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Parks Victoria Standard Operating Procedure

Biological Monitoring of Subtidal Reefs

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Parks Victoria Standard Operating Procedure:

Biological Monitoring of Subtidal Reefs

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Australian Marine Ecology Pty Ltd

November 2003

Executive Summary

Shallow reef habitats cover extensive areas along the Victorian coast and are dominated by seaweeds, mobile invertebrates and fishes. These reefs are known for their high biological complexity, species diversity and productivity. They also have significant economic value through commercial and recreational fishing, diving and other tourism activities. In order to effectively manage and conserve these important and biologically rich habitats, the Victorian Government has established a long-term Subtidal Reef Monitoring Program (SRMP). Over time the SRMP will provide information on the status of Victorian reef flora and fauna and determine the nature and magnitude of trends in species populations and species diversity through time.

This report provides the Standard Operating Procedure for the Subtidal Reef Monitoring Project. Specific objectives of the standard operating proceedure are to:

- provide consistent methods to be 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;
- provide a documented description of the methods for training new observers;
- ensure safe and healthy working conditions;
- enable scrutiny and transparency of methods to ensure integrity, reliability and acceptance by scientists and managers; and
- assist integration of standardised methods across the marine environment in Victoria and be consistent with other large-scale and long-term ecological monitoring programs (such as the long-term marine reserve monitoring program in Tasmania undertaken by the Tasmanian Aquaculture and Fisheries Institute).

The Victorian Standard Operating Procedure was originally developed by Australian Marine Ecology, from methods published by Edgar and Barrett (1997), for use in Victorian conditions. In 2001, a scientific workshop reviewed the method and concluded that it was scientifically sound, however it was recommended that cost efficiency could be improved by monitoring sites once a year (rather than twice) without significantly compromising the quality of data and its interpretation.

The Victorian Standard Operating Procedure involves 5 standard methods for surveying fishes (including cryptic fish), benthic invertebrates and macroalgae. There are specific methods for targeting reef fishes, kelp and specific invertebrate species.

The Victorian Government is making this method openly and freely available to encourage its broad use across subtidal reef habitat in Victoria.

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1.0 Introduction

1.1 BACKGROUND

Edgar and Barrett (1997) published standardised underwater visual census methods for monitoring biotic change in Tasmanian marine reserves. Three different census methods were implemented to estimate: the abundance and size structure of large mobile fish (Method 1); the abundance of cryptic fishes and benthic invertebrates, as well as size structure of selected invertebrates (Method 2); and the percentage cover of macrophytes (Method 3) (a full description of these methods is given in Section 2). These methods were based on widely used underwater visual census techniques (*e.g.* Russell 1977; Branden *et al.* 1986; McCormick and Choat 1987; Cole *et al.* 1990).

The Edgar-Barrett census methods were first implemented for the long-term monitoring of four marine reserves in southeastern Tasmania. Twenty-four sites, located inside and outside protected areas, have been surveyed at least once a year since March 1992. The monitoring proved to be valuable in determining the effects of the declaration of marine reserves on reef fishes, invertebrates and plants (Edgar and Barrett 1999). The same methods were used to quantitatively survey reef biota at 156 sites around the Tasmanian and Bass Strait island coasts, providing systematically collected data for the delineation of bioregions (Edgar *et al.* 1997). This study also proved to be useful for identifying associations between marine plants and animals, including species of commercial importance, as well as monitoring the changes in the distributions of introduced species (such as the kelp *Undaria pinnatifida*) and to detect their impact on native species. The systematic use of the Edgar-Barrett methods also proved useful for assessing the effects of an oil spill resulting from the grounding of the *Iron Barron* in northern Tasmania (Edgar 1998).

The visual census methods of Edgar-Barrett are now widely used for reef surveys in southern Australia. This is largely because they are non-destructive and provide quantitative data on a large number of species and the structure of the reef communities. These methods also make efficient use of underwater diving time, making them highly cost-effective. There are currently monitoring programs using this method in Victoria, New South Wales and Western Australia. In central Victoria, 63 monitoring sites were established by the former Department of Natural Resources and Environment between 1998 and 1999. This monitoring information has been used to describe the structure and distribution of reef assemblages, assess the ecological status of existing marine protected areas and provide baseline data for assessing impacts of introduced organisms and other environmental disturbances (Edmunds 2000; Edmunds, Roob and Blake 2000; Edmunds, Roob and Ferns 2000; Roob, Edmunds

and Ball 2000). The Edgar-Barrett methods have also been used by other organisations in Victoria for ecological comparisons of reef communities (*e.g.* Edmunds *et al.* 2001). The Victorian investigations have resulted in the establishment of two further census techniques: density of string kelp *Macrocystis* plants (Method 4); and densities of grazing invertebrates in sea urchin barrens associated with the urchin *Centrostephanus rodgersii* (Method 5).

1.2 STANDARDISATION OF TECHNIQUES

For integrity and reliability of results from any monitoring program, it is critical to maintain consistently high standards of data collection. This will ensure the data are comparable between different times and across locations. The standard operating procedures need to be rigorously enforced, particularly through implementation of quality control and quality assurance procedures. Deviation from these procedures, particularly the field operations, may result in a temporal/spatial discontinuity in the comparability of the data, as well as devalue its utility (real or perceived) for making management decisions.

Specific objectives of the standard operating proceedure are to:

- provide a documented description of the methods for training new observers;
- provide consistent methods to be used by trained observers to ensure comparability of the 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 scrutiny and transparency of methods to ensure integrity, reliability and acceptance by scientists and managers; and
- assist integration of standardised methods and be consistent with other large-scale and long-term ecological monitoring programs (such as the long-term marine reserve monitoring program in Tasmania undertaken by the Tasmanian Aquaculture and Fisheries Institute).

1.3 SCOPE OF THIS STANDARD OPERATING PROCEDURE

Parks Victoria uses the Edgar-Barrett methods for assessing subtidal reef communities for a variety of investigations. To ensure quality and enable integration of datasets, this standard operating procedure was developed.

This document details the field procedures used to obtain the data, the post-field procedures used to manage the data, and the scientific observer training required as part of the Victorian Subtidal Reef Monitoring Program. The operating procedures described here are designed to minimise biases and error associated with underwater visual census techniques, as well as comply with quality and occupational health and safety policies.

This subtidal reef monitoring procedure integrates with standardised procedures for monitoring intertidal and deep reef, deep sediment, seagrass and shallow sediment habitats in Victoria and elsewhere in southern Australia.

2.0 Overview of the Methods

2.1 GENERAL DESCRIPTION

The Edgar-Barret methods (Edgar and Barrett 1997, 1999; Edgar *et al.* 1997) are generally used for the repeated census of a set of sites within locations (usually within 10 km of coastline). The position of each site is fixed, as with the position of transects surveyed within each site. Two hundred metre transects of four contiguous 50 m sections are surveyed at each site.

Where possible, sampling is along the 5 m (± 1 m) depth contour, to minimise spatial variability between sites. The depth of 5 m is considered optimal for monitoring because diving times are not limited by decompression schedules and these reefs are subjected to heavy fishing pressure from wrasse fishers, rock lobster fishers and divers. Sampling in Victoria at some sites has to be deeper or shallower, depending on the available habitat and exposure to wave action, with sites ranging between 3 and 7 m deep.

Each site is located using differential GPS and marked with a buoy, or the boat anchor. A 100 m long numbered and weighted transect line is run along the appropriate depth contour either side of the central marker. The resulting 200 m of line is divided into four contiguous 50 m sections (T1 to T4). The sections are orientated the same way for each survey, with T1 generally toward the north or east (*i.e.* anticlockwise along the open coast).

