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

Subtidal Reef Monitoring

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

Subtidal Monitoring

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FOREWORD

The establishment of Victoria's Marine National Parks and Sanctuaries in 2002 has created a world-class system to conserve Victoria's unique and diverse marine environment. To foster and encourage community stewardship for a marine protected area, Parks Victoria and Deakin University have developed a set of three technical series which will allow your community group to monitor your marine national park or marine sanctuary. The name given to this series set is Sea Search and focuses on community-based monitoring. This will encourage community interest in your local marine protected area. Through community-based monitoring, a network of community monitoring groups can be established along the Victorian coastline.

Each technical series focuses on a specific marine habitat type and includes:

- Seagrass Monitoring – Technical Series 16
- Intertidal Monitoring – Technical Series 17
- Subtidal Monitoring – Technical Series 18

This set of technical series will allow your community group to learn about the animals and plants in your marine protected area in addition to applying scientific knowledge to obtain important biological information. Participation in long term monitoring will allow your group to accumulate biological data which will provide information on the environmental status of your marine protected area.

By engaging in monitoring, your community group has an active role in management. Active involvement and participation by your community group will increase local knowledge and awareness of the marine protected area and add value to the operations of the management agencies.

Data collected by your community group can be used to provide management authorities with quality advice. Your group has an important role in achieving the objectives of marine national park and marine sanctuary management. Community-based monitoring will allow you and your group to connect further with the marine environment and enjoy the wonders of Victoria's unique and diverse marine plants and animals.

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1.0 INTRODUCTION TO COMMUNITY-BASED MONITORING

1.1 What is community-based monitoring?

The newly created system of Marine National Parks (MNPs) and Marine Sanctuaries (MSs) in Victoria, provide the ideal opportunity for community groups to partake in community-based monitoring projects.

Community-based monitoring allows Friends and community groups to be interactive with their MNP or MS. It allows groups to conduct meaningful scientific surveys and collect biological information whilst having fun at the same time. All volunteers will learn new techniques and increase their knowledge of the marine plants and animals found in their marine protected area (MPA). Community-based monitoring is flexible and volunteers can choose when and where they would like to survey their marine habitat.

Biological information collected by community groups will assist in the management of Victoria's MNPs and MSs. Monitoring of Victoria's MPAs will allow community groups to develop awareness and to raise the profile of natural, cultural and social values of MPAs among the public. Community involvement can also build custodianship of an area and help communicate findings back to the broader community. Community-based monitoring of Victoria's MPAs is therefore valuable to management from both an ecological and social perspective. Community participation in activities allows communities and individuals to recognise that they have an important role in achieving the objectives of MNP and MS management (Parks Victoria 2003).

Figure 1.0 Four volunteers of the Deakin University Underwater Club ready to descend to the bottom of the dive buoy to initiate subtidal monitoring. (Image: R. Koss)

1.2 What does monitoring mean?

Monitoring is the repeated observation of a system, such as subtidal rocky reefs, usually to detect change (McKenzie & Campbell 2002). The types of methods used in monitoring will affect the ability to accurately detect change in a system. It is important that the methods in a monitoring program are designed to quantify the causes of change for a particular site. Monitoring can focus on a particular organism or habitat, with additional information on environmental conditions. A successful monitoring program examines a specific environmental concern (McKenzie & Campbell 2002). Well-designed monitoring programs will be able to detect disturbances and distinguish them from natural variation (Roob 2003).

Subtidal rocky reefs are popular to study in many parts of the world. There are numerous organisms, sessile, fast - or slow - moving, which can be easily seen. The types of organisms found on rocky subtidal reefs are diverse. These organisms display varying physiological and behavioural adaptations to the extreme physical factors of their environment (Underwood 1994). Due to competition for space and food, there are a variety of interactions which are influenced by variations in the environment.

Through community-based monitoring, patterns of these changes can lead to effective management decisions for an area. The most efficient and appropriate monitoring parameters are chosen to enable the minimal monitoring effort required to detect change which are statistically and biologically meaningful. Biological variables which are collected during subtidal monitoring include: size and abundance of fish, cephalopod counts, cryptic fish size and counts, invertebrate species counts, point count of algae, and point count for aggregate sessile invertebrates. Physical parameters are equally important and include substratum type, depth of monitoring, water temperature, and water visibility.

The method of collecting data will be dependent on the expected use of the data. Accuracy and precision of data collection is a requirement for accountability in coastal management decisions. This in turn has created a need for statistical rigour in the design of sampling programs for monitoring environmental impacts (McKenzie & Campbell 2002). Any impacts caused by human activities can then be separated from any natural variation within the system.

To find out the closest Victorian MNP or MS which your community group can monitor, contact the Parks Victoria Customer Service line on **13 19 63**, or visit their website at www.parkweb.vic.gov.au and click on Marine & Coasts.

1.3 What are the objectives of subtidal reef monitoring in Victoria's Marine National Parks and Sanctuaries?

The primary objectives of environmental research and monitoring programs related to one protected area management is to provide information on the status of natural values and threatening processes, and to determine the nature and magnitude of trends over time (Parks Victoria 2003). This will in turn provide increased knowledge, understanding change, benchmarking and provide vital signs to assist with management of these areas (Parks Victoria 2003).

The principal objectives for subtidal reef monitoring within Victoria's MPAs are:

1. to characterise subtidal plant and animal communities on each reef by providing data on populations, population size structure of common and potentially-impacted species and biological structure

2. to identify important variation in subtidal plant and animal species and communities spatially across reefs within MPAs and reference sites. (See Section 3.3 to find out what a reference site is).

3. to determine the nature and magnitude of natural changes to species populations and communities over time

4. to detect impacts of threats on species populations and communities with reference sites.

2.0 ALL ABOUT THE SUBTIDAL ZONE

2.1 Where is the subtidal zone located?

The subtidal zone covers the area of the ocean that lies next to the lower end of the intertidal, known as the sublittoral fringe. The subtidal zone is always covered by water at low and high tides. This area shows more variability in environmental conditions than the open ocean or the deep sea (Nybakken 2001).

The subtidal zone is affected by many processes, but the most influencing physical factor is turbulence, caused by wave action (Nybakken 2001). Turbulence is the interaction between waves, currents and upwellings from the ocean. The constant availability of nutrients, due to turbulence, increases the productivity rate of plankton and other organisms (Nybakken 2001). Long-period ocean swell and storm waves can affect the bottom substratum and organisms, causing substratum particles to be resuspended and hence, determining the type of particles present. Heavy wave action removes fine sediment particles by keeping them in suspension leaving mainly sand. Therefore, fine silt sediments can only occur in areas that have low wave action or are too deep to be affected by wave action (Nybakken 2001).

Turbulence stops the subtidal waters heating up and staying at warmer temperatures in temperate waters. However, there is a seasonal change in temperature that can act as a cue for organisms to begin or end reproduction (Nybakken 2001). Light penetration in the subtidal zone is reduced in contrast to the open ocean (Nybakken 2001). This is due to the break up of plants and other debris, both from the ocean and the land, found in the water column. Salinity in the subtidal is more variable than in the open or deep ocean and can be affected by large amounts of freshwater discharged from rivers (Nybakken 2001).

2.2 What is a subtidal rocky reef habitat?

Rocky subtidal reefs are common off rocky coasts (Levinton 2001). The rocky subtidal habitat can be composed of a hard substratum starting at the lower intertidal down to the upper limit of the deep sea (Witman & Dayton 2001). This includes sloping bedrock ledges, offshore banks and pinnacles, cobble and boulder fields, and rock walls. The rocky substratum is colonised by a variety of plants, colonial and individual animals, for example, colonial sea squirts and sponges and individual sea anemones and barnacles (Witman & Dayton 2001). (*See Sections 2.3 and 2.4 for more information on animal and plants found on subtidal rocky reefs).* Less is known about the ecology of rocky subtidal communities than the intertidal, largely because subtidal habitats are less accessible than intertidal ones (Witman & Dayton 2001).

The rocky subtidal reef can be divided into two zones (Witman & Dayton 2001):

- The infralittoral zone, which is the shallow zone dominated by macroalgae. The extent of this zone is dependent on the availability of light for photosynthesis. *(See Section 2.3 for information on macroalgae and a definition of photosynthesis)*
- The circalittoral zone, which is the region below the macroalgae zone dominated by mobile and sessile (non-mobile) invertebrates. *(See Section 2.4 for information on invertebrates).*

Community composition in the infralittoral zone is influenced by the slope of the rock bottom and the type of substratum. Horizontal and gently-sloping substrates are generally dominated by macroalgae. The higher light levels on the horizontal surface create a more favourable environment for the growth and survival of macroalgae (Witman & Dayton 2001). The circalittoral zone comprises of vertical and some horizontal walls which are usually covered with animal communities. Vertical and overhanging wall habitats, in the subtidal, are more sheltered from physical and biological disturbances than open and exposed horizontal rock platforms (Witman & Dayton 2001). These habitats are dominated by animals which do not require light for growth. The distribution and abundance of plants and animals found at different depths varies according to factors such as grazing, predation, competition, recruitment, disturbance, water flow, and sedimentation. As the depth gradient increases along the substratum, the abundance of macroalgae decreases, but the number of sessile invertebrates increases (Witman & Dayton 2001).

