



Examining the health of subtidal reef environments in South Australia

Part 3: An evaluation of the potential for the community to undertake environmental monitoring of temperate reef habitats: A review of the South Australian Reef Watch Program

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David Turner, James Brook, and Sue Murray-Jones

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by

David Turner,¹ James Brook,² and Sue Murray-Jones³

1. South Australian Research and Development Institute (Aquatic Sciences), PO Box 120, Henley Beach, South Australia, 5022
2. Conservation Council of South Australia Inc, 120 Wakefield St, Adelaide, SA, 5000
3. Coastal Protection Branch, Department for Environment and Heritage, PO Box 1047, Adelaide, South Australia, 5001

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More information:

Further information about the Reef Health Program along with copies of reports and technical documents may be obtained from the Reef Watch website at <http://www.reefwatch.asn.au>, or by contacting SARDI Aquatic Sciences.

South Australian Research and Development Institute

SARDI Aquatic Sciences
2 Hamra Avenue
West Beach, SA 5024

Telephone: (08) 8207 5400

Facsimile: (08) 8207 5406

<http://www.sardi.sa.gov.au>

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Author(s): David Turner, James Brook, and Sue Murray-Jones

Reviewers: Dr Grant Westphalen (SARDI), Dr Jackie Griggs (SA Water), Dr Scoresby Shepherd (SARDI), Sam Gaylard (EPA), and Bryan McDonald (DEH).

Approved by: Dr Tony Fowler

Signed:



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More information on the Reef Watch program and those currently active within it may be found on the program's website: <http://www.reefwatch.asn.au/>

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Executive summary

Community involvement in monitoring is becoming widespread and numerous examples are available from disciplines including meteorology, sociological, as well as a range of terrestrial and marine biological surveys. Successful community monitoring programs generally have strong linkages between community organisations and professional scientists. Community monitoring initiatives generally aim to gather, process and disseminate data of sufficient quality to facilitate management.

This report aims to provide an assessment of the potential use of volunteer recreational divers as part of a structured reef-monitoring program. Key factors such as diver aptitude, professionalism, and physical ability are identified and addressed. Assessments are made of the available resources and support structures necessary to operate such a program. The report examines the framework for a community-managed program and whether there is sufficient long-term interest to sustain it. This report does not provide an examination of the quality and reliability of data collected by such a program, as this is the subject of a future report.

In South Australia, a community run monitoring program known as Reef Watch has been operating since 1997, with joint aims: monitoring reefs using recreational divers; and educating the community to facilitate involvement in coast and marine management. Most of the examination of recreational diver potential in this report is based on experience in South Australia from the Reef Watch program.

Divers involved in the Reef Watch program generally approach training and the survey program with enthusiasm. Not all divers are able to immediately grasp the underlying principles of the survey methods, and many have trouble with certain aspects of identification; however, those that continue with the program generally improve with experience. Ongoing training and the need for a process of accreditation are particularly important.

Availability of divers (at least in the metropolitan area) is not a limiting factor for the program. Diver numbers have been strengthened through the involvement of a dozen recreational dive clubs (with memberships ranging from 20 to 500). Increased stewardship is also gained through an 'Adopt a Reef' program, which encourages clubs to regularly monitor a specific site.

Funding support for the program has allowed Reef Watch to subsidise monitoring activities by providing free training and monitoring kits. Current funding arrangements for the program are sufficient to maintain the employment of two part-time staff, one of whom is also a dive instructor, to oversee and coordinate the program, and provide training. A second instructor is also employed to cover additional training during peak periods.

Strong support is provided to the program in terms of expert assistance. Technical support is provided primarily through the program's steering committee, which comprises a range of

expertise including science, operations, and education. A number of government departments, research agencies and community organisations are represented on the steering committee.

Conclusions and recommendations

There is considerable support for community-based monitoring programs, both from management agencies and from the community itself. In general, community monitoring programs have the ability to meet a number of objectives, in particular to raise community awareness, and to provide data that can be linked back into the management of marine ecosystems.

A number of issues have been raised in this report as being critical to the future of any such program. These include the following points:

- the program needs adequate support, both in terms of money and resources, and people's time. Support is needed from local agencies, experts, as well as from volunteers and community groups;
- the survey methods should be within the capability of divers to master and physically manage;
- participation needs to be kept affordable for volunteers, both in terms of costs and the time commitment expected;
- information should be disseminated appropriately and frequently;
- training should be continuously assessed and adjusted;
- appropriate training resources are needed and should be continually updated;
- in-water training is essential;
- continuity of funding and hence the provision of a paid coordinator greatly facilitates progress and prevents loss of momentum.

Reef Watch provides a useful working model of a successful community reef-monitoring program. A number of shortfalls in the program have been addressed, and the program is generally regarded as successful. In South Australia, to build on the success of the existing Reef Watch program, this report makes the following recommendations:

- a communications strategy should be developed and updated regularly;
- efforts should be made to secure long-term funding. Looking forward and developing alternative funding strategies should be kept as a high priority;
- quality control and quality assurance are critical. At some point, validation of the methods, as well as the precision and accuracy of data collected by Reef Watch volunteers, is required to deflect criticism and maintain credibility;
- there is scope for additional technical input into the program and additional research into indicators that could provide a focus for monitoring and facilitate reporting.

1 Introduction

In order to facilitate adaptive management of coastal and marine ecosystems, baseline as well as ongoing information about habitats and their conditions is needed. One of the major objectives of the Reef Health program is to facilitate the engagement of community participants in environmental monitoring of reef habitats of South Australia. Because of the range of issues associated with community-based monitoring, the feasibility of this type of program needs to be examined.

The purpose of this report is to provide an assessment of an existing community monitoring program in South Australia, Reef Watch, as a framework for extending community involvement in reef monitoring and assessment. The Reef Watch program has been coordinating monitoring of inshore coastal reefs by volunteer scuba divers since 1997.

This document is divided into four parts. An introduction summarizes some background information on environmental monitoring and community involvement in this type of activity. The second section provides a brief history of Reef Watch and the program's activity. The third section examines the ability of divers to participate in community monitoring, and discusses the credibility and long-term sustainability of the program, while the final section makes some recommendations about community marine monitoring programs in general, Reef Watch in particular. Note that a later report will deal with issues such as precision and the accuracy of data collected within the Reef Watch program.

This is the third report in a series entitled 'Examining the health of subtidal reef environments in South Australia', published by SARDI as part of the Reef Health Program (Turner and Kildea 2006, Turner *et al.* 2006). Details of how to obtain reports in the series appear at the front of this document.

