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Biological Monitoring of Intertidal Reefs

Authors: Simon P Hart, Matt Edmunds

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Authors:

Simon P Hart
Matt Edmunds

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Parks Victoria Technical Series No. 21

Parks Victoria Standard Operating Procedure

Biological Monitoring of Intertidal Reefs

Simon P Hart

Matt Edmunds

Australian Marine Ecology Pty Ltd

March 2005

EXECUTIVE SUMMARY

Intertidal reefs support unique suites of species specially adapted to living under the constant influence of incoming and outgoing tides. Intertidal reef assemblages include large macroalgal species, herbivorous and carnivorous invertebrates such as gastropods and seastars as well as many suspension feeding species. Biological communities on intertidal reefs are particularly susceptible to change and impacts caused by human activities because they are in close proximity to land-based activities and are easily accessible to visitors.

In Victoria, important intertidal reefs are protected within a system of Marine National Parks and Marine Sanctuaries. To effectively manage and conserve these important and biologically rich habitats, the Victorian Government has established a long-term biological monitoring program for intertidal reefs. Biological monitoring is done to characterise macrobenthic intertidal reef communities, identify important spatial variation in populations and communities across reefs, to determine the nature and magnitude of natural changes in species populations and communities over time and to detect impacts on species populations and communities through comparison with appropriate reference sites. This report documents the Standard Operating Procedure for the Intertidal Reef Monitoring Program. The objectives of the Standard Operating Procedure are to describe in detail:

- standardised monitoring methods that can be tailored to different intertidal reefs to meet monitoring objectives; and
- standardised and controlled techniques so that comparable and high quality data are collected from all monitoring operations.

On each intertidal reef the biota is quantitatively surveyed using visual census of quadrats distributed along transects across the survey area. Specific survey techniques are used to determine the cover-abundance of macroalgal species and aggregating invertebrates and for determining the abundance of mobile macroinvertebrates. The size of commonly collected species is also measured.

The Victorian Government is making the intertidal monitoring method openly and freely available to encourage its broad use across intertidal reef habitats in Victoria or elsewhere.

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1.0 INTRODUCTION

1.1 Background

There are 13 highly protected Marine National Parks and 11 Marine Sanctuaries along the Victorian coast. These Marine Parks and Sanctuaries include significant areas of intertidal reef habitat. Indeed, some marine sanctuaries were gazetted specifically to protect important intertidal reefs (*e.g.* Mushroom Reef, Jawbone and Barwon Bluff Marine Sanctuaries). Biological communities on intertidal reefs are particularly susceptible to change and impacts caused by human activities because they are easily accessible and in close proximity to land-based activities.

Parks Victoria is the management agency responsible for the Victorian Marine National Parks and Sanctuaries. In accordance with the Marine Parks Management Strategy (Parks Victoria 2003), Parks Victoria has established a long-term biological monitoring program for intertidal reefs. This monitoring program is used to provide a basis for evaluating and reporting on the status of biological communities on intertidal reefs and to identify changes in these communities over time. Parks Victoria, in collaboration with Australian Marine Ecology, has developed a Standard Operational Procedure for intertidal reef monitoring. The Standard Operational Procedure was developed to meet the monitoring requirements of each marine protected area and to ensure that consistently high standards are maintained during all monitoring operations within and among reefs.

1.2 Monitoring Objectives for Marine Protected Areas

The purposes of monitoring in marine protected areas are for knowledge building, understanding change, bench marking and to provide vital signs to assist with management of these areas (Marine Parks Management Strategy 2003). Accordingly, the principal objectives for biological monitoring are to:

- characterise macrobenthic intertidal communities on each reef by providing data on populations, population size structure of common, potentially-impacted species and biological community structure;
- identify important spatial variation in species and communities spatially across reefs;
- determine the nature and magnitude of natural changes in species populations and communities over time; and
- detect impacts of threats on species populations and communities through comparison with appropriate reference sites.

The main threats to intertidal reefs in Victoria have been identified as: (1) high visitation causing disturbance and trampling of biota; (2) illegal collection of intertidal biota; (3) changes to nutrient status; and (4) freshwater inputs to intertidal reefs. Other threats to intertidal reefs include oil spills, pollution and global warming. The monitoring program has been designed around detecting change related to threats. Specific threats and their magnitude differ for each intertidal reef and specific monitoring objectives vary accordingly for different reefs.

1.3 Objectives of Standard Operational Procedure

The two broad objectives of this Standard Operational Procedure are to provide:

1. standardised monitoring methods that can be tailored to different intertidal reefs to meet the monitoring objectives (described above); and

2. standardised and controlled techniques so that comparable and high quality data are collected from all monitoring operations.

Specific objectives of the standard operational procedure are to:

- provide a documented description of the methods for training new observers;
- provide consistent methods used by trained observers to ensure comparability of data over time and space;
- standardise and minimise effects of biases and errors;
- incorporate quality control checks to detect and minimise mistakes and errors;
- incorporate quality assurance management procedures;
- ensure safe and healthy working conditions;
- enable proper scrutiny and transparency of methods to ensure integrity, reliability and wider acceptance by scientists and managers; and
- assist integration of standardised methods whilst being consistent as possible with other large-scale and long-term targeted ecological monitoring programs (such as long-term intertidal monitoring programs by Melbourne Water and the Westernport Region Water Board).

1.4 Scope of Standard Operational Procedure

The standard operational procedure was developed to provide:

- an overview of the methods;
- a brief rationale for the nature of the methods chosen;
- clear step-by-step procedures for implementing the methods, including pre-survey operations, site establishment and data collection and post-field procedures for managing data and collected specimens; and
- clear step-by-step procedures for training new scientific observers.

2.0 RATIONALE FOR THE SURVEY TECHNIQUE

2.1 General Approach

The survey procedures provide for quantitative assessments of a wide range of ecological components, including species populations, population size structure and biological community structure. These data are collected to adequately assess the status of communities, not just individual species, and to maximise the probability of detection of unforeseen ecological responses to environmental changes. As the knowledge of biological communities on intertidal reefs increases, the data collected will assist in the development of more specific indicators of change in response to specific threats. Where potentially useful indicators of impacts already exist, these have been included in the survey methods (*e.g.* Hormosira cover in response to trampling, presence-absence of species that respond to nutrient impacts, population size-structure of collected species).

2.2 Reference Locations

To adequately detect ecological change on a reef, and to reliably attribute changes to a specific cause, requires a comparison of the reef of interest to reefs at appropriate reference or control locations (Downes *et al.* 2002). For this reason, intertidal surveys occur at reefs within each marine protected area and at a matched reference location outside the MPA. Where possible, reference locations have very similar environmental conditions and biota to the reef of interest within the MPA. In addition, the reference areas are selected to enable assessment of threats specific to individual marine protected areas (Parks Victoria 2003).

It should be noted that in some cases, the position of reference locations is determined by the availability of intertidal reef. Selecting reference locations is particularly difficult for marine protected areas that have been established to protect a unique or isolated intertidal reef.

2.3 Substratum Type

On intertidal reefs there is generally significant spatial variation in species assemblages according to habitat type. Surveys are targeted to the predominant substratum type (*e.g.* solid sandstone reef, basalt boulder field) on each reef, which is the same between paired MPA and reference locations. The microhabitat within each survey quadrat is also recorded. These two features of the method allow for precise characterisation of the biota with respect to substratum type. This also allows for a more reliable comparison between paired MPA and reference locations (by reducing unexplained variance in the data). The nature, distribution and extent of other habitats (*e.g.* different substratum types, large rockpools) are also noted. This allows for a qualitative assessment of the generality of the survey results at each reef.

2.4 Distribution of Sampling Effort across the Shore

There is a trade-off between spreading limited survey time and resources across a large area of reef and concentrating the same resources in a smaller area. Surveying a large area of reef will more broadly characterise the intertidal assemblage and will have some utility in detecting spatial variation in assemblages across the shore. There is likely to be, however, increased unexplained variance in the data which can limit comparisons between shores. Concentrating resources in a smaller area may provide for better comparisons between shores (depending on the similarity of the areas surveyed), however it is unlikely that results could be generalised across an entire shore. Furthermore, some impacts may not be detected because only a relatively small area would be surveyed. The former strategy was used, to provide data from as large an area of the reef as possible.

Using the standard methods described here, surveys occur in quadrats placed along five fixed transects, which are distributed more or less evenly across the predominant habitat type. The maximum along-shore length that is surveyed is 200 m. This approach allows sampling to be tailored to the spatial area of each reef and is expected to broadly characterise the intertidal assemblage at each location. The actual sampling effort per unit area will vary depending on the size of the predominant habitat type on each reef.

The standard methods were designed to be suited to shores of different shapes, sizes and substratum characteristics. However, because the size of reefs can differ considerably, the sampling intensity can vary between paired MPA and reference reefs (even though every effort is made to match the size of reference sites with MPA sites). This can lead to unequal variances in the data which can make comparisons between reefs difficult. In this case, during analyses a subset of transects can be compared so that the sampling intensity between reefs is similar.

2.5 Fixed Transects

Fixed transects (relocatable) are used during surveys to minimise spatial variability in the data over time. This will increase the power of analyses to determine changes in biota over time, especially where changes relate to specific threats.

2.6 Height on Shore

On vertically-sloping intertidal reefs there can be large differences in environmental conditions at different heights on the shore. Physical and biological parameters that vary with height on shore include temperature, salinity, exposure to freshwater, food availability and predation. Therefore, height on shore has been identified as an important determinant of spatial variation in species assemblages on intertidal reefs.

To encompass and identify changes in biota with height on shore, quadrats are distributed at five fixed shore heights along each transect. Distributing quadrats in this way can also help identify changes in the distribution of biota over time. This is particularly important given that species distributions could change with global warming. Every effort is made so that the same shore heights are surveyed on each transect. On relatively flat shores, quadrats, and therefore sampling effort, are distributed evenly along each transect.

2.7 Random Positioning of Quadrats

Survey quadrats are randomly positioned at each shore height on each transect. Random positioning of quadrats allows for an unbiased representation of the assemblage within each stratum (transect-height combination). Random positioning of quadrats also allows for comparisons of results through time using relatively simple statistical methods (but has the disadvantage that more quadrats are often required for adequate statistical power to detect a change).