The surfaces of rocky reefs in temperate Australia are dominated by algae, particularly kelp (Butler 1995). Beneath the kelp canopy, where light is reduced, red algae and sessile invertebrates are more common. Not all rocky reefs provide the same habitat, and therefore the same types of organisms.

2.3 What types of marine plants are found on subtidal rocky reefs?

The terms ‘seaweed’ or ‘macroalgae’ are often used when describing plants which inhabit the subtidal zone. Seaweeds are algae, structurally simple plants without roots, stems, or leaves, and have primitive methods of reproduction (Christianson *et al*. 1988). Seaweeds and seagrasses are the major primary producers of coastal regions. They are eaten by vertebrate and invertebrate animals and therefore form the basis of many food webs (Christianson *et al*. 1988).

There are four main environmental factors which influence algal growth and distribution in the subtidal areas (Womersley & King 1995):

- *Dynamic factors* which include tide, water movement and wind

- *Physical factors* which include light, sea and air temperature, humidity, freshwater input, and substratum type
- *Chemical factors* such as salinity, nutrients, gas availability, pH and pollution
- *Biotic factors* which include recruitment, competition for space, grazing/predation, epiphytism and symbiotic relationships

The combination of all these factors varies on a daily, weekly and monthly basis.

There are three major forms of algae living on rocky subtidal reefs (Underwood & Chapman 1995):

Encrusting algae: These algae have a flat appearance and are tightly stuck down to the substratum. Due to the high levels of calcium in the plant structure, this alga can be hard and crunchy when touched. Most encrusting algae in temperate zones are not calcified, for example some greens and browns, which are tough and leathery in appearance (Levinton 2001). A red coralline alga is an example of an encrusting alga.

Foliose algae: These algae are usually upright and form branches which vary in length. They usually grow in very dense patches. Some are tough and wiry, while others are soft and flexible. The many branches often provide shelter for smaller animals to live in.

Canopy forming algae: These algae are taller, with fronds standing in the water column. They are able to form dense canopies, where they are likened to forests of the sea.

To view a variety of different macroalage species which grow in the sub tidal zone, download images from the Sea Search website www.parkweb.vic.gov.au/seasearch These images were compiled by Dr. Alecia Bellgrove from the School of Ecology and Environment, Deakin University.

Figure 2.0 Volunteers of the Deakin University Underwater Club undertaking algae identification training with Dr. Alecia Bellgrove at the Merri Marine Sanctuary, Victoria. (Image: D. Ierodiaconou)

Although there are many forms of algae, there are three major groups of macroalgae (or seaweeds) based on the forms of colouration.

- *Green algae*: Chlorophyta are characterised by their green colour due to their chlorophyll pigments, which assist in the capture of sunlight for photosynthesis (Womersley 1984). Shades can range from yellow-green to dark- or black-green. There are fewer species of green algae in the subtidal and they are often smaller in size and form than the reds and browns (Christianson et. al. 1988). Many are tolerant of extreme environmental conditions and can colonise new or cleared surfaces rapidly (Christianson et. al. 1988).
- *Chlorophyll* is the green pigment found in plant cells and acts as a receptor of light energy for photosynthesis, which uses the light energy to create chemical reactions and form chemical bonds with carbon dioxide and water. Through photosynthesis, most plants are able to produce energy to assist in growth.
- *Brown algae: Phaeophyta* are light- to dark-brown in colour due to the fucoxanthin (brown pigments) which covers the green chlorophylls (Womersley 1984). Colours range from pale-olive or yellow-brown to almost black (Christianson *et. al*. 1988). The brown algae vary greatly in form and size, and many of the common species in Australia grow nowhere else in the world (Christianson *et. al*. 1988).
- *Red algae: Rhodophyta* vary in shades of red due to phycoerythrin, the red protein pigment (Womersley 1984). Phycoerythrin can be destroyed easily by high light intensity and therefore many of the red algae may not appear bright red in colour (Womersley

1984). This group of algae dominates the subtidal reefs as their combination of photosynthetic pigments enable them to harvest light even at low intensity, common in deeper waters (Levinton 2001). Many subtidal red algae are endemic to southern Australia (Christianson *et al.* 1988).

- Large brown algae are often the community dominants in the infralittoral zone down to a depth of 10-25m (Witman & Dayton 2001). The upper canopy is usually dominated by large macroalgal species, such as kelps. The kelps create an upper canopy with an understorey of red and green macroalgae.

There are many different forms and colours of macroalgae found on subtidal reefs. They can be summarised in the following forms and groups:

There are three forms of macroalgae: *Encrusting, Foliose* and *Canopy*

There are three groups of macroalgae: *Green, Brown, and Red*

2.4 What are the different types of marine animals found on subtidal rocky reefs?

Mobile Invertebrates

An invertebrate is any animal that does not have a backbone (Purves *et. al*. 1992). This group includes animals such as snails, limpets, abalone, nudibranchs, sea stars, sea urchins, crabs, crayfish and cephalopods. There are many species occurring along the coast, but there are lots of similarities in the sorts of animals that you find (Underwood & Chapman 1995).

There are two types of snails found on subtidal rocky reefs. The first type of snail is known as an herbivore due to its diet which comprises of vegetative matter. These snails graze on microscopic stages of seaweeds and larger foliose algae and can be referred to as grazers. Limpets occur in great variety along the Victorian coast and are all herbivores, feeding on either microscopic or macroscopic algae (Underwood & Chapman 1995). They are closely related to other snails, with their body being the last part of the coiled shell of a snail (Underwood & Chapman 1995). Limpets have a very broad foot which allows them to cling on to the substratum.

Other herbivorous grazers include chitons which have a shell formed of eight plates and a broad foot that also allows them to stick tightly to rocks like the limpets. They are grazers feeding on microscopic plants and can usually be found under rock ledges.

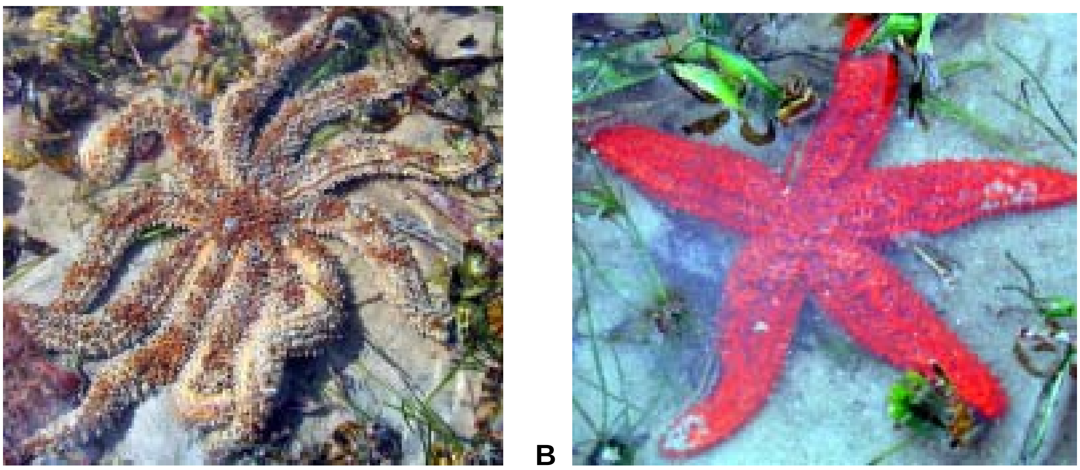
The second type of snail is known as a predatory snail with its diet mostly consisting of animal tissue. Predatory snails, such as whelks, are found on subtidal rocky reefs. The whelk actively seeks out prey by using a special tube called the siphon, which sticks out in front of the animal as it crawls along (Underwood & Chapman 1995). This siphon can be moved from side to side, and by using it as a ‘nose’ it can ‘smell out’ its prey. When water passes over the siphon, the whelk is able to pick up the prey’s smell and the direction it is coming from. The whelk will drill a hole through the shell of their prey to obtain the animal for food. The groove in the opening of the shell of predatory whelks is where the siphon comes out (Underwood & Chapman 1995). This feature is prominent on most predatory snails and can be used to distinguish between herbivorous and carnivorous snails *(See Figure 2.1 to find out the difference between a predatory and herbivorous snail).*

Figure 2.1 The predatory snail, *Cominella lineolata*, commonly known as the Lineated cominella or Checker board snail for its chequered appearance, on the left side of the image. Notice the siphon groove on the bottom left of the shell and the oval opening typical of a predatory snail. The herbivorous (grazers) snail, *Turbo undulatus*, commonly known as the Turban shell, on the right side of the image. Notice the round opening of the shell which is typical for herbivorous snails. (Image: R. Koss)

A B C

Figure 2.2 Various herbivorous snails found in Victoria. **A**) the Variegated limpet, *Cellana tramoserica*, **B**) the Black nerite, *Nerita atramentosa*, and the Warrener or Turbo shell, *Turbo undulatus*, and, **C**) the Blacklip abalone, *Haliotis rubra*. (Images: R. Koss)

Seastars have a star-shaped or pentagonal body with five or more arms. (*See Figure 2.3 for examples of native seastars*). Each arm contains part of the digestive system and the gonads on the internal side wall (Edgar 1997). The underside of the arm is lined by sensitive tube feet which are usually protected by a series of spines (Edgar 1997). The tube feet are usually pointed with a suction disc that allows them to grip onto solid surfaces. This enables the animal to move about and capture prey (Edgar 1997). The mouth of the seastar is found on the central under-surface of the animal. The seastar can throw out a thin sack-like stomach from the mouth. The stomach covers the prey where it can partially digest food outside the body (Edgar 1997). The seastar can feed on algae and invertebrates. Many are scavengers, feeding upon whatever is available at the time (Edgar 1997).



