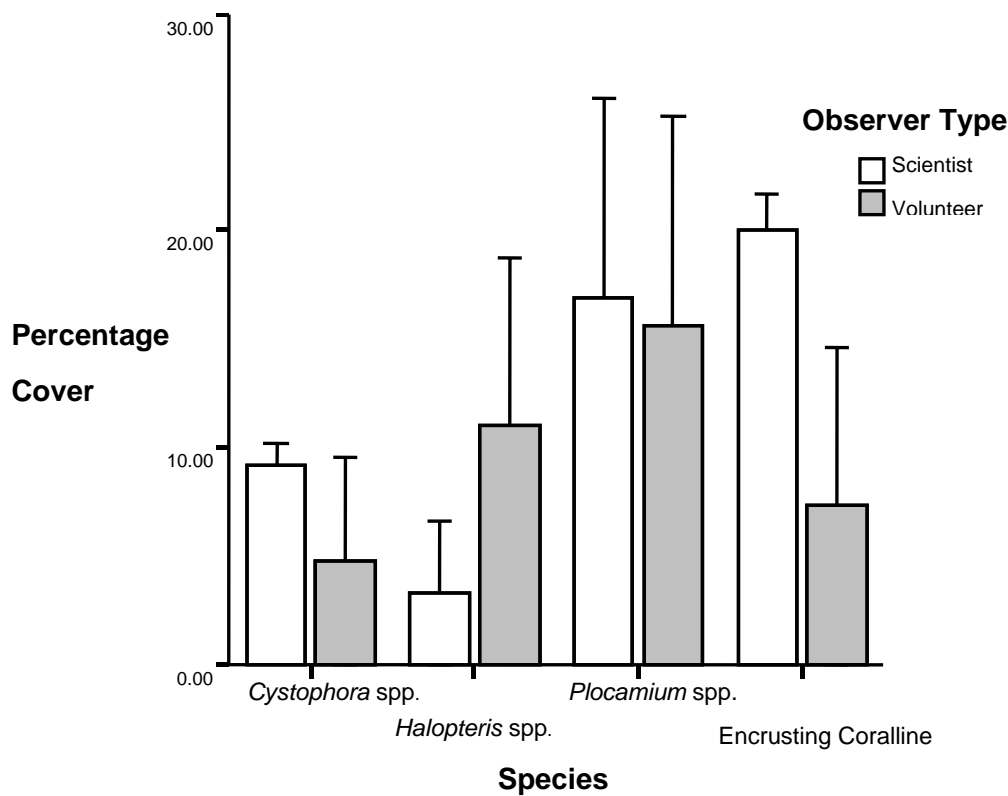
Figure 2 Mean percentage cover (±1 SE) of common algae along subtidal transects (in quadrats where they were recorded) for both volunteers and scientists.

Table 4 Mean (absolute) difference in algal percentage cover measured by volunteers and scientists. *t*-tests examine if this value is significantly different to 0. * $P < 0.05$, ** $P < 0.01$.

Species	Mean Difference (SE)	*t*-value	d.f.	*P*-value
Cystophora spp.	8.7 (8.1)	10.69	2	0.005**
Halopteris spp.	14.3 (5.9)	4.87	2	0.020*
Plocamium spp.	9.1 (1.1)	4.37	2	0.025*
Encrusting Coralline	16.3 (2.1)	7.89	2	0.008**

These differences can be expressed as error margins which are relative to the abundance of the species. As Table 5 shows, the selected species of algae had high error margins, indicating volunteer measurements were considerably different to actual abundances. *Halopteris* spp. was excluded from this examination as in 2 out of 3 instances of the species, scientists did not record cover but volunteers had, and it is uncertain whether this is due to volunteer misidentification, or observational error on behalf of the scientist.

Table 5 Error margins of volunteers' estimates of algal abundance. Values represent the mean difference (±) between volunteers' results and the actual abundance for quadrats in which the species occurs.

Species	Error Margin (%)	SE	n
Cystophora spp.	94.9	5.1	3
Plocamium spp.	79.6	23.5	3
Encrusting Coralline	84.0	16.0	3

The values in Table 5 relate to the accuracy of volunteers at the quadrat level – i.e. how much error can be expected from any given quadrat. At a broader scale, all quadrats from all sites/transects were averaged to give the 'overall' abundance for that species across the three sites/transects (Figure 3). This averages out fluctuations between volunteers and scientists and gives an indication of the accuracy of using several volunteers to record site-scale abundances. As Table 6 shows, with three volunteers averaged across all quadrats and sites, estimates of *Cystophora* spp., *Plocamium* spp. and encrusting coralline have a lower error margin than when analysed at the finer scale of quadrats (Table 5). However, the error margins for *Halopteris* spp. and encrusting coralline species still show volunteers' records are considerably different to scientists'.
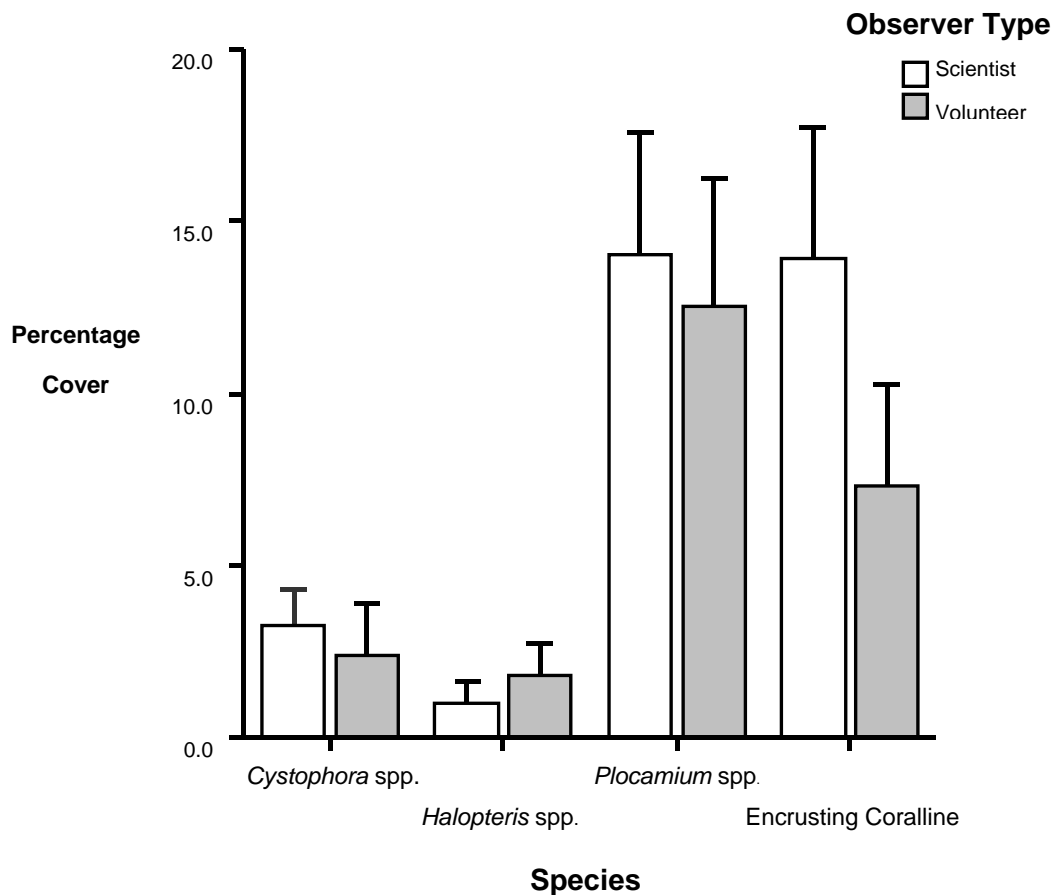
Figure 3 Mean percentage cover (±1 SE) of algae across all quadrats and sites for both volunteers and scientists (n = 30)

Table 6 Error margins of dominant algae representing the mean difference (±) between volunteers' results and the actual abundance when abundance is calculated over all 3 sites/transects.

Species	Error Margin (%)
Cystophora spp.	27.2
Plocamium spp.	11.3
Halopteris spp.	80.0
Encrusting Coralline	48.9

3.2 Ricketts Point Marine Sanctuary – Intertidal Rocky Reef Monitoring

Three sites were surveyed by a total of 13 volunteers. Four transects were run at Triangle Reef, Ricketts Point MS (9 May 2004), 5 at Teahouse Reef, Ricketts Point MS (22 May 2004) and 3 at the reference site Breakwall Reef, Black Rock (23 May 2004).

3.2.1 Species Richness and Diversity

A total of 30 species were recorded throughout the intertidal monitoring (Table 7). While scientists observed all 30 of these, volunteers recorded only 29, missing one individual of *Onchidella patelloides* (Ocean beach slug).

The accuracy of volunteers' species richness measurements (difference between volunteers' measurements and scientists') did not vary between sites when tested with an ANOVA ($F_{2,9}$ = 0.085, P = 0.920). Pooled across all sites, volunteers recorded a mean species richness very similar to that recorded by scientists (Figure 4). The difference between their measurements was not significant (t = 0.713, d.f. = 11, P = 0.491), with a power of 0.628..
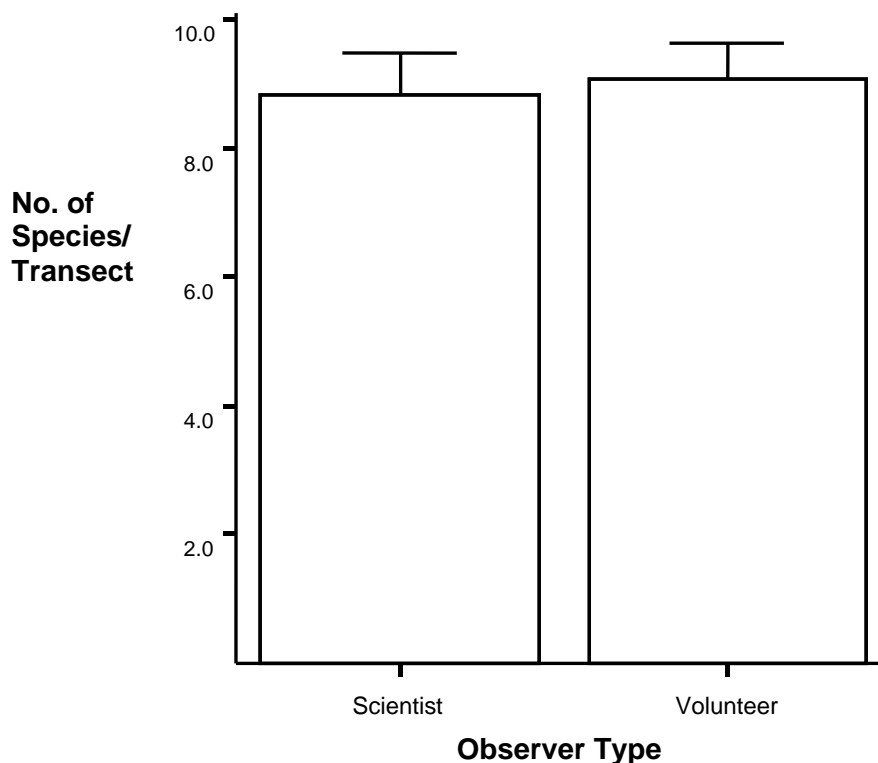
Figure 4 Mean species richness (±1 SE) of intertidal transects, pooled across all sites and shown for both volunteers and scientists.

Table 7 Intertidal species recorded by scientists and/or volunteers and at what site they occurred. R1 = Triangle Reef, Ricketts Point MS, R2 = Teahouse Reef, Ricketts Point MS, B1 = Breakwall Reef, Black Rock. Common names sourced from Quinn et al. (1992).