For each transect, four different census methods were used to obtain adequate descriptive information on reef communities at different spatial scales. These involved the census of: (1) the abundance and size structure of large fishes; (2) the abundance of cryptic fishes and benthic invertebrates; (3) the percent cover of macroalgae; and (4) the density of string-kelp *Macrocystis* plants. A fifth method was recently implemented to document the abundance of invertebrate grazers within sea urchin barrens present in eastern Victoria. This method is only used at a small number of sites. The depth, horizontal visibility, sea state and cloud cover are recorded for each site. Horizontal visibility is gauged by the distance along the transect line to detect a 100 mm long fish. All field observations are recorded on underwater paper. The following descriptions for Methods 1 to 3 are derived from Edgar and Barrett (1997).

2.2 METHOD 1 – MOBILE FISHES AND CEPHALOPODS

The densities of mobile large fishes and cephalopods are estimated by a diver swimming up one side of a 50 m section, and then back along the other. The diver records the number and estimated size-class of fish, within 5 m of each side of the line. The size-classes for fish are

25, 50, 75, 100, 125, 150, 200, 250, 300, 350, 375, 400, 500, 625, 750, 875 and 1000+ mm. Each diver has size-marks on their underwater slate to enable calibration of their size estimates. The data for easily sexed species is recorded separately for males and female/juveniles. Such species include the blue-throated wrasse *Notolabrus tetricus*, herring cale *Odax cyanomelas*, barber perch *Caesioperca rasor*, rosy wrasse *Pseudolabrus psittaculus* and some monacanthids. A total of four 10 x 50 m sections are censused for mobile fish at each site.

2.3 METHOD 2 – INVERTEBRATES AND CRYPTIC FISHES

Cryptic fishes and megafaunal invertebrates (non-sessile: *e.g.,* large molluscs, echinoderms, crustaceans) are counted along the transect lines used for the fish survey. A diver counts animals within 1 m of one side of the line (a total of four 1 x 50 m sections). A pole carried by the diver is used to standardise the 1 m distance. The maximum length of abalone and the carapace length and sex of rock lobsters are measured *in situ* using vernier calipers whenever possible. Selected specimens are collected for identification and preservation in a reference collection.

2.4 METHOD 3 – MACROALGAE

The area covered by macroalgal species is quantified by placing a 0.25 m^2 quadrat at 10 m intervals along the transect line and determining the percent cover of all plant species. The quadrat is divided into a grid of 7 x 7 perpendicular wires, giving 50 points (including one corner). Cover is estimated by counting the number of times each species occurs directly under the 50 positions on the quadrat (1.25 m^2 for each of the 50 m sections of transect line). Selected specimens are collected for identification and preservation in a reference collection.

2.5 METHOD 4 – *MACROCYSTIS*

In addition to macroalgal cover, the density of *Macrocystis angustifolia* plants is estimated. While swimming along the 200 m transect line, a diver counts all observable plants within 5 m either side of the line, for each 10 m section of the transect (giving counts for 100 m^2 sections of the transect). This survey component commenced during spring 1999.

2.6 METHOD 5 – QUADRAT INVERTEBRATES

For selected sites, the density of grazing invertebrates and other animals is determined within the 0.5 x 0.5 m quadrats. This method is generally only implemented in sea urchin barren habitats, dominated by *Centrostephanus rodgersii* and other grazers such as limpets.

2.7 SPECIES AND TAXONOMIC CATEGORIES MONITORED

All observed species pertinent to the census method are recorded, including rarely observed species that are not necessarily well documented by the above census methods. The most commonly encountered species in Victoria using the above methods are listed in Tables 2.1, 2.2 and 2.3. For Method 1, this includes all freely swimming fish that can be sighted while swimming along the census lane, including those swimming in the water column, above the kelp canopy, within and beneath the canopy and within crevices and caves. Fish species that are unknown to the observer are described on the field sheet and later identified using field guides and discussions with taxonomic experts. The sighting can be identified in most cases to species level. Where the sighting opportunity did not enable positive identification, the observation is placed in an 'Unidentified Fish' category.

For Method 2, the diver moves along the bottom searching all habitats in the transect lane, pushing aside the kelp canopy, and counts all species found on or within the macrophytes, on the tops of rock surfaces and within cracks and crevices. Invertebrate species that are unknown to the observer are collected and identified on the boat using field guides. Cryptic fish that are unknown are described on the sheet and later identified, as with the mobile fish census. Identifications are to species level in most cases for this census method. Non-species categories include 'Unidentified Hermit Crab' and *Amblypneustes* spp.

For Method 3, all plants positioned under the quadrat points are documented. However, many species cannot be readily identified underwater, or at certain times of the year when there are no reproductive structures present. In addition, some sites and times have an exceptional number, but low abundance, of small thallose red algal species. Considerable training and experience is required to document all of these species during the survey of a site. Where possible, unidentified species are documented and collected for later identification. Otherwise, a wide range of higher-taxonomic order pooling categories are used. These include *Ulva* spp, *Codium* spp, filamentous green algae, *Sargassum* spp, brown algal turf, unidentified brown algae, unidentified structural coralline algae, encrusting corallines, filamentous red algae and thallose fleshy algae.

Table 2.1. Species commonly encountered during the fish census (Method 1).

Fish Species	Fish Species	Fish Species
Heterodontus portusjacksoni	*Enoplosus armatus*	*Siphonognathus beddomei*
Parascyllium variolatum	*Pentaceropsis recurvirostris*	*Neoodax balteatus*
Cephaloscyllium laticeps	*Parma victoriae*	*Haletta semifasciata*
Dasyatis brevicaudata	*Parma microlepis*	*Seriolella brama*
Myliobatis australis	*Chromis hypsilepis*	*Thyristes atun*

Fish Species	Fish Species	Fish Species
Urolophus paucimaculatus	*Aplodactylus arctidens*	*Acanthaluteres spilomelanurus*
Genypterus tigerinus	*Crinodus lophodon*	*Acanthaluteres vittiger*
Hippocampus abdominalis	*Cheilodactylus fuscus*	*Brachaluteres jacksonianus*
Phyllopteryx taeniolatus	*Cheilodactylus nigripes*	*Thamnaconus degeni*
Caesioperca lepidoptera	*Cheilodactylus spectabilis*	*Monacanthus chinensis*
Caesioperca rasor	*Nemadactylus macropterus*	*Scobinichthys granulatus*
Paraplesiops meleagris	*Nemadactylus douglasi*	*Meuschenia australis*
Trachinops caudimaculatus	*Nemadactylus valenciennesi*	*Meuschenia flavolineata*
Trachinops taeniatus	*Dactylophora nigricans*	*Meuschenia freycineti*
Dinolestes lewini	*Latridopsis forsteri*	*Meuschenia galii*
Sillaginodes punctata	*Sphyraena novaehollandiae*	*Meuschenia hippocrepis*
Trachurus declivis	*Achoerodus viridis*	*Meuschenia venusta*
Arripis spp.	*Coris sandageri*	*Meuschenia scaber*
Parequula melbournensis	*Ophthalmolepis lineolata*	*Nelusetta ayraudi*
Chrysophrys auratus	*Dotalabrus aurantiacus*	*Eubalichthys bucephalus*
Upeneichthys lineatus	*Notolabrus gymnogenis*	*Eubalichthys gunnii*
Upeneichthys vlaminghii	*Notolabrus tetricus*	*Eubalichthys mosaicus*
Pempheris multiradiata	*Notolabrus fucicola*	*Aracana aurita*
Kyphosus sydneyanus	*Pseudolabrus psittaculus*	*Aracana ornata*
Girella tricuspidata	*Pictilabrus laticlavius*	*Contusus richei*
Girella elevata	*Suezichthys aylingi*	*Tetractenos glaber*
Girella zebra	*Odax acroptilus*	*Diodon nichthemerus*
Scorpis aequipinnis	*Odax cyanomelas*	**Non-Fish Species**
Scorpis lineolata	*Siphonognathus attenuatus*	*Arctocephalus pusillus*
Atypichthys strigatus	*Siphonognathus radiatus*	*Sepioteuthis australis*
Tilodon sexfasciatus	*Siphonognathus tanyourus*	*Sepia apama*

Table 2.2. Species commonly encountered during the invertebrate and cryptic fish census (Method 2).