A B

Figure 2.3 Native seastars found in Victoria's coastal waters **A**) The eleven arm seastar, *Coscinasterias muricata*, and **B**) the bright orange seastar, *Uniophora granifera*. (Images: R. Koss)

Sea urchins also posses tube feet, like the seastar, but walk about mostly on their spines. The appearance of the sea urchin is of a ball-like shell with a mouth on the under surface (Underwood & Chapman 1995). The spines protect it from predators. Sea urchins are grazers and use their hard jaw plates in their mouths to scrape at algae fronds or encrusting algae on hard substrates (Underwood & Chapman 1995).

Figure 2.4 A sea urchin hidden in a crevice. (Image: R. Koss)

Some crabs and crays are predatory, feeding on small animals. During the day, many take refuge under boulders, rocks and algae so as not to be seen by predators. The body is made up of a head with six fused segments, a thorax with eight segments, and an abdomen with six or seven segments (Edgar 1997). Crabs generally have a forked first antennae and a pair of compound eyes which may be stalked or directly attached to the head (Edgar 1997).

Cephalopods are squid, octopuses, cuttlefish and nautilus. The mantle, which is the outer body, covers the major body organs and internal shell (Norman & Reid 2000). They have a ring of arms surrounding the mouth. The nautiluses live in a shell chamber and have about 90 sucker-less tentacles around the mouth (Norman & Reid 2000). Squid, octopuses and cuttlefish have eight arms which possess suckers and hooks (Norman & Reid 2000). Cephalopods have the ability to change colour and texture to camouflage to their environment.

Sessile Invertebrates

Sessile animals are attached permanently to a substrate and cannot move from this position. Substratum space is limited on subtidal rocky reefs, so once an animal is attached, that space is not available for other animals or algae. Violent water movement, and the nature and concentration of food, will be important for the survival and growth of sessile animals. Sessile animals include mussels, oysters, tube worms, sea squirts and barnacles.

Animals known as bivalves, such as mussels and oysters, are abundant on the subtidal substratum. Bivalves have two hinged shells *(See Figure 2.5 for an example of a bivalve invertebrate)*. Mussels attach to the substratum by strong filaments, which are produced by the foot of the animal and stick out through the shell (Underwood & Chapman 1995). Oysters stick to surfaces by using a glue, which acts like a cement, on one side of their shell (Underwood & Chapman 1995). Spaces in between mussel and oyster groups, provide shelter for smaller animals. Bivalves feed on small animals and particles in the water column. The water is pulled through the gills which act as a sieve, selecting out small animals and particles from the water. Hence, these animals are called *suspension* or *filter-feeders* (Underwood & Chapman 1995).

Figure 2.5 The Doughboy scallop, *Chlamys asperrimus,* blending in with other sponges on the rocky substratum. (Image: R. Koss)

Barnacles are also filter-feeders. They are small animals that live inside a shell cemented tightly to rock surfaces and are related to crabs and lobsters. Once a barnacle has settled on a surface, it will never move (Underwood & Chapman 1995). Barnacles use an elaborate system of modified legs to small animals out of the water column (Quinn *et. al.* 1992).

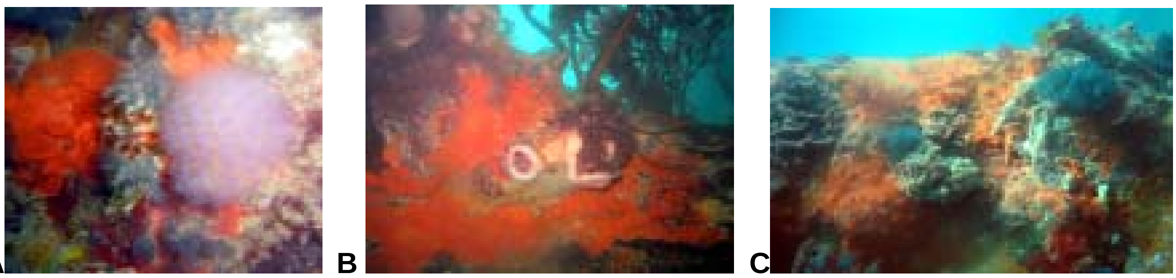
Bristleworms and tube worms use their tentacles to filter out food particles from the water column. The tentacles stick out of long tubular cylinders and can vary in size, colour and fan pattern. Feather-duster worm have tubes built out of sand grains and a crown of tentacles (Butler 1995).

Sea anemones produce juveniles which leave the parent and attach to the rock nearby (Butler 1995). Sea anemones can form groups. The base of the animal adheres to the rock surface and a mass of tentacles stick out from the upper surface opening. This opening has a dual role of the mouth and the anus. The tentacles can be pulled back into the opening so that the animal appears like a small, soft mass of jelly. Unlike other filter-feeders, sea anemones capture small animals, such as small fish. They do this with their stinging cells which are found on the surface of their tentacles (Quinn *et. al.* 1992). In Victoria there is one type of sea anemone which is mobile and not sessile. This anemone *(See Figure 2.6 below)* is commonly called the swimming anemone and has the ability to swim through the water column.

Figure 2.6 The swimming sea anemone, *Phlyctenactis tuberculosa*, distinguished by the bright orange round vesicles which form its body. (Image: R. Koss)

Modular Sessile Animals

Many of the subtidal sessile animals are *modular* or *colonial* (Butler 1995). They are termed modular as they are able to reproduce replicates of a basic unit or module of themselves (Butler 1995). When the replicated modules remain attached together, they form a *colony*. The dominant animal groups of the subtidal rocky reef display colonial formation (Butler 1995). These groups include sponges, bryozoans, sea squirts, and cnidarians (for example, corals).



A B C

Figure 2.7 A variety of sessile filter-feeders found in Victoria, **A**) the purple coloured colonial sea squirt *Clavelina molluccensis* **B**) the sea squirt *Herdmania momus* surrounded by orange sponges and seaweed, and **C**) hard substratum covered by a variety of colonial sponges and sea squirts. (Images: R. Koss)

Sea squirts are found extensively in the subtidal zone, where they are able to filter feed from the water column. The outer layer can be tough and leathery, ranging in colour from purples to pinks and dark reds to black. They can be covered by encrusting green and brown algae

(Quinn *et. al.* 1992). They are stuck to the surface by a tough calcareous base and filter feed by pumping large quantities of water through their bodies via the two siphons found at the top of the animal (Underwood & Chapman 1995). If the siphons are touched or pushed, squirts of water will be released.

Mobile Vertebrate Animals

A vertebrate is an animal that has a backbone. The different groups of vertebrate animals which can be found on subtidal rocky reefs are collectively termed fish because of their adaptations for life in water (Edgar 1997). This can be confusing as many sea mammals (warm-blooded animals) are also vertebrates, such as whales, seals, and dolphins, or reptiles such as turtles, and birds such as penguins. For subtidal community-based monitoring, the term fish will refer to bony fish and sharks and not to mammals, reptiles or birds. If other vertebrate animals are seen, they can be noted during monitoring *(See Section 3.7 for more information on data collection).*

Fish of varying size and type are often seen swimming through the water column near subtidal rocky reefs or maintaining territory on the rocky substratum. Depending on the type of fish, some swim in schools or as individuals. Some fish are cryptic and blend in with the seaweeds, substratum or animals found on the reef. Fish are often surface predators, feeding on organisms which are exposed at the surface or near the surface without disrupting the sediments (Nybakken 2001).

There are four main fish groups (Edgar 1997):

- Lampreys (also known as jawless fish)
- Hagfish
- Sharks and Rays
- Bony Fish.

Lampreys have an eel-like body and a sucking mouth with numerous teeth in circular rows, but no jaws (Edgar 1997). They have a single nostril on top of their head and seven gill slits on the side of their body. Lampreys lack fins and scales and have a skeleton made up of cartilages rather than bones (Edgar 1997).

Sharks and rays are jawed fish and have skeletons formed by cartilage rather than bones (Edgar 1997). They have five to seven gill slits on each side of the body and possess two fins on the top part of their body (Edgar 1997).

Bony fishes have a skeleton made up of bones and have a single gill opening on each side of the head (Edgar 1997). They possess at least one row of scales on the side of their bodies and many have a fin on the top part of the body. The bony fish represent a large and diverse animal group with over 20,000 different species (Edgar 1997).

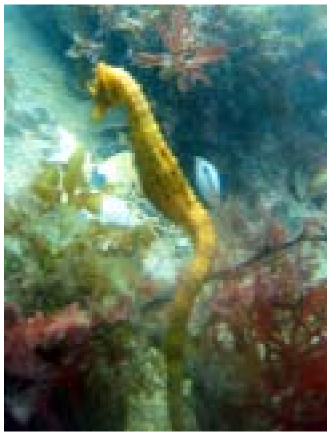
A  B 

Figure 2.8 Examples of two bony fish A) The Rough leather jacket, *Scobinichthys granulatus* and B) the Big-bellied seahorse, *Hippocampus abdominalis*. (Images: R. Koss)

2.5 What are the possible human impacts on the subtidal zone?

Although coastal areas are influenced by natural processes such as storms, erosion and deposition of sands and substrates by wave and tide action, the natural pattern of adjustment is increasingly influenced directly and indirectly by human activities (Woodroffe 2003). Occasional natural catastrophic events such as cold winters, hot summers, extreme storms and toxic algal blooms also occur (Thompson et. al. 2002). Subtidal zones are also influenced strongly by offshore and near-shore processes such as upwellings and freshwater inputs from nearby flooded rivers (Thompson et al. 2002). Some of the human-induced impacts are described below.