Common Name	Scientific Name	Recorded by		Recorded in		
		Sci	Vol	R1	R2	B1
Green Bait Weed	*Enteromorpha* spp.	✓	✓	✓	✓	✓
Sea Lettuce	*Ulva* spp.	✓	✓	✓	✓	✓
Neptune's Necklace	*Hormosira banksii*	✓	✓	✓	✓	✗
Turfing Red Algae	*Capreolia implexa*	✓	✓	✓	✓	✓
Coralline Algae	*Corallina* spp.	✓	✓	✓	✓	✓
Encrusting Coralline	Corallinaceae	✓	✓	✓	✗	✗
Red Algae	*Laurencia* spp.	✓	✓	✓	✗	✓
Sydney Coral	*Galeolaria caespitosa*	✓	✓	✓	✓	✓
Chiton	Polyplacophora	✓	✓	✗	✗	✓
Black Nerite	*Nerita atramentosa*	✓	✓	✗	✗	✓
Conniwink	*Bembicium melanostomum*	✓	✓	✓	✓	✓
Conniwink	*Bembicium nanum*	✓	✓	✗	✗	✓
Ribbed Top Shell	*Austrocochlea constricta*	✓	✓	✓	✓	✓
Warrener	*Turbo undulates*	✓	✓	✓	✓	✓
Variegated Limpet	*Cellana tramoserica*	✓	✓	✓	✓	✓
False Limpet	*Siphonaria diemenensis*	✓	✓	✓	✓	✓
Tall Ribbed limpet	*Patelloida alticostata*	✓	✓	✗	✗	✓
Wine-mouthed lepsiella	*Lepsiella vinosa*	✓	✓	✓	✓	✓
Mudwhelk	*Batillaria australis*	✓	✓	✗	✓	✗
Spengler's Rock Whelk	*Cabestana spengleri*	✓	✓	✗	✗	✓
Lineated Cominella	*Cominella lineolate*	✓	✓	✓	✓	✓
Ocean Beach Slug	*Onchidella patelloides*	✓	✗	✗	✗	✓
Scallop	Bivalvia	✓	✓	✓	✗	✗
Mussel	Mytilidae	✓	✓	✓	✓	✓
Beaked Mussel	*Brachidontes rostratus*	✓	✓	✗	✗	✓
Common Sea Star	*Patiriella calcar*	✓	✓	✗	✗	✓
Waratah Anemone	*Actinia tenebrosa*	✓	✓	✓	✓	✓
Anemone	*Anthothoe albocincta*	✓	✓	✗	✗	✓
Little Shore Crab	*Brachynotus spinosus*	✓	✓	✓	✗	✗
Barnacle	Cirripedia	✓	✓	✗	✗	✓

Species diversity was examined separately according to the method used to measure abundance (count or percentage cover). There was no effect of site on the accuracy of diversity measurements for organisms that were counted ($F_{2,9}$ = 0.654, P = 0.543) or those that had percentage cover estimated ($F_{2,9}$ = 2.064, P = 0.183). This allowed sites to be pooled, with t-tests results indicating no significant difference between volunteers' and scientists' measurements of diversity (Table 8).

Table 8 Mean intertidal diversity recorded by volunteers and scientists. Separate values are given for organisms that were counted and those that had percentage cover estimated. t-tests examine the significance of the difference between volunteers and scientists.

Abundance Measure	Mean Diversity (SE)		t-test Statistics			
	Volunteer	Scientist	t-value	d.f	P-value	Power
Individual Count	1.30 (0.11)	1.33 (0.11)	1.34	11	0.207	0.999
Percent Cover	0.82 (0.09)	0.86 (0.10)	0.89	11	0.391	0.531

3.2.2 Accuracy of Species Abundances

Four species from each of the abundance scales (counts and percentage cover) were examined for differences between volunteers' and scientists' measurements of density (Figure 5). The species selected were those that occurred on the most number of transects (greatest replication).
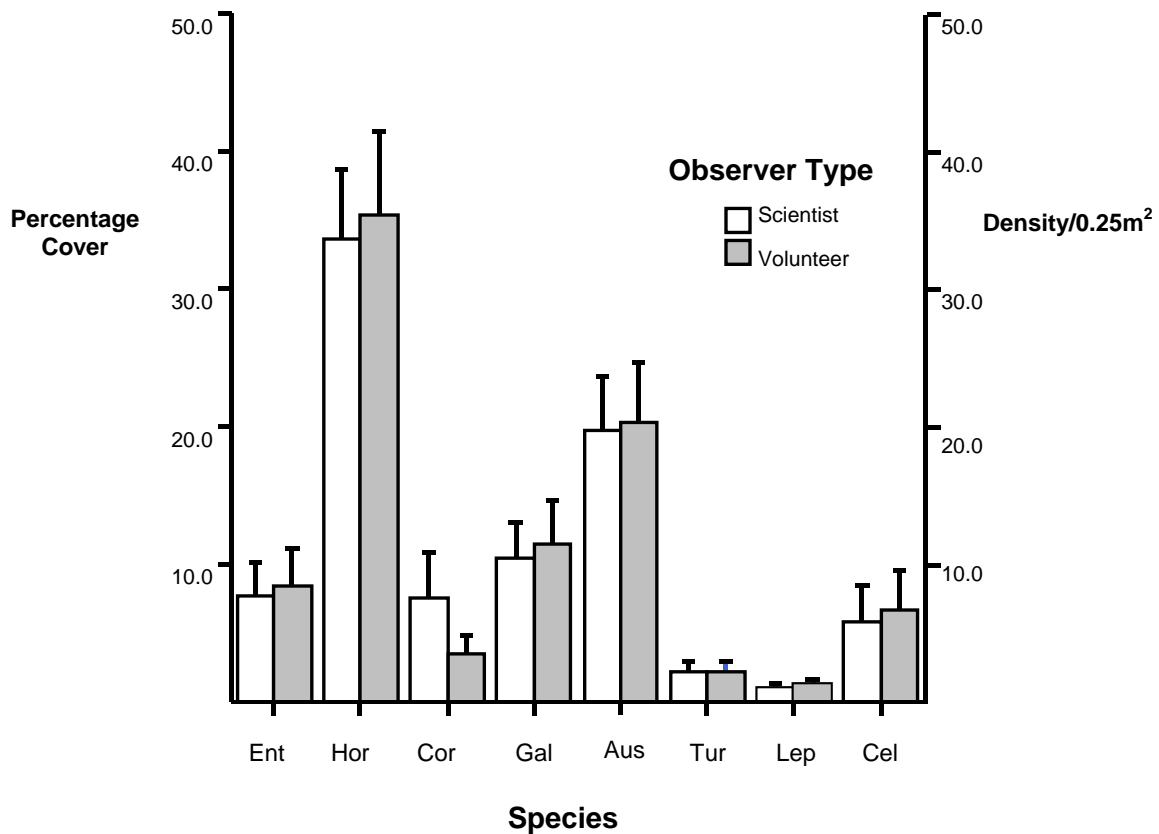
Figure 5 Abundance / Density (±1 SE) of most common intertidal species measured by volunteers and scientists averaged across all transects of all sites. Ent = *Enteromorpha spp.*, Hor = *H. banksii*, Cor = *Corallina spp.*, Gal = *G. caespitosa*, Aus = *A. constricta*, Tur = *T. undulatus*, Lep = *L. vinosa*, Cel = *C. tramoserica*.

To test if site had any effect on the difference between volunteers and scientists, one-factor ANOVAs were performed on each species in question (Table 9). *A. constricta* was the only species for which site was a significant factor and was tested separately for each. Pooling across site, all of the other species showed a significant difference between measurements of abundance taken by volunteers and scientists (Table 10).

Table 9 Results from one-way ANOVA analyses testing if site had an effect on the absolute difference between volunteers' and scientists' measurements of abundance. † Fourth root / ‡ Square root transformed to improve normality and homogeneity of variances. ** P<0.01

Species	F-Ratio	d.f	P-value
Enteromorpha spp. [†]	0.44	2,7	0.663
Hormosira banksii [†]	0.67	1,7	0.439
Corallina spp. [†]	2.86	2,6	0.135
Galeolaria caespitosa [†]	0.93	2,8	0.435
Austrocochlea constricta [‡]	10.30	2,9	0.005**
Turbo undulatus [†]	0.52	2,4	0.632
Lepsiella vinosa [†]	1.29	2,4	0.370
Cellana tramoserica [‡]	2.74	2,5	0.158

Table 10 Absolute difference (untransformed) between volunteers' and scientists' measurements of species abundances, pooled across all sites with t-tests checking if this value is significant. †Fourth-root / ‡Square-root transformed to improve normality * P<0.05, ** P<0.01

Species	Mean Difference per Quadrat (SE)	t-value	d.f.	P-value
Enteromorpha spp. [†]	4.4 (0.91)	16.86	9	0.000**
Hormosira banksii [†]	3.1 (0.92)	15.47	8	0.000**
Corallina spp. [†]	5.6 (3.18)	6.01	8	0.000**
Galeolaria caespitosa [†]	5.2 (1.34)	15.88	10	0.000**
Turbo undulatus [†]	1.1 (0.42)	3.71	6	0.005**
Lepsiella vinosa [†]	0.8 (0.09)	32.42	6	0.000**
Cellana tramoserica [‡]	1.5 (0.85)	2.67	7	0.016*

Similarly, volunteers' and scientists' records of the density of *Austrocochlea constricta* were significantly different to each other for each site, with a much larger difference evident for results from Teahouse Reef (Table 11). As Figure 6 shows, the abundance of *A. constricta* was also far higher at this site. A plot of the absolute difference against abundance (pooled across the three sites) indicates a strong, significant relationship between these two variables, with the difference increasing directly in proportion to abundance (Figure 7).

Table 11 Absolute difference (untransformed) between volunteers' and scientists' measures of abundance for *A. constricta* for each site with t-tests checking if this is significant (Square root transformed to improve normality). * P<0.05, ** P<0.01

Site	Mean Difference / Quadrat (SE)	t-value	d.f.	P-value
Triangle Reef	1.3 (0.46)	2.98	3	0.030*
Teahouse Reef	7.5 (1.67)	8.80	4	0.000**
Breakwall Reef	1.4 (0.23)	11.80	2	0.004**
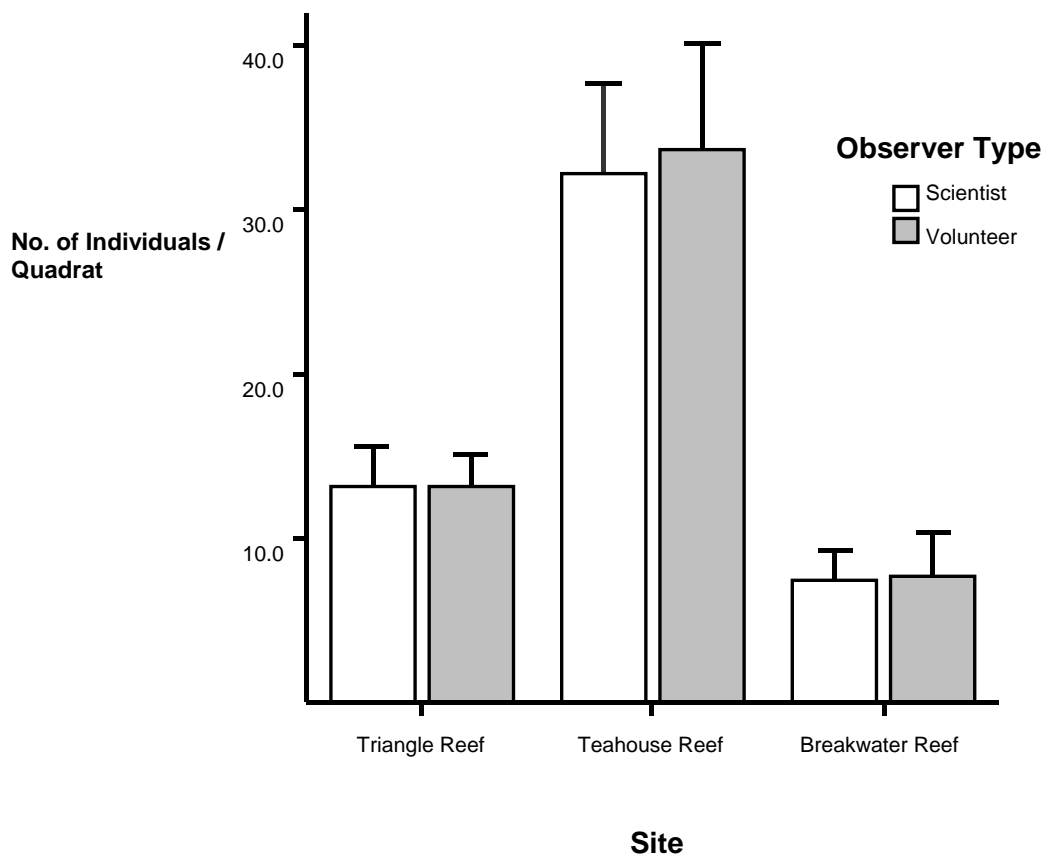
Figure 6 Mean (±1 SE) density (number of individuals/quadrat) of *A. constricta* as measured by volunteers and scientists at each intertidal site**.**
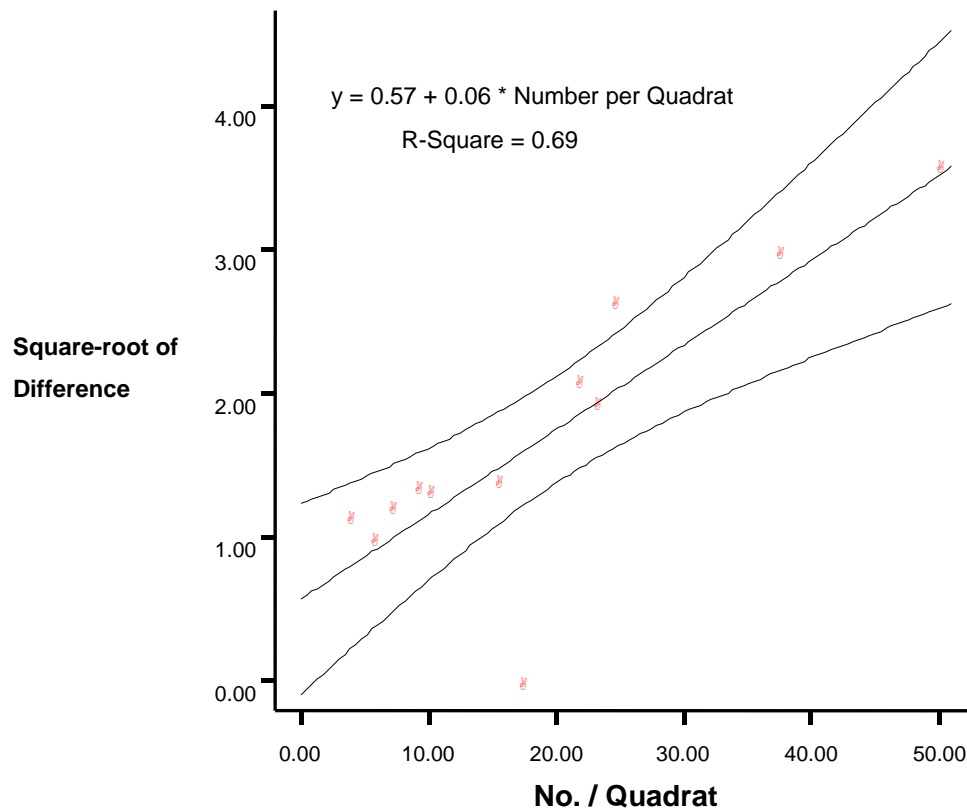
Figure 7 Scatterplot of the density of *A. constricta* against the absolute difference between volunteers and scientists (square-root transformed) showing a significant positive relationship ($F_{1,10} = 22.00$, $P = 0.001$). 95% confidence intervals of the mean are shown.