2.8 Quadrat Visual Census Techniques

Using the standard methods, biota is surveyed in quadrats distributed along transects. Quadrat visual census techniques were adopted for these standard procedures because:

- transects and quadrats can be randomly located and easily replicated;
- they allow collection of quantitative data;
- data can be collected on a wide range of species;
- the same sampling unit (the quadrat) can be used for both cover and count data;
- quadrats can be surveyed relatively quickly given the limited survey time (*i.e.* low tide); and
- when used carefully, they do not cause impacts on biota.

2.9 Photographic Quadrats

Many intertidal studies sample using photographic or still-video quadrats that are later examined back in the laboratory. This has the advantage of rapid field sampling, particularly for the lower intertidal regions but has the disadvantage of lower resolution of species determination and individual detection, as well as longer total data collection time. For the standard methods, in situ counts and measurements were selected as a standardised approach to maximise precision and accuracy of as many species as possible and enable size measurements to be taken. In situ measurements can also be taken in a greater range of weather conditions. Wherever possible, digital photographs of the quadrats are taken to

provide a permanent visual record for supplementary (qualitative) analysis and quality assurance purposes.

2.10 Specimen Collections

Small specimen collections are considered necessary as vouchers, as well as for taxonomic, genetic, pathological and other studies that may assist greatly in interpreting results of the monitoring program. Permits are required in Victoria for any scientific collection in marine national parks or marine sanctuaries. The levels of sampling to ensure compliance with ethical and impact criteria are determined during the permit provision process.

Figure 2.1. Marine biologists counting invertebrates within quadrats during intertidal reef monitoring surveys.

3.0 DESCRIPTION OF SURVEY TECHNIQUE

3.1 Selection of Survey Areas

3.1.1 Reefs within Marine Protected Areas

The intertidal area to be surveyed is determined by the specific requirements of each project. Monitoring of Marine Protected Areas is designed to assess the status of intertidal reefs within each MPA and to identify impacts on the biota. Survey areas within each MPA are selected on the basis of: (1) availability of intertidal reef and (2) exposure to potentially threatening processes.

Within many MPAs there is a limited area of intertidal reef to survey. Furthermore, some MPAs are designed specifically to protect a single intertidal reef (*e.g.* Mushroom Reef and Point Danger Marine Sanctuaries). Where there is a limited area of intertidal reef within an MPA, surveys generally occur on the largest and safest area of available intertidal reef.

Where there is more than one intertidal area, or a very large area of intertidal reef within an MPA, surveys occur on reef habitats that are exposed to the threatening processes of interest. For most intertidal reefs in Victoria the predominant (relatively short-term) threatening processes have been identified as: (1) high visitation causing disturbance to, and trampling of, biota; (2) collection of intertidal biota; (3) changes to the nutrient status of reefs; and (4) freshwater inputs. For example, the Barwon Bluff Marine Sanctuary has high rates of visitation and may also be exposed to higher than normal nutrient loads because of its proximity to the Black Rock outfall.

3.1.2 Reference Locations

Monitoring for impacts or changes in reef communities requires surveys to occur at intertidal reefs within an MPA and at suitable reference location(s) (see Section 2). Where possible, reference locations have very similar environmental conditions and biota to the reef of interest within the MPA. In all cases, the reference area will be outside the marine protected area of interest. For some intertidal reefs, there are specific threats that need to be addressed (*e.g.* high levels of visitation by the public). In these cases, reference locations are selected such that the threat levels are different (*e.g.* comparisons of a reef with high visitation to a reef with low visitation).

In most cases in Victoria, the positioning of a reference location is highly restricted by the availability of intertidal reef habitat in the vicinity of the marine protected area.

3.2 Site Establishment

3.2.1 Establishing Baselines and Transects

Surveys occur at a single reef during a single low tide. Surveys are targeted to the predominant substratum type at each intertidal reef. At each location, the predominant broad substratum type is recorded (*e.g.* basalt boulder field, flat sandstone reef, basalt reef). The maximum along-shore distance that is practical to sample in a single tide using this method is 200 m. If the predominant substratum type extends further than 200 m, an area < 200 m long is selected to be sampled. If different areas of the shore have different susceptibilities to impacts, then surveys occur on the area most susceptible to impacts.

Within the area to be surveyed, the high- and low-shore regions are identified. On vertically sloping shores, the high shore corresponds to the area that is submerged for the shortest period of time during each tidal cycle. On relatively flat shores with little variation in vertical height across the shore, the high shore is at the landward edge and the low shore is at the seaward edge. A weighted tape measure or numbered transect line is placed along the high shore, beginning at the right hand side of the shore when looking towards the sea. This is the high-shore baseline (Figure 3.1). Similarly, a low shore baseline is established by placing a transect line along the low shore. The positions of each end of both baselines are recorded using dGPS, photographed and permanently marked using minimally invasive techniques (providing appropriate permits have been provided). If permits have not been provided then endpoints should not be marked.

Five fixed transects, each running from high to low shore, are positioned across the intertidal area to be surveyed (Figure 3.1). Transect 1 is furthest to the right-hand side and Transect 5 to the left-hand side of the reef when looking out to sea. Each transect runs between points on the high- and low-shore baselines. To determine the endpoint of each transect along the baselines, the baseline distances are divided by six. For example, if the length of the high-shore baseline is 180 m, then one end (the high-shore end) of each transect will be placed every 30 m along the high-shore baseline. The coordinates are recorded using dGPS and endpoints are permanently marked using minimally invasive techniques (this should only occur providing appropriate permits have been provided).

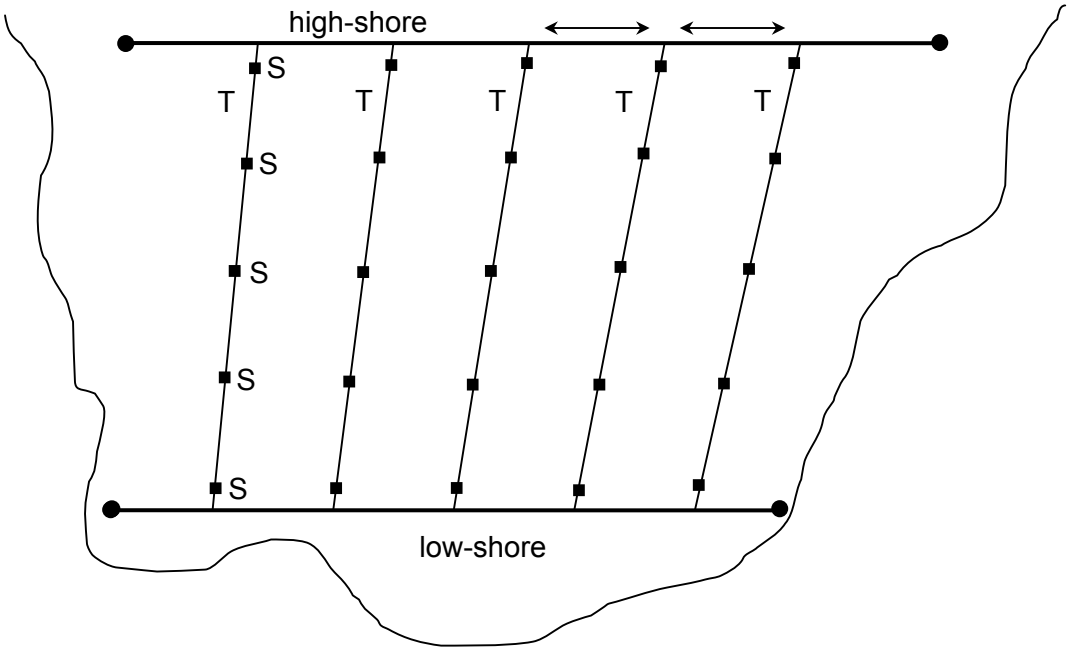

Figure 3.1. Layout of high- and low-shore baselines and transects on an intertidal reef. Transects (T1-T5) run across the shore from right to left when looking towards the water. Endpoints of each transect are equidistant along each of the baselines. Sampling Locations (S1-S5) are arranged downshore along each transect and where appropriate should encompass differences in substratum height down the shore.

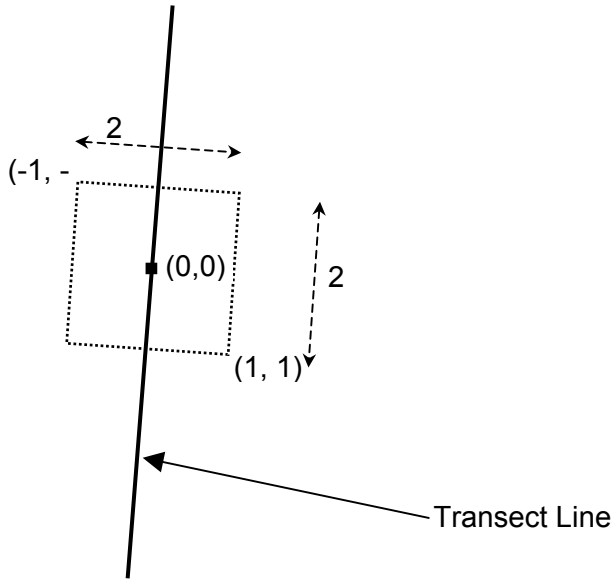

Figure 3.2. Configuration of a sampling location along a transect. Each 2 x 2 m sampling location is centred on a point along the transect line. A quadrat is placed randomly within the sampling location using random x- and y-coordinates between -1 and 1.

3.2.2 Establishing Sampling Locations

Surveys of biota occur in quadrats, which are randomly placed during each survey, at five fixed sampling locations (2 m x 2 m area) along each transect (Figure 3.2). The fixed sampling locations are positioned to distribute sampling effort along each transect and to encompass any changes in substratum height across the reef.