Invertebrates	Invertebrates	Invertebrates
Jasus edwardsii	*Conus anemone*	*Uniophora granifera*
Jasus verreauxi	*Mitra glabra*	*Goniocidaris tubaria*
Paguristes frontalis	*Cymbiola magnifica*	*Centrostephanus rodgersii*
Trizopagurus strigimanus	*Ceratosoma brevicaudatum*	*Amblypneustes spp.*
Nectocarcinus tuberculatus	*Hypselodoris bennetti*	*Holopneustes porossimus*
Plagusia chabrus	*Mytilus edulis*	*Holopneustes inflatus*
Petrocheles australiensis	*Equichlamys bifrons*	*Holopneustes pycnotilus*
Haliotis rubra	*Chlamys asperimus*	*Heliocidaris erythrogramma*

Invertebrates	Invertebrates	Invertebrates
Haliotis laevigata	*Ostrea angasi*	*Stichopus mollis*
Haliotis scalaris	*Octopus maorum*	**Cryptic Fishes**
Scutus antipodes	*Sepia apama*	*Parascyllium variolatum*
Phasianotrochus eximius	*Cenolia trichoptera*	*Scorpaena papillosa*
Phasianella australis	*Cenolia tasmaniae*	*Glyptauchen panduratus*
Phasianella ventricosa	*Tosia australis*	*Gnathanacanthus goetzii*
Turbo undulatus	*Tosia magnifica*	*Vincentia conspersa*
Astralium tentoriformis	*Pentagonaster dubeni*	*Pempheris multiradiata*
Cypraea angustata	*Nectria ocellata*	*Parma victoriae (juv)*
Charonia lampas rubicunda	*Nectria macrobranchia*	*Parma microlepis (juv)*
Cabestana spengleri	*Nectria multispina*	*Bovichtus angustifrons*
Cymatium parthenopeum	*Nectria wilsoni*	*Parablennius tasmanianus*
Argobuccinium vexillum	*Petricia vernicina*	*Norfolkia clarkei*
Ranella australasia	*Fromia polypora*	*Forsterygion varium*
Sassia subdistorta	*Plectaster decanus*	*Heteroclinus johnstoni*
Dicathais orbita	*Echinaster arcystatus*	*Nesogobius sp.*
Agnewia tritoniformis	*Nepanthia troughtoni*	*Brachaluteres jacksonianus*
Pleuroploca australasia	*Patiriella brevispina*	*Diodon nichthemerus*
Penion mandarinus	*Coscinasterias muricata*	

Table 2.3. Species commonly encountered in Victoria during the macroalgal census (Method 3).

Macroalgae	Macroalgae	Macroalgae
Ulva spp	*Caulocystis cephalornithos*	*Plocamium angustum*
Chaetomorpha sp	*Acrocarpia paniculata*	*Plocamium costatum*
Abjohnia laetevirens	*Cystophora platylobium*	*Plocamium dilatatum*
Cladophora prolifera	*Cystophora moniliformis*	*Plocamium potagiatum*
Codium duthieae	*Cystophora grevillei*	*Plocamium mertensii*
Caulerpa remotifolia	*Cystophora pectinata*	*Plocamium pressianum*
Caulerpa scalpelliformis	*Cystophora monilifera*	*Plocamium cartilagineum*
Caulerpa longifolia	*Cystophora expansa*	*Plocamium leptophyllum*
Caulerpa trifaria	*Cystophora retorta*	*Phacelocarpus alatus*
Caulerpa brownii	*Cystophora siliquosa*	*Phacelocarpus complanatus*
Caulerpa obscura	*Cystophora retroflexa*	*Phacelocarpus peperocarpus*
Caulerpa flexilis	*Cystophora subfarcinata*	*Nizymenia australis*
Caulerpa flexilis var. muelleri	*Carpoglossum confluens*	*Hypnea ramentacea*
Caulerpa geminata	*Sargassum decipiens*	*Polyopes constrictus*
Caulerpa annulata	*Sargassum sonderi*	*Thamnoclonium dichotomum*

Macroalgae	Macroalgae	Macroalgae
Caulerpa cactoides	*Sargassum varians*	*Gracilaria secundata*
Caulerpa simplisciuscula	*Sargassum verruculosum*	*Curdiea angustata*
Halopteris spp	*Sargassum fallax*	*Melanthalia obtusata*
Cladostephus spongiosus	*Sargassum vestitum*	*Champia* sp.
Dictyota dichotoma	*Sargassum linearifolium*	*Botrocladia obovata*
Lobospira bicuspidata	*Sargassum spinuligerum*	*Gliosaccion brownii*
Padina sp.	*Gelidium asperum*	*Erythrymenia minuta*
Dictyopteris muelleri	*Gelidium australe*	*Rhodymenia australis*
Chlanidophora microphylla	*Pterocladia lucida*	*Rhodymenia* spp
Distromium spp	*Pterocladia capillacea*	*Ceramium* spp
Homeostrichus sinclairii	*Delisea pulchra*	*Griffithsia* sp
Zonaria angustata	*Ptilonia australasica*	*Ballia callitricha*
Zonaria spiralis	*Asparagopsis* spp.	*Ballia scoparia*
Zonaria turneriana	*Amphiroa anceps*	*Euptilota articulata*
Lobophora variegata	*Corallina officinalis*	*Hemineura frondosa*
Carpomitra costata	*Haliptalon roseum*	*Dasya* sp
Perithalia cordata	*Cheilosporum sagittatum*	*Dictymenia harveyana*
Bellotia eriophorum	*Metagoniolithon radiatum*	*Jeannerettia lobata*
Encyothalia cliftoni	*Sonderopelta coriacea*	*Jeannerettia pedicellata*
Colpomenia spp.	*Peyssonnelia* sp.	*Lenormandia marginata*
Macrocystis angustifolia	*Callophyllis rangiferinus*	*Lenormandia smithiae*
Ecklonia radiata	*Stenogramme interrupta*	*Laurencia filiformis*
Durvillaea potatorum	*Rhodoglossum* sp	*Echinothamnion hystrix*
Xiphophora chondrophylla	*Gigartina* sp.	**Seagrasses**
Phyllospora comosa	*Callophycus laxus*	*Halophila ovata*
Seirococcus axillaris	*Erythroclonium sonderi*	*Amphibolis antarctica*
Scaberia agardhii	*Areschougia congesta*	*Heterozostera tasmanica*

3.0 Planning and Pre-Field Operations

3.1 PERSONNEL

3.1.1 Introduction

The following information is a general guide to personnel and diving requirements.

3.1.2 Team Size

A minimum of three people are required for the collection of visual census data using this technique. Two people do the survey while a third person remains in the boat as surface support. In this case, one diver usually surfaces halfway through the survey and swaps with the boat-person. Each respective boat person fulfils all dive-supervisor, dive attendant and boat-attendant roles.

For many sites, particularly those prone to currents or at 10 m depth, a minimum team of four is required. Three divers do the survey at once with a dive supervisor/boat attendant on the surface. Each site takes up to 180 diver-minutes to survey – a survey with three divers provides a substantial safety margin in terms of residual nitrogen levels and exposure to marine environmental elements. For remote sites at 10 m depth (*e.g.* Wilsons Promontory) a minimum team of 6 is required: four divers, one diver's attendant and a boat handler.

At remote sites the DCIEM no-decompression times are also shortened, depending on the accessibility of a recompression chamber and medical assistance. Using four divers for these surveys means that residual nitrogen levels remain within the adjusted tables.

3.1.3 Scientific Diving Requirements

All scientific divers must be trained and accredited scientific divers, in accordance with the relevant Federal and State regulations and Parks Victoria policy. Divers must hold a current first aid certificate and current certificate in oxygen provision/oxygen therapy. What follows are some guidelines on other issues to consider.

Ideally divers should have (but is not mandatory): a coxswains certificate (limited or higher), a radio operators certificate of proficiency and a car drivers licence. Each diver must also be competent at handling the increased demands of underwater visual census and other scientific techniques over and above normal diving requirements. Personnel must be able to work under adverse conditions. Although every effort should be made to time surveys with good weather, changes often occur while diving, or tight schedules may require diving under marginal conditions.