Figure 8 shows the error margins calculated for each of the species examined. The error margins of volunteers' results were calculated in the same manner as for subtidal data. However, unlike the subtidal results, where a volunteer recorded an organism and a scientist did not, it was concluded that the scientist had 'missed' it, and an error margin of -100% was assigned (the opposite of when a volunteer 'missed' an organism). Unlike observations in the subtidal habitat, the 'missed' intertidal species were common, relatively easy to identify and had no logical alternative recorded by the scientist.

There is clearly a high degree of variability in volunteer accuracy (Figure 8). The most accurately recorded species was *H. banksii*, followed by *A. constricta*. The most inaccurately recorded species was *G. caespitosa*, followed by *L. vinosa* and *Corallina* spp. The unusual result of a 'negative' accuracy margin for *C. tramoserica* can be explained by two cases where volunteers recorded this species but scientists did not, consequently reducing the mean error margin to below 0.
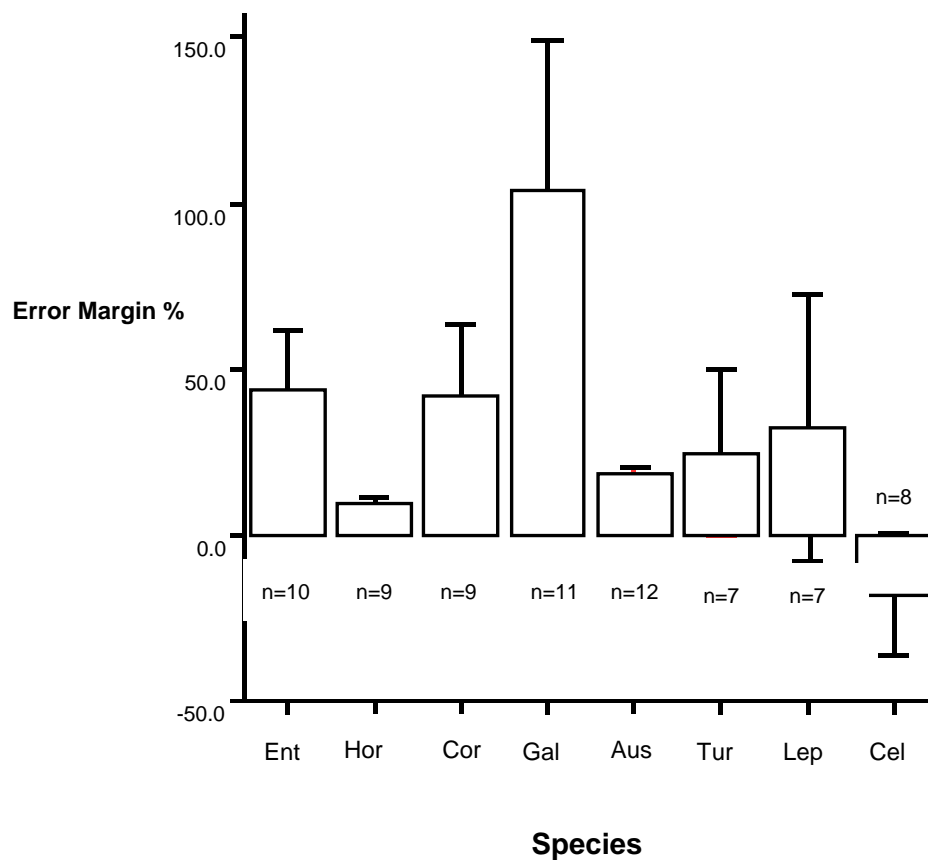
Figure 8 Error margins of dominant intertidal species (±1 SE), indicating the average difference at the quadrat level between volunteers' results and scientists' as a percentage of the abundance. *Ent = Enteromorpha spp., Hor = H. banksii, Cor = Corallina spp., Gal = G. caespitosa, Aus = A. constricta, Tur = T. undulatus, Lep = L. vinosa, Cel = C. tramoserica.*

The error margins in Figure 8 give an indication of the variability expected from volunteers when examining results at the scale of quadrats. Estimates of density/abundance at the scale of site can be calculated by averaging abundances across all quadrats (at a site). Comparing volunteers' results to scientists' at this level shows an overall reduction in error margins, with *A. constricta* and *H. banksii* being the most accurately assessed species (Figure 9). This confers with accuracy results at the quadrat level. However, *G. caespitosa* had a very high error margin at the scale of quadrats, though is the third most accurately measured species at the site level. *L. vinosa* and *Corallina* spp. were inaccurately assessed, with high and variable deviations from the actual abundance.
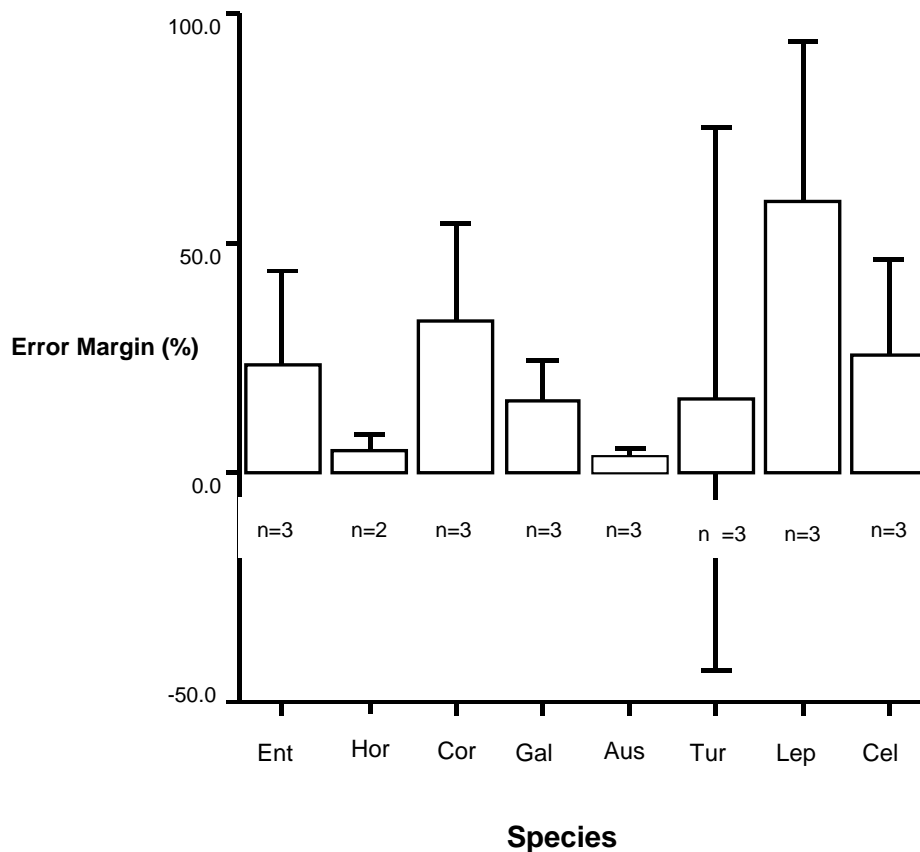
Figure 9 Error margins (±1 SE) of dominant intertidal species indicating the difference between volunteers' and scientists' site-level measurements of abundance as a percentage of the abundance. *Ent = Enteromorpha spp., Hor = H. banksii, Cor = Corallina spp., Gal = G. caespitosa, Aus = A. constricta, Tur = T. undulatus, Lep = L. vinosa, Cel = C. tramoserica.*