Each 2 m x 2 m sampling location is centred on different points along each transect. The highest and lowest sampling locations are initially positioned 1 m from the high-shore and low-shore end of each transect respectively. The distance between these and the remaining three sampling locations is calculated by measuring the length of each transect, subtracting two (for the highest and lowest sampling locations already determined) and then dividing the total by four. For example, if a transect is 20 m long, then each sampling location is 4.5 m from the next. If a transect is less than 10 m long then there is not sufficient length for five sampling locations. In this case, three sampling locations are used - the upper, middle and lower locations.

At some intertidal reefs, changes in vertical substratum height may not occur consistently across the shore. For example, in some survey locations there may be little change in the height of the substratum across most of the shore, but then a relatively sharp decline in the height of the substratum at the seaward edge. It is important that sampling locations along each transect encompass major changes in substratum height across the shore. Therefore, if rapid changes in substratum height are not encompassed by the calculated position of sampling locations, small changes in the position of some sampling locations may be required. In each case and with discretion, the closest calculated sampling location is moved to encompass rapid vertical height changes. This should be done by an experienced biologist. Furthermore, if sampling locations do not occur on the predominant substratum type (*e.g.* in a rockpool) then in each case the sampling location is moved the shortest possible distance along the transect to the nearest area of predominant substratum.

Finally, the vertical height on shore of each sampling location should correspond closely to equivalent sampling locations on all adjacent transects. If required, adjustments are made so that similar shore heights are surveyed along each transect. The final position (*i.e.* the number of metres along each transect) at which each sampling location has been placed is recorded (0 m is at the high shore end of each transect).

3.3 Quadrat Placement

Quadrats are randomly positioned within each 2 m x 2 m sampling location (Figure 3.2). To do this, the five fixed transects are positioned as described above. The first sampling location on Transect 1 is located by walking down-shore along the transect. Random coordinates (x, y)

for the position of each quadrat within the sampling location are determined using random numbers between -1 and 1. The centre of the quadrat is placed over the random coordinates. The substratum type is recorded and then the quadrat is quantitatively assessed using the visual census techniques described below.

This procedure for quadrat placement and then survey is repeated for each sampling location along each transect. If the tide has not fully receded, then surveys of sampling locations in the high shore areas of each transect are done before beginning sampling lower on the shore.

3.4 Visual Census Techniques

3.4.1 Method A – Mobile Invertebrates

The density of non-sessile invertebrates, such as gastropods and sea stars, is measured by counting individuals within 0.5 x 0.5 m quadrats (Figures 3.3, 3.4; Table 3.1). The observer counts all observable individuals on the rock surface or within crevices and algal fronds. To ensure the monitoring has minimal impact over time, rocks are not overturned or disturbed. Selected specimens are collected for identification and preservation in a reference collection. Permits are required for any scientific collection in marine national parks or marine sanctuaries.

The shell length of 50-100 abundant species of gastropod are measured at each site. This is done to identify changes in the size structure of commonly collected species over time, which may indicate impacts on populations due to illegal shellfish collection. Data collected also provides general information on population size structure and recruitment dynamics. Species measured include those that are commonly collected on intertidal shores for bait or food, such as *Cellana tramoserica* and *Austrocochlea constricta* as well as non-collected 'control' species, including *Siphonaria diamenensis*, *Cominella lineolata* and *Bembicium nanum*.

3.4.2 Method B – Macroalgae and Sessile Invertebrates

The abundance of algae and highly aggregated sessile invertebrates, such as tubeworms and mussels, is measured as proportional cover of the substratum. This is done using a points-intersection method. A 0.5 x 0.5 m quadrat is divided into a grid of 7 x 7 perpendicular wires, giving 50 regularly spaced points (including one corner). Cover is estimated by the number of points directly above each species (Figures 3.3, 3.4). Selected specimens are collected for identification and preservation in a reference collection.

Some species have been shown to respond to changes in nutrient and freshwater inputs on Victorian intertidal reefs (Fox *et al.* 2000). Fluctuations in the population status of these species may indicate changes in nutrient loadings affecting MPAs or other intertidal areas.

Species that may respond include the algae *Ulva rigida, Cladophora subsimplex, Capreolia implexia, Ceramium flaccidum, Corallina officinalis*, *Hormosira banksii* and the tubeworm *Boccardia proboscidea*. The presence/absence of these species within each quadrat is recorded (if present and not detected under any points).

3.4.3 Video/Photo Quadrats

Whenever weather conditions and time permit, a digital photograph is taken of the substratum and biota at each quadrat position. This is done to provide a permanent qualitative record of the biota and microhabitat conditions.

3.4.4 Qualitative Observations

At each site, observers record general observations of topography, reef structure (rugosity, relief, boulder sizes, etc.), biogenic habitat structure (*Hormosira*, algal turfs) and a general description of the flora and fauna. Video and photographic records are also taken at each site.

For each quadrat, the substratum microhabitats are recorded. These are classified as:

(h) horizontal surface, flat, rock top;

(p) rock pool;

(r) rocky rubble or cobble;

(s) sand; and

(v) vertical surface, rock side, crevice.

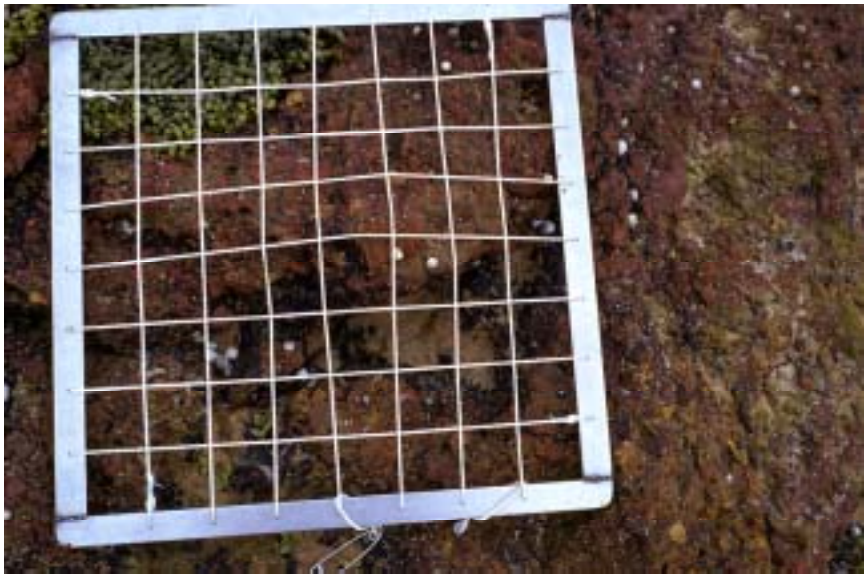

Figure 3.3. Quadrat with the alga *Hormosira banksii* and snail *Bembicium nanum*. The abundance of each gastropod is counted within the quadrat. The cover of macrophytes and highly aggregated animals is measured by the number of points intersecting each species on the quadrat grid.

Table 3.1. Examples of intertidal species in south eastern Australia surveyed using Methods A and B.

Algae	Sessile Invertebrates	Mobile Invertebrates
Blue-Green Algae	**Tube Worms**	**Limpets**
Rivularia sp.	*Galeolaria caespitosa*	*Patella peronii*
	Boccardia proboscidia	*Patella chapmani*
Green Algae		*Cellana tramoserica*
Ulva spp	**Barnacles**	*Patelloida alticostata*
Enteromorpha spp	*Catomerus polymerus*	*Patelloida latistrigata*
Codium fragile	*Cthamalus antennatus*	*Notoacmea mayi*
	Chamaeshipho tasmanica	*Notoacmea* spp
Brown Algae	*Tesseropora rosea*	*Siphonaria diamenensis*
Leathesia difformis	*Austromegabalanus nigrescens*	*Siphonaria zelandica*
Splanchnidium rugosum	*Tetraclitella purpurascens*	*Siphonaria tasmanica*
Scytosiphon lomentaria		*Siphonaria funiculata*
Colpomenia sinuosa	**Bivalves**	
Notheia anomala	*Mytilus edulis planulatus*	**Snails**
Hormosira banksii	*Xenostrobus pulex*	*Austrocochlea constricta*
	Brachidontes rostratus	*Austrocochlea odontis*
Red Algae	*Saccostrea glomerata*	*Austrocochlea cancamerata*
Gracilaria spp		*Turbo undulatus*
Porphyra lucasii	**Ascidians**	*Nerita atramentosa*
Porphyra columbina	*Pyura stolonifera*	*Bembicium nanum*
Spongites hyperellus		*Nodilittorina unifasciata*
Capreolia implexa	**Sea stars**	*Dicathais orbita*
Corallina officinalis	*Patiriella exigua*	*Lepsiella vinosa*
Ceramium flaccidum	*Patiriella calcar*	*Cominella lineolata*
Cladophora subsimplex		
	Sea Slugs	**Anemones**
	Onchidella patelloides	*Actinia tenebrosa*
		Oulactis muscosa
		Aulactinia veratra