Each diver must be deemed suitably fit to dive by a doctor trained in underwater medicine following a medical examination (in accordance with the relevant Federal and State regulations and Parks Victoria policy). The dive medical must be updated annually and it is the responsibility of the diver to ensure its currency.

Prior to any dive, the diver must advise the dive coordinator of any medical condition that may preclude them from diving. This includes: giving blood 48 hours prior to a dive; colds and influenza, sinus or middle ear blockages; feeling of malaise; and physical injuries. The final decision to dive rests with the diver, however a diver cannot enter the water without approval from the dive coordinator.

3.1.5 Training and Calibration

Underwater observers must be properly inducted and trained in the standard operating procedure. Once trained and capable, all observers collecting survey data must participate in on-going review and calibration exercises.

3.2 MOBILISATION AND FIELD CONDITIONS

Tasks to be completed prior to each field operation are:

1. Review and revise the dive plan;
2. Check, service and maintain diving, boating and navigation equipment;
3. Ensure the appropriate collection permits have been obtained and are readily accessible.;
4. Prepare underwater forms – photocopy forms onto underwater paper (*e.g.* Celcast Permanent Paper, PP4);
5. Ensure an adequate supply of expendables, including pencils, rubber bands, plastic calipers, string, electrical tape and GPS batteries;
6. Assess the timing of good weather windows and favourable tides, 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 4);
9. Revise the species at that location;
10. Notify the relevant Fisheries and Parks Victoria authorities, or the authorites pertinent to the region; and
11. Monitor the Bureau of Meteorology weather forecasts and mobilise team as soon as favourable.

4.0 Equipment List

4.1 DIVING

- a complete set of scuba diving equipment for each diver, as per the Australian Standard Dive Regulations;
- addtional air cylinders;
- spare equipment, tools and spare parts;
- a dive flag and mermaid catcher;
- an oxygen therapy unit – Oxygen D cylinder and DAN regulator (or equivalent); and
- communications equipment and spare batteries.

4.2 BOATING

All equipment required to meet relevant commercial navigation and Marine Board of Victoria survey requirements.

- life jackets/PFDs and life ring with lights;
- flares, EPIRB, visual and acoustic signalling devices;
- a VHF radio;
- a first aid kit;
- a knife, boathook and bucket; and
- charts, compass, barometer and clock.

4.3 NAVIGATION

- maps, site coordinates, transect directions, site photographs and
- a portable differential Global Positioning System (GPS).

4.4 SAFETY

- diving safety equipment (see above);
- boating safety equipment (see above); and
- sun cream, hat, sunglasses, wet weather clothing, warm hat, towel, water and food.

4.5 UNDERWATER VISUAL CENSUS

- a weighted line (2 kg) with a large marker buoy (12 m of rope) and a metal ring near the weight to attach transect lines;
- transect lines (numbered and weighted at regular intervals) on reels, ends weighted and with a clip to attach to site marker;

- underwater slates with rubber bands and attached pencil and plastic calipers;
- pre-printed plastic data forms;
- calibration poles, 1 m long with clip for attachment to diver;
- catch bags with clip for attachment to diver;
- quadrats (weighted or metal), 0.5 x 0.5 m with internal grid of 7 x 7 points (string or stainless wire) and clip for attachment to diver; and
- a stowage box, pencils, rubberbands, datasheets, electrical tape and pencil sharpener.

4.6 SPECIMEN COLLECTIONS

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

4.7 DOCUMENTATION

- collection and survey permits (Fisheries Victoria and Parks Victoria);
- a dive record booklet, incorporating dive plan, emergency response plan, nominated contact details, briefing checklist, dive tables and dive record sheets;
- the relevant diving policies and AS2299.2 Scientific Diving;
- the Standard Operations Procedure (this document); and
- navigation charts

4.8 POST-DIVING

- spare slate, datasheets, pencils, rubber bands, calipers, batteries, pencil sharpeners;
- general stationery, including red pens;
- licences (e.g. car drivers, coxswains, radio operators, diving, first aid, oxygen provision);
- identification guides;
- species lists and data codes;
- a laptop computer;
- back-up disks and/or portable zip drive;
- communications equipment – mobile phone, facsimile, internet, etc.; and
- a change of clothes

5.0 Field Operations

5.1 PRE-DIVE PROCEDURE

5.1.1 Diving and Observation Conditions

Site conditions must be assessed at the beginning of each day for their suitability for access by boat and suitability for diving and underwater visual censuses. Limiting boating conditions include:

- lee (exposed) shores, particularly with winds over 25 knots;
- heavy seas, particularly waves over 1.5 to 2 m;
- stormy weather and poor visibility;
- confused seas;
- dangerous state of barways (such as at Inverloch/Bunurong); and
- dangerous state of channels (such as Port Phillip Heads).

Diving conditions suitable for underwater visual censuses include:

- weather and sea conditions accessible by boat (see above);
- low swells, with ground surge less than 1-2 m in one direction;
- currents less than 0.25 knots;
- horizontal underwater visibility equal to or greater than 5 m; and
- reasonable sunlight conditions.

Sampling is best done between 0900 and 1600 hours in winter and between 0830 and 1700 in summer to avoid periods of high fish activity during early morning and late afternoon, in addition to poor lighting because of low sun angle. Fish censuses are not attempted in visibility less than 5 m. This is because fish tend to be extremely diver wary and skittish in low visibility conditions, and the detectability of various species is likely to be affected. Accuracy of transect setting and diver safety are also compromised in low visibility conditions.

5.1.2 Dive Briefing and Equipment Check

An on-site pre-dive briefing and equipment check is required before every dive. Observers should be assigned their respective census methods, transects and tasks during the briefing.

5.2 LOCATION OF SAMPLING SITE

The central position of sampling sites is located with differential GPS to maintain accuracy of ± 5 m. The position is marked with a weighted buoy line and the boat is anchored nearby. Where large diving support vessels are used, such as at Wilsons Promontory, a small tender with portable GPS is launched prior to the dive and used to position the marker buoy. All coordinates are recorded using the Australian Geodetic Datum 1994.

The accuracy of the current GPS system varies (albeit infrequently) according to the configuration and the operational limitations of satellites. Sites that can only be located accurately with the GPS are not sampled on days when the GPS is unreliable. Many sites are positioned immediately adjacent to distinctive natural features (such as underwater bombies or rocky outcrops on the shoreline). These features are used to accurately position the marker when the use of the GPS system is inappropriate.

5.3 UNDERWATER VISUAL CENSUS PROCEDURE

1. Divers gear-up on the boat, methods and transects are assigned to each observer and the direction of the first transect section (T1) is clarified;
2. Two divers descend to the marker weight with the transect reels, clip the ends off and swim off in opposite directions along the same isobath, unreeling the 100 m transect lines as they go. The divers swim above the kelp canopy (where present), navigating using a depth gauge, compass and familiar underwater features. Care is taken to ensure the transect line will be at the desired depth once it settles beneath the kelp canopy;
3. The resulting 200 m of transect line (with the marker in the centre) is divided into four 50 m contiguous sections, labelled T1 (*i.e.* Transect 1), T2, T3 and T4 (Figure 5.1). The transect line is numbered every metre (colour coded for each 10 m section), has a lead weight every 5 m and two lead weights at 50 m. The direction of T1 is fixed, being the same for each survey at each site. The direction of T1 to T4 is in a clockwise direction around the coast (*i.e.* generally from east to west);
4. To minimise diver disturbance, fish surveys are always completed first, and diver movements are organised so that no diver moves through an area being surveyed by another diver;
5. Once the transect line is set, the two outer divers commence the fish census (Method 1, described below) of T1 and T4;
6. If there are only two divers, they then survey fish on T2 and T3 (Figure 5.2);
7. If there are three or four divers, they descend down the marker line once the transect is set (5-7 min) and commence the fish census of T2 and/or T3 (Figure 5.3);