3.2.3 Community Composition

Multivariate analyses allow the abundance and composition all of species in a sample (transect) to be compared in a single test. Volunteers' and scientists' results were relatively similar to each other compared to the differences between transect (Figure 10). This is supported by a two-way ANOSIM analysis showing no significant difference between volunteers and scientists (R = -0.197, P = 0.966). A difference between sites was apparent (R = 0.582, P = 0.001). This difference could be detected using only the data from scientists - a NMDS ordination shows three clear grouping of samples, corresponding to the three sites from which they were collected (Figure 11). ANOSIM analysis revealed site to be a significant factor (R = 0.615, P = 0.001) with all pair-wise comparisons being significantly different (Table 13). However, an NMDS ordination of only samples taken by volunteers indicates only two clear groupings (Figure 12).
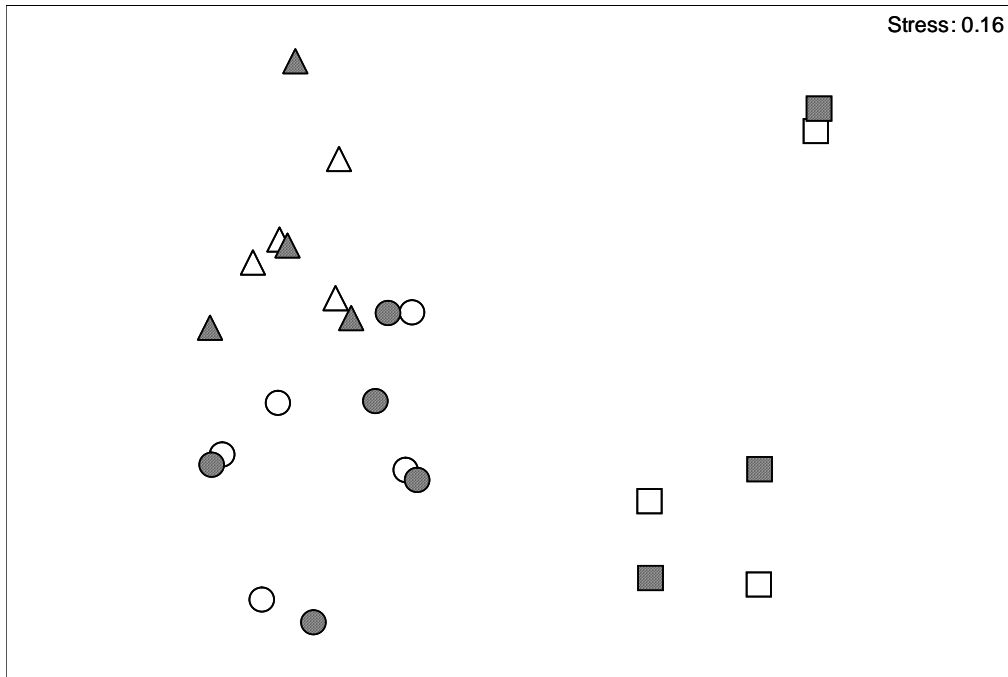
Figure 10 NMDS ordination plot derived from Bray-Curtis similarity indices of scientists' (hashed) and volunteers' (clear) samples of species abundances. Stress < 0.20 indicates plot is a good representation of the relationships. △ = Triangle Reef, Ricketts Point MS, ○ = Teahouse Reef, Ricketts Point MS, □ = Breakwall Reef, Black Rock.
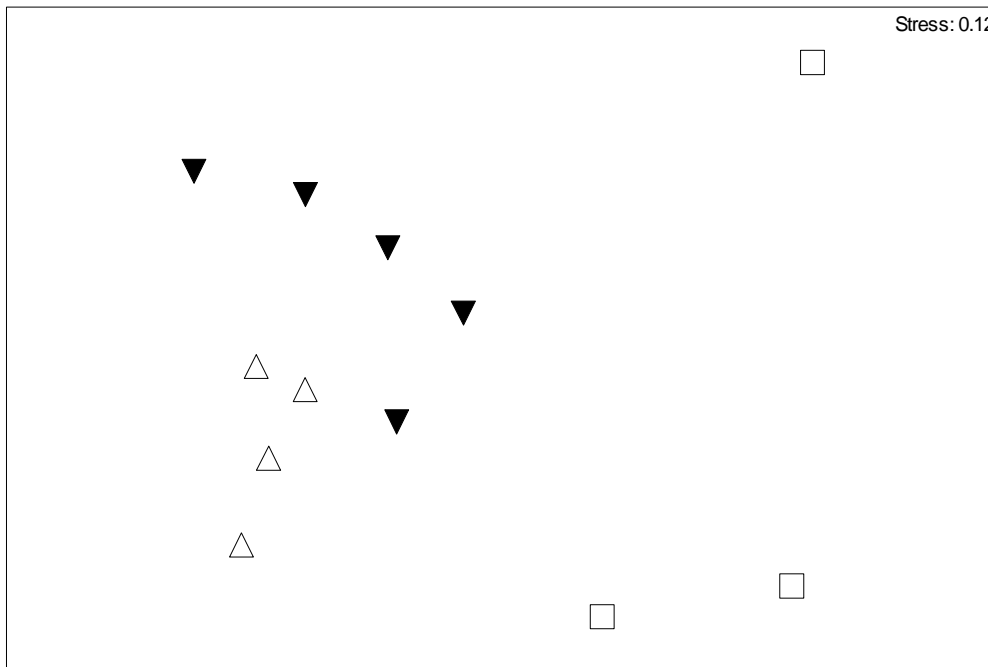
Figure 11 NMDS ordination plot derived from Bray-Curtis similarity indices of scientists' samples of species abundances. Stress < 0.20 indicates plot is a good representation of the relationships. △ = Triangle Reef, Ricketts Point MS ,▼ = Teahouse Reef, Ricketts Point MS,□ = Breakwall Reef, Black Rock.
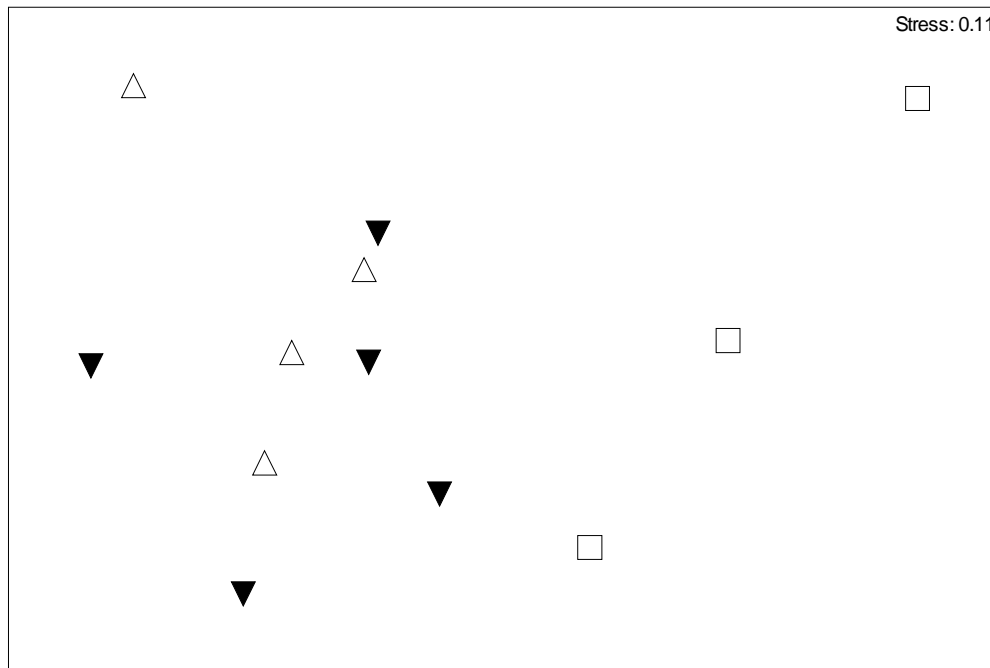
Figure 12 NMDS ordination plot derived from Bray-Curtis similarity indices of volunteers' samples of species abundances. Stress < 0.20 indicates plot is a good representation of the relationships.   = △ Triangle Reef, Ricketts Point MS, ▼= Teahouse Reef, Ricketts Point MS, □= Breakwall Reef, Black Rock.

ANOSIM analysis again revealed a significant difference between sites (R = 0.550, P = 0.002), though unlike for scientists, pair-wise comparisons did not show a distinction between site 1 and 2 - the two Ricketts Point MS sites (Table 14). Volunteers' samples were therefore not as precise as scientists as they were less able to discern different sites.

Table 13 ANOSIM pair-wise comparisons of site for samples collected by scientists. Group 1 = Triangle Reef; 2 = Teahouse Reef; 3 = Breakwall Reef. * P <0.05

Group Comparison	R-Statistic	P-value
1,2	0.438	0.016*
1,3	0.778	0.029*
2,3	0.774	0.018*

Table 14 ANOSIM pair-wise comparisons of site for samples collected by volunteers. Group 1 = Triangle Reef; 2 = Teahouse Reef; 3 = Breakwall Reef. * P <0.05

Group Comparison	R-Statistic	P-value
1,2	0.219	0.111
1,3	0.759	0.029*
2,3	0.805	0.018*

3.2.4 Measurement of Size

A. constricta was the only species that occurred in sufficient numbers to allow a comparison of accuracy between sites. ANOVA analysis showed that the mean absolute difference (square-root transformed) between volunteers and scientists varied significantly between site ($F_{2,9}$ = 5.11, P = 0.033). Analysing each site separately revealed the difference between volunteers and scientists to be significant in every case (Table 14). Though the differences in Table 14 are significant, they are small when compared to the actual size of the animals, as the error margins in Table 15 show. If all quadrats are averaged first to give a mean overall size for each site (Figure 13), the difference between volunteers and scientists (error margin) is further reduced to just 2.5% (SE = 1.1, n = 3).

Table 14 Mean difference between volunteers' and scientists' measurements of *A. constricta* at the level of quadrats. t-test results based on square root transformed data. * P < 0.05 ** P < 0.01

Site	Difference in mm (SE)	*t*-value	d.f	*P*-value
Triangle Reef	0.4 (0.1)	6.207	3	0.004**
Teahouse Reef	0.7 (0.2)	6.785	4	0.001**
Breakwall Reef	1.5 (0.4)	7.745	2	0.008**

Table 15 Accuracy margins for volunteers' estimates of the size of *A. constricta*, expressed as a percentage of the actual size.

Site	Error Margin %	SE	n
Triangle Reef	3.1	0.9	4
Teahouse Reef	4.7	1.5	5
Breakwall Reef	10.0	2.0	3
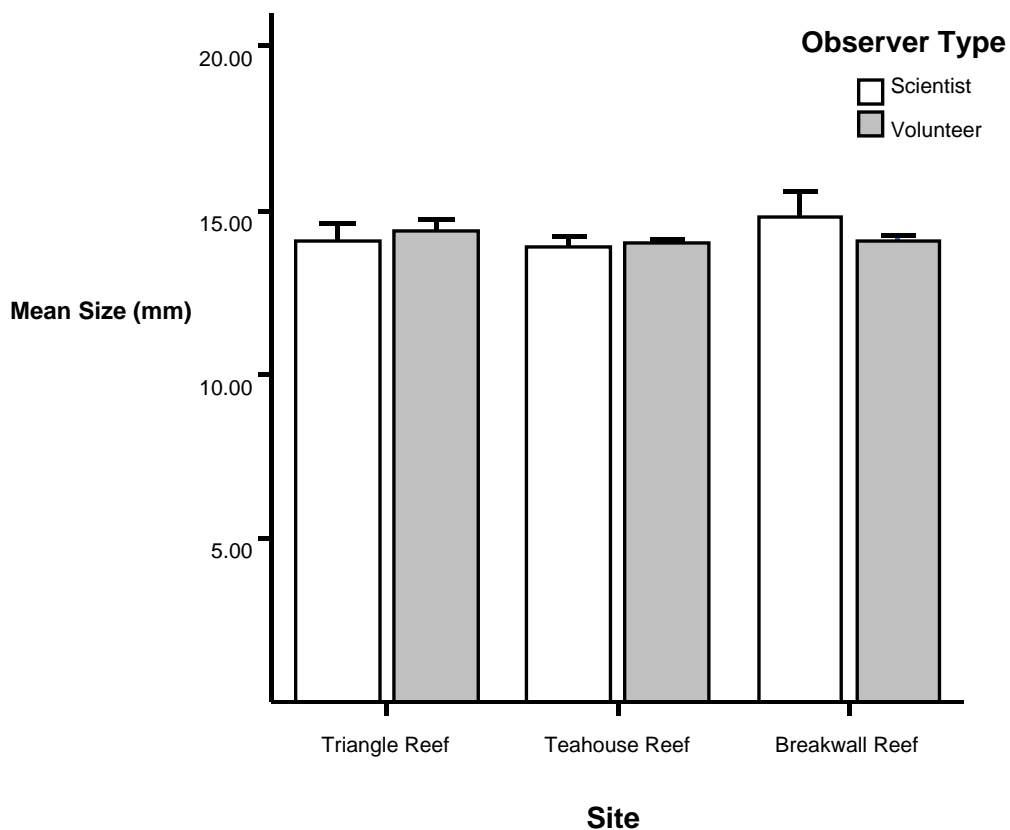
Figure 13 Mean size of *A. constricta* (±1 SE) measured by scientists and volunteers at each site.

Size comparisons were also made between observers' measurements of *C. tramoserica,* though analysis was limited to Black Rock because of a lack of data from the other sites. The mean difference in length of +/- 0.9 mm was not found to be significant (t = 2.722, d.f. = 2, P = 0.057). A power of 0.911 means a high level of confidence in this result. This translated to an error margin of 4.9% (SE = 1.8, n = 3), which was reduced further to just 0.4% when the mean size of individuals was calculated for the entire site (Figure 14).
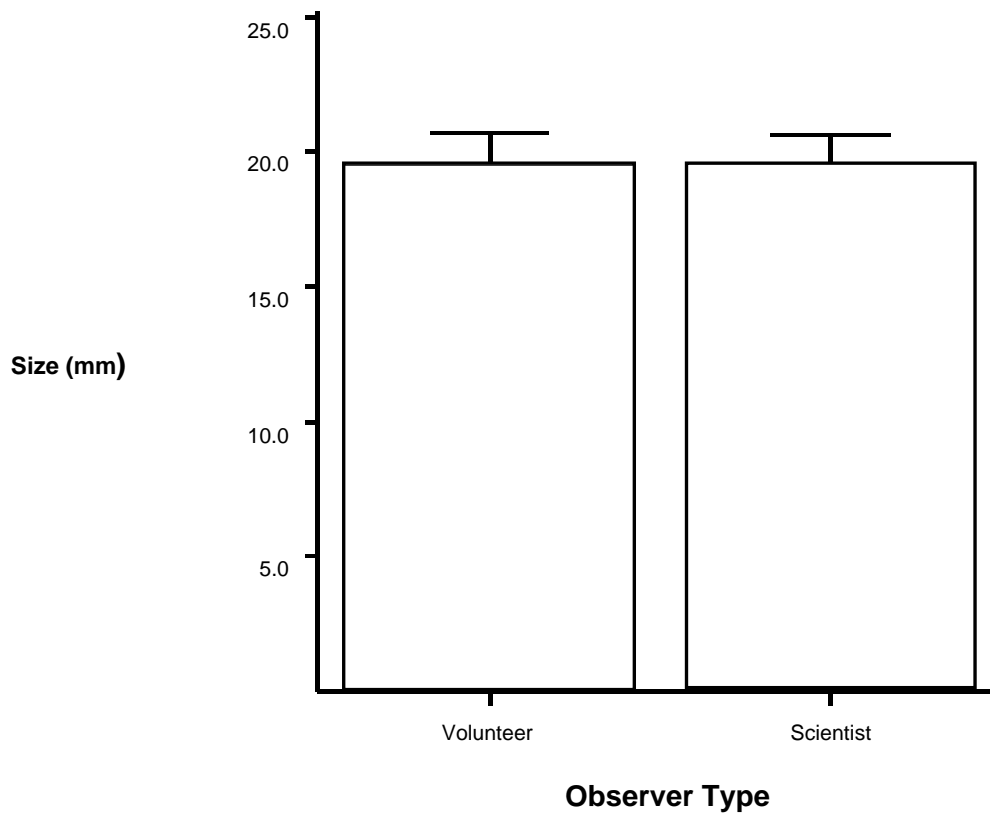
Figure 14 Mean size of *C. tramoserica* (±1 SE) at the Black Rock site as measured by both volunteers and scientists.