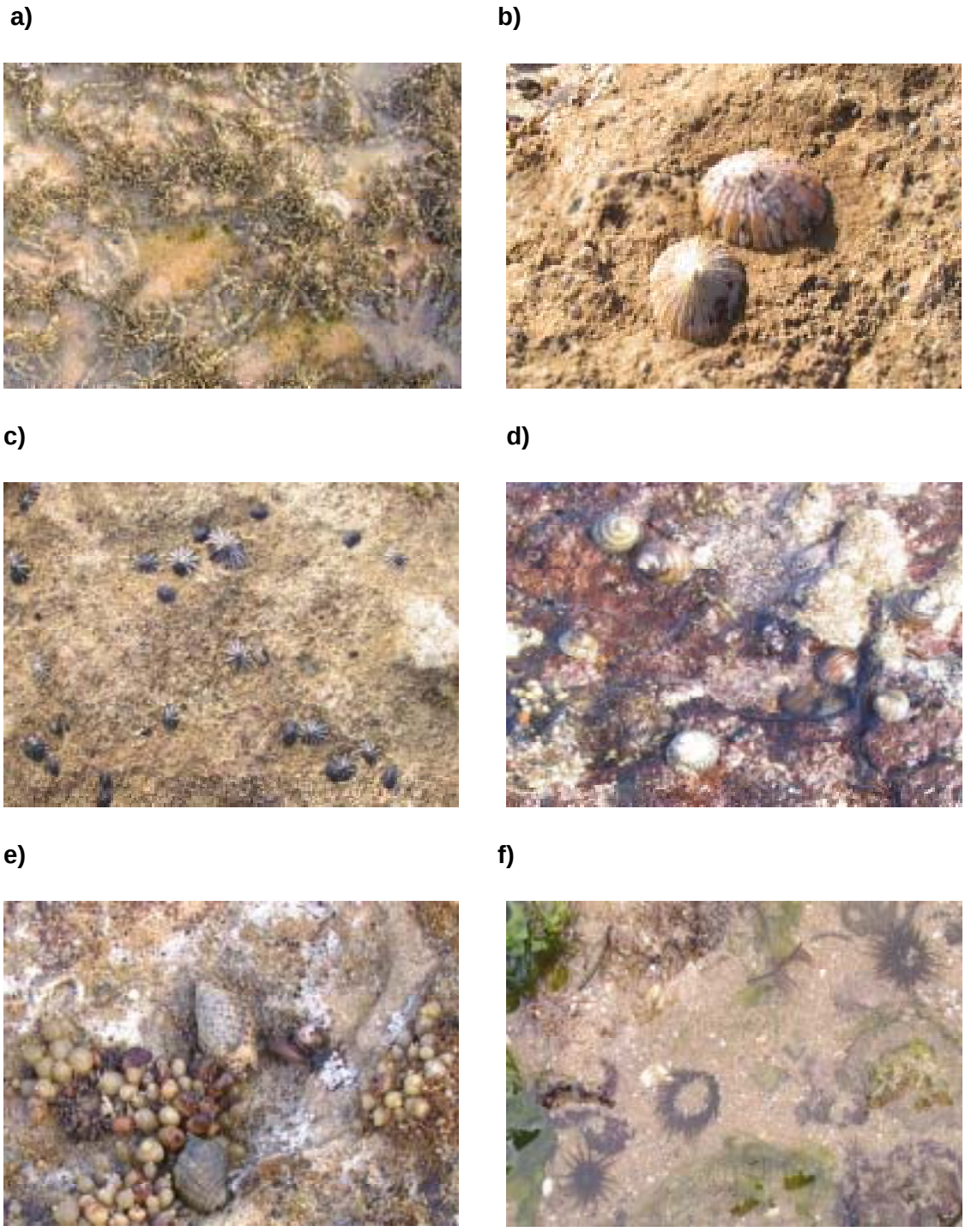

Figure 3.4. Examples of typical flora and fauna on intertidal reefs: (a) the green alga *Hormosira banksii*; (b) the common limpet *Cellana tramoserica*; (c) the limpets *Siphonaria diemenensis* (centre) and *Notoacmea mayi*; (d) the gastropods *Bembicium nanum* (bottom) and *Austrocochlea constricta*; (e) the gastropods *Cominella lineolata* (top) and *Dicathais orbita*; and (f) the anemone *Aulactinia veratra* and the green alga *Ulva* spp. in standing water.

4.0 SELECTION OF SURVEY AREAS

4.1 Reefs within Marine Protected Areas

Survey areas within each Marine Protected Area are selected on the basis of: (1) availability of intertidal reef and (2) exposure to potentially threatening processes. The process for selecting intertidal reefs within Marine Protected Areas follows.

1. The locations of substantial areas of intertidal reef habitat within the protected area are determined.

2. If there is only a small area of intertidal reef, then surveys occur on the largest and safest area of available intertidal reef.

3. If there is a single large reef (> 200 m along shore), or multiple reefs within a protected area, then surveys should occur in areas that are likely to be exposed to the main threatening processes identified for that MPA. Important threatening processes include (1) high visitation causing disturbance to, and trampling of, biota; (2) illegal collection of intertidal biota; (3) changes to the nutrient status of reefs; and (4) freshwater inputs.

4.2 Reference Locations

Monitoring for impacts or changes in reef communities requires surveys to occur at intertidal reefs within an MPA and at suitable reference location(s). The process for selecting suitable reference locations follows.

1. Identify intertidal reefs outside each MPA. This can be done using maps, talking to people with local knowledge and by site reconnaissance. In most cases, reference locations will be within the general vicinity of the MPA.

2. If there is limited intertidal reef outside the MPA, then the reference location occurs on the available intertidal reef. Substratum type and environmental conditions should be matched as closely as possible to the MPA reef.

3. If there are multiple areas of intertidal reef outside the MPA, then the reference location should occur on the area of reef that is most similar to the survey location within the MPA. The ideal reference location would have similar physical conditions, including substratum type and extent, aspect, slope, exposure to wind, waves and currents and freshwater input. The reference location should also have similar biological community structure.

4. A focus of monitoring at some reefs is to detect if an impact is occurring because of a specific threat (*e.g.* high levels of visitation by the public at Point Lonsdale within the Port

Phillip Heads MNP). In these cases, reference locations should be chosen so that the main difference between the reef of interest and the reef at the reference location is in the level of exposure to the principal threat.

5.0 PLANNING AND PRE-FIELD OPERATIONS

5.1 Personnel

5.1.1 Introduction

The following information is a general guide to personnel requirements. Specific requirements should be detailed in the relevant organisation's Occupational Health and Safety Manual.

5.1.2 Team Size

A minimum of two people is required to complete the surveys using the methods described. With two people, one person must remain at a higher level (or more inshore) than the other and act as a lookout for rogue waves. Preferably, the lookout person should be the scribe while the other person does the quadrat census.

Surveys of intertidal areas are restricted to periods of low tide which limits survey time. Furthermore, sea conditions can make work in intertidal areas unpredictable and hazardous. A minimum team size of three observers is mandatory for exposed or steep rocky shores.

5.1.3 Induction and Registration

All field personnel must receive an induction on the relevant organisation's occupational health and safety policies and procedures and register with the appropriate OHS Officer. These procedures must be detailed in the relevant organisation's Occupational Health and Safety Manual.

5.1.4 Fieldwork Requirements

All fieldwork must be in accordance with the relevant organisation's safe work practice for field operations. Personnel should be competent swimmers and hold appropriate first aid certificates, car and radio licences.

5.1.5 Training and Calibration

Intertidal observers must be inducted and trained in the standard operational procedures. Once trained and capable, all observers responsible for site establishment and the collection of survey data must participate in on-going review and calibration exercises.

5.2 Planning and Approvals

To ensure contractual, quality and safety requirements are met, each project stage must be approved before the next set of tasks can proceed. The approvals process is documented in all cases. The Project Manager is responsible for facilitating the appropriate documentation and authorisation by the project participants, OHS Officer and Quality Manager.

Principal steps in the planning and approvals process are:

1. Prepare and approve quality plans, work package plans and budgets.

2. Register personnel on project team with OHS Officer.

3. Induct personnel in occupational health and safety policies and procedures.

4. Prepare and approve project/task risk assessments.

5. Approve purchase orders for equipment, materials and services.

6. Approve field excursion plans, emergency response plans and nominated contact sheets.

Documentation of the procedures required for these approvals are listed in Table 5.1.

Table 5.1. Approval procedures for implementing the intertidal reef monitoring procedures. Abbreviations: (OHS) Occupational Health and Safety Manual; and (QMS) Quality Management System.

Activity	Prepared by	Approved by	Documentation
Project quality plan,	Project Manager	Project Director	QMS
Personnel registration	Team Member	OHS Officer	OHS
Personnel induction	Project Manager/ Field Coordinator	Project Manager/ OHS Officer	QMS OHS
Purchase of equipment, materials and services	Project team member	Project Manager, OHS Officer	QMS OHS
Project risk assessment	Project Manager & Team	OHS Officer	OHS
Application for collection permits	Project Manager	Government Departments	
Field plans	Field Coordinator	OHS Officer	OHS

5.3 Mobilisation and Field Conditions

Tasks to be completed prior to each field operation are:

1. Review and revise field plan.

2. Check, service and maintain scientific, navigation and safety equipment.

3. Prepare waterproof forms (Table 12.2) – photocopy forms onto weatherproof paper (e.g. Celcast Permanent Paper, PP4).

4. Ensure adequate supply of expendables, including pencils, rubber bands, plastic callipers, string, electrical tape and GPS batteries.

5. Revise species lists for location.

6. Assess timing of tides and good weather windows; place staff and service providers on stand-by.

7. Organise transport, subsistence and other logistics associated with the excursion.

8. Pack equipment and recheck all items are present (listed in Section 5).

9. Notify relevant Fisheries and Parks Victoria authorities, and other appropriate authorities for each region.

10. Monitor Bureau of Meteorology weather forecasts and mobilise team as soon as both tides, weather and sea conditions are favourable.

6.0 EQUIPMENT LIST

6.1 Navigation

- maps, site photographs.
- site coordinates, permanent baseline coordinates.
- portable differential Global Positioning System (dGPS).
- compass, dumpy level (optional)

6.2 Safety

- first aid kit.
- sun cream, hat, sunglasses, wet weather clothing, warm hat, towel, sensible footwear.
- water and food.
- floatation vests, harnesses.
- copy of field plan, emergency response plan, nominated contact details and safe work practices.

6.3 Intertidal Reef Census

- record of baseline endpoints.
- record of transect endpoints.
- record of the position of each sampling location along each transect.
- random number tables for determining quadrat location
- weighted transect lines (baselines).
- plastic tape measures (at least 30 m long).
- underwater slates with rubber bands and attached pencil and plastic callipers.
- pre-printed plastic data forms (Table 12.2) and/or Pocket PC with formatted spreadsheet for data entry.
- quadrats (weighted or metal), 0.5 x 0.5 m with internal grid of 7 x 7 points (string or stainless wire).
- datasheet stowage box, spare pencils, rubber bands, data sheets, electrical tape and pencil sharpeners.
- digital video camera, digital camera and/or underwater camera.

- tripod, scale bar and quadrat labels.

6.4 Specimen Collections

- zip-lock plastic bags
- specimen labels
- herbarium pressing sheets, newspaper, muslin, pencils
- dissection equipment
- silica gel bags, sample tubes, ethanol, etc.