8. If there are four divers, an optimal arrangement is for the diver responsible for the algal survey to swim the transect line out, with a second diver commencing the fish survey of T1 at the westerly end. The algal survey diver waits at the end of T1 until the fish survey diver appears and commences the return swim. The algal diver can then commence the quadrat surveys (Figure 5.4). Algae is only surveyed by one diver at each site and is usually the most time consuming task (*i.e.* a rate limiting step). This survey arrangement saves 5-10 minutes of dive time (a valuable saving in winter);
9. The diver responsible for the algal quadrat survey (Method 3, described below) then commences from the start of T1, sampling through to the end of T4. The same diver surveys *Macrocystis* abundance (Method 4) and, where appropriate, invertebrate quadrat counts (Method 5);
10. Divers responsible for the invertebrate survey (Method 2, described below) work in a T4 to T1 (easterly) direction along their assigned transects;
11. The diver responsible for the algal survey records the underwater conditions;
12. The diver responsible for the algal survey winds up the transect line from T4 to the central marker. The diver responsible for the invertebrate survey of T1 winds up the transect line from T1 to the central marker;
13. Divers ascend with the transect reels and quadrat; and
14. The marker buoy is retrieved from the boat.

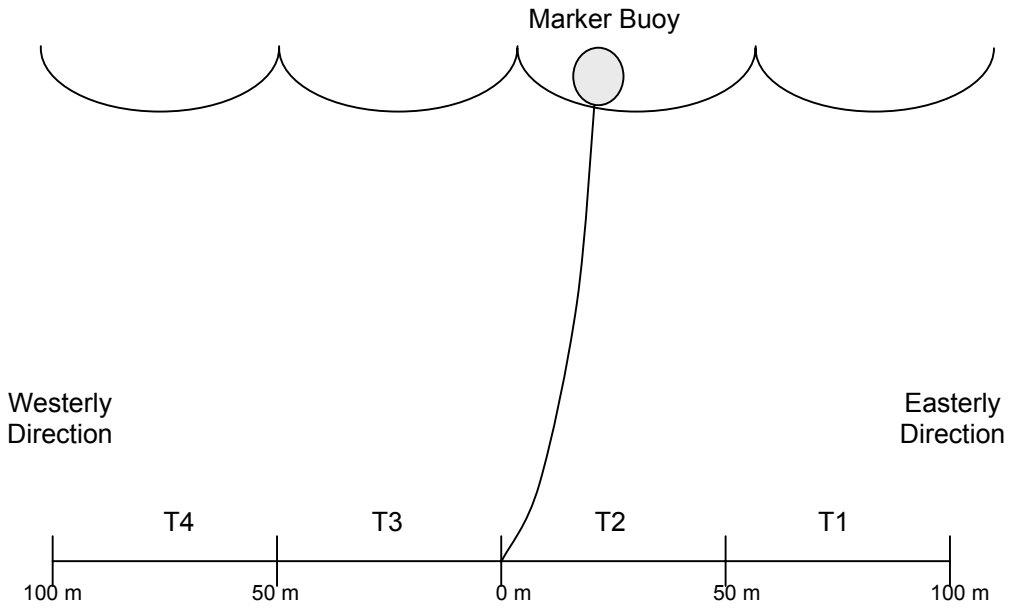

Figure 5.1. Arrangement of transect lines for underwater visual censuses (not to scale).

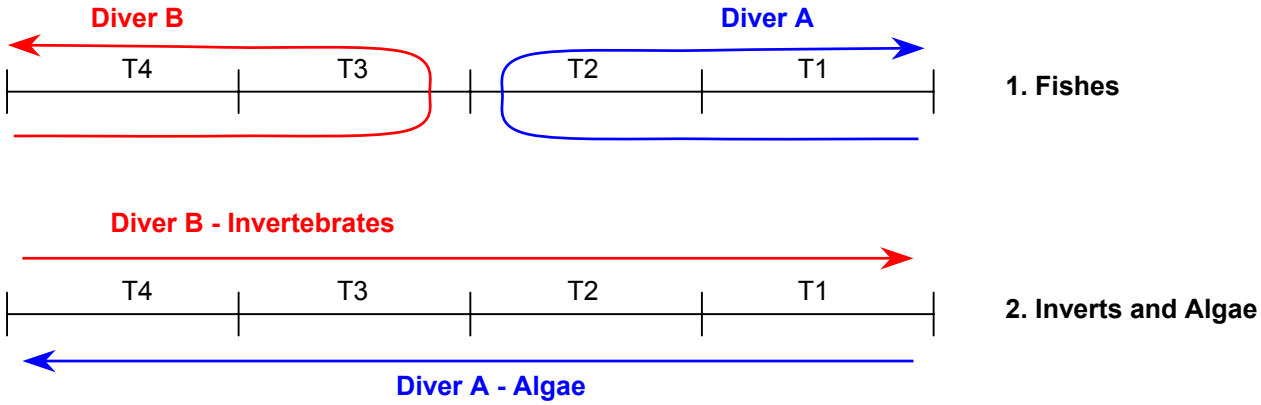

Figure 5.2. Typical sequence of surveys using two divers. Divers A and B reel out transect line.

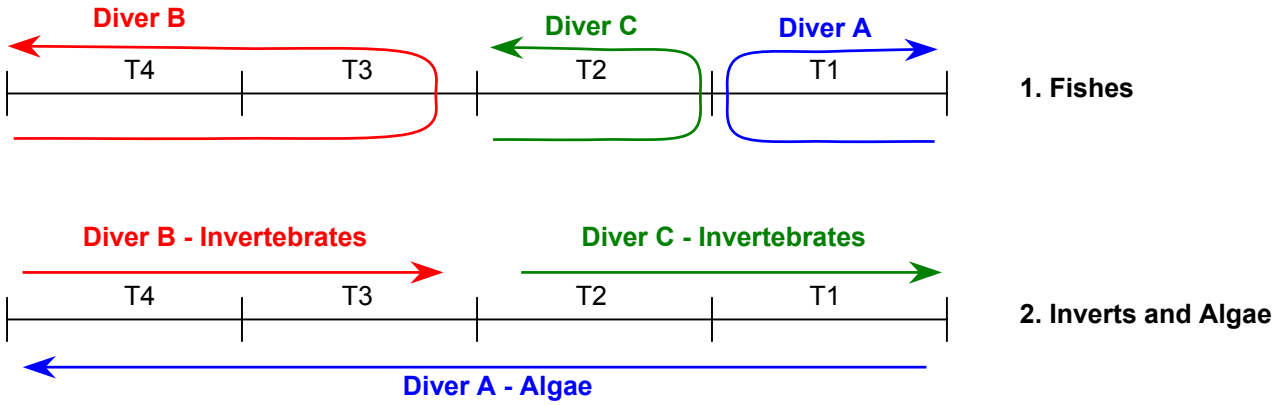

Figure 5.3. Typical sequence of surveys using three divers. Divers A and B reel out transect line.

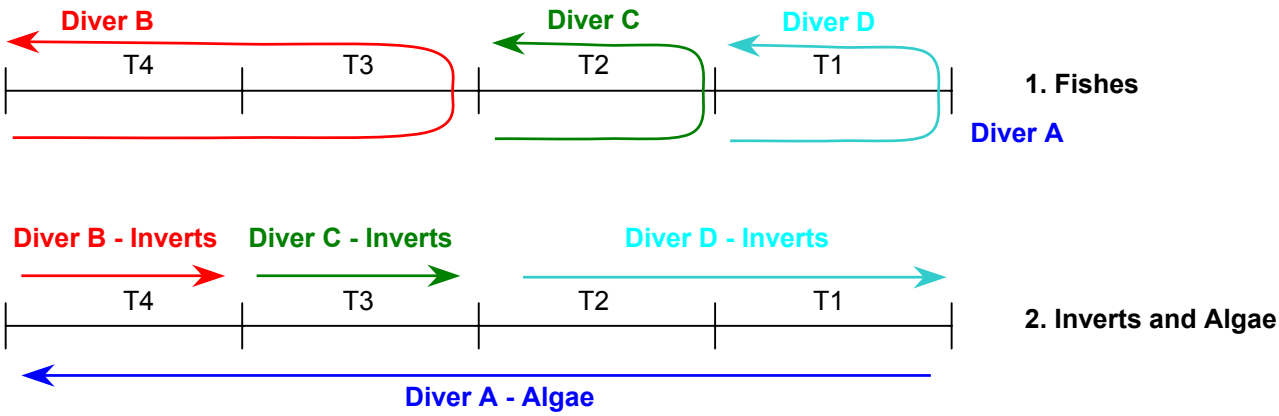

Figure 5.4. Typical sequence of surveys using four divers. Diver A reels out and waits off the end of T1 until Diver C commences the return fish lane of T1. Diver A then commences laying quadrats behind Diver D.