3.3 Corner Inlet Marine National Park - Seagrass Monitoring

Seven volunteers participated in the summer training session. Due to inclement weather, *P. australis* monitoring data was not collected by these volunteers and only one was able to participate in a subsequent excursion (14 March 2004). Two volunteers from the S.E.A.L. Diving Services group were involved in a monitoring exercise on the 11 June 2004 in colder winter conditions. Overall, three transects were completed by three volunteer-scientist pairs over two separate days. Only *P. australis* was present along these transects and consequently identification skills were not addressed.

Observer bias was high and variable for estimates of single leaf epiphyte cover, and total epiphyte cover. The mean proportional difference between volunteers' estimates and scientists' estimates was 49.0% for single leaf epiphyte cover and 24.3% for total epiphyte cover (Figure 15). The net differences between volunteers' and scientists' estimates are shown in Figures 16 and 17 for leaf cover and total cover respectively. Though neither were significantly different, the very low power of the tests (high standard deviation and low level of replication) means that this result is unreliable.
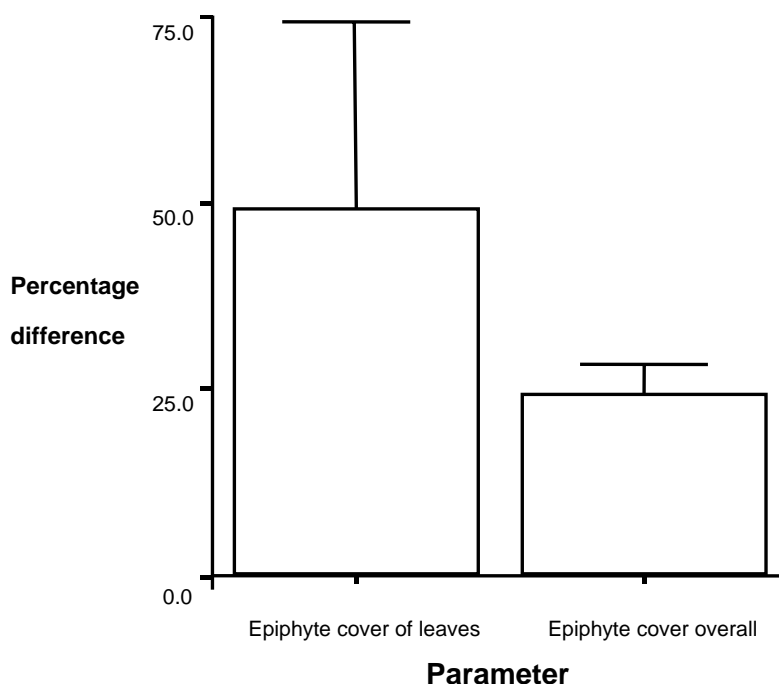
Figure 15 The percentage difference (±1 SE) between volunteers' and scientists' estimates of epiphyte cover on *P. australis* shown for single leaf measurements, and overall.
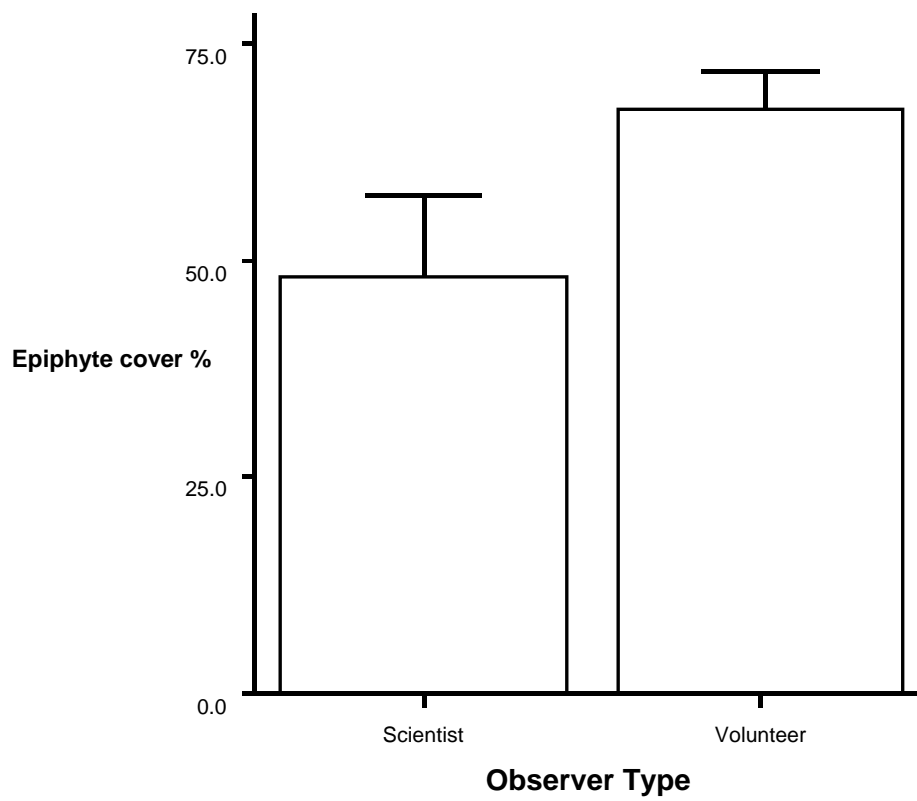
Figure 16 Mean epiphyte cover (±1 SE) of individual leaves of *P. australis* estimated by scientists and volunteers. The difference between the observers was not significant (t = 2.199, d.f. = 2, P = 0.159, Power = 0.053).
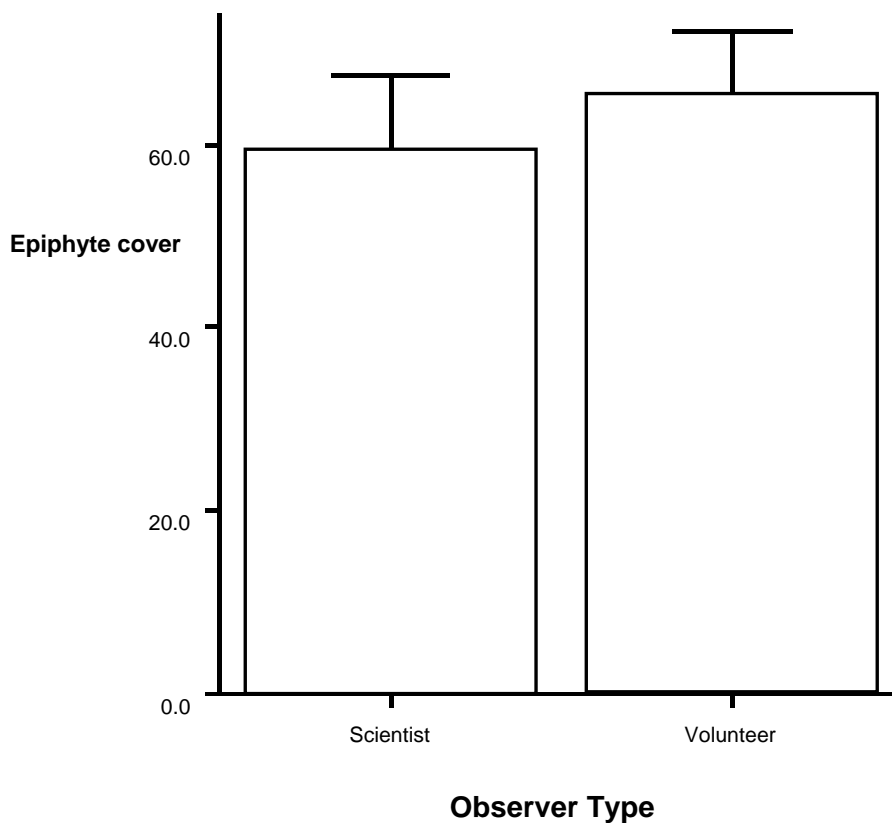
Figure 17 Mean estimates of epiphyte cover (±1 SE) on *P. australis* in sub-quadrats for both scientists and volunteers. The difference between observers was not significant (t = 0.654, d.f. = 2, P = 0.580, Power = 0.062).

The difference between observers measurements of shoot density was 0.16 (shoots/plant). This was only 6% of the mean density and not a significant value (t = -0.903, d.f. = 2, P = 0.462). There was also little variation in shoot height measurements between volunteers and scientists, with a mean difference of 0.1 cm, or 4% of the height measured by scientists. This difference was not significant (t = 0.549, d.f. = 2, P = 0.638). Despite the low power of these tests to detect a significant difference (0.144 and 0.153 respectively), the overall mean differences were relatively small. The mean shoot density and height as measured by volunteers and scientists are shown in Figures 18 and 19 respectively.
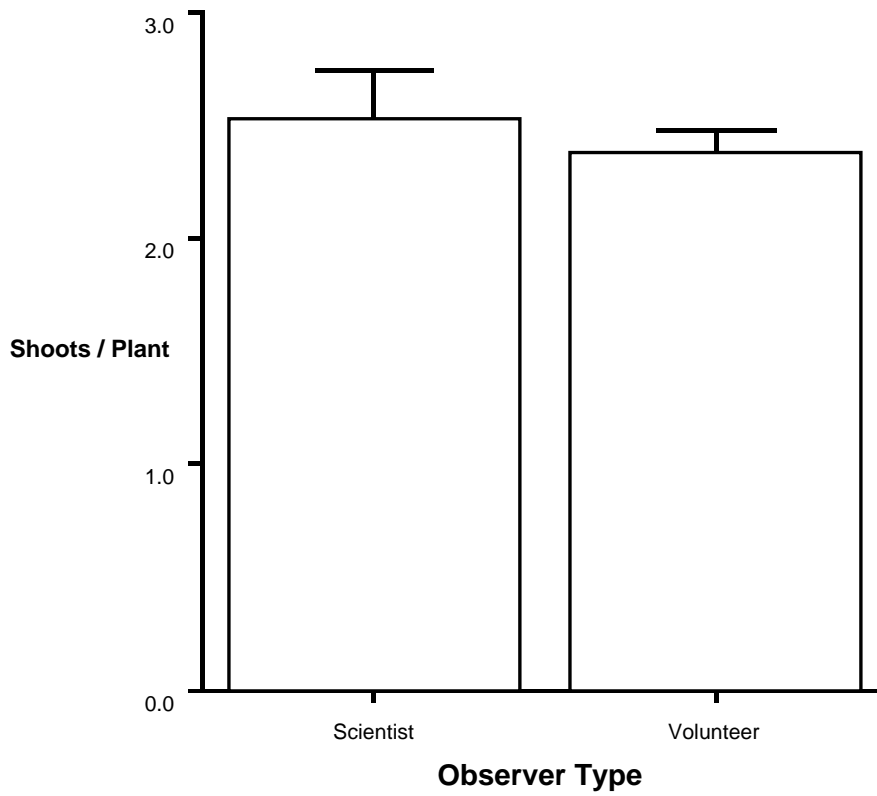
Figure 18 Mean number of shoots (±1 SE) per *P. australis* plant measured by volunteers and scientists.
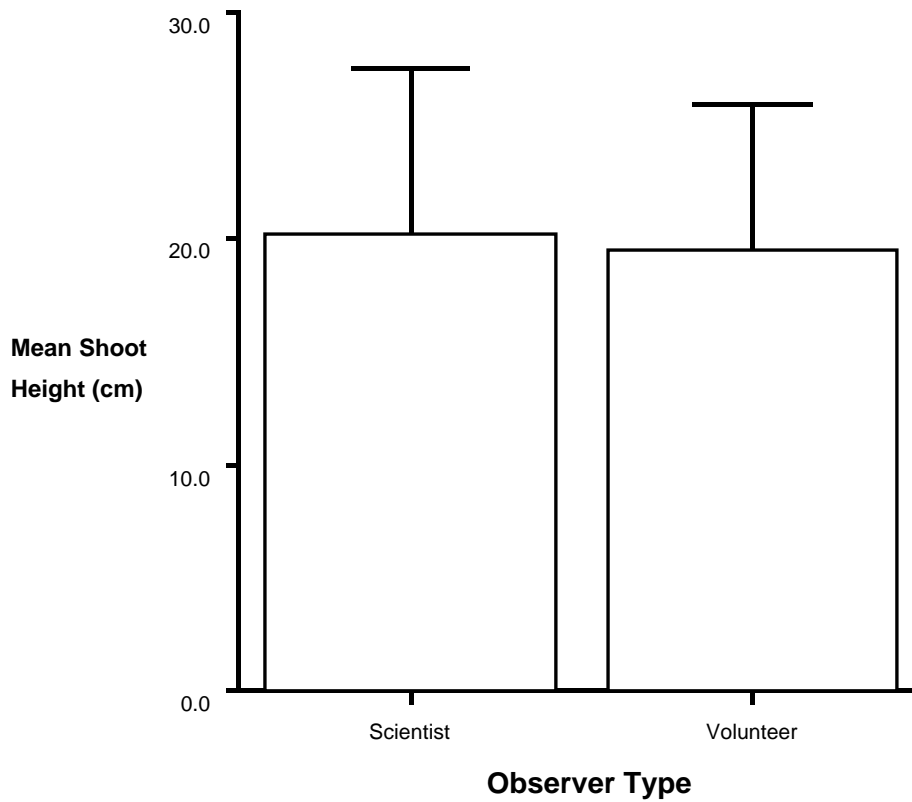
Figure 19 Mean shoot height (±1 SE) of *P. australis* measured by volunteers and scientists.