6.5 Documentation

- collection and survey permits (Fisheries Victoria and Wildlife and/or National Parks Act)
- field record book containing risk assessment, field plan, emergency response plan, nominated contact details, briefing checklist
- Relevant Safe Work Practice from Occupational Health and Safety Manual
- Standard Operational Procedure (this document)
- Project Quality Plan

6.6 Post Survey

- spare slate, datasheets, pencils, rubber bands, callipers, batteries, pencil sharpeners.
- general stationery, including red pens.
- data correction sheets for managing data quality.
- licences (*e.g.* car drivers, coxswains, radio operators, diving, first aid, oxygen provision).
- identification guides.
- species lists and data codes.
- laptop computer and/or palm top computers.
- back-up disks and/or memory cards.
- communications equipment – radio, mobile phone, facsimile, internet, etc.
- change of clothes.

7.0 SITE ESTABLISHMENT

7.1 Methods Overview

Surveys occur at a single reef during a single low tide. On each intertidal reef the predominant habitat type is quantitatively surveyed using visual census of quadrats. Two baselines are established - one along the high shore and another along the low shore. Transects, running from high to low shore, are placed between points on the high-shore and low-shore baselines. A total of five fixed transects are positioned along the length of the shore. Surveys occur in the quadrats, which are randomly placed during each survey, at five fixed sampling locations along each transect. Sampling locations are positioned to encompass any changes in substratum height down the shore (Figure 7.1, 7.2).

7.2 Reconnaissance

Each intertidal area is assessed before sampling to: (1) familiarise observers with the survey site; (2) record important physical and biological features; (3) identify possible OH&S issues; and (4) determine locations of transects and sampling locations according to standard methods. The following site conditions are assessed:

- dimensions of the intertidal reef;
- substratum type and structure including variation across the intertidal area;
- reef slope, including location of high- and low- water height bands, and variation across the shore;
- relief, including presence of large areas of vertical relief and/or variation in relief across the platform;
- presence and location of large rock pools;
- presence and location of prominent biological assemblages including large beds of fucoid algae such as *Hormosira banksii*, mussel beds, barnacle zones, *Pyura* beds;
- exposure to wind and waves; and
- proximity of potentially unstable cliffs.

Site photographs and video should be taken at this stage. If possible, a photograph taken from height, with georeferenced transect lines in the field of view, would assist with production of a site/habitat map. Mapping of areas is also assisted by using the tracking function of the dGPS and walking the unit around boundaries.

The predominant substratum type is recorded. The predominant substratum type is the largest area of broadly similar substratum *e.g.* sandstone platform, basalt boulder field, basalt platform. Rockpools are not surveyed.

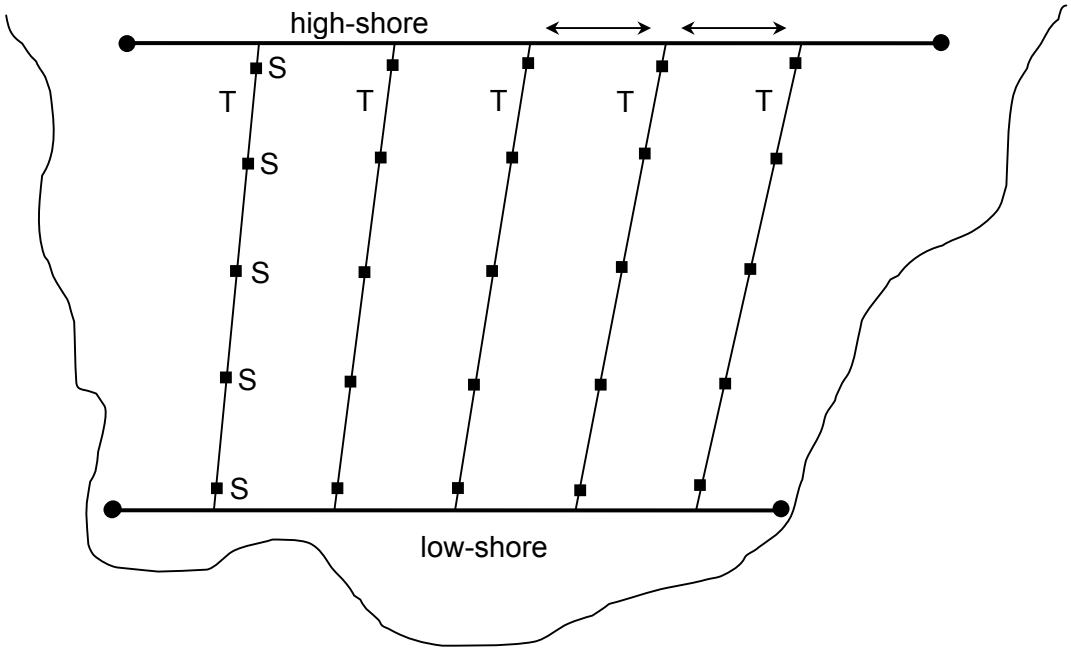

Figure 7.1. Layout of high- and low-shore baselines and transects on an intertidal reef. Transects (T1-T5) run across the shore from right to left when looking towards the water. Endpoints of each transect are equidistant along each of the baselines. Sampling Locations (S1-S5) are arranged downshore along each transect and where appropriate should encompass differences in substratum height down the shore.

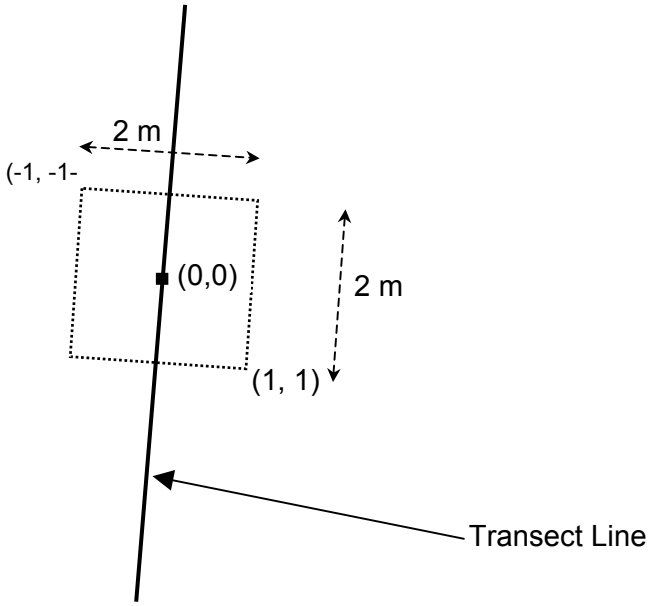

Figure 7.2 Configuration of a sampling location along a transect. Each 2 x 2 m sampling location is centred on a point along the transect line. A quadrat is placed randomly within the sampling location using random x- and y-coordinates between -1 and 1.

7.3 Transect Establishment

A minimum of five transects are established across the shore in each intertidal area (Figure 7.1). Transects run from high shore to low shore.

The broad physical structure of intertidal reefs is variable within and between shores. The method described above is relatively easy to apply to shores that are predominantly flat and/or where the high and low regions of the shore are easy to identify. An experienced biologist should use discretion in applying the method to more irregular shores where differences in height across the shore are less clear. In all cases, transects should be located so that (1) each transect traverses all heights on shore from low to high water (taking into account OH&S considerations); and (2) maximum coverage of the predominant habitat type occurs, both within and among transects.

The procedure for establishing transects follows.

1. The predominant substratum type is identified.

2. The maximum along-shore distance that is sampled is 200 m. If the predominant habitat type extends further than 200 m, the area (< 200 m long) that will be sampled is determined.

3. The locations of highest and lowest water within the predominant habitat type and within safe working limits (*e.g.* avoiding unstable cliffs at high water and exposure to waves at low water) are identified. If there are no clear differences in height across the intertidal area (*i.e.* no clear high and low water bands), the high (landward) and low (seaward) shore regions are identified. In all cases, changes in height on individual rocks and boulders are ignored.

4. Beginning at the right-hand side of the survey area when looking towards the water, a weighted tape measure (or numbered transect line) is placed along the length of the high-shore band within the survey area. This is repeated for the low-shore band. These are the high- and low-shore baselines. If it is not possible to access the low area of the shore, work continues high on the shore until the tide has fully receded.

5. The position of each end of the high and low shore baselines is photographed and the coordinates recorded using differential Global Positioning System (dGPS). In accordance

with recent changes to national standards, all coordinates are recorded using the Geodetic Datum of Australia 1994 (≈ WGS 84).

6. To easily locate endpoints of both baselines on future surveys, endpoints are marked, provided appropriate permits have been granted. This can be done using a small chisel, placing a small screw or bolt in the rock using a drill or by marking the rock with a small amount of epoxy or other suitable and appropriate means. If permits have not been provided then the platform should not be altered, disturbed or marked. Permanent, natural markers, such as prominent rock outcrops, may be used instead.

7. Transects run between corresponding points on the high and low-shore baselines. To determine the position of these points, the along-shore length of the high-shore baseline is divided by six. The calculation is repeated for the low-shore baseline. For example, if the length of the high-shore baseline is 180 m, then one end (the high-shore end) of each transect will be placed every 30 m along the high-shore baseline. If the low-shore baseline is 150 m long, then one end (the low-shore end) of each transect will be placed every 25 m along the low-water baseline.

8. Transects are numbered 1-5. Transect number 1 is furthest to the right when facing the sea. Beginning with transect number 1, a numbered and weighted transect line is placed between the corresponding points (calculated in Step 6) on the high- and low-shore baselines. This can only be done when the tide has receded and the low-shore baseline is in place.

9. If a transect traverses large areas of habitat that is not the predominant habitat type (particularly large rockpools), then the transect is moved to more appropriate habitat while maintaining spatial coverage down and across shore.

10. The final position (in metres) of both ends of each transect (1-5) along the high- and low-shore baselines is recorded.

11. To easily locate endpoints of each transect on future surveys, each point is marked, providing appropriate permits have been approved. This can be done using a small chisel, placing a small screw or bolt in the rock using a drill or by marking the rock with a small amount of epoxy or other suitable and appropriate means. If permits have not been provided then the platform should not be altered, disturbed or marked. Transects can be relocated by finding their position along the baseline.