Harvesting

Direct effects can include harvesting subtidal organisms such as abalone, sea urchins, gastropods, bivalves, crays and crabs for eating or as bait (Creese & Kingsford 1998). Spear fishing is a popular recreational activity. Humans are potentially strong predators in subtidal systems with their predatory activities causing numerous direct, indirect and subtle effects on the structure and dynamics of subtidal communities. Harvesting is not allowed in any Victorian MNP or MS.

Pollution

Pollution can affect marine organisms at the very simplest level of biological organisation through cellular processes, to changes at the ecosystem level. Pollutants such as oils and dispersants, sewage, urban runoff, pesticides, landfill leachate, antifouling paints or heavy metals and PCBs can decrease abundance and/or species diversity, reduce reproductive output and cause behavioural changes (Creese & Kingford 1998; Thompson *et. al.* 2002). Filter-feeding molluscs on rocky shores can pose a threat to public health through accumulating toxins and incubating diseases such as gastroenteritis from faecal pollution (Creese & Kingsford 1998). The effects will differ among different pollutants and for different associations of animals (Butler 1995).

Eutrophication and Algal Blooms

Eutrophication is the product of high nutrient loads entering the marine environment, usually from waste water discharged from sewer treatment works or run off from phosphate fertilized agricultural land (Roob 2003; Thompson *et. al*. 2002). High concentrations of nutrients can cause microalgal blooms, which attach to and/or shade macroalgae (Thompson *et. al.* 2002). With a reduced amount of light, algae are not able to photosynthesise effectively. The reduction in photosynthesis causes a reduction in plant metabolic rates and can lead to eventual death of the macroalgae on the subtidal reef. High nutrient loads entering the ocean are introduced by a variety of ways including storm water run off from urban and catchment areas and raw sewage discharge.

Introduced Species

Accidental or deliberate introduction of species either as a consequence of transporting stocks for aquaculture, via release of ballast water from ships or from fouling on the underside of ships can lead to dramatic effects on the native species (Thompson et. al. 2002). The arrival of alien species represents one of the most important threats to the subtidal habitat, especially for native species which have no natural defence mechanisms to introduced pathogens or predators. Unlike pollution and harvesting, introductions of exotics are irreversible (Thompson et. al. 2002).

Boat and Diver Damage

Damage to subtidal reef beds can be caused by anchor moorings on top of the reef. Anchor removal from the rocky reef can detach animals and plants from the rock surface. Diver fins can accidentally brush across the rocky substratum causing plants and animals to be broken at the rocky surface interface.

3.0 HOW TO MONITOR SUBTIDAL ROCKY REEFS IN VICTORIA'S MARINE NATIONAL PARKS AND SANCTUARIES

3.1 Safety procedures to follow before initiating subtidal monitoring

In each community group, one volunteer must be nominated to act as the supervisor of the subtidal monitoring group. This person will be responsible for contacting the Parks Victoria Ranger, organising dates for monitoring, assessing weather forecasts prior to and on the day of monitoring and organising and checking that each volunteer is fit and has the appropriate equipment and attire to proceed with monitoring. This person also is the dive coordinator for the community group. The role of the dive coordinator is to maintain safety standards and has the authority to refuse any volunteer diver who is not fit or well to dive. The following safety procedure is the checklist which the nominated supervisor must follow prior to monitoring.

1. Setting an appropriate date/s for subtidal monitoring can be done in consultation with the Parks Victoria Regional Ranger. This will provide an appropriate amount of time for the Park Ranger to organise volunteer insurance and time log forms and monitoring equipment. To contact a Parks Victoria Ranger for your MNP or MS, call **13 19 63** and ask to be connected to the office associated with your MPA. Once dates have been set, the appropriate Fisheries personnel for the region should be notified by ringing the Departments of Environment and Sustainability and Primary Industries Service (DPI & DSE) Centre on **13 61 86**. There are no seasonal restrictions for undertaking monitoring, but be aware that during winter months seawater and air temperatures can be cooler.

2. The night prior, and the morning of monitoring assess the weather forecast, tidal movement and sea conditions. This can be done by checking the Bureau of Meteorology via the website: http://www.bom.gov.au/weather/vic/

3. Notify all volunteers to meet in one specific location before embarking on the monitoring. This ensures that no volunteers become lost. This is important if travelling to the monitoring site by boat.

4. The monitoring supervisor must take a head count of all volunteers and ensure that each volunteer signs and dates the Parks Victoria Volunteer Insurance and Time Sheets prior to proceeding with subtidal monitoring. These can be obtained from your local Parks Victoria Ranger.

5. A diving and snorkelling operations manual has been produced by Parks Victoria. This manual consists of diving regulations based on the Australian Scientific Diving Regulations.

The Parks Victoria Diving and Snorkelling Operations Manual can be obtained from your local Parks Victoria Ranger. This manual describes SCUBA diving procedures and safety protocols that are considered to be the minimum required by community groups involved in monitoring subtidal reefs in Victorian MNPs and MSs.

6. All dive volunteers must have adequate and currently approved SCUBA gear. This includes wetsuits which provide adequate warmth for the duration of the subtidal monitoring and SCUBA equipment that has been checked regularly according to the Australian Standards as set out in the Parks Victoria Diving and Snorkelling Operations Manual.

7. Protection against the elements such as a hat, sunscreen, sunglasses and water bottle is necessary if travelling to the monitoring site by boat. If rain is predicted, ensure you have adequate wet weather gear such as a jacket or plastic poncho and a change of dry clothes. *(See Appendix 2 for a complete personal and scientific equipment checklist)*

8. A current first aid kit and Diver Emergency Handbook, must be on site if a shore dive, or on the boat.

9. Ensure that all volunteers are aware of dangerous marine animals such as the blue ring octopus, sea jellies and cone shells.

10. Be aware of a sudden change in weather conditions and use common sense to stop monitoring if the situation looks dire.

11. Ensure that at least one volunteer acts as a lookout for sudden large waves, changes in weather conditions, and for any diver who may be in danger or difficulty.

12. An operable communication device such as a mobile phone on shore, or a marine radio on the boat, should be present during each monitoring session.

Scientific Diving Requirements

It is recommended that volunteer divers feel comfortable and competent in the water during monitoring. Unlike leisure diving, subtidal monitoring requires the diver to work and manipulate scientific equipment underwater. Although the scientific equipment is not difficult to use, it does require the diver to have certain skills underwater to manipulate the equipment whilst collecting data. A useful way to gain these skills is to undertake dive courses. For example, volunteers of the Deakin University Underwater Club, who participated in subtidal monitoring, undertook a PADI recognised and certified Research Diver course. This course took one weekend to complete. The volunteer divers learnt how to identify and measure different fish species, how to count sessile and mobile invertebrates in a quadrat and how to identify and measure macroalgae. It also taught divers how to manage scientific equipment underwater whilst maintaining safe diving practices. This course was run by Phil Kerr, a PADI accredited dive instructor. *(For further information on the PADI Research Diver course, contact Philip Kerr, PADI Dive Instructor at Aqua Agri Enterprises, by email: pdk@deakin.edu.au)*

A 

B 

Figure 3.0 Deakin University Underwater Club volunteers undertaking **A**) the PADI Research Diver course under the instruction of Phillip Kerr, and **B**) the macroalgae identification session with Dr. Alecia Bellgrove. (Images: R. Koss & D. Ierodiaconou)

3.2 How to choose a subtidal rocky reef monitoring site in Victoria's Marine National Parks and Sanctuaries

Mapping programs have been produced by Primary Industries Research Victoria Marine and Freshwater Systems (PIRVIC – MFS) and the Department of Sustainability and Environment (DSE) over the past five years and reports, maps and geo-spatial databases are now available for most areas around Victoria's coastline.

Using the PIRVIC-MFS and DSE reports and maps, long-term subtidal monitoring sites can be chosen. With the assistance of a Parks Victoria Ranger, the subtidal sites chosen by volunteers can complement other reports and datasets used to predict threats and identify impacts.

If no previous reports or mapping programs have been undertaken in a monitoring region, consultation with the local Parks Victoria Ranger may assist in determining the best monitoring sites. *(Phone 13 19 63 to contact the Parks Victoria Customer Centre.)*

Monitoring site selection should represent the subtidal reef community for the area and the threats and impacts which can determine the distribution of organisms. Site selection should also incorporate the range of habitats used by the plants and animals and should not be logistically difficult to revisit. Ensure that the subtidal reef is the dominant habitat of the site.

Monitoring sites in Victoria's Marine National Parks and Sanctuaries cannot be permanently marked with pickets or any other structure. The use of a Global Positioning System (GPS) in conjunction with a Parks Victoria Ranger, will provide co-ordinates for monitoring sites to be re-measured over the long term. *(See Appendix 1 for information on how to use a GPS).*

Monitoring sites within each Victorian MNP or MS are selected on the basis of:

- availability of subtidal reef
- exposure to potentially threatening processes.