3.4 Survey of participants and community group members

Survey response rates were generally good with a total of 122 surveys returned. Volunteers who participated at Merri had a response rate of 56% (n=9) while those from Ricketts Point had a response rate of 77% (n=13). Corner Inlet volunteers also had a 56% (n=9) response rate. Non-participants from the community groups were more varied. Approximately 10% (n=50) from Merri, 48% (n=65) from Ricketts Point and 45% (n=200) from Corner Inlet returned the non-participant surveys.

3.4.1 Demographics

The demographics of the different community groups varied considerably (Table 16). Participants tended to fall in younger age brackets than non-participants, although the Ricketts point group showed a more even spread of age. Overall, group members had very high levels of education, with 66% of respondents having tertiary qualifications. The majority of participants at Corner Inlet and Ricketts Point were employed, with the Merri group consisting solely of students. More than a third of non-participants who responded from Corner Inlet were retired.

While all of the members at Merri (n=9), and 92.5% of Ricketts Point members (n=40) lived less than 50 km from the monitoring site, 86.1% of the members from the Corner Inlet group lived more than 50 km and 63.9% lived more than 150 km away.

Approximately half of all respondents (n=122) were also involved in other conservation groups and/or other volunteer/friends groups.

Table 16 Demographic profile of community group members who returned surveys and participated (P), or did not participate (NP) in monitoring. Where column totals do not equal 100% the difference represents the proportion who chose not to respond to that question.

Variable	Category	Merri		Ricketts Point		Corner Inlet		Total	
		P (n=5)	NP (n=4)	P (n=10)	NP (n=31)	P (n=5)	NP (n=67)	P (n = 20)	NP (n=102)
Age	18-30 years	100	100	30	19	0	8	40	15
	31-45 years	0	0	20	23	80	27	30	25
	46-60 years	0	0	30	23	20	30	20	27
	Over 60 years	0	0	20	36	0	36	10	34
Gender	Male	60	25	40	48	80	49	55	48
	Female	40	75	60	48	20	51	45	51
Education	Secondary	40	75	10	13	20	15	20	17
	Tafe/Technical	0	0	50	3	20	13	30	10
	Tertiary	60	25	40	77	60	67	50	69
	Other	0	0	0	7	0	3	0	4
Occupation	Student	100	100	10	10	0	0	30	7
	Employed	0	0	50	45	100	61	50	54
	Retired	0	0	20	32	0	34	10	32
	Unemployed	0	0	0	3	0	0	0	1
	Domestic Duties	0	0	0	10	0	3	0	5
Income	1-15,599	40	75	10	26	0	6	15	15
	15,600 – 25,999	60	25	30	10	0	19	30	17
	26,000 – 41,599	0	0	30	26	20	27	20	26
	41,600 – 51,999	0	0	10	13	0	21	5	18
	52,000 – 77,999	0	0	0	13	20	12	5	12
	78,000+	0	0	10	7	40	5	15	5

3.4.2 Participant Volunteer Profile

The main reason behind people participating in the monitoring was to assist with scientific research, which was consistent across sites (Table 17). One respondent from the Deakin University Underwater Club stated that they participated 'to gain experience'.

Table 17 Main reasons given by respondents for taking part in the monitoring program.

Main reason for participating in monitoring	Percentage of respondents (n = 20)
To work close to nature	30
To socialize with others with same conservation passions	5
To learn more about marine habitats	10
To assist with scientific research	50
Other	5

3.4.3 Exertion and Time Involved in Monitoring

More volunteers from Corner Inlet (20% n=5) and Merri (40% n=5) said that they exerted a lot of physical effort in undertaking the monitoring than did those at Ricketts Point (11% n=9). Sixty percent of volunteers at these sites (n=5) also thought that the monitoring took a long time compared to only 33% at Ricketts point (n=9). Table 18 shows the amount of time volunteers intended to stay to complete the monitoring, and indicates that Ricketts Point participants generally planned for less than a day whereas other groups had varied notions about how long was required.

Table 18 Amount of time volunteer respondents from different groups intended to stay to complete the monitoring.

Intended Time	Merri (n=3)	Ricketts (n=10)	Corner Inlet (n=5)	Total (n=18)
0-5 hours	33	70	40	55
5-8 hours (day)	33	20	40	30
> 8 hours (>1 day)	33	10	20	15

3.4.4 Training and Identification

Forty percent of volunteers (n=5) from Merri said they were not confident identifying the flora and fauna. At Ricketts Point however, this value was only 10% (n = 10). Similarly, more volunteers at Ricketts Point (60% n=10) found the flora and fauna identification guide easier to use than did volunteers working at Merri (40% n=5). However, suggestions for improving the guides were particularly detailed from the Ricketts Point group, and are typified by the response by one volunteer:

'In some instances, pictures of an organism from more than one angle, and with varying degrees of wear, markings, shape and colouring – maybe 4 or 5 pictures for certain difficult organisms' (MCFRP volunteer, May 2004).

Interestingly, despite the higher confidence levels at Ricketts Point, there was a higher rate of dissatisfaction with the training. While all of the volunteers that responded from Corner Inlet (n=5) and Merri (n=5) thought that the training information was clearly delivered and easy to understand, 40% of volunteers from Ricketts Point thought that the information was not clearly delivered and 30% thought that it was not easy to understand (n=10). Again there was much feedback from this group on how to improve the training, mainly dealing with explanations of complex/confusing methods, and is an indication of the dedication and thoroughness of group members. Only 10% (n=10) from the group thought that more time needed to be spent on training, with 20% from Merri and 0% from Corner Inlet responding in the same way. All respondents (n=20) said that they understood why the monitoring required specific guidelines to be followed.

3.4.5 Non-Participant Volunteer Profile

The reasons given for not participating are shown in Table 19. Clearly a lack of time was the primary reason for not being involved with 54% (n=102) citing this. The next most frequently recorded response was 'Other', with a variety of reasons being given. The most commonly occurring ones included not being able to swim, living too far away, being 'too old'/physically incapable or not knowing about the project.

Table 19 Percentages of non-participant respondents who cite particular reasons for not being involved in the monitoring project.

Reasons for not participating in monitoring	Percentage of respondents (n = 102)
Lack of time	54
Do not enjoy being involved in scientific monitoring	3
Lack of confidence in ability to conduct scientific monitoring	10
Prefer to be financial supporter without doing activities	5
Ill health	5
Financial limitations	5
Other	23
No response	9

Not surprisingly therefore, *a range of suitable dates* (45%) and *further information on what is required* (54%) were the two most frequently marked responses when asked what could be done to encourage participation (Table 20). Other forms of encouragement most commonly

suggested involve changing the type of monitoring (to something less physically demanding). All respondents (n=4) from Merri, 89% (n=27) from Ricketts Point and 73% (n=62) from Corner Inlet said that they would participate in the future. This is however an idealistic response with many people qualifying it with clauses such as:

'Time permitting and other commitments' (Friends of the Prom member, March 2004).

Table 20 Forms of encouragement cited by non-participant respondents as being factors that may influence their future involvement.

Form of encouragement	Percentage of Respondents (n=72)
Payment to be involved in scientific monitoring	7
A range of suitable dates to undertake the scientific monitoring	44
Greater involvement from other community group members	0
Further scientific support from Parks Victoria/Deakin University	6
Further information on what is required of me	54
Other	10

When non-participants were asked how much time they would be willing to commit to voluntary scientific monitoring, 64 people responded (out of 102). Those from Ricketts Point and Merri stated an average commitment approximately double that proposed by Friends of the Prom members (Figure 20). Interestingly, Friends of the Prom members were more likely to give a response in terms of days / year whereas the Ricketts Point and Merri groups were more likely to express it as hours / week. This is perhaps indicative of the level of commitment required to monitor habitats that may be far away from the majority of group members.
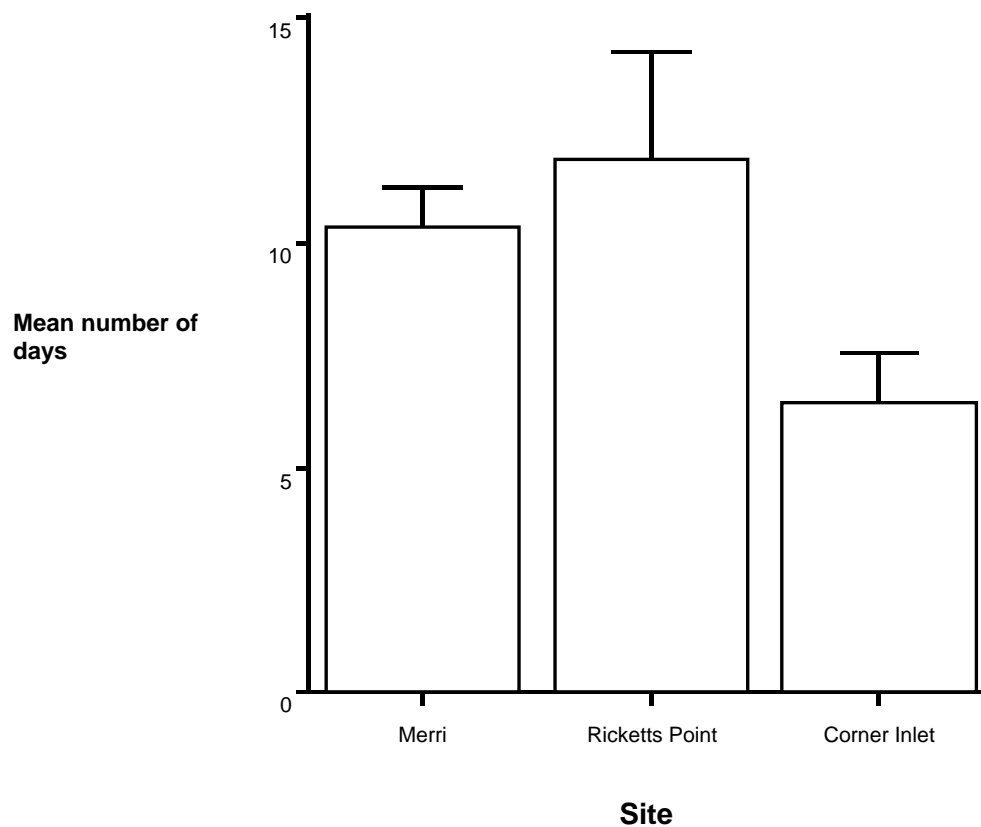
Figure 20 Mean number of days per year (±1 SE) that respondents from different sites said that they would be willing to commit to future monitoring.

3.4.6 Sustainability of Monitoring

In total, all volunteer respondents (n = 20) said that they enjoyed the monitoring, though one volunteer did qualify this:

'Got very cold through being under then out of the water continually' (Friends of the Prom member, February, 2004).

After completing the monitoring, 18 out of 19 volunteers said that they felt that they had contributed something to the environment and 14 out of 15 thought that the monitoring had a broader value.

While 90% of Ricketts Point volunteers (n=10) thought that they could train other members, only 60% thought so in the Merri (n=5) and Corner Inlet (n=5) groups. One person from Corner Inlet was the only one who thought that their community group could not conduct this annually:

'If the monitoring is only to be done once a year the same people are unlikely to be available and much of the training will have been forgotten' (Friends of the Prom member, March 2004).

When asked if they would participate in the monitoring again, all respondents said yes (n= 12).

3.5 Parks Victoria Ranger Survey

Nineteen rangers completed the Parks Victoria Ranger survey on 17 August 2004. All respondents (100%) agreed that it is important to engage community groups in scientific monitoring of Victoria's MPAs. Table 21 summarises the response rate, in percentages, of key survey questions.