1.1 Requirements for a successful monitoring program

Monitoring involves the repeated measurement of a parameter or parameters over time with a sufficient level of resolution to detect significant changes (Kingsford and Battershill 1998). Background levels of variability need to be assessed, and issues of power, replication and experimental design considered. To be successful, such a program needs to contain a number of components, and must maintain a focus on the key objectives of the program (Vos *et al.* 2000) which need to be well-defined. Considerations for the design of a reef monitoring program suitable for temperate Australia have already been summarised (see Turner *et al.* 2006) and only a brief summary is provided here; however, for any community-based monitoring program, the design will need to be adapted to the abilities of volunteers.

As a general rule, the approach taken will reflect the objectives of the program and the habitats present. Different monitoring needs require different approaches (e.g. Stem *et al.* 2005), but any

successful monitoring program has some common elements. These include (Jacoby *et al.* 1997, Vos *et al.* 2000):

- professional input;
- a well-defined sampling program;
- a database;
- models;
- input into management efficacy;
- assessment of management actions;
- feedback mechanisms;
- a data validation mechanism; and
- an information-dissemination mechanism.

Each of these needs to be properly designed and generally requires specialist knowledge and careful planning. Monitoring programs intended to support adaptive management strategies need to maintain ongoing research and development components and a flexible approach (Vos *et al.* 2000).

The most labour-intensive aspect of any monitoring is the sampling program, and care needs to be taken in its design to ensure that any data collected are of use. For most monitoring, locations of interest need to be compared to control locations, with appropriate methods and statistically adequate replication at all levels (Kingsford and Battershill 1998). The biology of the organisms or assemblages of interest also need to be considered (Kingsford and Battershill 1998) and an appropriate taxonomic resolution used.

1.2 Community involvement in monitoring programs

Volunteer involvement in environmental data acquisition is not new, and has intuitive appeal to both researchers and environmental managers (Root and Alpert 1994, Mims 1999). Volunteer programs are open to criticism, however, which makes program design and training particularly important. The biggest criticism involves the quality of information obtained from such programs. Some scientists argue that it is easier and cheaper to do the work themselves rather than spend time training volunteers; others claim that volunteers cannot easily be trained to the appropriate skill level. There are two major arguments to support the use of volunteers in collecting environmental data:

1. Promoting a wider community involvement in monitoring creates an increased level of awareness and education when a large number of people are actively involved in the program. This may lead to a sense of community stewardship and can generate additional benefits such as impact reduction and efforts in rehabilitation (Cuthill 2000). In addition, community monitoring programs facilitate more informed participation in decision-making processes about local natural

resources which can empower local communities (e.g. ESD strategy, Commonwealth of Australia 1992; Agenda 21, United Nations Conference on Environment and Development 1993).

2. The second argument relates to the increased volume of information that can be obtained from a larger number of participants – more eyes in the water. This enables more data to be collected, over wider spatial and temporal scales. On the other hand, programs need to be designed within the limits of the skills of volunteers, so that data can be collected without loss of precision.

Given that many of the components needed for a successful monitoring program (listed in the previous section) are beyond the scope of the broader population, many community monitoring programs evolve as partnerships between the community, through ‘grass roots’ organisations, and professionals attached to research institutions and or government departments (Savan *et al.* 2003). For such programs to be successful in the long term, linkages need to be fostered and maintained.

1.3 Examples of successful community programs

A number of studies have demonstrated that properly trained volunteers can collect data of high quality, which can feed directly into the management of natural resources. Volunteers have been of major benefit throughout Australia with various Land Care initiatives (Curtis and Nouhuys 1999) and in monitoring physiochemical parameters such as wind erosion (Leys *et al.* 2001). The use of volunteers in coastal areas has also become more common in recent years (Cuthill 2000).

Monitoring programs using trained volunteers have been established to target specific plants and animals throughout the world. Examples of these studies include vegetation surveys (Freeman 2004, Stenhouse 2004), bird observations (Hartup *et al.* 2001, Greenwood 2003, Bennett and Milne 2004), frog censuses (Walker 2002, Stewart-Koster *et al.* 2003) and various mammal studies (Owens 2000, Anon 2003a, Evans and Hammond 2004, Sadlier *et al.* 2004). A useful model of a highly successful program is the collection of data by over 7,000 amateur bird watchers. These data are incorporated into the national Birds Atlas of Australia¹.

In terms of aquatic habitats, a number of programs utilise volunteers to assist in monitoring water quality parameters (Anon 1997, Devlin *et al.* 2001, Nicholson *et al.* 2002), and the flora and fauna of streams (e.g. Fore *et al.* 2001, Engel and Voshell 2002). Some have become national programs, such as Waterwatch², a community water quality monitoring network established by the Australian Government during 1993. There are now nearly 3000 Waterwatch groups

¹ www.birdsaustralia.com.au

² www.waterwatch.org.au/

monitoring water quality at over 7000 sites throughout 200 catchments in Australia. Waterwatch groups conduct biological and habitat assessments plus physical and chemical water tests.

Estuarine monitoring programs are also becoming common (e.g. Arundel and Fairweather 2002) as coastal systems receive more focus (Cuthill 2000), and indeed Waterwatch in some areas is attempting to instigate an estuarine monitoring program.

Marine monitoring programs that utilise volunteers have also become more common with the increasing popularity of recreational diving. Well-developed programs are in place to monitor tropical reef environments, including the international Reef Environmental Education Foundation (REEF) Program (initially based in Florida, USA; Pattengill-Semmens and Semmens 2003)³, Reef Check (initially Queensland; Hodgson 1999; Cuthill 2000)⁴, now an international program (e.g. Hodgson and Stepath 1998; Hodgson 2000)⁵. Some of these organisation are now widespread: Reef Check, for example, provides useful resources, feedback to divers and reporting on reef health in tropical coral systems, and is now active in 82 countries and territories.

Temperate marine monitoring also occurs in many countries including the United Kingdom (Davies *et al.* 2001), Italy (Goffredo *et al.* 2004), Canada (Whitelaw *et al.* 2003), the United States (Pattengill-Semmens and Semmens 2003); and Australia (Barrett *et al.* 2002, Wheeler 2003).

Support for volunteer monitoring programs needs to cover training aspects as well as project coordination and administration. Training is critical. Lack of training can lead to volunteers misidentifying taxa, failing to record all individuals, or confounding statistical designs by not completing replicates (Stokes *et al.* 1990, Stadel and Nelson 1995, McLaughlin and Hilts 1999). Furthermore, lack of support (financial and intellectual) may also cause a decline in monitoring activity and a loss of interest amongst participants (Stadel and Nelson 1995, Freeman 2004). Feedback and reporting of findings is also of fundamental importance if the monitoring program is to be of use in the ongoing management of the natural resource (Vos *et al.* 2000, Stem *et al.* 2005), and helps to maintain volunteer interest. This process is often facilitated if some level of professional involvement is maintained within the program (Savan *et al.* 2003).