The process of selecting a monitoring site in a Victorian MNP or MS is as follows:

- Subtidal reefs of substantial size within the MNP or MS are selected.
- If there is only a small area of subtidal reef, then monitoring occurs on the largest and safest area available.
- If there is a single large subtidal reef (>200m), or multiple subtidal reefs within a MNP or MS, then monitoring should occur in areas that are likely to be exposed to the main threatening processes identified for that specific MPA. These processes include illegal fishing, illegal collection of subtidal plants and animals, changes to nutrient inputs, freshwater inputs, and introduction of exotic species.

Figure 3.1 The Merri Marine Sanctuary (the approximate boundary is defined by the black lines), Warrnambool, Victoria, one of the subtidal sites monitored by the Deakin University Underwater Club.

3.3 What is a reference site and why should it be included in subtidal rocky reef monitoring?

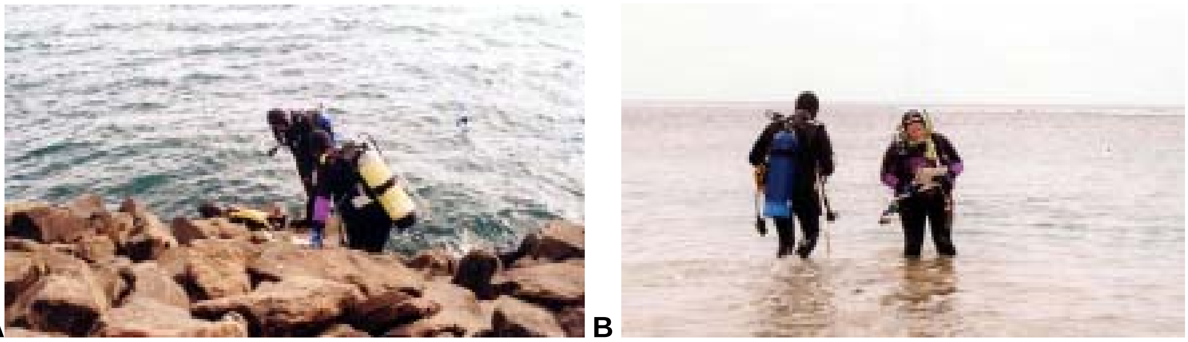
In order to be able to accurately detect changes in populations or communities within the MPAs from the natural variation that occurs between sites and over time, it is imperative to also monitor multiple reference sites. A reference site is a monitoring site outside of the MNP or MS. In a subtidal rocky shore monitoring program it is important to measure as many sites as possible within the MNP or MS. This will ensure that trends or patterns are representative for the whole MPA. The reference site must be similar to sites within the MPA by having the same dominant type of rocky substratum. In order to assess whether subtidal rocky reefs and associated marine animal and plant assemblages are changing due to the habitat being protected, areas which are not protected must also be assessed. Over the long term, patterns in variation can be detected in both protected and unprotected subtidal rocky reef habitats. If the variation is due to natural causes, this will be reflected in both protected and non-protected subtidal rocky reef habitats over time. However, if a trend is occurring, for example, in protected subtidal rocky reefs and this is not seen in unprotected subtidal rocky reefs, then an assumption can be made that protecting an area may cause this variation. For example, in a MPA the number of a specific species of snails may be greater than the same species of snail found in the non-MPA. This could imply that creating a MPA has protected this snail specie from possible human induced impacts.

If possible, it is important that each monitoring program has at least two reference sites. This of course will be dependent on subtidal rocky reef habitat availability outside the MPA. Reference sites can be chosen in conjunction with a Parks Victoria Ranger. *(Call 13 19 63 to find out the Parks Victoria Ranger responsible for your MPA.)* By monitoring the MPA and reference sites over a long time-period, more trends can be identified and supported by the collected data.

Reference sites are chosen by the following process:

- Identify subtidal reef areas outside the MNP or MS. Most reference sites will be within the general vicinity of the MPA.
- If the subtidal reef outside the MNP or MS is limited in size, then the reference site will be on this limited amount of subtidal shore. The substrate type and environmental conditions should be matched as closely as possible to the site within the MPA.
- The more reference sites monitored the better the estimation of natural background variability and therefore the better the ability to detect other changes within the MPAs. The number of reference sites monitored will depend on the availability of suitable locations (see below) and logistical constraints such as the amount of time and/or volunteers to monitor multiple sites within a given period of time. To limit differences between sites with differences over time (for example seasonal changes), all reference sites and protected sites should be sampled within two weeks of each other.
- Reference sites would have similar physical conditions such as substrate type and area, vertical gradients, exposure to wind, waves and currents and freshwater input. The reference sites should also have similar plant and animal community structure.

- If the focus of monitoring at a subtidal reef in a MPA is to detect if an impact is occurring because of a specific threat, for example illegal harvesting of plants and animals, then the reference sites should be chosen so that the main difference between the subtidal reef in the MPA and the reef at the reference sites is the level of exposure to the threat.



A B

Figure 3.2 Deakin University Underwater Club volunteers in a buddy pair with monitoring equipment **A**) the first reference site at Portland Breakwater Wall, Victoria, and **B**) the second reference site at Pea Soup, Port Fairy, Victoria. (Images: R. Koss)

3.4 How often should subtidal rocky reef monitoring be conducted?

There are no set rules as to how often your group should monitor your MPA and reference sites. During summer the weather is warmer and more desirable to work in the water. Winter poses the problem of cooler air and water temperatures, where thicker and warmer wetsuits or drysuits are needed. The frequency of monitoring is dependent on your community group and time commitments for each individual volunteer. It is also sensible to recognise that some volunteers may not wish to partake in subtidal monitoring during the winter months due to the cooler water temperatures.

There could be seasonal effects on the distribution and types of animals and plants found on the subtidal rocky reefs. For example, some seaweeds grow in greater densities during Spring and die back during the Summer months. This is a natural seasonal variation. Over time it is important to identify this as a natural trend. However, human induced impacts may not show the same fluctuating trends through time. There may changes to subtidal rocky reefs occurring slowly over time, or it may be a large scale impact which can take place within a few weeks. In order to not make the wrong assumptions, it is best that monitoring take place each season if possible at both MPA and reference sites. *(See Section 3.3 for details of selecting a reference site.)* It is possible to choose sampling dates with the Parks Victoria Ranger *(See Section 3.1 for Parks Victoria contact details)* who may recommend certain periods during each season which may produce favourable conditions for subtidal monitoring.

3.5 What equipment is needed to conduct monitoring at a subtidal rocky reef site?

Materials and Equipment

- 1 x 100 m fibreglass measuring tapes (transect lines)
- 0.5 m x 0.5 m open quadrats (1 per 4 divers)
- 0.25 m^2 (50 cm x 50 cm) quadrat divided into a grid of 7 x 7 perpendicular wires, giving 50 regularly-spaced points (1 per 4 divers) *(See Figure 3.5 for a diagram of a point quadrat).*
- buoy with dive flag
- dive compass
- GPS (Global Positioning System)
- Waterproof monitoring datasheet (*the datasheet can downloaded from the Sea Search website www.parkweb.vic.gov.au/seasearch and photocopied onto waterproof paper*), underwater slate and pencil
- map of site (if available)
- wetsuits, mask, snorkel, fins, buoyancy control vest, weights, regulators, gauges and air tank.

Figure 3.3 Deakin University Underwater Club volunteers in buddy pairs swimming towards the dive buoy at the Pea Soup reference site, Port Fairy, Victoria. (Image: R. Koss)

3.6 How to establish transect lines and proceed with subtidal monitoring

The following method of monitoring has been adapted from the Standard Operational Procedure for Subtidal Reef Monitoring by Australian Marine Ecology (Hart & Edmunds 2003) produced for Parks Victoria.

- At the chosen subtidal monitoring site, place a buoy with a dive flag in the water or attach a dive flag to the boat. This will indicate to all watercraft that there are divers in the water.
- At the position of the dive buoy, take a GPS reading or a compass bearing to prominent land feature.
- Divers 1 to 4 descend the dive buoy line. Diver 1 hooks the transect line to the dive buoy and then will proceed to reel out the transect line of 100 m in a chosen compass direction along the same depth contour. A depth of 12 m or less is optimal for monitoring as diving times are not restricted by decompression periods. Note the compass direction on the datasheet. (*Download the datasheet from the Sea Search website www.parkweb.vic.gov.au/seasearch*)
- Whilst Diver 1 unreels the transect line, Divers 1 and 2 will monitor the large fish and cephalopods. Divers 3 and 4 wait at the bottom of the dive buoy. *(See Figure 3.4 for a detailed diagram of the monitoring technique.)*
- Once Divers 1 and 2 are out of sight, Divers 3 and 4 initiate the cryptic fish and large invertebrate count.
- Once Divers 1 and 2 have finished monitoring the large fish and cephalopods at the end of the 100 m transect line, the first macroalgal quadrat can be set at the 100 m mark. Quadrats are placed on the left side of the transect line at the required distance when swimming back to the 0 m position. Divers 1 and 2 will continue to measure macroalage every 10 m in the direction towards the 0 m mark. The last macroalgal quadrat will be at 10 m.
- Divers 3 and 4 will initiate the small invertebrate monitoring at the 100 m mark upon finishing the cryptic fish and large invertebrate monitoring. Divers 3 and 4 will continue to measure the numbers of invertebrates every 10 m in the direction towards the 0 m mark. The last invertebrate quadrat will be at 10 m.