5.3.1 Census Method 1 – Mobile Fishes and Cephalopods

Mobile large fishes and cephalopods are censused within 5 m wide lanes each side of the transect line. Four 10 x 50 m sections of the transect are sampled per site (see Figure 5.5).

1. The diver swims directly to the pre-planned start point of the section (described above). The direction and order of transect sections is designed to minimise diver disturbance/attraction of fish;
2. The diver swims along the offshore (deeper) side of the transect line first then returns on the shallower side;
3. The diver swims down an imaginary line 2.5 m from the transect line. This distance is approximately one body length (with fins) and estimation of this distance is calibrated by sighting down the transect line to halfway between the line-weights (which are 5 m apart);
4. The diver swims just above the kelp canopy (if present) and scans forward into the visible area. The observations include looking into the kelp canopy, visible crevices and caves, on top of bombies and the water column;
5. The diver swims as slowly as feasible, but without stopping (as any fish following the diver will move into the field of view);
6. The diver records the number and size of each species of fish and cephalopods sighted within the 5 m census belt;
7. Fish sizes are recorded in size categories: 25, 50, 75, 100, 125, 150, 200, 250, 300, 350, 375, 400, 500, 625, 750, 875 and 1000^{+} mm. A scale ruler is on the underwater slate for calibration of size estimates;
8. As each individual is sighted, a mark is placed on the field sheet in the appropriate size category on the appropriate species line;
9. The data for easily sexed species is recorded separately for males and female/juveniles. Such species include the blue-throated wrasse *Notolabrus tetricus*, senator wrasse *Pictilabrus laticlavius*, rosy wrasse *Pseudolabrus psittaculus*, eastern blue groper *Achoerodus viridis*, herring cale *Odax cyanomelas*, barber perch *Caesioperca rasor*, six-spine leatherjacket *Meuschenia freycineti*, toothbrush leatherjacket *Acanthaluteres vittiger* and other monacanthids;
10. Once a fish is sighted and recorded it is ignored, even if it is seen leaving and immediately re-entering the census area;
11. All fish sighted within the census area are recorded, including fish seen moving into the census area from the front or sides (fish moving in from behind the diver are not recorded);

12. Easily recognisable fish that circle the diver throughout the census, particularly male *Notolabrus tetricus* are ignored after the initial sighting;
13. For dense aggregations or schools, the abundance is estimated using the approximate volume of 10-20 counted fish (the abundance therefore written in 10s or 100s); and
14. The characteristics of unidentified species are noted on the field sheet. Species are determined immediately after the dive from discussions with other observers, or at the end of the day by using reference texts.

5.3.2 Census Method 2 – Invertebrates and Cryptic Fishes

Cryptic fishes and megafaunal invertebrates (non-sessile: *e.g.* large molluscs, echinoderms, crustaceans) are counted along the transect lines used for the fish survey. Four 1 x 50 m sections of the transect are sampled per site (see Figure 5.5).

1. The diver starts each invertebrate transect at the westerly (T4) end and heads in a general easterly direction towards the end of T1. This search direction is fixed for all sites;
2. The diver carefully searches the substratum for invertebrates and cryptic fishes within 1 m of the transect line, on the shoreward (shallower) side of the transect;
3. The macroalgae are swept aside to obtain a clear view of the substratum, with the diver often proceeding along the transect beneath the kelp canopy;
4. All crevices are investigated to the best of the divers view;
5. A pole is carried by the diver to standardise the 1 m distance. However, each diver also has a known body distance for checking and calibration the transect width (such as left fingertip to right BC buckle) – this method being more practical to apply in thick kelp and difficult ground swell;
6. All non-sessile invertebrates > 20 mm within the transect lane are counted, including decapod crustaceans (crabs, rock lobster and hermit crabs, but excluding shrimps), gastropods, bivalves (mainly scallops), octopus, crinoids (feather stars), asteroids (seastars), echinoids (sea urchins) and holothurians (sea cucumbers);
7. Annelids (worms), polyplacophorans (chitons), shrimps and ophiouroids (brittle stars) are not counted as they are mostly cryptic and too numerous (and therefore cannot be properly enumerated in a multi-species census);
8. Unknown or unidentifiable invertebrate species are placed in the catchbag, with a corresponding note on the field sheet, and taken to the surface for further examination and identification on the boat;

9. Cryptic and sedentery fish are counted, including cryptic juvenile stages of large mobile species counted in the fish census. The size of individuals is recorded, as with the fish census. Cryptic species include members of the Parascyllidae, Urolophidae, Muraenidae, Sygnathidae, Scorpaenidae, Apogonidae, Pempheridídae, Gnathanacanthidae, Pomacentridae (juveniles), Bovichtidae, Tripterygiidae, Clinidae and Gobiidae Families;
10. The maximum length of *Haliotis* spp (abalone) is measured. From the start of the transect, all individuals encountered are measured *in situ*, until the sample size is at least 36 (three lines on the data sheet), or the transect is finished. Some individuals are inaccessible for measurement, but are still counted;
11. Some sites are designated abalone population monitoring sites (see Table 10.3, Section 10) and a minimum of 100 abalone are measured at these sites. Where a total of 100 abalone were not measured from the four invertebrate transect sections, additional measurements are taken from the nearest aggregation to the transect, taking care to measure all individuals within a crevice or patch to ensure unbiased selection; and
12. The carapace length of *Jasus* spp (rock lobsters) individuals is estimated *in situ*. Calipers are held as close as possible to the individual to improve accuracy and precision of measurement. Sex is recorded where observable. If individuals can be easily caught without loss of appendages and stress to the animal, then the carapace length is measured properly and sex determined. However, catching *Jasus* spp. is discouraged to prevent long-term affects of the surveys on resident populations.

5.3.3 Census Method 3 – Macrophytes

The area covered by macroalgal species is quantified by placing a 0.25 m^2 quadrat at 10 m intervals along the transect line and determining the percent cover of all the plant species (see Figure 5.5). Twenty quadrats are sampled per site.

1. The diver starts the algal quadrats at the easterly (T1) end and heads towards the end of T4. This quadrat order is fixed for all sites;
2. The first quadrat is placed at the 100 m mark on T1, with subsequent quadrats placed at 10 m intervals (indicated by numbers on the transect line and line weights). No quadrat is sampled at 0 m;
3. Each quadrat is placed on the offshore side of the transect (opposite to the invertebrate transect), with the top edge of the quadrat running along the transect line, and the marker weight in the centre of this edge;

4. The quadrat is divided into a grid of 7 x 7 perpendicular wires, giving 50 points (including one corner – the one to the right and closest to the observer). The number of quadrat points covering each species is counted;
5. The quadrat is first held over the kelp canopy, and the points-cover of each canopy species recorded;
6. The canopy is then swept aside, the quadrat placed on the substratum and smaller species enumerated;
7. Points-counts are recorded for each lowest identifiable taxon, usually to species level. However, functional categories are used for unknown or unidentifiable species, including: other thallose reds, other erect corallines, encrusting corallines, filamentous reds, filamentous browns and other small browns; and
8. Specimens of particular interest are collected for later examination on the surface, but collection of all unknown species, and their subsequent identification and curation, is impracticable.