³ www.reef.org

⁴ www.reefcheckaustralia.org

⁵ www.reefcheck.org/

2 A brief history of the South Australian Reef Watch Program

The Reef Watch Community Environmental Monitoring Program was established in 1997 as a joint initiative involving organisations with a common interest in community-based reef monitoring (Table 1).

Table 1. Organisations involved in the initial establishment of the Reef Watch program in 1997.

Conservation Council of South Australia (CCSA)
South Australian Environment Protection Agency (EPA)
South Australian Research and Development Institute – Aquatic Sciences (SARDI)
Marine Life Society of South Australia (MLSSA)
Marine and Coastal Community Network (MCCN)
Scuba Divers Federation of South Australia (SDF)
Threatened Species Network (TSN)
University of Adelaide (UofA)

Initial funding of \$10,000 was provided by the EPA in 1997, as well as through an Australian Federal Government initiative known as Coastcare (Marine Group Environment Australia 1999; \$4,000; see Table 2). This allowed for the employment of a part-time project officer to coordinate the establishment of the program and support volunteer involvement.

Reef Watch was established as a long-term program with the following key objectives:

- to monitor temperate reef environments in South Australia with the support of recreational divers;
- to establish an information database to house data collected by the program;
- to provide community education and increase awareness of the issues affecting temperate reefs systems; and
- to increase community involvement in coast and marine management.

Further funding was obtained from the EPA in 1998, and from Coastcare in 1999 and 2000 (Table 2). The program expanded through several 'Dive with Reef Watch' days, which were held in conjunction with community events including 'National Science Week' and 'National Threatened Species Day'. A website for the program was established towards the end of 1999⁶.

By the year 2000, the program had developed considerable momentum and a number of new initiatives were launched including:

⁶ www.reefwatch.asn.au

- the augural 'Marathon Dive' at Noarlunga Reef, which involved about 50 divers and snorkellers, who participated in fish surveys at different locations along the reef;
- a public lecture at which Prof Anthony Cheshire (at the time a lecturer at the University of Adelaide) spoke about the importance of local reef environments, and specifically on the results of scientific reef health surveys undertaken by the University of Adelaide (see Cheshire *et al.* 1998, Cheshire and Westphalen 2000);
- a marine invertebrate identification workshop with 12 guest tutors and speakers from various government and educational institutions, which attracted over 65 participants. This was open to both Reef Watch volunteers and the general public. The format allowed participants to work in small groups and obtain hands-on experience identifying marine invertebrates and macroalgae.

Marathon dives, public lectures and marine identification workshops are now held on an annual basis.

The program suffered considerable setbacks in 2001, due to the loss of funding and consequent loss of the project officer. In response, a new steering committee was formed, which rebuilt the program with the help of a one-day per week in-kind staff contribution provided by the South Australian Department for Environment and Heritage (DEH), to act as a program coordinator.

Funding problems were addressed in 2002 and a new part-time project officer was appointed using funding through the Natural Heritage Trust (NHT) Fisheries Action Program (Anon 2003b). As the Reef Watch program again gained momentum, it became apparent that a number of significant issues were threatening the monitoring aspect of the program. The two main problems were:

- dramatic increases in the cost of liability insurance resulting from an increasingly litigious culture, increased canvassing by lawyers for class action suits, a trend towards courts upholding strict liability, and the collapse of HIH Insurance (Anon 2002);
- legal advice that the program would fall under the realm of the newly developed scientific diving standard in Australia (AS/NZS2299-2 2002). This implied that recreational divers involved in the program would need to obtain expensive occupational training.

Following extensive negotiations, these liability issues were overcome through the development of an accredited specialty course by the Professional Association of Diving Instructors (PADI). This course effectively defined the survey methods as being a recreational rather than a scientific activity.

In 2003, a gap between the NHT1 and the regionally based NHT2 funding programs was bridged by a \$32,000 grant from DEH. A grant from the World Wildlife Fund's Threatened Species Network for \$30,000 was also given specifically to set up a subprogram to monitor introduced marine pests and marine species of conservation concern ('Feral or in Peril').

The advent of NHT2 and NRM funding processes led to an increased and eventually more secure funding base with forecasts of indicative funding for two years in advance. This allowed the Reef Watch program to bring to fruition many initiatives previously developed in an *ad hoc*

manner, and resulted in an increase in the overall level of community participation. Major activities and milestones of the Reef Watch are summarised in Table 2.

New developments include:

- development of on-line data entry pages;
- some simple, automatically-generated reports on the information gathered;
- a number of scientific expeditions around SA to survey reef fish populations;
- development of a benthic identification manual supported by on-line tutorials and quizzes;
- development of a 'Feral or in Peril' kit to involve volunteers in looking for introduced pests as well as for species of conservation concern;
- further educational events including slide nights and quiz nights;
- progress towards an intertidal monitoring program.

The program is based at the Conservation Council of SA (CCSA), which is an umbrella organisation for 60 environmental groups. Twenty percent of all grant money goes to CCSA in exchange for the following facilities and services:

- office space;
- receptionist;
- banking and financial administration;
- broadband internet and IT support;
- office equipment including printing (b/w and colour), laminating and photocopying facilities;
- volunteer management;
- general administrative support;
- human resources support;
- meeting space; and
- access to community and conservation networks.

Over the history of the SA Reef Watch program, approximately 850 surveys have been completed at various locations around the state, excluding surveys carried out during training courses.

Table 2. Summary of activity associated with the Reef Watch program, 1997 to present.

Year	No of surveys (no. of dives)	Events	Funding (approximate years)	Milestones/Major Events
1997	7 (3)		\$10,000 – Environment Protection Agency (EPA) Marine Environment Protection Fund; \$4,000 – Coastcare (Marine Group Environment Australia 1999)*	Basic training kits developed; manuals developed; training commenced
1998	77 (26)		\$5,000 - EPA Marine Environment Protection Fund; \$22,000 - Coastcare	Ongoing training; newsletters; dive organisation
1999	105 (39)		\$45,000 – Coastcare	Website launched
2000	124 (29)	Marathon Dive; public lecture; identification workshop		1 st Marathon Dive; first public lecture; 1 st marine life identification workshop
2001	76 (18)	Marathon Dive		2 nd Marathon Dive
2002	88 (25)	Marathon Dive; scientific expedition; identification workshop	\$40,000 – Natural Heritage Trust Fisheries Action Program (FAP)	First scientific expedition, 3 rd Marathon Dive
2003	57 (25)	Scientific expedition	\$32,000 – SA Department for Environment and Heritage (DEH); \$7,000 – World Wildlife Fund Threatened Species Network	Website upgrades including on-line data entry; manuals revised; PADI Reef Watch Survey Diver course developed; Feral/In Peril kit developed
2004	99 (27)	Marathon Dive; scientific expedition; slide night	\$50,000– Mt Lofty and Greater Adelaide Interim Integrated Natural Resources Management Board	First slide night; 4 th Marathon Dive
2005	126 (29)	Marathon Dive; public lecture; Quiz Night; identification workshop; intertidal workshop; scientific expedition	\$70,000 – Adelaide and Mt Lofty NRM Board	1 st quiz night; on-line identification tutorials and quizzes developed; intertidal program under development; 5 th Marathon Dive
2006	86 (20) to 30 th June	Marathon Dive; scientific expedition	\$80,000 – Adelaide and Mt Lofty NRM Board; \$10,000 – Kangaroo Island NRM Board; \$10,000 – Northern & Yorke NRM Board	6 th Marathon Dive