Table 21 Parks Victoria Ranger survey responses associated with CBM programs (n = 19)

Question	Yes (%)	No (%)
Are community groups capable of collecting scientifically sound data?	95	5
Are data collected by community groups valid for scientific analysis?	89	11
Is data collection by community groups feasible in the long term?	95	5
Do you feel that community groups will be interested in maintaining annual monitoring of MNPs and MSs?	89	11

The top five limitations for using community groups to undertake scientific monitoring in MNPs and MSs, as perceived by rangers, include:

1. Funding/Logistics/Equipment.

2. Skills and training of volunteers.

3. Accuracy of data collection.

4. Volunteers understanding scientific concepts.

5. Fading enthusiasm by volunteers for long term monitoring.

Positive aspects associated with community-based monitoring of MNPs and MSs, as perceived by respondents, were:

1. Ownership/Custodianship/Stewardship of the MPA by the community group.

2. Contribution to management of Victoria's MPAs.

3. Increased awareness (values and objectives) of MPAs and the management authority's role in managing Victoria's MPAs.

4. Capacity building and forming relationships between community groups and management authority staff.

5. Baseline data accumulation of Victoria's MPAs.

4 DISCUSSION

Volunteers working on intertidal sites recorded the most accurate data, possibly due to their familiarity with the habitat and the greater ease with which it could be surveyed. Subtidal records of abundance and species diversity were largely unreliable however they suffered from a lack of replication due to adverse conditions. Poor weather and the problem of organising volunteers at short notice were also issues facing investigations at Corner Inlet MNP. Logistical considerations and community group demographics appear to be important issues affecting both the reliability of data, and the long-term sustainability of monitoring.

4.1 Data Integrity

4.1.1 Merri Marine Sanctuary Subtidal Monitoring

Data collected by volunteers was highly variable and often very different to that collected by scientists. Interpretation of these results must be cautious however, as only three transects (replicates) were surveyed, one incompletely. This generally led to very low statistical power for detecting difference. It should also be kept in mind that results from this dynamic habitat will inherently have a high degree of variability (Barrett *et al.* 2002).

Both volunteers and scientists 'missed' species which were recorded by their counterpart. Studies such as Darwall and Dulvy (1996) have attributed this to misidentification of species by the volunteers. Misidentification, particularly of algal species, is certainly a possibility and could account for scientists not recording a species where volunteers did. However, in one case, a crayfish (*Jasus edwardsii*) was recorded by a volunteer but not by a scientist and in this instance it is very unlikely that the species was misidentified. This could be explained by the differing viewpoints of the paired volunteer and scientist. Due to the rugose structure of the reef, it is unlikely that pairs of observers witnessed exactly the same things. This makes identification and observational discrepancies very difficult to separate from each other, despite there being a trend for scientists to record more species. While data from more comparisons of volunteers and scientists would aid this, experimental evaluation of identification skills may be more informative.

As with species diversity and richness measurements, variation in algal abundance records of volunteers and scientists may also relate to a combination of observational and identification errors. The net result is that volunteers' measurements have a high margin of error. Mean estimates of quadrat cover were more than 75% above or below the actual cover. At this scale, volunteer data may be questionable. By averaging across all the quadrats the error margin is reduced. Though this is at the expense of information such as depth, co-occurring species, etc, broad scale information collected by volunteer divers may

prove to be useful in detecting large shifts in community ecology, such as the population explosions of *Coscinasterias muricata* detected by Barrett *et al.* (2002).

The difference between volunteers and scientists may also have links to the underlying diving skills held by scientists. In an environment where there are many physical and mental demands on participants' concentration, it would not be surprising if more accurate records are made simply because the observers are more comfortable and competent in the water, allowing them to devote more attention and energy to surveying the reef. Other complications relating to surveying the subtidal environment may further compound differences observed between volunteers and scientists. This can include the limited availability of reference material underwater and the similar morphology of many species of algae. Furthermore, the time limits imposed by diving (i.e. air/nitrogen restrictions) only serve to add an element of haste to observations and measurements.

Further training of volunteers has been shown by Darwall and Dulvy (1996) to improve accuracy, though this may relate as much to the enhanced diving experience as to the training. Volunteer monitors in the present study could also be expected to show improvements in performance with additional training or perhaps merely with an increase in experience level.

Barrett *et al.* (2002) and Campbell and McKenzie (2001) also found that averaging across several volunteers significantly improved the agreement between their results and research divers. This means that given sufficient experience, training and favourable conditions, volunteers may be able to survey sites with sufficient accuracy as to provide useful results to natural resource managers on broad changes in subtidal MPAs.

4.1.2 Ricketts Point Marine Sanctuary Intertidal Monitoring

Intertidal rocky reefs at Ricketts Point MS and at the reference site at Black Rock were easily accessible and were not as reliant on weather conditions for monitoring as either the Merri MS, or Corner Inlet MNP sites. This allowed 3 sites and a total of 12 transects to be surveyed and a large number of volunteers to become involved. This is indicative of the potential for establishing sustainable monitoring programs at similar locations.

Volunteers made accurate assessments of both the species richness and diversity in the intertidal habitat. In the present study discrepancies between volunteers and scientists could mainly be attributed to observational error (i.e. did not see) as there were few cases in which species could have potentially been confused. This contrasts with subtidal surveys where algal identification was more difficult. Also, studies on other intertidal reefs throughout

Victoria (Edmunds *et al.* 2003) have found numerous morphologically similar species that could be easily confused by volunteers or inexperienced scientists. Most of the species recorded had been observed by the volunteers through previous experience and it would be of interest to examine the accuracy of less experienced volunteers. Grouping of similar or unidentifiable species into higher taxonomic categories may allow more robust assessments to be made if identification skills are in doubt (Darwall and Dulvy 1996; Oliver and Beattie 1996).

The independence of volunteers and scientists may be questionable considering the close working conditions inherent in the design. This may have improved volunteer accuracy in assessing species richness, even though interaction was kept to a minimum. Correct identification was a priority for these volunteers and it is likely that several had equal or superior taxonomic skills to some of the scientists. Separating volunteers and scientists completely, or using controlled experiments, may increase precision of the evaluation.

Volunteers were able to measure the abundance of *Hormosira banksii* and *Austrocochlea constricta* at a site quite accurately, on average within 5% of that assessed by scientists. When examining the distribution of species within a site however, information at the quadrat level is required. At this scale the error margins were increased substantially, and the confidence in volunteers' measurements drops. The useability of this data therefore depends on the level of accuracy required by managers. While site level abundances can be used, they may ignore important changes in community distribution. This could include spatially variable effects like trampling (Keough and Quinn 1998). Also, should the abundance data only be used at the site level, the monitoring methodology may be unnecessarily complex considering it is designed to detect within shore variations. Simplification could make it more volunteer-friendly, better meeting the requirements of community-groups and managers alike.

Foster-Smith & Evans (2003) found that using qualitative abundance scales, volunteers could only accurately assess the abundance of the common and easily identified lugworm, *Arenicola marina,* out of a variety of intertidal organisms. The two species most accurately assessed in this study were also the two most commonly occurring. This may influence volunteer measurements in several ways. Firstly, small, random variations between volunteers and scientists would have a much larger effect on abundance measurements of rarer species compared to abundant ones. Secondly, when volunteers are frequently encountering a common species, they would be more familiar with it and more likely to observe, identify and record it. Thirdly, both *A. constricta* and *H. banksii* are relatively large,

conspicuous, easily identified organisms. Less abundant, smaller, and more difficult to identify species such as *Corallina* spp. or *L. vinosa* are conversely less accurately measured.

Multivariate statistics are being used increasingly to analyse community and environmental changes (Clarke and Warwick 1994; Barrett *et al.* 2002; O'Hara *et al.* 2002). The data collected by scientists in this study was more informative than that collected by volunteers as it allowed all three sites to be separated based on their community composition. Volunteers' results on the other hand were unable to discern between the two Ricketts Point MS sites. Volunteers' data will thus not be as precise in detecting changes in intertidal communities, though the question is: how precise do they need to be? Barrett *et al.* (2002) similarly found that volunteer NMDS ordinations were not as precise as scientists, though they were sufficiently able to detect community changes that occurred over short periods of time. Considering that professional scientific monitoring will still continue, the more frequent monitoring by volunteers may still yield useful results in detecting any major changes that could occur over shorter periods of time, such as infestations of exotic pests.

Volunteers were found to accurately measure the shell length of both *Austrocochlea constricta* and *Cellana tramoserica*. This agrees with results from Foster-Smith and Evans (2003) for volunteer measurements of the size of the intertidal molluscs *Nucella lapillus*, *Gibbula cineraria* and *Gibbula umbilicalis*. The accuracy is dependent on a sufficient number of samples being taken. Approximately 50 measurements of *A. constricta* in this study gave a mean difference between volunteers and scientists of <5%, and would be considered a minimum.

4.1.3 Corner Inlet Marine National Park Seagrass Monitoring

While data collection was limited due to adverse weather, conditions on the days when monitoring actually took place were close to ideal. It should therefore be kept in mind that under less suitable conditions the monitoring would become more difficult to conduct due to reduced visibility, waves and exposure. The accuracy of results under less than favourable conditions may be reduced accordingly.

Volunteer estimates of epiphyte cover were not accurate. This may relate to the fact that as they were essentially qualitative in nature, they rely entirely on the judgement of the volunteer. Similar studies examining qualitative measurements taken by volunteers have found them to be variable and often unreliable (Campbell and McKenzie 2001, Foster-Smith and Evans, 2003). Quantitative measurements such as height and shoot density were far more accurately measured by volunteers and provided useable information at the transect

level. This was found to be an appropriate scale for monitoring the *P. australis* beds at Corner Inlet (O'Hara *et al* 2002).

To improve volunteer estimates of epiphyte cover, Campbell and McKenzie's (2001) used multiple volunteers per transect and averaged their results. Considering the low number of volunteers that were available to participate in the present study, this would reduce the capacity of monitoring groups. An alternative may be to change the survey methodology so that epiphyte cover is assessed quantitatively.

4.2 Community Volunteer Training

Training requirements differed between habitat types. Extensive training was required before volunteers could undertake subtidal monitoring and was considered critical in ensuring their safety. Similar community monitoring programs involving SCUBA in Mafia Island Marine Park, Tanzania, trained volunteer groups in species identification and ecological survey techniques through dive training (Darwall & Dulvy 1996). The training program used in the present study allowed organisers to evaluate the 'in-water' competency of divers in a controlled, safe environment, rather than in potentially hazardous field conditions. This is important considering that divers not only need to have basic dive skills, but also need to be competent in equipment manipulation, underwater observations and data collection whilst maintaining buoyancy control and buddy contact. Training of volunteers for intertidal and seagrass monitoring took less time as the methods and identification guidelines were relatively straightforward. This was reflected in the fact that MCRP participants were more confident in their identification skills than participants from the Deakin University Underwater Club group.

Despite more than 60% of all participants reporting that they could train other members in the monitoring techniques, it is recommended that initial training of volunteer groups should be undertaken by a professional who is familiar with the techniques and their underlying principles. The reasons for this are two-fold. First, it will reduce inconsistencies in data collection that may arise from volunteers teaching volunteers. Second, visible involvement by the management body will help participants realise that there is an investment in the data they will be collecting as being important and therefore, needs to be collected accurately. Professional training would introduce community volunteers to best scientific practices when selecting appropriate monitoring sites, aid in species identification, and the appropriate management of collected data.

Many successful volunteer based monitoring programs have cited the use of a facilitator from the management authority or a research group to train, supervise and support volunteer monitoring (Arundel and Fairweather 2003; Barrett *et al*. 2002; Campbell and McKenzie

2001; Darwell and Dulvy 1996; Hodgson *et al.* 2003). Community monitoring of Tasmanian inshore reef ecosystems (Barrett *et al.* 2002) found that with good training and professional facilitation of volunteers, CBM may provide data with sufficient reliability to detect substantial shifts in reef ecosystems. These representatives, or facilitators, can provide groups with access to monitoring materials such as reference guides, transects, quadrats, slates, data sheets and other equipment and also play a valuable role in providing feedback to the volunteers (Campbell & McKenzie 2001), many of whom in this study expressed a strong interest in the outcomes of the monitoring research. It is also essential that events are well coordinated and adequate post monitoring support is available to ensure species are identified and recorded accurately and legibly (Barrett *et al.* 2002).

Initial training on monitoring methods and flora and fauna identification will allow community group volunteers to pass on this knowledge to other members in the group. This, in turn, can lead to an increase in volunteer monitoring participation. This was supported in this study by survey results where only 1 from 21 participating volunteers, across all three habitat types, viewed that the community group could not undertake monitoring annually as the training would be forgotten. This indicates the need for on-going support by management authorities, through Parks Victoria Rangers, to community groups involved with MPA monitoring.