5.3.4 Census Method 4 – *Macrocystis*

The density of *Macrocystis angustifolia* plants is estimated for ten 100 m^2 sections of the transect at each site.

1. *Macrocystis* plants are counted by the diver doing the algal quadrats, as she/he swims between each 10 m quadrat station. Individual *Macrocystis* are readily distinguished from other species in the canopy by their lighter colour and morphology. In some instances, individuals are distinctly higher than the kelp canopy, sometimes forming an over-storey at the surface;
2. The diver swims along the transect, counting all observable plants within 5 m either side of the line between quadrat stations;
3. The estimation of 5 m distance is calibrated by positioning at a transect line weight, and sighting down the transect to the next line weight (5 m away); and
4. Counts are recorded on the bottom line of the field sheet.

5.3.5 Census Method 5 – Grazing Invertebrates

For selected sites, the density of grazing invertebrates and other animals is determined within the 0.5 x 0.5 m quadrats. This method is currently implemented in sea urchin barrens maintained by *Centrostephanus rodgersii* and other grazers such as limpets.

1. The quadrat placements for algae are used (see method 3), with quadrats placed every 10 m along the transect;
2. All observable sedentary invertebrates are counted within the quadrat, including echinoids (sea urchins), asteroids (seastars) and gastropods (including limpets). Highly mobile species, such as crabs, are not counted; and
3. Selected, easily detectable sessile species are also counted, including fan-worms (*e.g. Sabellastarte* sp) and tunicates (*e.g. Herdmania momus*).

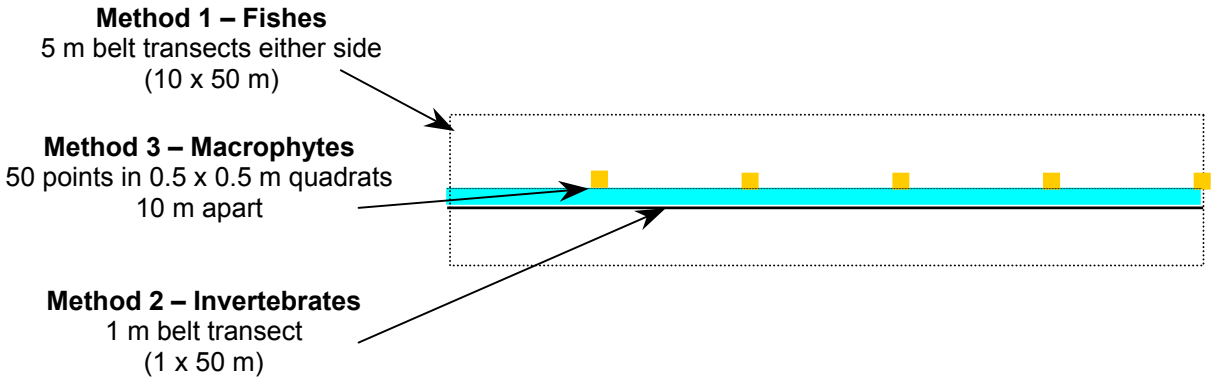

Figure 5.5. Configuration of census areas for each 50 m section of the transect. For fishes, the deepest 5 m wide lane is surveyed first, then the inshore, shallower lane. For invertebrates, the inshore side of the transect is surveyed. For macrophytes, quadrats are placed on the offshore side of the transect, with the top of the quadrat running along the transect line and with the transect marker weight at the centre of the top edge.

Figure 5.6. Biologist-diver with transect reel, calibration pole, slate and catch bag.

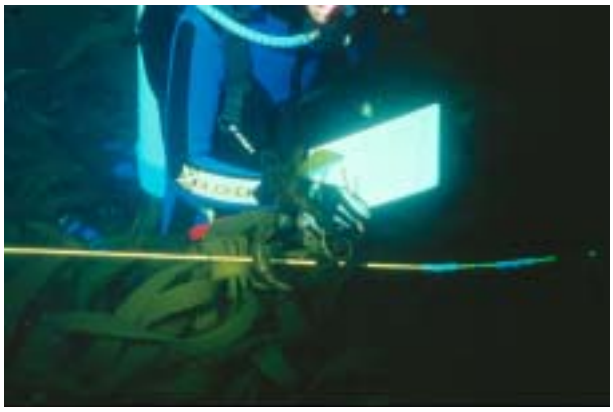

Figure 5.7. Divers record species counts on underwater paper attached to a slate. The 50 m mark is identified by two line-weights, as shown here, as well as green colour coding of numbers on the line.

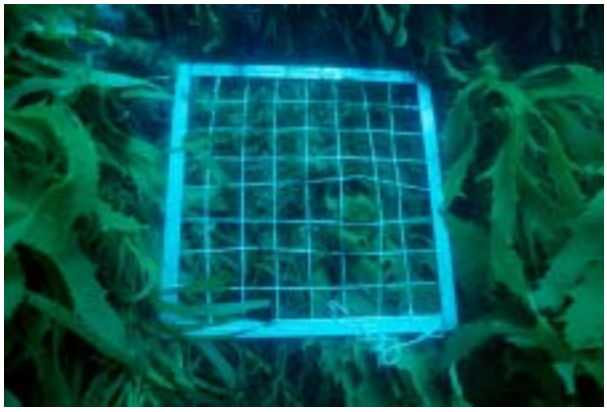

Figure 5.8. The cover of macrophytes is measured by the number of points intersecting each species on the quadrat grid. The canopy is quantified first (shown here), and then pushed aside to assess the understorey species.

5.3.6 Underwater Data Recording

A standard form on the underwater field sheets is used for recording data for all methods. The field sheet form includes columns for species name, species code, abundance counts, size frequency categories and size measurements. The form also prompts for site conditions such as site name, date, diver, depth, visibility, cloud cover, sea conditions and ground surge. Quality control items include a scale for fish size estimation and signature spaces for data entry and data checking.

The form and the method of data recording onto the form ensures each diver records the data in the same manner, and in a form compatible with the data entry spreadsheet. This standardisation of data recording also aids the detection of any errors and makes data entry

efficient. An example of the recording format is given in Figure 5.9. The method for data recording follows.

1. Each species for each method and transect occupies a separate row on the data sheet;
2. Species names are written in the far left column and, to save time, often abbreviated to the first 3 or 4 letters of the genus and species, for example 'Sco aeq' for *Scorpis aequipinnis*;
3. This is inappropriate for *Cystophora moniliformis* and *Cystophora monilifera* and abbreviations are 'Cys mis' and 'Cys mra' respectively;
4. Appropriate descriptions/characteristics are written for unknown species names;
5. F or M is written after the species name for identifiable females or males respectively;
6. Males and females of the same species are recorded on separate rows;
7. Abundance and size data are written to the right of each species name, leaving the coding column blank;
8. Data for transect and method are separated by a line drawn on the sheet (and blank rows where possible);
9. The transect number is written to the right of appropriate species and circled;
10. Stroke marks are used for individual sightings;
11. Multiple counts are placed in the appropriate column and bracketed (single and double digits);

Method 1 - Fish

12. For fish, stroke marks are placed under the appropriate size category (marked in centimetres along the top of the sheet);
13. For fish larger than 40 cm, the size followed by the count is written in the row and bracketed, for example: (50 cm x 4), (87 cm x 3) and (100 cm). Larger size categories are listed at the bottom of the form;
14. Multiple counts are placed in the appropriate size column and bracketed;
15. For highly abundant species (*e.g. Caesioperca rasor*), the bracketed size followed by the count notation may be used where the space within size categories is too small for clear recordings;

Method 2 - Invertebrates

16. Counts for invertebrates are recorded as a series of stroke marks for individuals, or bracketed numbers for group/multiple counts. These are added up later during the data entry phase;
17. Sizes for invertebrates are recorded within each column and are not bracketed – the size measurement is also used as an individual count marker. Sizes of 111 mm are underlined to differentiate the record from three count strokes;
18. Three (or more) consecutive rows are usually used for *Haliotis* size measurements (for target n = 36);
19. Counts of unmeasurable *Haliotis* individuals are recorded as stroke marks and/or numbers in brackets, on the same rows as the measurements;
20. An 'e' (denoting estimate) is placed after *Jasus* size measurements that were not measured directly. F or M is also placed after the size, if determined;

Method 3 - Macrophytes

21. Algal points abundance (a one or two digit number) is written under the appropriate quadrat distance marked at the top of the form (100 m at the start of T1 to 10 m at the end of T2, 10 m at the start of T3 to 100 m at the end of T4);
22. Care must be taken to ensure clear separation of the two quadrat abundances present within each column;

Method 4 - Macrocystis

23. *Macrocystis* counts are written in the last row of the form and denoted in the species column as 'Mac ang count';
24. *Macrocystis* counts (1-3 digit number) are written under the appropriate distance marked at the top of the form. For T1 and T2, the distance marker is for the start of each 10 x 10 m section. For T3 and T4, the distance marker is for the end of each 10 x 10 m section;
25. Care must be taken to ensure clear separation of the two abundances present within each column;

Method 5 – Quadrat Invertebrates.