Note: The original proposal estimated that 20 dive groups would be involved, each with approximately 50 active members (i.e. 1000 data collectors)

3 Towards a successful reef monitoring program

In order for a community reef monitoring program to be considered successful, the elements described in the introduction, as well as the following issues, must be addressed. These can be loosely divided into three areas:

- the ability of community divers to effectively carry out the tasks involved in reef monitoring;
- program credibility and output quality;
- long-term sustainability and support for the program.

These issues will be discussed below with reference to the SA Reef Watch program.

3.1 Ability of community divers to effectively participate in reef monitoring

The focus of this section is the feasibility of using recreational divers from a range of backgrounds, not necessarily with any relevant vocational training, to monitor reefs; it looks at their physical abilities and interest levels. Note that it does not consider issues of scientific credibility, as these will be the focus of a further report.

The main requirement for participation is that divers are competent in the water, with a keen desire to learn about and participate in the survey program. While participants reach different levels of expertise, those who persist do master the ability to perform reef surveys competently. Volunteers start with considerable variability in their level of background knowledge.

Aptitude and professionalism

The Reef Watch program has demonstrated that the majority of divers can be trained to conduct a range of sampling procedures and identify organisms using lifeform⁷ codes. Currently the program uses three sampling methods (Table 3): belt transects (fish), and quadrats and line intercept transects (benthic flora and fauna; note that methods are similar to those used in the Reef Health surveys by scientifically trained personnel; Turner and Kildea 2006). The major difference is that the Reef Watch community surveys utilise a functional group classification system (lifeform codes) to describe biota, rather than taxonomic data (Table 3). This is more reliable than expecting divers to develop high-level taxonomic abilities.

⁷ Rather than going to genus and species, lifeform codes use labels such as "BBRANCH" for brown (i.e. Phaeophyta) branching alga. The full list of lifeform codes can be found on the Reef Watch website, www.reefwatch.asn.au

Table 3. List of sampling methods employed in the Reef Watch program and the functional classification system.

Description	Reference
<i>Sampling methods currently employed by Reef Watch</i>	
50 m belt transect fish surveys	(Reef Watch 2004b)
1 m ² quadrat surveys scoring % cover of canopy and understory species, and counts or % cover of sessile &/or sedentary invertebrates	(Reef Watch 2004c)
Line intercept transect surveys	(Reef Watch 2004d)
<i>Functional classification of life forms</i>	
Identification of macroalgae using a matrix comprised of three phyla and 10 functional codes	(Reef Watch 2004e)
Invertebrate identification based on 28 codes	(Reef Watch 2004e)
Identification of the majority of 36 fish taxa to genus or species	(Reef Watch 2004a)

Divers wishing to participate in Reef Watch monitoring need to undertake the appropriate training course, which is provided free of charge by Reef Watch. There are four basic activities (i.e. fish identification and survey methods, and benthic identification with quadrat and line intercept transect methods), which can generally be covered in three dives. For many volunteers, the preference is to complete the training in three separate outings, allowing time in between to digest the information, although a number of divers with prior identification skills have completed the course in a single day.

In addition to the basic course, volunteers need to spend some time studying the methods in order to become fully proficient. The time taken to do this varies depending on the individual. Some are able to return useful data on their first dive after a good initial briefing, while others need to complete several surveys, with feedback, to master the technique.

Although most volunteers are able to learn the various steps, not all are able to easily grasp the underlying principles, leading to variation in the retention of survey skills. A number of divers require regular reinforcement of identification skills and reminders of the important details surrounding each survey method. There has been a range of improvements incorporated into training since the program's inception, which have addressed many of these initial issues. The training methods are regularly reviewed and new techniques trialled. Volunteers can now use on-line quizzes and tutorials to improve their identification skills, and there is an annual one-day identification workshop, which enables people to gain hands-on experience in small groups, facilitated by scientific and/or educational experts. Overall, volunteers participating in the Reef Watch program have demonstrated a reasonable level of competency when conducting surveys.

Reef Watch has developed a dive club-based approach known as 'Adopt a Reef'. Clubs are asked to nominate and monitor a specific reef. This program has also created a mentoring system whereby divers demonstrating higher levels of aptitude are available to tutor and encourage the newer recruits.

Volunteers generally complete the survey to the best of their abilities. The main factors that may reduce a diver's level of interest in or willingness to complete a survey are:

- volunteers may feel very cold due to the stationary nature of some surveys. This may cause loss of concentration and a decline in performance with increasing length of the survey;
- a volunteer's confidence may be lowered if the diver becomes overwhelmed by the complexity of the method and / or the environment (e.g. abundance and diversity of organisms, particularly where there is a diverse understorey);
- volunteers may have underestimated the difficulty of the dive e.g. surge, current, and be unable to complete the task.

Maintaining interest

There is always a chance that divers undertaking a survey will become momentarily distracted by something that takes their interest, but this is also true for professionals. In the longer term, volunteers may feel that the process is no longer fun, and lose enthusiasm. For maintaining both short and long-term interest, appropriate training and an appreciation of the importance of correct technique and the underlying principles should develop a greater sense of pride and responsibility in participants. Reef Watch management needs to make sure to foster a sense of fun and joint purpose, while maintaining a focus on good data quality.

Time commitments

For most volunteers, diving is a recreational pastime that must be balanced with other commitments, and most like to experience a range of diving activities, limiting time available for undertaking monitoring dives. There is a wide range of diving experiences available for recreational divers in South Australia, highlighted by the Tourism SA website,⁸ with which Reef Watch has to compete. These include:

- diving on historic wrecks, artificial reefs, jetties;
- diving with charismatic species e.g. sea lions, leafy sea dragons, cuttlefish spawning aggregations, blue groper;
- hunting and gathering e.g. lobster, abalone, scallops.

Interest in underwater photography as a component of all these activities has increased as digital cameras and housings become more affordable, and is not easily compatible with the Reef Watch

⁸ http://dive.southaustralia.com/best_dive_secrets.html

methods, as both hands are needed for surveying. Divers also increasingly travel to interstate or overseas locations.