5. One transect line takes approximately 1 hour of monitoring time to complete. The number of transect lines that can be monitored may depend on the size of the site and availability of safe diving time. However, each transect line should be at least 25 m apart. At least

two transect lines should be monitored at each site. Monitoring can be undertaken by different groups at the one site. This ensures that all divers descend and re-surface together.

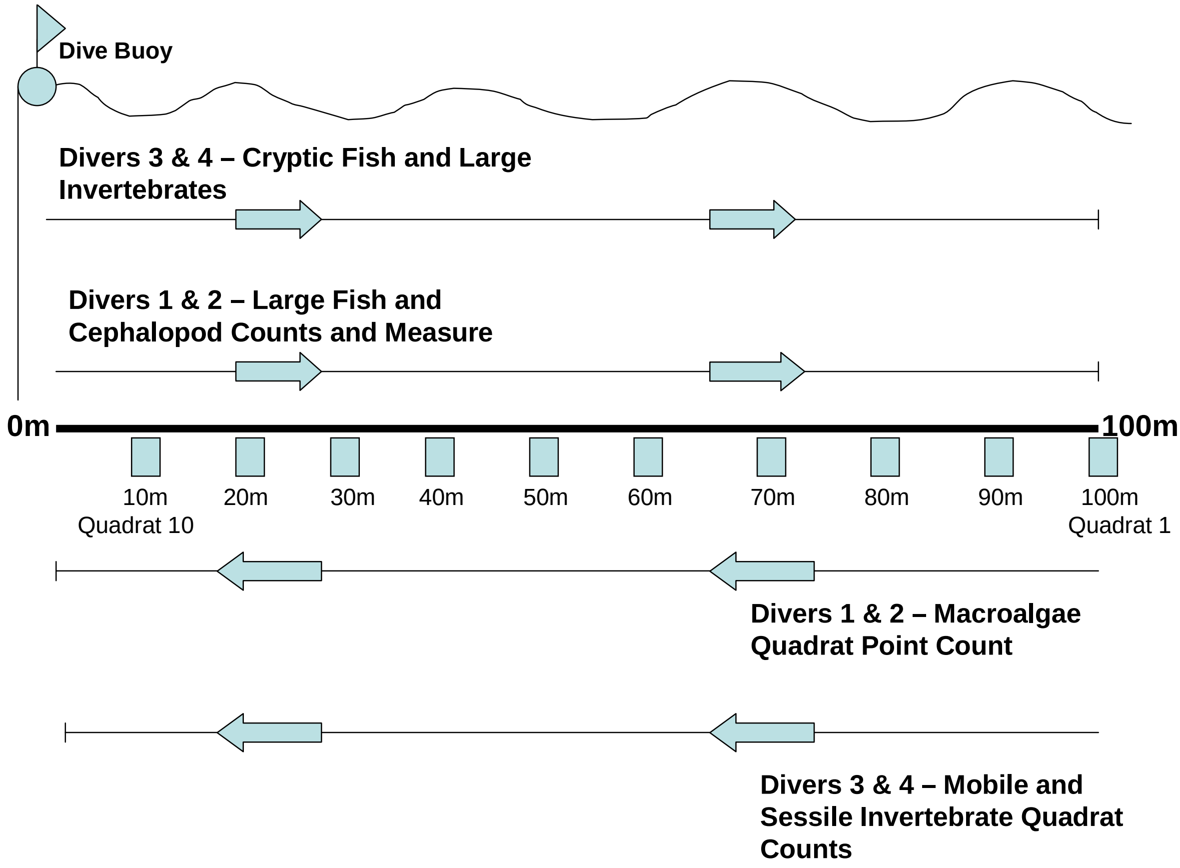


Figure 3.4 Subtidal monitoring techniques. Divers 1 and 2 monitor large fish, cephalopods and macroalgae, whilst Divers 3 and 4 monitor cryptic fish, large invertebrates, mobile and sessile invertebrates along the 100 m transect line.

3.7 What types of information need to be recorded during subtidal monitoring?

Five sets of data are to be collected from each transect.

1. Abundance and size structure of large fish and cephalopods

The densities of large fish and cephalopods are measured by counting individuals along the 100 m transect line. Whilst swimming along the transect line, all large fish and cephalopods that can be seen swimming in the water column are counted. Divers 1 and 2 will record the number and estimated size class of fish within 2.5 m either side of the transect line. The size-class of fish and cephalopods are: <10 cm, 10-20 cm, 20-30 cm, 30-40 cm, 40-50 cm, 50-60 cm, 60-70 cm, 70-80 cm and >90 cm. The twelve most common species of fish and cephalopods for the MNP or MS are written on the data board under the large fish and cephalopod column. The spare rows are for other species sighted during monitoring.

- Divers 1 and 2 will swim along the 100 m transect line above the kelp canopy (if present) and scan forward into the visible area which is 2.5 m either side of the transect line.
- Divers 1 and 2 will swim as slowly as possible, but without stopping (as any fish following the diver will move into the field of view).
- Divers 1 and 2 record the number and size of each species of fish and cephalopod sighted with a mark on the datasheet. *(The subtidal monitoring datasheet can be downloaded from the Sea Search website www.parkweb.vic.gov.au/seasearch)*. Fish are recorded in their size classes, that is, how large the fish is in centimetres, on the datasheet.
- Once a fish or cephalopod has been sighted and recorded it is ignored, even if it has been seen leaving and immediately re-entering the monitoring area. Fish moving into the monitoring area from behind the diver are not recorded. Fish that circle the diver throughout the monitoring are ignored after the first sighting.
- Dense fish and cephalopod aggregations or schools, has an abundance estimation using the approximate value of 10-20, and therefore the abundance is written in 10s or 100s on the datasheet.
- Unidentified species are noted on the datasheet with any distinguishing characteristics. These fish can be identified post-monitoring using references.

2. Abundance and size structure of cryptic fish and abundance of large mobile invertebrates

The density of cryptic fish and large mobile invertebrates are measured by counting individuals along the 100 m transect line. Large mobile invertebrates include crayfish abalone, sea urchins, sea stars and crabs. All cryptic fish and large mobile invertebrates that can be seen within and below the algal canopy, on the substratum, in crevices, and below ledges are counted. Divers 3 and 4 will record the number and estimated size class of cryptic fish and large invertebrates within 1 m either side of the transect line. The size-classes of cryptic fish are: <10 cm, 10-20 cm, 20-30 cm, 30-40 cm, 40-50 cm, 50-60 cm, 60-70 cm, 70-80 cm and >90 cm. The size classes for large invertebrates are: <2.5 cm, 5 cm, 7.5 cm, 10 cm, 12.5 cm, 15 cm, 17.5 cm and >20 cm. The twelve most common species of cryptic fish for the MNP or MS are written on the data board under the cryptic fish and large invertebrate column. The spare rows are for other species sighted during monitoring.

- Divers 3 and 4 will commence swimming along the 100 m transect line once Divers 1 and 2 are out of site.
- Divers 3 and 4 will scan into and below the algal canopy, on the substratum, in crevices and below ledges for cryptic fish and large mobile invertebrates 1 m either side of the transect line.
- Divers 3 and 4 record the number and size of each species of cryptic fish and large mobile invertebrates sighted on the datasheet. Cryptic fish and large invertebrates are recorded in their size classes, that is, how large the fish or invertebrate is, onto the datasheet.
- Once a cryptic fish or large mobile invertebrate has been sighted and recorded it is ignored, even if it has been seen leaving and immediately re-entering the monitoring area. Cryptic fish moving into the monitoring area from behind Divers 3 and 4 are not recorded. Easily recognisable cryptic fish that circle the diver throughout the monitoring are ignored after the first sighting.
- Dense cryptic fish and large mobile invertebrate aggregations or schools, uses an estimated abundance number using the approximate value of 10-20, and therefore abundance is written in 10s or 100s.
- Unidentified species are noted on the datasheet with any distinguishing characteristics. These fish can be identified post-monitoring using reference texts.

3. Macroalgal percentage cover

A 0.25 m^2 (50 cm x 50 cm) quadrat *(See Figure 3.5 for a diagram of the point quadrat and how it is point cover is estimated)* is used to estimate algal percentage cover and is divided into a grid of 7 x 7 perpendicular wires, giving 50 regularly-spaced points which includes using the bottom right corner of the quadrat. Cover is estimated by counting the number of points falling directly above each species. *(See Figure 3.5).* Five to ten of the most common species for the three macroalgal groups, that is red, brown and green algae, in the MNP or MS are recorded onto the datasheet under the macroalgae column. The spare rows are for other species sighted during monitoring.

- The quadrat is placed every 10 m along the transect line, starting at 100 m, by Divers 1 and 2 on completion of the mobile fish monitoring. The depth of the quadrat position is recorded on the datasheet.
- Using the point intersections and the bottom right corner point, Divers 1 and 2 will count how many points cover each species of macroalgae.

- If there is a kelp canopy, the quadrat is held over the canopy and the points cover for the kelp is recorded. Diver 1 will push the kelp canopy aside gently to minimise any disturbance and impacts on the kelp. Diver 2 will then place the quadrat on the substratum and will count the macroalgae species growing under the canopy.