12. Standing at the high shore end of each transect, the bearing of the transect toward its low-shore endpoint is recorded using a compass. This will allow work to occur in the

higher shore areas in future surveys when it is not possible to access the lower part of the reef during a receding tide.

13. The endpoint of each transect is photographed and coordinates recorded using dGPS.

7.4 Sampling locations

During each intertidal survey, quadrats are randomly positioned within five fixed sampling locations along each transect. On vertically-sloping shores these locations correspond to different tidal heights down the shore. The procedure for positioning the sampling locations follows.

1. Each transect is positioned (described in section 7.2).

2. The locations of the highest and lowest sampling locations are 1 m from each end of each transect.

3. The distance between sampling locations is calculated by measuring the length of each transect, subtracting two (for the highest and lowest sampling locations already determined during Step 2) and then divided by four. For example, if a transect is 20 m long then each sampling location is 4.5 m from the next.

4. If a transect is less than 10 m long there is not sufficient transect length for five sampling locations. Therefore, three sampling locations are used – the upper, lower and middle points.

5. The locations along each transect where relatively sharp changes in the vertical height of the substratum occur are identified. For example, in some survey locations there may be little change in the height of the substratum across most of the shore, but then a relatively sharp decline in the height of the substratum at the seaward edge.

6. It is determined whether the sharp declines in substratum height identified in Step 5 would be surveyed with sampling locations positioned in Step 3. If not, then in each case the closest calculated sampling location is moved to encompass these locations. After this is done, the locations of the sampling locations should encompass most (or all) major changes in vertical height across the shore.

7. All sampling locations should occur on the predominant substratum type. If some sampling locations occur in rockpools or on substratum that is not the predominant substratum type, then the sampling location is moved to the closest area of predominant substratum.

8. The height on shore of each sampling location should correspond closely to equivalent sampling locations on all adjacent transects. If required, adjustments are made so that similar shore heights will be surveyed along each transect.

9. The final position (*i.e.* the number of metres along each transect) at which each sampling location has been placed is recorded (0 m is at the high shore-end of each transect).

8.0 SURVEY METHOD

8.1 Pre-Survey Procedure

8.1.1 Observation Conditions

As per risk assessment procedures in the Occupational Health and Safety Manual, site conditions, including tides, sea state and weather, are assessed at the beginning of each day for their suitability for access and safe survey by observers.

Limiting conditions may include:

- higher tides;
- lee (exposed) shores, particularly with winds over 25-30 knots;
- heavy seas, particularly waves over 1.5 to 2 m or waves breaking over intertidal survey area;
- stormy weather and poor visibility; and
- extreme heat.

8.1.2 Briefing and Equipment Check

An on-site pre-census briefing is required. Observers are assigned tasks during the briefing, including safety look-outs. Safety issues are discussed and work boundaries are determined if appropriate (*e.g.* if some areas of the intertidal reef are affected by waves). Equipment is checked.

8.1.3 Observer Assignments

Operators work in pairs or groups of three. One member of the pair (the lookout) is responsible for recording data and keeping a lookout on safety conditions, particularly waves, at all times. The other members of the group are responsible for placing high- and low- shore baselines and transects and for positioning and surveying quadrats at each sampling location. Census observations are called out to the Lookout for recording. Observers and Lookouts should regularly rotate between roles during the survey of each site to integrate observer biases and minimise risks of occupational overuse syndrome.

8.2 Intertidal Visual Census Procedure

8.2.1 General Site Preparation and Quadrat Placement

1. The ends of the high- and low-shore baselines are located using dGPS and permanent marks. Permanent marks need scientific research permits in Victoria.

2. Weighted tape measures or numbered transect lines are placed between endpoints for both the high- and low-shore baselines (0 m is positioned at the right-hand endpoints when facing the sea). If it is not possible to locate the low-shore baseline because the tide has not fully receded, operations continue in high-shore areas until it is safe and appropriate to access the low shore.

3. The endpoints of Transect 1 are located by using the distances along the baselines recorded during site establishment and by locating permanent marks.

4. A weighted transect line is placed between the two endpoints. If it is not possible to access the low-shore baseline then the bearing recorded during site establishment is used to place the transect down the shore as far as practical.

5. Quadrats are randomly positioned within a 2 m x 2 m square centred on each fixed sampling location. The coordinates of each sampling location are (0,0) within the 2 m x 2 m square. Beginning with the highest fixed sampling location on Transect 1, the x- and y-coordinate for quadrat placement within the 2 m x 2 m area is determined using a table of random numbers between -1 and 1 (Table 12.1)

6. The centre of the quadrat is placed over the random coordinates.

7. The substratum type within the quadrat is recorded.

8. The quadrat is quantitatively assessed using Method A and Method B (described below).

9. The procedure is repeated for each fixed sampling location along the transect.

10. If the tide has not fully receded at the beginning of the survey then it may be necessary to move along the shore surveying the higher sampling locations on each transect before surveying lower on the shore.

11. With three operators it may be possible to survey two transects at the same time, with one person (the Lookout) recording data for two observers. This will only be possible if transects are positioned relatively close together.

8.2.2 Census Method A – Mobile Invertebrates

The density of all animal species, including molluscs, crustaceans, echinoderms and cnidarians is determined using the quadrat-counts method, following Method 5 of the subtidal monitoring SOP.

1. The observer searches the quadrat systematically for all observable mobile invertebrates within the quadrat. The observer searches within algae, on the tops and sides of boulders and in all cracks and crevices. Rocks and boulders are not overturned.

2. Some intertidal species are exceptionally numerous, even within the 0.25 m^2 quadrat (*e.g. Nodilittorina unifasciata*). For very abundant species (> 100 per quadrat), the sampling quadrat is divided into four quarters. Counts are made in ¼ of the quadrat and the count multiplied by four. Smaller quadrat segments may be used for more abundant animals but the area used must be recorded.

3. Field guides are used to confirm species identification *in-situ*, reducing the need for disturbance or collections of biota.

4. Specimens of particular interest are collected for more detailed examination in the laboratory.

5. The length of 50-100 individuals of selected common species is measured. For Victoria, the species *Cellana tramoserica*, *Austrocochlea constricta*, *Bembicium nanum*, *Siphonaria diamenensis* and *Cominella lineolata* are typically selected, depending on the location. Individuals are selected randomly by selecting five individuals (of each species) encountered within the 2 x 2 m sampling location. Measurements should occur first in quadrats. If necessary, at the end of the quadrat sampling additional size measurements are taken from all individuals within aggregations nearest to the observer, but within the sampling location.

8.2.3 Census Method B – Macroalgae and Sessile Invertebrates

The percent cover of all plant species and highly abundant aggregating sessile invertebrates (*e.g.* Galeolaria caespitosa) is determined using the points-cover method, following Method 3 of the subtidal monitoring SOP.

1. The quadrat is divided into a grid of 7 x 7 perpendicular wires, giving 50 points (including the nearest right-hand corner). The number of quadrat points covering each species is counted.

2. Points-cover counts are recorded for each lowest identifiable taxon, which is to species level for most organisms. However, functional categories are used for unknown or unidentifiable species, including other thallose reds, other erect corallines, encrusting corallines, filamentous reds, other small browns.

3. Field guides are used to confirm species identification in situ, reducing the need for disturbance or collections of biota.

4. Specimens of particular interest are collected for more detailed examination in the laboratory.

8.2.4 Photoquadrats

Photoquadrats are taken for as many of the sampling quadrats as is practical given time and weather constraints.

1. The camera or video is mounted vertically on a tripod at a height that encompasses the 50 x 50 cm sampling area.

2. The camera is positioned over the same area to be sampled quantitatively, incorporating the quadrat position marker label wherever possible.

3. A digital still image or photograph is taken.

8.2.5 Data Recording

A standard form (Table 12.2) printed on waterproof paper is used for recording data. The field sheet form includes columns for transect and sampling location number, species name, species code, abundance counts and size measurements. The form also prompts for site conditions such as site name, date, observers, cloud cover, sea conditions and tide conditions. Quality control items include signature spaces for data coding, entry and checking.

The field data sheet ensures each observer records data in the same manner and in a form compatible with the data entry spreadsheet. Standardisation of the data recording also aids the detection of any errors and makes data entry efficient. An example of the recording format is given in Figure 7.2. The methods for data recording follow.

1. The first six rows of the data sheet are used to record transect number, sampling location, quadrat position coordinates (x, y), habitat class code and observer code.

2. Each species occupies a separate row on the data sheet – Method A abundances are recorded in the upper half of the sheet and Method B abundances are recorded on the lower half of the sheet.

3. Species names are written in the far-left column and, to save time, often abbreviated to the first three or four letters of the genus and species. For example ‘Hor ban’ for *Hormosira banksii*.

4. Abundance data (counts of individuals or points-cover) are written to the right of each species name in the appropriate quadrat column.

5. Species for which presence-absence data is to be obtained (Ulva rigida, Cladophora subsimplex, Capreolia implexia, Ceramium flaccidum, Corallina officinalis, Hormosira banksii, Boccardia proboscidea), a plus, "+' sign is written if these species are present but not encountered beneath one of the 50 points.

6. Size measurements are recorded at the bottom of the sheet below abundance and points-cover data. Two clearly separated size measurements are recorded in each cell. Two rows are used for each species measured (up to five species per site).

Alternatively, data may be entered directly into an excel spreadsheet on a Pocket PC. The Excel spreadsheet should be formatted exactly as Table 12.2.