Dive clubs arrange different types of dives at least on a weekly basis and generally aim to provide a monthly or seasonal calendar that provides for a variety of diving experiences. The general consensus among clubs is that Reef Watch monitoring is an activity they would consider conducting either monthly or quarterly, and many clubs are beginning to include Reef Watch dives on their dive calendars.

The amount of time necessary for divers to become proficient at monitoring varies for each individual and is often related to levels (and relevance) of prior vocational training, and/or degree of interest in the program. Many of the training methods employed by Reef Watch have been designed to contain social and entertainment components so as to increase diver enjoyment, and social events always include an educational component to reinforce training.

Physical capability

Normal recreational divers are physically capable of the survey work expected of them by Reef Watch. Diving times, physical exertion and equipment needed for Reef Watch surveys are compatible with recreational pursuits. The distance covered during a survey is comfortably within the bounds of an average recreational dive. Reef Watch survey methods have been formally recognised as a recreational activity by its incorporation into a specialty recreational dive course organised through the Professional Association of Diving Instructors (PADI).

Costs to the volunteer

Monetary costs that would potentially be borne by the volunteer are those for their own dive equipment, SCUBA training, and normal recreational dive costs e.g. air fills, getting to the site, or boat hire costs.

The divers most likely to participate regularly in the Reef Watch program tend to have their own SCUBA equipment. For those who do not own their own gear, the cost of hiring a full kit is about \$60 per day. A number of dive stores now offer discounts of around 30% for Reef Watch participants. Costs for an air fill range between \$5 and \$12, although a growing number of dive stores are also offering discounts (e.g. 2 for 1 deals) for divers undertaking Reef Watch activities, or free air fills for special events such as Marathon Dives.

The survey equipment used is relatively simple and costs about \$50 for a complete set. In many cases, clubs and active individuals are provided with kits free of charge by the Reef Watch program. These kits are partially funded through a grant from the PADI Project 'AWARE' Foundation.

Costs of training

The Reef Watch program provides free training for divers wishing to be involved in the program. The training is in the form of:

- an introductory talk with an explanation of the lifeform identification codes, coupled with a slide show;
- a free dive course endorsed and conducted under the auspices of PADI, comprising four dives (Reef Watch 2004a). This includes fish identification and survey methods, and benthic identification along with quadrat and line intercept transect (LIT) surveys.

Reinforcement of this initial training occurs through the provision of training manuals along with on-line interactive tutorials and quizzes⁹. An advanced certification with more stringent performance requirements is currently being developed. It is anticipated that a process of accreditation will accompany this advanced qualification. This training will also be provided free.

In addition to the standard training program, Reef Watch also organises annual identification workshops with the help of many professional marine scientists, including staff from the SA Museum, Flinders and Adelaide Universities, the State Herbarium, SA Research and Development Institute, and other Government agencies. Feedback from these workshops has been very positive. Indeed a number of university students compared them very favourably with their formal tuition. A nominal amount (about \$10) is charged for attendance.

3.2 Credibility of the program

To be fully credible, a community monitoring program needs to demonstrate that the data collected is precise and reproducible. The Reef Watch program ensures that identification of organisms by community divers is required only to a level that is consistently achievable with only a moderate amount of training – this ranges from species or genus level identifications for indicator fish up to broad morphologically based lifeform codes for macroalgae. Furthermore, the methods are documented as a number of well prescribed steps in manuals. A major focus of the Reef Health project in the future will be a comparison of the results of surveys carried out by scientific survey personnel, with those completed by trained volunteers from Reef Watch. Information generated will be fed back to Reef Watch to be incorporated into a quality assurance program.

A second component of program credibility relates more to the external perception of the program and whether scientists and ecosystem managers will accept the validity of information generated through such a community monitoring program. A rigorous comparison of Reef Watch and Reef Health data as described above should finally resolve these issues; however, the

⁹ www.reefwatch.asn.au/

program has been running for nearly ten years, and it is timely to discuss the credibility of the current program.

The program is well respected in South Australia, particularly because of the range of community, academic and government organisations, and hence skills and expertise that are represented on the steering committee and sub-groups that oversee the project. Volunteer divers, scientists and managers are all represented on the active steering committee. The representation of management agencies on the steering committee greatly facilitates feedback from government to Reef Watch and *vice versa*. A scientific panel comprised of professional biologists makes decisions regarding aspects of sampling design and also handles the majority of data analysis and interpretation. The SCUBA instructors who handle training and manage diving operations also have professional marine biological survey experience.

The scientific procedures and training methods are frequently reviewed, and new elements incorporated as information becomes available. Resources such as videos are being produced and incorporated into training, and the website is being streamlined and more information placed upon it. A process of accreditation and ongoing assessment provides continuous improvement of data quality. Increased precision of data will lead to greater confidence in information generated through the program. Continued involvement by scientists and agency professionals will facilitate the incorporation of data from community monitoring into a broader management framework.

Communications is an essential tool in keeping interest and participation high. Accessibility to the data has improved in recent years, with the fish data being summarised on the website by species and location and a couple of written summaries on aspects of the Reef Watch data. In addition, three reports have been published in the Reef Watcher newsletter to give feedback to divers about the data collected:

- Newsletter 4.2 (August 2000). A comparison of fish abundance at Noarlunga for the 2000 Marathon Data with the 1996 Reef Health data;
- Newsletter 7.2 (August 2004), which presented a summary of trends over three Marathon dives in fish diversity and benthic cover;
- Newsletter 9.1 (March 2006), which reported in trends in the number of leatherjackets, bullseyes and wrasses recorded at Noarlunga over the last decade (from both Reef Watch and scientific studies).

A report on the data collected in the first decade and the lessons learnt during this period is now imminent. The reporting framework generated as part of this process will be incorporated on the website as a calculator to automatically generate and publish future reports (complete with appropriate graphics). This framework will include comparisons with scientific data obtained by the SARDI Reef Health program and its predecessors, and will apply any applicable indicators for assessing reef health.

3.3 Long-term viability of the program

In order for any community monitoring program to be viable in the long-term, some key elements need to be in place. These include: making sure that both volunteers and management agencies have confidence in the program; maintaining the interest and enthusiasm of volunteers; providing high quality training and resources, as well as feedback to divers; reporting; quality assurance; maintaining funding to ensure project coordination; and careful and ongoing planning.

Volunteer contributions

A survey of Reef Watch members (60 responses) showed that divers strongly believe the community has a role to play in monitoring subtidal reefs, and has the capability to do so. Their reasons for being involved include:

- to engage in another diving activity (c. 25% of respondents);
- to dive with like-minded divers (c. 50% of respondents);
- they felt a responsibility to help manage reef environments (c. 50% of respondents);
- to improve skills and gain experience (c. 50% of respondents).