- Unidentified species are noted on the datasheet. These macroalgae can be identified after monitoring using reference texts.

- To calculate the percentage cover of each species, the number of times a species is covered by an intersecting point in the 50-point quadrat, the value is doubled (for example, 35 points x 2 = 70% cover or 35 points/50 intersecting points x 100 = 70% cover).

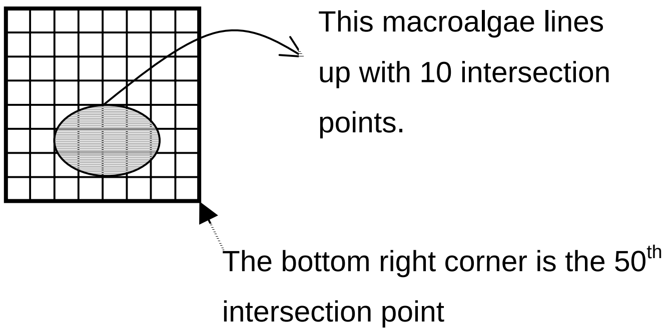


Figure 3.5 Estimation of percentage cover of macroalgae using the point quadrat with 50 intersecting points. This example has 10 points x 2 = 20% cover.

4. Small mobile invertebrate and sessile invertebrate abundance

- The density of grazing, predatory and sessile invertebrates (this includes colonial sessile invertebrates), are measured using the 0.25 m^2 (50 cm x 50 cm) open square quadrat. Five of the most common species for each invertebrate group are recorded onto the datasheet under the invertebrate column. The spare rows are for other species sighted during monitoring.

- The quadrat is placed every 10 m along the transect line, starting at 100 m, by Divers 3 and 4 on completion of the cryptic fish and large invertebrate monitoring. The depth of the quadrat position is recorded on the datasheet.

- Divers 3 and 4 will count the number of individuals for each species sighted within the quadrat. These counts are marked on the datasheet.

- Unidentified species are noted on the datasheet with any distinguishing characteristics. These invertebrates can be identified post-monitoring using reference texts.

5. Essential information

There are a number of important qualitative sets of data which need to be noted at the time of monitoring and these can be found at the top of the mobile and cryptic fish datasheets. These include:

- name of volunteer
- date of monitoring
- start and end time of monitoring
- temperature of the water
- depth of monitoring
- underwater visibility
- site (GPS co-ordinate or compass bearing to a geological feature on the land)
- transect number and direction
- type of day, for example overcast, sunny, few clouds
- major habitat type
- dominant canopy cover
- tidal movement.

3.8 What to do if you think you have found a marine pest

If you suspect you have seen a marine pest, you should report it to the Department of Sustainability and Environment Customer Service Centre on **13 61 86**. It is important that you have all information corresponding to the animal or plant available. This includes a description of the animal or plant and its approximate size, the location where you saw the pest, the date and time of siting and the number of individuals seen. At the bottom of the subtidal monitoring sheet there is room for making notes on any marine pests sited.

Figure 3.6 Deakin University Underwater Club volunteers after the completion of one subtidal monitoring survey at Pea Soup, Port Fairy, Victoria. For safety, dive buddies ascend to the water surface and exit the water together. (Images: R. Koss)

3.9 What are the procedures on completion of a subtidal monitoring session?

- Divers 1 and 2 will reel up the transect line. Divers 3 and 4 wait at the bottom of the dive buoy for Divers 1 and 2 to return.
- All divers will ascend to the surface together at a safe ascension rate. Divers will signal to the lookout that they are safe. If the monitoring took place from a boat, the boat will pick up the divers. If the monitoring took place from the shore, the divers will swim back to the shore together. The dive supervisor must refer to the Parks Victoria Diving and Snorkelling Operations Manual for a complete set of instructions to follow after a subtidal monitoring session has been completed. This manual can be obtained from your local Parks Victoria Ranger.
- Once all monitoring has been completed and all divers have surfaced, the monitoring group's dive supervisor must do a head count to check that all volunteers are present. This is very important and should always be done on completion of any subtidal monitoring session.
- 4. Once on shore, check that all datasheets have been filled out and all figures are clear and legible. Check figures for discrepancies and anomalies (such as fish densities or point counts outside the normal range) with errors corrected and/or annotations added if necessary. Ensure that all essential information (See Number 5 in Section 3.7) has been completed. Any unidentified species must be checked in a reference guide. Place datasheets in a folder or envelope where they will not be lost.
- Once on land the transect lines and quadrats are rinsed in fresh water and allowed to dry before placing in storage.

- Diving and boating equipment must be cleaned at home.

- Underwater boards are cleaned and pencils sharpened at the dive supervisor with assistance form other volunteers can clean the underwater boards and sharpen pencils. New underwater datasheets can be placed onto the underwater boards in preparation for the next subtidal monitoring session. This can be done at the dive supervisors or a volunteer's house. *(Underwater datasheets can be produced by photocopying or printing tables on to underwater paper. This makes data transfer between dives easier if there are multiple dives in one day.)*

- All subtidal monitoring data must be entered into an Excel worksheet. This can be done at the dive supervisor's house with the assistance from volunteers. *(See Section 3.9 for more information on entering subtidal monitoring data onto a database.)*

Figure 3.7 Deakin University Underwater Club volunteers on completion of subtidal monitoring. (Images: R. Koss)

3.10 How to enter subtidal monitoring data into a Microsoft Excel worksheet

There will be an accumulative amount of data which must be entered into a Microsoft Excel spreadsheet and saved as soon after the completion of a monitoring session. This ensures that the valuable monitoring information is not lost. The following data entry procedures are relatively simple and will guide you in entering the data. By following the spreadsheet, it will allow community groups and management authorities to analyse the data without needing to transform the data layout. (*The Excel spreadsheet can be downloaded from the Sea Search website www.parkweb.vic.gov.au/seasearch)*

- Open a new Microsoft Excel worksheet.

- The first sheet (see the tabs on the bottom of the Excel sheet) is for large mobile fish, cephalopod, cryptic fish and large invertebrate data.

- Type the word *Transect* at the top of the first column.
- Move to the top of the second column and type the word *Name*, this stands for common name of the animal.
- Move to the top of the third column and type the first size range, for example, 0-10.
- Move to the top of the fourth column and type the second size range. Follow this procedure for the rest of the size classes.
- Under the common column, type in all the large fish, cephalopods and cryptic fish names, each row containing a separate animal name. Names can be abbreviated to accommodate the space, for example, Blue Throat Wrasse can be abbreviated to BTWrasse.
- Type the monitoring data on the spreadsheet according to the size class and common name of the animal.
- Under this set of large fish, cephalopod and cryptic fish data, type the same column headings as above, correcting the size classes relevant to large invertebrates.
- Under the common column, type the names for the large invertebrates, each row containing a separate animal name.
- Press the Save function often during data entry.
- Once all data has been entered, save this spreadsheet according to the site name and date. At the bottom left of this spreadsheet there is a tab with sheets named Sheet 1, Sheet 2 and Sheet 3. The large mobile fish, cephalopods, cryptic fish and large invertebrates count data has been saved on Sheet 1. Click on Sheet 2, which will open a new spreadsheet. Sheet 2 is still recognised under the same file name. Sheet 2 should be for small invertebrate counts.
- Type the word *Transect* at the top of the first column.
- Move to the top of the second column and type the word *Quadrat*.
- Move to the top of the third column and type the first species common name, for example, Turbo.
- Move to the top of the fourth column and type the next common name and so on. The names can be abbreviated to accommodate to the space, for example, Seastar can be abbreviated to Sstar.
- Enter the data for each species according to the transect and quadrat numbers.

- Press the Save function often during data entry.
- Once all data has been entered, save this spreadsheet. The large mobile fish, cephalopods, cryptic fish and large invertebrates count data has been saved on Sheet 1 and the small invertebrates on Sheet 2. Click on Sheet 3, which will open a new spreadsheet. Sheet 3 is still recognised under the same file name. Sheet 3 should be for algal percentage cover.
- Type the word transect at the top of the first *Column*.
- Move to the second column and type the word *Quadrat*.
- Move to the third column and type the first macroalgal species name. This name can be abbreviated, for example, *Macrocystis angustifolia* can be abbreviated to *Mac.angus*.
- Move to the fourth column and type the next species name and so on.
- Type the percentage cover for each species according to the transect and quadrat numbers.
- Press the save function often during data entry.