Site: 4107 Pt Cook Date: 15/1/03 Observer: Depth: Vis:
Coded:

Cloud: 4 Windir: NE Winsp: 15 kn seaht: 1 swht: 1 Surge:
Curr: Entered:

Time In: MaxD: BTime: TLow: 1103, 0.2 THigh: 1815, 1.5
Checked:

Taxon	Code	2.5 100 90	5 80 70	7.5 60 50	10 40 30	12.5 20 10	15 10 20	20 30 40	25 50 60	30 70 80	35 90 100	37.5	40	50
Transect		1	1	1	1	1	2	2	2	2	2	3	3	
Sampling loc		1	2	3	4	5	1	2	3	4	5	1	2	
x		-0.2	0.8	0.5	-0.3	0.4	0	0.9	-0.7	-0.8	0.2	0.7	0.1	
y		0.7	0.6	-0.5	-0.5	0.8	0.3	-0.2	0.3	0.6	-0.1	0.5	-0.6	
Substr		h	h	hv	hv	v	hr	vs	h	h	hv	hvr	v	
Observ.		38	38	38	38	38	22	22	22	22	22	22	22	
Method A														
Cell tramo		24	14	10	5	0	5	15	10	5	7	3	1	
Ner atr			4	7			6	4						

Tur und			5	8			3	2						
Aus constricta		4	25	20	6	7	17	32	5	4	5	6	2	
Siph diem		48	53	28	32	45	32	58	27	19	18	3	30	
Actin tene									3					
Pat calc									5					
Method B														
Hor ban		23			24	45			22	23	34	21	45	
Ulva spp			8	5			12	17						
Enc corr		2	4	5			4	5						
Cor offic			4	2			1	3						
Galeol caesp			20	10			5	6						
Sizes														
Cell tra (mm)		32 42	33 27	24 34	32 28	28 26	33 39	49 37	39 22	27 36	23 33	24 34	23 33	27 36
		28 26	32 42	27 29	32 28	27 36	27 36	27 29	24 34	32 26				
Siph die (mm)		16 23	18 19	22 14	28 25	22 22	19 18	16 23	18 19	22 14	28 25	22 22	19 16	18 18
		32 42	33 27	24 34	32 28	28 26	33 39	49 37	39 22	27 36	27 36	27 29	24 34	32 26
Aus cons (mm)		16 23	18 19	22 14	28 25	22 22	19 18	16 23	18 19	22 14	28 25	22 22	19 16	18 18
		32 42	33 27	24 34	32 28	28 26	33 39	49 37	39 22	27 36	27 36	27 29	24 34	32 26

March 2003Other fish size categories: 62.5, 75, 87.5, 100+

Figure 8.1. Example format of data recorded during intertidal surveys (fictional data). Species names are abbreviated to the first three or four letters of the genus and species. Size measurements for common gastropod species are written at the bottom of the datasheet, below the count data collected using Method A and Method B. Data from different methods are ruled off or separated by blank lines where possible. The blank form can be seen in Table 12.2.

8.3 Post Survey Procedures

1. Specimens are placed in labelled bags for later curation.

2. Field sheets are sighted by the project manager to check for discrepancies and anomalies (such as species outside the normal range), with errors corrected and/or annotations added if necessary.

3. All sheets are collected and placed in a secure, designated stowage container.

4. New field sheets (kept in the stowage container) are placed on the slates, pencils are sharpened if necessary.

8.4 End of Field Day Procedures

1. Field equipment is cleaned and organised for the following day.

2. Field sheets are washed and dried.

3. Collected specimens are curated.

4. Field sheets are checked and additional identifications are made using reference texts where necessary (from descriptions on field sheet or collected specimens).

5. Field sheets are coded with red ink.

6. Digital stills (photoquadrats) are downloaded onto the computer and saved in the appropriate file according to site and location.

7. Data entry into spreadsheet is commenced/continued.

8. Weather forecasts are checked.

9.0 SPECIMEN CURATION

9.1 Introduction

Selected floral and faunal specimens are collected for identification and preservation in a reference collection. Permits are required for any scientific collection in marine national parks and marine sanctuaries in Victoria. Macroalgal specimens should be pressed, with additional representative samples dried using silica-gel where possible. Animals should be either frozen or fixed in formalin and then preserved in alcohol.

9.2 Drying – Herbarium Pressings

Reference specimens of seaweeds and other marine macrophytes are generally preserved by drying through sheet pressings.

1. Rinse specimens in freshwater to prevent salt attracting moisture to dried specimens.

2. Select a mounting sheet of size appropriate for the specimen (A4 or A3, 250 or 300 gsm white tablex card) and label with date, site and collector details, as well as species name if known.

3. Place specimen in the centre of the card and arrange into a natural position – trimming parts where necessary to provide an appropriate two-dimensional view, and adequately presenting morphological features of taxonomic or ecological importance.

4. Arrangement may be easier underwater in a specimen tray, but has the disadvantages of thoroughly soaking the card, thereby increasing drying time.

5. Where possible, the card is kept as dry as possible, with water from a squirt bottle used to arrange the specimen and wash sand and other particulate matter from the sheet.

6. Place a sheet of muslin over the specimen, followed by several sheets of folded newspaper.

7. The specimen cards with inter-leafed newspaper and muslin are stacked together, with stiff cardboard placed in between groups of samples to keep the cards as flat as possible.

8. Moderate weight (several kilograms) is placed on top of the stack, which is stored in a warm dark place (where possible).

9. The newspaper (but not the muslin) is changed 1-2 times a day for the first week, every second day for the second week (or more frequently for wetter specimens), and every 2-4 days thereafter until the specimens are dry.

10. For dry specimens, the muslin is carefully removed, ensuring brittle specimens are not broken.

11. The muslin is soaked in bleach or other agent (such as Nappy-San) to remove fungi, rinsed and dried for further use.

12. Where the specimen is not stuck to the sheet, the specimen is re-glued (using clear PVA glue) onto a new, clean sheet, taking care to copy all details from the old sheet onto the new sheet.

13. For specimens stuck naturally to the sheet, parts which are not stuck are glued down using clear PVA glue.

14. Each specimen is identified, where possible, and given a catalogue number, with all relevant information pencilled on the sheet.

15. Information from the sheets are entered into the catalogue spreadsheet.

16. Specimens are submitted to appropriate taxonomic experts for identification.

17. Amended taxonomic and additional information is entered into the catalogue and labels are affixed to each specimen.

18. Monitoring/survey databases are amended according to information from the collections.

19. Specimens are stored in a cool, dark, dry place, free of insects.

9.3 Drying – Silica Gel

Macrophyte specimens are currently being preserved by rapid drying using silica gel, particularly where the specimens are for genetic analysis.

1. Prepare drying containers with silica gel drying beads (c.a. 10 g for small bags/tubes, 30-50 g for large bags).

2. Place whole specimen in bag if small. For genetics samples of larger seaweeds cut a 2-3 cm2 tissue fragment from a healthy portion of the plant (note: do not sample from sporophylls for Undaria).

3. Place label in bag/tube (Form 51) and seal tightly.

4. Check drying process is adequate, if not change the drying beads.

5. Record specimens in the appropriate catalogue.

9.4 Genetics Specimens

Animal specimens collected for genetic analysis generally involve preservation of small amounts of selected tissues in ethanol.

1. Prepare sample tubes, *e.g.* Eppendorf tubes, with 70-95% ethanol.
2. Prepare labels to fit sample tubes.
3. Remove selected tissue from organism and place in tube. For echinoderms, this may some tube feet, a piece of the test or the tip of an arm.
4. Write details on label and place in tube.
5. Record specimens in the appropriate catalogue.

9.5 Wet Specimens

Wet specimens may be fixed and preserved as wet specimens. This procedure may be required for a range of reasons, but should be avoided wherever possible because of safety hazards associated with the chemicals involved. Drying and freezing methods should be considered first.

1. Review appropriate fixative and preservation chemicals for the specimen (some structures are affected by particular chemicals.
2. Review health and safety policies and procedures associated with selected chemicals, including Material Safety Data Sheets, PPE and storage.
3. Prepare appropriate fixative and preservative mixtures, containers and labels.
4. Fix specimens according to the fixative protocols, *e.g.* 5% buffered formalin/seawater for a period appropriate to the specimen size.
5. Include label with specimen.
6. Record specimen in appropriate catalogue.
7. Preserve specimens in preservative fluids, *e.g.* 70% ethanol, keeping the original label in the specimen container.
8. Monitor fluid levels in containers and top up when necessary.

9.6 Freezing (-20 °C)

1. Place specimen in sealable container or bag to prevent drying.

2. Place label in bag.

3. Record specimen in appropriate catalogue.

4. Seal bag and stack specimens carefully so they will not lock together when frozen, or be unduly distorted (*e.g.* so bags not crumpled).

5. Monitor specimens for external icing and loosen specimens at regular intervals – note gloves must be worn when handling frozen specimens.

10.0 TRAINING AND CALIBRATION

10.1 Census Training

Training in the standard operational procedures involves an initial training period of laboratory and field exercises, followed by a period of on-going learning and calibration while doing actual surveys.

10.1.1 Syllabus for Novice Observers

1. Ensure the trainee has fulfilled all qualification, experience and registration requirements (Section 4).

2. Familiarise trainee with commonly encountered species and their distinguishing features, using reference texts, photographic collections, specimen collections and diving excursions.

3. Assist and promote self-study and revision of species.

4. Describe methods in laboratory by Principal Scientist and experienced intertidal observers using reference texts, whiteboard diagrams and land simulations.

5. In field situations new observers initially work as a Lookout and scribe. An experienced observer familiarises the new observer with intertidal species and procedures for counting, measuring, and determining cover.

6. New observers survey quadrats and the experienced observer (as Lookout and scribe) supervises species identification, measuring and counting of species. Experienced observers correct non-conformance to the standard operational procedures where necessary.

7. Macroalgal surveys (Method B) require familiarity with a larger number of species and diagnostic features. This method is generally more demanding of observer-concentration as well as being more time consuming. Reference texts and materials should be studied to become familiar with diagnostic features, in addition to tutoring from trained and experienced observers.

8. Data collected by novice observers are closely scrutinised for mistakes or anomalies.

9. Training, demonstration and close supervision of novices also occurs during data entry, checking and management tasks.

10.2 On-Going Calibration

On-going training and calibration of field observers occurs through discussion and comparison of data during and at the end of every field day and at the end of every survey. Training and standardisation also occurs through regular revision of species identification texts, specimen collections and the standard operational procedures.

11.0 REFERENCES AND IDENTIFICATION GUIDES

11.1 References

Downes B. J., Barmuta L. A., Fairweather P. G., Faith D. P., Keough M. J., Lake S. P., Mapstone B. D., Quinn G. P. (2002) *Monitoring Ecological Impacts: Concepts and Practice in Flowing Water*s. Cambridge University Press.