In terms of continuing diver contributions in the future, there appear to be both long-term interest, and a continuing influx of new participants to the program. This is evidenced by the number of divers (167, not including Port Vincent Primary School participants) that have been actively involved in the monitoring program over a period of several years, with some maintaining an active involvement since 1997.

The training procedure, which is undertaken as a formal PADI course, has received a lot of interest. Since its establishment in January 2003, 275 people have commenced the course, and of these 75 have completed it. Approximately half of the graduates have undertaken surveys since the completion of their training. Even many of those who have not completed all training modules have performed surveys using the methods that they have already learnt; for example, if they have completed the fish identification training, they may have performed a fish survey, but not be ready to undertake benthic surveys until they have completed their course.

A number of dive clubs are beginning to be involved in the 'Adopt a Reef' program. Others are rejoining Reef Watch after losing touch with the program during funding gaps. Reef Watch expects numbers to increase over the next financial year, and has placed an increased focus on training.

As the number of trained volunteers increases, a higher level of monitoring coverage should be achievable. With the involvement of more than 300 divers spread across a dozen clubs (as well as some who are not associated with a club), it is expected that the program will be able to

achieve quarterly monitoring of 6-8 reefs, with an additional one-off focus at two distinct locations each year (Marathon Dive).

The above estimates are supported by a recent members' survey, which indicated that:

- almost all divers were interested in attending an annual Marathon Dive; and
- divers would be prepared to undertake at least two monitoring dives each summer, one in winter, and one or two in the other months.

According to the survey, the main reason given for divers not participating over the last twelve months was lack of time (about one quarter of respondents). Less common responses included: lack of money, sickness or lack of awareness of the dives.

Divers who did not attend the 2005 Marathon Dive were surveyed. Half of the respondents said they were not available to dive that day due to another activity. This can be at least partially addressed by choosing and publicising dates well in advance; to make sure it is on all dive club calendars.

In May 2006, a planning meeting was held to discuss the directions and scope of the program. Aspects of the program discussed included: retention of divers; improving the effectiveness of the monitoring program; and the best use of limited resources to achieve the twin objectives of collecting scientifically valid data and general education and raising awareness. Recommendations from the day included:

- in many cases, the club-based "adopt a reef" project had produced data that was too sparse to make a useful contribution, and there was a need to focus the existing monitoring resources on particular locations/seasons that would extend existing time series or improve the overall understanding of reef characteristics;
- a hierarchical system of monitoring methods was required that would on the one hand allow newcomers to the program to progress more quickly through training to the point of collecting valid data, while allowing participants the opportunity for ongoing development towards more advanced monitoring techniques. In particular, the number of benthic surveys being taught needs to be rationalised, as well as the number of taxa/lifeforms required for identification;
- while the annual identification workshops are a key component of the education program, it was felt that they could be more tailored for the divers most likely to undertake monitoring, using the same or less resources. It was therefore decided to hold a series of smaller workshops at times and venues appropriate to the individual clubs.

In terms of staff, there are currently two paid instructors with the appropriate qualifications¹⁰ to conduct training, along with a dozen volunteer assistants who participate at various times. It is likely that within 2006 at least two of these assistants will attain the appropriate qualifications to enable them to conduct the training themselves.

¹⁰ defined as qualified PADI instructors with appropriate general experience, which includes the certification of at least 25 divers, and demonstrated experience in performing reef surveys

Ongoing funding

The Reef Watch program has indicative funding of approximately \$73,000 for each of the next two financial years (2006-7 and 2007-8) through Natural Resource Management groups, primarily the Mount Lofty Ranges and Greater Adelaide NRM group. This will ensure current staffing levels are maintained.

Information dissemination

A key to sustaining the project is to continue to interest the community, and to convince managers the program is worth continuing support for. An important component is the dissemination of information. A communications strategy is urgently needed. One was developed in about 1998, but it has not been used and badly needs updating. Reef Watch is mindful of the need to communicate effectively, and does this in a number of ways, listed below:

- Web - both in the form of static reports (in the form of pdf files) and dynamic information generated from the on-line database. The dynamic information is currently textual in nature but will be expanded over the forthcoming six months to include graphical displays;
- e.mail - there are 500 addresses on the Reef Watch e.mail list, including a dozen dive clubs which each have between twenty and 500 members;
- Newsletters - 300 newsletters are produced quarterly. Hard copies are distributed to a mailing list of 150, and through dive outlets (150). An electronic version is circulated to the e.mail list, and both current and back issues made available on the website;
- Regular updates on events are sent to the e.mail list in addition to newsletters;
- Community publications - articles appear in various community journals, such EcoVoice and Southern Fisheries, on a quarterly basis;
- Posters - as the 'Adopt a Reef' program develops, Reef Watch intends to develop posters that provide information about reef status and trends for display at dive club premises;
- Publicity - media releases are circulated before major events. Some, such as Marathon Dives, attract attention from metropolitan newspapers, TV and radio;
- Schools programs and talks to dive clubs and other community groups;
- Linked projects and extension work: for imai 0 6hich each extenst14 Tc 011ETM-4(ayJ-0-(tiDaTc 01 ar

Support for community reef monitoring initiatives has also increased following the establishment of the Reef Health program, based at SARDI Aquatic Sciences. This program will further the development of education and training initiatives, and establish a process of accreditation for recreational divers.

Threats to sustainability

- In 2001, lack of funding and the concomitant lack of a project officer lead to a major loss of momentum. Without a paid coordinator, the program is unlikely to be viable in the long term, hence lack of funding is a major risk;
- Volunteers may become bored, or feel they have 'been there, done that' and look for other experiences;
- Loss of experienced staff. It may be difficult to replace existing staff. Qualified dive instructors with survey and training experience may not be willing to work part-time;
- Poor weather e.g. in summer 2005-6, attempts were made to hold a monitoring dive in Victor Harbor. However, poor weather meant the dive was cancelled and rescheduled five times in three months;
- Perception of danger e.g. in 2005 an Adelaide University researcher was taken by a white shark, and many recreational divers stopped diving for varying periods of time;

4 Conclusions and Recommendations

There is considerable support for community-based monitoring programs, both from management agencies and from the community itself. Academic institutions tend to be less enthusiastic, and validation of methods and skills of divers are needed to increase confidence. In general, community monitoring programs have the ability to meet a number of objectives, in particular to raise community awareness, and to provide data that can be linked back into the management of marine ecosystems. Before undertaking such a community monitoring scheme, it is important to assess the level of support available, the ability to provide training and logistical services, and the skills and levels of commitment and enthusiasm amongst the volunteer pool.