Monitoring data stored in this form can be easily reproduced and used for analysis. Long-term monitoring may or may not display trends which can be easily seen by using graphing and statistical applications in the Microsoft Excel software package. A copy of your group's monitoring data can be saved on to a disk or CD and sent to the Parks Victoria Ranger who assisted your community group subtidal monitoring or a Parks Victoria Ranger responsible for the management of your MPA. *(Ring Parks Victoria on 13 19 63.)*

GLOSSARY

Abdomen	A segmented section of the body located behind the thorax
Adaptation	A particular structure, physiological process, or behaviour that makes an organism better able to survive and reproduce
Algae (plural)	A photosynthetic, plant-like single or multi-cellular organism
Carnivore	An organism that feeds on animal tissue
Circalittoral	The region below the macroalgae zone in the subtidal which is dominated by mobile and sessile invertebrates
Epiphytism	The description given when a small plant grows attached to another plant
Gonad	The testis or ovary
GPS	Global Positioning System
Grazer	An animal which feeds on vegetable tissue from herbaceous plants
Habitat	The environment in which an organism lives
Herbivore	An animal which eats plant tissue
Infralittoral	The shallow zone of the subtidal dominated by macroalgae
Invertebrate	An animal without a backbone
MNP	Marine National Park
MPA	Marine Protected Area
MS	Marine Sanctuary
Salinity	A measure of dissolved salt concentration in water
Sessile	Attached, not free to move about
Sublittoral	The low-zone which is usually covered with water at low and high tides; another term used to define the subtidal zone
Substratum	A base to which a sessile animal or plant is fixed
Sub tidal	The low-zone which is usually covered with water at low and high tides
Temperate	Having a moderate climate

Tide	The rise and fall of the ocean's water relative to the earth-moon rotational cycle
Thorax	The central section of the body consisting of several segments behind the head and in front of the abdomen
Turbulence	The interaction between waves, currents and upwellings from the ocean

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APPENDIX 1 – USING A GPS

A complete GPS Guide can be downloaded from the Parks Victoria website:

http://www.parkweb.vic.gov.au/1park_display.cfm?park=256

What is a coordinate system / datum?

In order to translate the coordinates on a map or chart to a location on the ground using a handheld GPS, there are several important steps that must be understood.

A coordinate system is a set of infinite lines that divides the earth up into sections for the purpose of map reading. Victoria is divided into two separate zones: zones 54 and 55. These zones relate to the Universal Transverse Mercator projection used by many countries to map the earth.

A datum is a best fit model of the earth's surface. In 2000, the Geocentric Datum of Australia (GDA-94) replaced the Australian Geodetic Datum 1966 (AGD-66) as the standard for all of Australia. It was chosen because it is directly adaptable to the World Geodetic System 1984 (WGS-84) which is used world-wide for GPS receivers. Prior to this, AGD-66 was widely used, and provided a best fit model for Australia *only*. Although GDA-94 in current industry standard many maps/charts made prior to 2000, list coordinates relative to AGD-66.

There are two coordinate systems used in Australia to match these datums. They include MGA-94 (Map Grid of Australia) for the GDA-94 datum and AMG-66 (Australian Map Grid 1966) for AGD-66 datum.

Latitudes and Longitudes can be displayed in a variety of formats. The most widely adopted for general maps are Degrees, Minutes and Seconds. The best way to understand this system is to simply considerate it like a clock. The world is broken up into 360 degrees and each degree can be thought of as an hour. Each degree is broken up into 60 minutes and each minute is broken up into 60 seconds.

Latitudes and Longitudes can also be expressed in degrees, minutes and decimal minutes. This is generally only used in Victoria for nautical charts. The difference between this and the previous method, is that each degree is still broken into 60 minutes, however each minute instead of being divided into sixty seconds is divided up into hundredths. In order to correctly chart Marine National Park coordinates onto a nautical chart this needs to be understood. All GPS receivers will convert between these two display formats.

In order to find your ground location on a map using a GPS receiver, it is important to understand to which datum your GPS receiver is set, what projection your map is, and in which format your coordinates are expressed. If it is set incorrectly, position differences of up to several hundred metres will occur.

How to find marine national parks and sanctuaries using your GPS receiver

It is important to familiarise yourself with your GPS Receiver and more importantly, the accuracies attainable. Being able to switch between coordinates systems and datums is also useful, as not all maps or coordinates give positions in the same format. Latitude and Longitude are usually provided in the geodetic datum on which GPS is based (WGS-84).

GPS is not precise. The design of the system ensures that the average member of the public can achieve a reasonable accuracy with their GPS Receiver, without locating a definitive 'X marks the spot' position.

It is, however, still possible to reduce the error of the position to less than 10-15 metres by ensuring that:

- the coordinate system and datum in the receiver are correct
- the GPS receiver is in Differential mode.

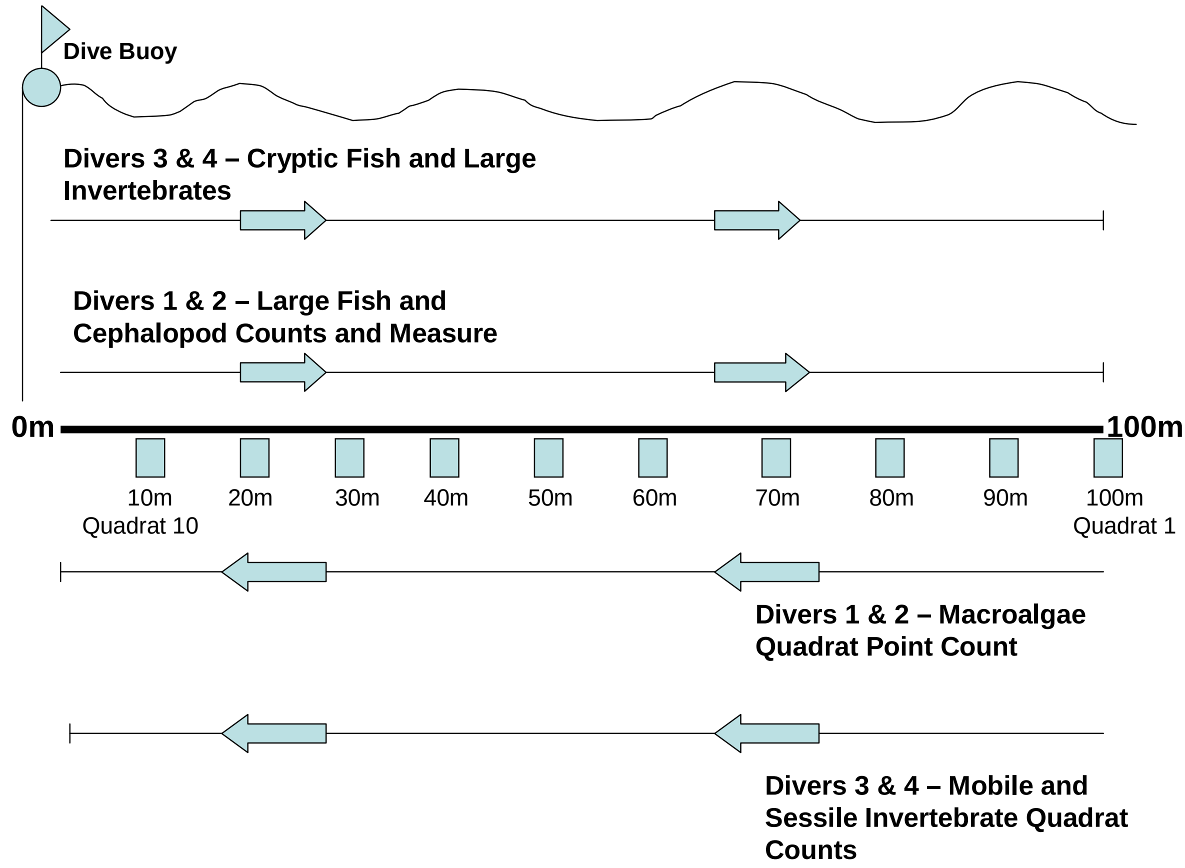
Differential GPS uses a known position on the earth and makes corrections to the GPS coordinates for that same position. These corrections are then applied to your GPS receiver, guaranteeing that the error in your position is minimised.

APPENDIX 2 – PERSONAL/SCIENTIFIC EQUIPMENT SHEET

Personal and Scientific Equipment Summary Sheet to be checked by the dive supervisor of the subtidal monitoring group as outlined in Section 3.1.

PERSONAL EQUIPMENT	Tick	SCIENTIFIC EQUIPMENT	Tick
Each volunteer has an appropriate wetsuit for the water conditions.		4 x 100 m measuring tapes	
Each volunteer has working and current SCUBA equipment as outlined in the Parks Victoria Diving and Snorkelling Manual.		4 x 0.25 m^2 intersecting point quadrats	
Each volunteer has a hat, sunscreen, sunglasses, and a towel.		4 x 0.25 m^2 open quadrats	
Each volunteer has a water bottle with water.		GPS or compass	
Each volunteer has wet-weather gear if rain is predicted.		Waterproof datasheets, underwater boards, pencils, rulers and rubber bands.	
Each volunteer has adequate clothing to protect against the elements.		Map of site (if available)	
A current First Aid Kit for the whole group.		Field summary sheet	

APPENDIX 3 – SUBTIDAL MONITORING FIELD SHEET



- Divers 1 and 2 will monitor large fish and cephalopod, and macroalgae point cover.
- Divers 3 and 4 will monitor cryptic fish and larger invertebrates, and mobile and sessile invertebrate count cover.

Data Collection

- abundance and size structure of large fish and cephalopods
- abundance and size structure of cryptic fish and abundance of larger invertebrates
- macroalgae point cover using the 50 intersecting point quadrat
- small mobile invertebrate and sessile invertebrate abundance
- essential information.

Parks Victoria is responsible for managing the Victorian protected area network, which ranges from wilderness areas to metropolitan parks and includes both marine and terrestrial components.

Our role is to protect the natural and cultural values of the parks and other assets we manage, while providing a great range of outdoor opportunities for all Victorians and visitors.

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

Healthy Parks Healthy People

For more information contact the **Parks Victoria Information Centre** on **13 1963**, or visit **www.parkweb.vic.gov.au**

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