4.3 COMMUNITY- BASED MONITORING SUSTAINABILITY

4.3.1 Monitoring Effort

Maintaining volunteer enthusiasm, interest and motivation is essential for the long-term sustainability of any volunteer-based monitoring project, a notion supported by Campbell & McKenzie's (2001) three year study on community-based seagrass monitoring in Queensland. Volunteer participants who undertook subtidal or seagrass monitoring, in the present study of Victoria's MPAs, felt that they had exerted a lot more energy and time conducting the surveys than intertidal rocky reef volunteers. These two factors may limit volunteer involvement in subtidal and seagrass habitat monitoring. Discomforts such as exposure to cold water, time taken to put on SCUBA equipment, and descent time to the monitoring start position for subtidal monitoring, contributed to monitoring effort. The requirement of technical equipment (e.g. SCUBA, wetsuits and waterproof materials) for seagrass and subtidal monitoring may also be seen by community-groups as too difficult to obtain or they may be limited by a lack of SCUBA qualifications. Intertidal monitoring did not require a great amount of energy to execute. MCRP volunteers were able to undertake monitoring during all types of weather conditions, and the intertidal platform was accessible from the shore during low tide. Intertidal rocky reef monitoring took less time then expected to complete as wetsuits and specialised equipment were not needed. Reference books were

easily accessible and utilised during intertidal monitoring to identify unknown flora and fauna. Because of the decreased amount of effort required, intertidal rocky reef monitoring appears to be the most sustainable of the three habitat monitoring procedures.

Despite the amount of effort and energy required for subtidal and seagrass monitoring, all volunteer participants across the three habitat types responded that they enjoyed monitoring and would partake in monitoring again. All participating volunteers, across all three habitat types, would like to undertake monitoring on an annual basis. Whether or not this is feasible, is dependent upon the organisation and motivation of individual groups. Although a single session of monitoring only takes 2-3 hours to complete at each site, an ideal situation, for most members, would require monitoring dates to suit them when they have no other commitments and the weather is favourable for monitoring. This highlights the importance for organisation and scheduling of monitoring with advance notice. Initial assistance from the management authority is crucial for planning and structuring the monitoring requirements, goals and timeframes (Campbell & McKenzie, 2001). This needs to be followed by continued support, such as regular reports to community groups, presentations and ongoing training (Campbell & McKenzie, 2001). This demonstrates to the community groups that their efforts are producing valuable information, particularly as many were involved primarily to assist with scientific research in this study.

4.3.2 Community Group Demographics

The demographic profile of a community group is an important factor when identifying volunteer commitment time for participation and sustainability of monitoring. For sustainable monitoring of a Victorian MNP or MS, community groups need to be associated with an MPA which is in close proximity to their residence so that members are willing to commit time to undertake surveys at least annually. There is a correlation between the distance a volunteer lives from a monitoring site and volunteer monitoring time commitment. Community group volunteers living in close proximity to the monitoring site are willing to spend more time participating in a monitoring program. In the present study, all volunteer monitoring participants who responded to the survey, stated that they would be involved in monitoring again. A large proportion of non-participants (>70%) responded that they would participate in the future, though the majority of these responses were conditional to factors such as suitable monitoring dates and more information on the monitoring requirements. The actual number likely to become involved could be a lot less than this. The amount of time community-group members proposed they would commit to monitoring would also be subject to these conditions. University students in the Deakin University Underwater Club were enthusiastic to participate in the monitoring. However, much of their free time was limited by the need to study, as was also found by Barrett *et al.* (2002).

The proposed involvement of non-participants is notably lower for the FOP community group than for MCRP or Deakin University Underwater Club. The lower non-participant involvement for FOP members can be attributed to:

- The majority of group members live >150km from the MPA.

- There are a high proportion of members over the age of 60, and while this is similar to the ratio RPMC, many respondents envisaged their physical mobility and fitness to be too low.

- The group is primarily associated with the terrestrial Wilsons Promontory National Park, monitoring of Corner Inlet MNP was often beyond members' fields of interest.

This highlights some important demographic features of a rural community group, as opposed to a regional or urban community group, that may affect the long-term success of a monitoring program.

4.3.3 Community Group Stewardship

The collection of scientific data is not the sole outcome of engaging community members in research (Foster-Smith & Evans 2003). A range of secondary benefits flow on from the experience and knowledge gained by volunteers:

- A filtering effect of knowledge into the greater volunteer group, and then the wider community.

- Raising public awareness through media interest of volunteer surveys not normally given to scientific studies.

- Increasing the sense of personal/group custodianship of an area, leading not only to continued monitoring, but also promoting responsible use of the local resource.

Monitoring methods should not be seen as constricting enjoyment, but rather encouraging discovery of marine flora, fauna and at a larger scale, habitats. This assists in promoting marine habitat education, awareness, conservation and stewardship. The knowledge of a volunteer can be communicated to other members in the group and at a greater scale to the local community. Volunteer enjoyment in monitoring a MPA leads to a sense of custodianship for that marine habitat, and therefore the volunteer is willing to continue the monitoring for the long term. Foster-Smith and Evans (2003) found major educational and social benefits involving volunteers in scientific projects. Some of these benefits included raising volunteer's feelings of responsibility to the environment, increasing their knowledge of environmental issues, to broadening their horizons through meeting different people and experiencing different ecosystems, and providing oppurtunites for volunteers to solve

environmental problems (Foster-Smith & Evans 2003). In addition to this, the media are keen to report the results of studies involving volunteers, and therefore the results of volunteer surveys may have wider impacts than scientific studies undertaken by research institutions (Foster–Smith & Evans 2003).

Management authorities need to recognise the importance of developing strong partnerships with community groups for long term sustainability of CBM programs. Collaborative management through partnerships allows community groups to be involved in coastal management and care (Wescott 1998). Co-ordination of community groups and reporting findings back to the groups are important components to a program's success. Feedback from community groups can be incorporated into management policies and community programs to be evaluated accordingly. Programs such as Reef Check (Hodgson *et al.* 2003) and Seagrass-Watch in Queensland (McKenzie & Campbell 2002) are examples of partnership programs between government, research centres and community groups. Campbell and McKenzie (2001) found that community volunteers believed that ongoing commitment of government co-ordination, support, reporting and feedback at state and national levels is not only a key element to the programs success, but also for the ongoing success of the Seagrass–Watch program.

Management authorities should sponsor projects which truly empower the community group (Wescott 1998). This will encourage community group participation and long term sustainability of the monitoring. Awarding of certificates to individual volunteers within the group or to the community group as a whole, acknowledges and recognises their contribution towards MPA baseline data collection and at a higher level, coastal zone management. It may be an excellent way to formally acknowledge the help of volunteers, whilst building a sense of custodianship and responsibility for an area. Regular presentations of how volunteer collected data are used can be undertaken to demonstrate the importance of continuing monitoring over the long term.

4.4 Parks Victoria Rangers' Perceptions of Community - Based Monitoring

Parks Victoria Rangers' responses indicate that community - based monitoring in Victoria's MPAs can be successful and lead to positive benefits such as community ownership of an MPA. Many responsees did highlight the importance for community - based monitoring to be successful in the long term, the community groups must be well trained and supervised with ongoing support and funding from the management authority. To maintain community group enthusiasm and energy, many Rangers indicated that the data collected by the community group must be seen as of value to the management authority. Some problems which may

arise with long term monitoring include the community groups being dynamic and changeable not only in member numbers, but areas of environmental interest, and an aging population involved with voluntary groups. Some suggestions to ensure success of community - based monitoring included: weekend workshops to train and supervise community groups, involvement of school groups and a "marine volunteer club" with an annual newsletter.

5 CONCLUSION

Local community groups are often the first to notice changes in their local coastal marine environment (Campbell & McKenzie 2001). Community – based monitoring of Victoria's MNPs and MSs has the potential to provide useful, reliable information to management authorities. With correct implementation and adequate support, the long-term sustainability of a monitoring program is possible. Results from this study do show however that there will be varying levels of success across different habitat types.

The rocky intertidal habitat at Ricketts Point MS proved to be effectively surveyed by MCRP volunteers. Although the volunteers were not as accurate as scientists, they were suitably able to detect shifts in the abundance and size distribution of common organisms. The majority of members lived in close proximity to the sanctuary and were very keen to contribute time and energy to long-term, repeated monitoring.

The subtidal habitat at the Merri MS was not accurately assessed by volunteer Deakin University Underwater Club divers, and only a small amount of information and replication was gathered relative to the investment of resources. Enthusiasm levels were high in volunteers, especially taking into account the additional physical and mental demands associated with underwater monitoring. However, study pressures on students (Barrett *et al* 2002), and the transitory nature of club members may make this a less than ideal example of a sustainable community group monitoring. Further investigation of the potential of community groups to monitor subtidal habitats is required.

While the seagrass habitat at Corner Inlet MNP had a higher degree of monitoring accuracy than the Merri MS, the quantity of data collected was similarly low. Further research over the summer months, when favourable weather patterns are more frequent, may improve the rate of data collection in these habitats. Most Friends of the Prom members generally live a long distance from the monitoring site and commitment levels were consequently lower. The S.E.A.L. Diving Services group is based closer to the MNP and has a demonstrated interest in the local marine environment.

This study has highlighted several important factors for development of a successful sustainable community – based monitoring program:

▪ Community group should be in close proximity to and involved directly with the MPA.

▪ Monitoring of rocky reef intertidal habitats, where possible, will provide the greatest return of investment.

- Provision of a professional facilitator to train, guide and act as a liaison between the community group and the management authority.

- Provision of numerous, detailed photographic reference aids and monitoring equipment.

- Use of quantitative data and multiple volunteers to reduce overall variation and improve reliability of results.

The motivation and involvement of the management authority in community based monitoring of Victoria's MPAs must be clearly defined before delivery of the monitoring protocols to community groups.

This monitoring program will not substitute professional, experienced evaluation of habitats although it will aid management strategies over time and can be effective in detecting large shifts in communities (such as caused by introduced pests) that would not be detected sooner than if monitored on a less frequent basis. Additionally the flow on effect of increased community knowledge, awareness and sense of custodianship fits into the management strategies of Victoria's MPA (Parks Victoria, 2003).

6 SUGGESTED APPROACHES TO COMMUNITY - BASED MONITORING FOR MANAGEMENT AGENCIES

Suggestion 1: Initial training of community group volunteers should be delivered by a professional facilitator who is familiar with the standard operating methodologies, the flora and fauna of that habitat and is known to be a good communicator.

Suggestion 2: Management authorities should provide on-going support and equipment for CBM through partnership programs.

Suggestion 3: A web based data system should be established for ease of data entry. This information can then be accessed by all community groups as well as mangers for the MPAs.

Suggesttion 4: Certificates of participation for community groups to recognise and acknowledge their contribution to the understanding and management of Victorian MPAs and regular presentations of how the data is used by the management authority.

Suggestion 5: Park Victoria Rangers should continue to assist and support community-based monitoring in Victoria's MPAs.

Suggestion 6: Newspaper and radio advertising for initial training will increase public awareness and participation in the monitoring.

Suggestion 7: Community groups involved in monitoring of Victoria's MPAs should be informed that they can contact one another on the Parks Victoria website.

Suggestion 8: Annual reports or newsletters produced to inform involved community groups how community data collection is assisting management.

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APPENDIX 1

Community- Based Monitoring of Victorian Marine National Parks and Sanctuaries

Survey of Parks Victoria Rangers

This is an anonymous survey. Please do not write your name, or any other comments that will make you identifiable on the following pages. These details are <u>only</u> required on the separate Consent Form which will not be linked with this survey at any time. Please read the covering letter and fill in the enclosed Consent Form before you complete the following questions. **Please answer the questions in this survey on behalf of <u>yourself</u> only (i.e. do <u>not</u> include answers for other family members or other members of your household).**

Section A.

1. Is it important to engage community groups in scientific monitoring of Victoria's Marine National Parks and Sanctuaries? (Please circle)

Yes   No

If No, why not?

_____

2. Are community groups capable of collecting scientifically sound data? (Please circle)

Yes   No

If No, why not?

_____

3. Are data collected by community groups valid for scientific analysis? (Please circle)

Yes   No

If No, why not?

_____

4. Are you willing to train community groups the scientific methodologies to undertake data collection? (Please circle)

Yes   No

If No, why not?

_____

5. Do you feel confident using and demonstrating the use of basic scientific equipment? (Please circle)

Yes   No

6. Is liaising and organising days for community groups to undertake data collection part of your Parks Victoria Ranger role? (Please circle)

Yes   No

If No, why not?

_____

7. Is data collection by community groups feasible in the long term? (Please circle)

Yes   No

If No, why not?

_____

8. Do you feel that community groups will be interested in maintaining annual monitoring of the marine national parks and sanctuaries? (Please circle)

Yes   No

If No, why not?

_____

9. Is acting upon feedback from community groups an important part of your role as a Parks Victoria Ranger? (Please circle)

Yes   No

If No, why not?

_____

10. What are the limitations for using community groups to undertake scientific monitoring in marine national parks and sanctuaries? (Please state below)

_____

11. What are the positive aspects of including community groups in scientific monitoring in marine national parks and sanctuaries? (Please state below)

_____

12. Are community groups involved with scientific monitoring in the long term, a positive investment for Parks Victoria and why? (Please state below)

_____

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