A number of issues have been raised in this report as being critical to the development and maintenance of any type of community monitoring program. These include the following points:

- the program needs adequate support, both monetary and from local agencies, experts, and of course, from volunteers and community groups;
- the survey methods should be within the capability of divers to manage;
- participation needs to be kept affordable for volunteers, both in terms of costs and the time commitment expected;
- information should be disseminated appropriately and frequently, at a variety of levels, from articles in magazines and program newsletters to reports back to funding bodies and management agencies;
- training should be continuously assessed and adjusted to meet the needs of the program;
- appropriate training resources are needed and should be continually updated (e.g. books, website, photo index, DVDs and videos);
- in-water training is an essential component;
- continuity of funding and hence the provision of a paid coordinator greatly facilitates progress and prevents loss of momentum. It is extremely difficult to run such a program without at least a part-time coordinator.

The South Australian Reef Watch program can be used as a model of a successful monitoring program. The Reef Watch program provides a working demonstration that community involvement in reef monitoring is both viable and useful, and the educational component of the program is also highly regarded. Indeed, the level of public interest in events such as Marathon Dives, quiz nights and identification workshops has been surprising, and was not limited to Reef Watch volunteers.

In South Australia, to build on the success of the Reef Watch program, it is recommended that that:

- a communications strategy be developed and updated regularly;
- efforts should be made to secure long-term funding. A case should be presented to supporting bodies to obtain at least indicative funding in advance (Note that this has now happened for the next two years with indicative funding of \$73,000 per year secured through NRM Boards). Probably the biggest threat to the program is the loss of

momentum during funding gaps. Looking forward and developing alternative funding strategies should be kept as a high priority;

- quality control and quality assurance are critical. At some point, validation of the methods, as well as the precision and accuracy of data collected by Reef Watch volunteers, is required to deflect criticism and maintain credibility. The focus of the Reef Health program on a comparison of the work of scientific divers with community divers is timely. It will provide vital information on the ability of such a community group to collect meaningful data that can be relied upon. In addition, it will provide input back into training and methods that may further improve the program.
- There is also scope for additional technical input into the program and additional research into indicators that could provide a focus for monitoring and facilitate reporting, in order to maximise the usefulness of these types of assessments and applicability to management.

References

- Anderson MJ, Diebel CE, Blom WM, Landers TJ (2005) Consistency and variation in kelp holdfast assemblages: Spatial patterns of biodiversity for the major phyla at different taxonomic resolutions. *Journal of Experimental Marine Biology and Ecology* 320: 35-56
- Anon (1997) Volunteer stream monitoring: A methods manual. United States Environmental Protection Authority, Washington, DC
- Anon (2002) Public liability submission to ministerial forum. Insurance Council of Australia Inc., Sydney
- Anon (2003a) A management program for the Greater Bilby (*Macrotis lagotis*) in the Northern Territory of Australia. Parks & Wildlife Commission of the Northern Territory, Darwin
- Anon (2003b) Fisheries Action Program, Strategy and action plan. Department of Agriculture, Fisheries and Forestry, Canberra
- Arundel H, Fairweather PG (2002) South-west intertidal habitat assessment and education project. Parks Victoria, Melbourne
- AS/NZS2299-2 (2002) Occupational diving operations - Scientific diving. Standards Australia, Canberra
- Barrett NS, Edgar GJ, Morton A (2002) Monitoring of Tasmanian inshore reef ecosystems: An assessment of the potential for volunteer monitoring programs and summary of changes within the Maria Island Marine Reserve from 1992-2001. Technical report series no. 10. Tasmanian Aquaculture & Fisheries Institute, Hobart
- Bennett LP, Milne RJ (2004) Criteria to assess and select sites for long-term avian monitoring in an urbanizing landscape. *Environmental Monitoring and Assessment* 94: 147-162
- Cheshire AC, Westphalen G (2000) Assessing the status of temperate reefs in Gulf St. Vincent IV. Results of the 1999 surveys. University of Adelaide, Adelaide
- Cheshire AC, Hall SJ, Havenhand J, Miller D (1998) Assessing the status of temperate reefs in Gulf St. Vincent II: Survey results. University of Adelaide, ISBN 0 86396 631 4, Adelaide
- Commonwealth of Australia (1992) National strategy for ecologically sustainable development. Australian Government, Canberra
- Curtis A, Nouhuys MV (1999) Landcare participation in Australia: The volunteer perspective. *Sustainable Development* 7: 98-111
- Cuthill M (2000) An interpretive approach to developing volunteer-based coastal monitoring programs. *Local Environment* 5: 127-137
- Davies J, Baxter J, Bradley M, Connor D, Kahn J, Murray E, Sanderson W, Turnbull C, Vincent M (2001) Marine monitoring handbook. 405 pp, ISBN 1 85716 550 0, pp 405
- Devlin M, Waterhouse J, Brodie J (2001) Community and connectivity: Summary of a community based monitoring program set up to assess the movement of nutrients and sediments into the Great Barrier Reef during high flow events. *Water Science and Technology* 43: 121-131
- Engel SR, Voshell JR (2002) Volunteer biological monitoring: Can it accurately assess the ecological condition of streams? *American Entomologist* 48: 164-177
- Evans PGH, Hammond PS (2004) Monitoring cetaceans in European waters. *Mammal Review* 34: 131-156
- Fore LS, Paulsen K, Laughlin K (2001) Assessing the performance of volunteers in monitoring streams. *Freshwater Biology* 46: 109-123