Parks Victoria (2003) *Victoria's System of Marine National Parks and Marine Sanctuaries: Management Strategy 2003-2010*. Parks Victoria, Melbourne.

11.2 Identification Guides

Edgar G. J. (1997) Australian Marine Life. The Plants and Animals of Temperate Waters. Reed Books, Melbourne.

Fuhrer B., Christianson I. G., Clayton M. N. and Allender B. M. (1981) Seaweeds of Australia. Reed Books, Sydney.

Huisman J. M. (2000) Marine Plants of Australia. University of Western Australia Press, Nedlands, Western Australia.

Shepherd S. A. and Thomas I. M. (eds) (1982) Marine Invertebrates of Southern Australia. Part I. Handbooks of the Flora and Fauna of South Australia. South Australian Government Printer, Adelaide.

Shepherd S. A. and Thomas I. M. (eds) (1989) Marine Invertebrates of Southern Australia. Part II. Handbooks of the Flora and Fauna of South Australia. South Australian Government Printer, Adelaide.

Womersley H. B. S. (1984) The Marine Benthic Flora of Southern Australia. Part I. Handbooks of the Flora and Fauna of South Australia. South Australian Government Printer, Adelaide.

Womersley H. B. S. (1987) The Marine Benthic Flora of Southern Australia. Part II. Handbooks of the Flora and Fauna of South Australia. South Australian Government Printer, Adelaide.

Womersley H. B. S. (1994) The Marine Benthic Flora of Southern Australia. Part IIIA.

Flora of Australia Supplementary Series Number 1. Australian Biological Resources Study, Canberra.

Womersley H. B. S. (1996) The Marine Benthic Flora of Southern Australia. Part IIIB. Flora of Australia Supplementary Series Number 5. Australian Biological Resources Study, Canberra.

12.0 FORMS AND TABLES

Table 12.1 Table of random numbers that may be used as x- and y- coordinates for quadrat positioning. Observers should not use the same coordinates for different surveys.

1	*0.3*	*-0.8*	*0*	*0.2*	*0.1*	*0.3*	*-0.8*	*0*	*-0.3*
-0.3	*0.7*	*1*	*-0.3*	*0*	*-0.7*	*0.5*	*-0.9*	*-0.3*	*0.3*
0.3	*0.7*	*0.2*	*1*	*0.5*	*0*	*0.8*	*-0.8*	*0.7*	*-0.1*
0.6	*-0.3*	*1*	*-0.7*	*-0.6*	*-0.2*	*-0.2*	*0.9*	*-0.4*	*-0.8*
-0.9	*0.6*	*0.9*	*-0.8*	*-0.7*	*-0.5*	*-0.3*	*0.6*	*-0.4*	*-0.2*
-0.6	*0.5*	*0.6*	*-0.4*	*0.6*	*-0.3*	*-1*	*-0.5*	*-0.9*	*0.1*
0.4	*-0.7*	*-0.9*	*-0.7*	*0.5*	*0.2*	*1*	*0.5*	*0.2*	*-0.3*
0.9	*0.4*	*-0.4*	*-0.7*	*0.2*	*0.3*	*-0.6*	*0.7*	*0.2*	*0.1*
0.8	*-0.2*	*-0.6*	*-0.9*	*0.4*	*0.3*	*0.2*	*-0.9*	*-0.3*	*0.7*
-0.7	*-0.8*	*0.6*	*0.5*	*-0.2*	*0.1*	*-0.8*	*-0.3*	*-0.2*	*-0.4*
0.5	*0.4*	*-0.9*	*0.3*	*0.6*	*-0.4*	*-0.1*	*-1*	*-0.8*	*-0.4*
-0.9	*-0.4*	*0.1*	*1*	*-0.1*	*0*	*0.5*	*0.2*	*0.4*	*0.8*
-0.3	*0.1*	*0.5*	*-0.3*	*0*	*-0.9*	*0.4*	*0.9*	*0.2*	*-0.3*
0.6	*-0.8*	*-0.1*	*-0.9*	*0.1*	*0.6*	*-0.5*	*0.7*	*-0.5*	*-0.4*
0.9	*-0.1*	*0*	*-0.3*	*0.1*	*-0.5*	*-0.9*	*0.8*	*-0.7*	*-0.1*
0.3	*-0.9*	*-0.2*	*0.4*	*0.9*	*0.3*	*-0.8*	*0*	*0.1*	*0.9*
0.5	*0.4*	*0.6*	*-0.9*	*0.3*	*-0.2*	*-0.6*	*0.7*	*0*	*0.3*
0.6	*0.5*	*0.9*	*0.3*	*0.7*	*0.1*	*-0.9*	*0.1*	*0.5*	*-0.4*
0.7	*-0.3*	*0.5*	*-0.1*	*-1*	*0.2*	*-0.2*	*0.2*	*0*	*-0.8*
0.9	*0.6*	*0.5*	*0.6*	*0.9*	*0.6*	*0.9*	*0*	*0.8*	*0*
-0.2	*0.3*	*0.5*	*-0.2*	*-0.6*	*-0.9*	*0.3*	*-0.5*	*0.2*	*-0.6*
-0.6	*-0.3*	*-0.8*	*0*	*-0.3*	*-0.8*	*-0.8*	*0.7*	*-0.1*	*0.9*
0.1	*-0.5*	*0.9*	*-0.1*	*-0.7*	*0.1*	*0.8*	*-0.4*	*-0.5*	*0.6*
0.7	*-1*	*0.6*	*-0.2*	*0.8*	*0*	*-0.1*	*0.4*	*0.4*	*-0.5*
0.8	*0.9*	*-0.7*	*-0.2*	*0.3*	*0.4*	*-1*	*0.8*	*0.2*	*0.6*
0.7	*-0.6*	*-0.2*	*-0.3*	*0.2*	*0.8*	*0*	*-0.5*	*0.5*	*-0.8*
-0.2	*0.5*	*0.7*	*-0.1*	*-0.7*	*0.4*	*0*	*0.3*	*-0.3*	*-0.1*
0.3	*0.6*	*-0.6*	*0.5*	*0.4*	*0*	*0.9*	*-0.3*	*-0.3*	*0.9*
0.8	*1*	*0.2*	*0.7*	*-0.3*	*-0.3*	*0.2*	*-0.7*	*-0.3*	*0*
0.9	*0.5*	*0.7*	*-0.1*	*0.1*	*-0.9*	*-0.7*	*-0.2*	*-0.2*	*-0.6*
0.6	*-0.6*	*-0.2*	*-0.2*	*0.7*	*0*	*-0.8*	*0.2*	*-0.5*	*0.3*
0.4	*-0.9*	*-0.1*	*0.4*	*0.4*	*-0.8*	*-0.4*	*-0.9*	*1*	*0.6*
0.5	*0.4*	*-0.2*	*0.3*	*0.3*	*-1*	*-0.3*	*0.5*	*0.3*	*0.4*
0.6	*0.3*	*0.2*	*0.6*	*-0.1*	*0.2*	*0.7*	*0.9*	*-0.4*	*-0.5*
-1	*0.3*	*0.4*	*-1*	*0*	*0.1*	*0.3*	*0.4*	*0.5*	*-0.1*
-0.5	*-0.2*	*0.1*	*-0.2*	*-0.3*	*0.2*	*0.6*	*-0.1*	*-0.5*	*0.8*
0.2	*-0.3*	*-0.9*	*-0.3*	*0.2*	*0.3*	*-0.5*	*-0.6*	*0.7*	*0.4*
0.9	*-0.5*	*-0.8*	*0.6*	*1*	*-0.8*	*0.2*	*-0.5*	*0*	*-0.4*
-0.9	*-0.6*	*0.9*	*-0.2*	*0.5*	*0*	*-0.1*	*0.1*	*0.6*	*0.7*
0.6	*0.4*	*0.7*	*-0.7*	*-0.6*	*-0.7*	*-0.3*	*0.1*	*0.7*	*-0.6*
0.7	*-0.4*	*-0.7*	*0.3*	*0.4*	*-0.6*	*0.7*	*-1*	*0*	*-0.9*
0.4	*0.6*	*0.9*	*-0.4*	*-0.4*	*0.9*	*0.9*	*0.4*	*-0.2*	*0.9*
0.5	*-0.4*	*0.6*	*0.9*	*0*	*-0.6*	*0.4*	*-0.3*	*0.4*	*-0.7*
0.9	*-0.9*	*0.1*	*-0.7*	*0.4*	*0.7*	*-0.7*	*-1*	*0.6*	*0.8*
0.9	*-0.3*	*-0.2*	*-0.2*	*0.8*	*0.3*	*-0.7*	*-0.2*	*-0.7*	*-0.7*
-0.6	*-0.8*	*0.9*	*-0.2*	*-0.6*	*-0.3*	*0.9*	*-0.3*	*0.5*	*-0.1*
0	*0.2*	*0.1*	*-0.1*	*-0.6*	*0.3*	*-0.1*	*0.6*	*-0.5*	*0.7*
0.5	*-0.8*	*-0.2*	*0.4*	*-0.2*	*0.7*	*-0.9*	*-0.8*	*0.6*	*0.6*
-0.4	*0.5*	*0.2*	*0.9*	*-0.5*	*0.5*	*0.4*	*0.6*	*0.5*	*0.3*
0.6	*-0.7*	*-0.1*	*-0.4*	*-0.8*	*-0.4*	*-0.6*	*0.9*	*0.5*	*0.2*

Table 12.2 Example of intertidal data sheet

Site: Date: Observer: Depth: Vis:
Coded:

Cloud: Windir: Winsp: seaht: swht:
Surge: Curr: Entered:

Time In: MaxD: BTime: TLow: THigh:
Checked:

Taxon	Code	2.5 100 90	5 80 70	7.5 60 50	10 40 30	12.5 20 10	15 10 20	20 30 40	25 50 60	30 70 80	35 90 100	37.5	40	50

Date: Other fish size categories: 62.5, 75, 87.5, 100+

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