- Freeman AND (2004) Constraints to community groups monitoring plants and animals in rainforest revegetation sites on the Atherton Tablelands of far north Queensland. *Ecological Management and Restoration* 5: 199-204
- Goffredo S, Piccinetti C, Zaccanti F (2004) Volunteers in Marine Conservation Monitoring: a Study of the Distribution of Seahorses Carried Out in Collaboration with Recreational Scuba Divers. *Conservation Biology* 18: 1492-1503
- Greenwood JJD (2003) The monitoring of British breeding birds: a success story for conservation science? *The Science of The Total Environment* 310: 221-230
- Haig J, Russell B and Murray-Jones S (2006) Offshore marine habitat mapping and near-shore marine biodiversity within the Coorong bioregion. A report for the SA Murray-Darling Basin Natural Resource Management Board. Department for Environment and Heritage, Adelaide. Pp 74. ISBN 1 921018 23 2
- Hartup BK, Dhondt AA, Sydenstricker KV, Hochachka WM, Kollias GV (2001) Host range and dynamics of mycoplasmal conjunctivitis among birds in North America. *J Wildlife Diseases* 37: 72-81
- Hodgson G (1999) A Global Assessment of Human Effects on Coral Reefs. *Marine Pollution Bulletin* 38: 345-355
- Hodgson G (2000). Coral Reef Monitoring and Management Using Reef Check. *Integrated Coastal Zone Management* 1: 169 - 179.
- Hodgson G and Stepath CM Using Reef Check for long-term coral reef monitoring in Hawaii. *Proceedings of the Hawaii Coral Reef Monitoring Workshop - A tool for management. June 9-11, 1998. East-West Center, Honolulu, HI, USA.*
- Jacoby C, Manning C, Fritz S, Rose L (1997) Three recent initiatives for monitoring of Australian coasts by the community. *Ocean & Coastal Management* 36: 205-226
- Kingsford MJ, Battershill CN (1998) Procedures for establishing a study. In: Kingsford MJ, Battershill CN (eds) *Studying temperate marine environments - A handbook for ecologists*. Canterbury University Press, Christchurch, pp 29-48
- Leys J, McTainsh G, Shao Y (2001) Wind erosion monitoring and modelling techniques in Australia. In: Stott DE, Mohtar RH, Steinhardt GC (eds) *Sustaining the global farm. Selected papers from the 10th international soil conservation organisation meeting, May 24-29 1999, Purdue University*, pp 940-950
- Marine Group Environment Australia (1999) *Improving performance in partnership. Midterm evaluation of coasts and clean seas 1997-1999, final report*. Environment Australia, Canberra
- McLaughlin L, Hilts S (1999) Monitoring accuracy and the decomposition of error committed by volunteers in a wetland wildlife monitoring program *Leading Edge Conference Proceedings*. Niagara Escarpment Commission, Burlington, Ontario
- Metaxas A, Hunt HL, Scheibling RE (1994) Spatial and temporal variability of macrobenthic communities in tidepools on a rocky shore in Nova Scotia, Canada. *Marine Ecology Progress Series* 105: 89-103
- Mims FM (1999) Amateur Science: strong tradition, bright future. *Science* 284: 55-56
- Nicholson E, Ryan J, Hodgkin D (2002) Community data - where does the value lie? Assessing confidence limits of community collected water quality data. *Water Science and Technology* 45: 193-200
- Owens H (2000) *Guidelines for vertebrate surveys in South Australia using the biological survey of South Australia. Section 1: Pre-survey and the survey process*. National Parks & Wildlife, South Australia, Adelaide

- Pattengill-Semmens CV, Semmens BX (2003) Conservation and Management Applications of the Reef Volunteer Fish Monitoring Program. *Environmental Monitoring and Assessment* 81: 43-50
- Reef Watch (2004a) Reef Watch fish identification slate v3. Reef Watch Community Environmental Monitoring Program, Adelaide
- Reef Watch (2004b) Reef Watch fish survey manual v3. Reef Watch Community Environmental Monitoring Program, Adelaide
- Reef Watch (2004c) Reef Watch benthic quadrat survey manual v4. Reef Watch Community Environmental Monitoring Program, Adelaide
- Reef Watch (2004d) Reef Watch line intercept transect survey manual v3. Reef Watch Community Environmental Monitoring Program, Adelaide
- Reef Watch (2004e) Reef Watch benthic identification manual v4. Reef Watch Community Environmental Monitoring Program, Adelaide
- Root TL, Alpert P (1994) Volunteers and the NBS. *Science* 263: 1205
- Sadler LMJ, Webbon CC, Baker PJ, Harris S (2004) Methods of monitoring red foxes *Vulpes vulpes* and badgers *Meles meles*: Are field signs the answer? *Mammal Review* 34: 75-98
- Savan B, Morgan AJ, Gore C (2003) Volunteer environmental monitoring and the role of the Universities: The case of citizens' environment watch. *Environmental Management* 31: 561-568
- Stadel AV, Nelson JG (1995) The role of citizen participation in ecosystem monitoring. In: Herman T, Bondrup-Nielsen S, Willison JHM, Munro NWP (eds) *Ecosystem Monitoring and Protected Areas: Proceedings of the Second International Conference on Science and the Management of Protected Areas*, Dalhousie University, Halifax, Nova Scotia, Canada, pp 447-453
- Stem C, Margoluis R, Salafsky N, Brown M (2005) Monitoring and evaluation in conservation: A Review of Trends and Approaches. *Conservation Biology* 19: 295-309
- Steneck RS, Dethier MN (1994) A functional group approach to the structure of algal-dominated communities [review]. *Oikos* 69: 476-498
- Stenhouse RN (2004) Local government conservation and management of native vegetation in urban Australia. *Environmental Management* 34: 209-222
- Stewart-Koster B, Dobbie M, Harch B, Correll R (2003) Community collected data for the assessment of ecosystem health: Statistical analysis of the South Australian frog census data, 1994-2001. CSIRO Mathematical & Information Sciences, CMIS 03/85, Brisbane
- Stokes P, Harvas M, Bridges T (1990) Public participation and volunteer help in monitoring programs: An assessment. *Environmental Monitoring and Assessment* 15: 225-229
- Turner DJ, Cheshire AC (2003) Encounter 2002 expedition to the Isles of St Francis, South Australia: Structure and productivity of subtidal macroalgal communities. *Transactions of the Royal Society of South Australia* 127: 153-166
- Turner DJ, Kildea TN (2006) Examining the health of subtidal reef environments in South Australia, Part 2: Status of selected South Australian reefs based on the results of surveys undertaken in 2005. South Australian Research & Development Institute (Aquatic Sciences), RD03/0252-6, Adelaide
- Turner DJ, Kildea TN, Murray-Jones S (2006) Examining the health of subtidal reef environments in South Australia, Part 1: Background review and rationale for the development of the monitoring program. South Australian Research and Development Institute (Aquatic Sciences), RD03/0252-5, Adelaide

- United Nations Conference on Environment and Development (1993) Agenda 21, Program of action for sustainable development. United Nations, New York
- Vos P, Meelis E, Ter Keurs WJ (2000) A Framework for the design of ecological monitoring programs as a tool for environmental and nature management. *Environmental Monitoring and Assessment* 61: 317-344
- Walker S (2002) Frog Census 2001: Community monitoring of water quality and habitat condition in South Australia using frogs as indicators. South Australian Environmental Protection Authority, Adelaide
- Wheeler K (2003) Marine community monitoring manual: An early warning system for detecting change in the marine environment. Marine Conservation branch, Department of Conservation & Land Management, Fremantle
- Whitelaw G, Vaughan H, Craig B, Atkinson D (2003) Establishing the Canadian Community Monitoring Network. *Environmental Monitoring and Assessment* 88: 409-418
- Wright IA, Chessman BC, Fairweather PG, Benson LJ (1995) Measuring the impact of sewage effluent on the macroinvertebrate community of an upland stream - the effect of different levels of taxonomic resolution and quantification. *Australian Journal of Ecology* 20: 142-149