26. Invertebrate quadrat species are denoted with a 'q' to separate them from Method 2 species;

27. Invertebrate counts within each quadrat are written under the appropriate quadrat distance marked at the top of the form (100 m at the start of T1 to 10 m at the end of T2, 10 m at the start of T3 to 100 m at the end of T4); and

28. Care must be taken to ensure clear separation of the two abundances present within each column.

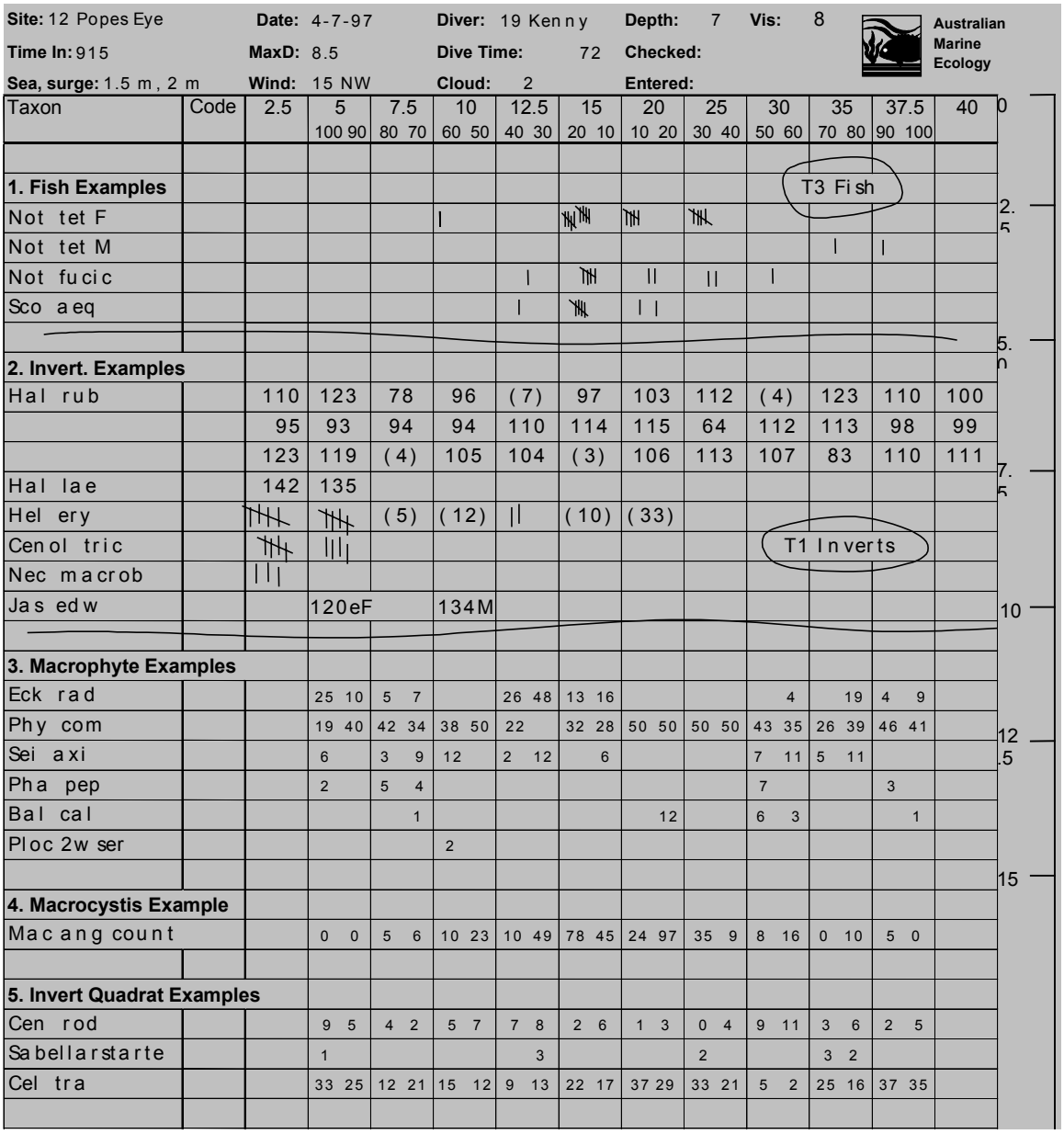

Figure 5.9. Example format of data recorded during underwater surveys (fictional data). Species names are usually abbreviated, as shown here. The sizes of individual fish are recorded by stroke marks within the appropriate size category (marked at the top of the form in centimetres). The ruler down the right side of the page assists with fish size estimation. Abalone sizes (*e.g. Haliotis rubra* and *H. laevigata* shown here) are written after the species and individuals that could not be measured are counted and written as a number in brackets. Counts written in Arabic numberals are bracketed to differentiate from counts written as stroke marks. Quadrat and transect section data (Methods 3, 4 & 5) are written under the appropriate distance marked at the top of the page (100 m at start of T1 on left to 100 m at end of T4 on right). Note: the data sheet header details have since changed slightly. They now include information on the tides and currents, bottom time and more detail about the wind and the sea (see Section 9).

5.4 POST DIVE PROCEDURES

1. The diver responsible for the algal survey records the surface conditions;
2. Collected specimens are examined, identification verified and returned to the sea alive if practical, or preserved if important;
3. Specimens are placed in labelled bags for later curation;
4. Sightings and observations are discussed among divers and field sheet notes are added if necessary (such as expanding species names);
5. Field sheets are sighted by the project leader to check for discrepancies and anomalies (such as fish sizes smaller or larger than expected, species outside the normal range), with errors corrected and/or annotations added if necessary;
6. All sheets are collected and placed in a secure, designated stowage container;
7. New field sheets are placed on the slates, pencils are sharpened if necessary;
8. The stowage container is returned to a safe and secure place in the cabin of the boat;
9. Scuba tanks are changed;
10. Diving details are recorded and appropriate no-decompression calculations are made; and
11. The vessel is moved to the next site, site assessment and dive briefing commences, procedure is repeated.

5.5 END OF DIVE DAY PROCEDURES

1. Diving and boat equipment is cleaned and organised for the following day;
2. Scuba tanks are filled;
3. Field sheets are washed and dried;
4. Collected specimens are curated;
5. Field sheets are checked and additional identifications are made using reference texts where necessary (from descriptions on field sheet or collected specimens);
6. Field sheets are coded with red ink;
7. Pertinent information entered into dive log, including general survey observations and notes;
8. Data entry into spreadsheet is commenced/continued; and
9. Weather forecasts are checked.

6.0 Specimen Curation

Specimen collection and curation can only be done in Victoria by trained experts and under the relevant permits from the Department of Sustainability and Enviroment.

6.1 INTRODUCTION

Selected floral and faunal specimens are sometimes collected for identification and preservation in a reference collection. For example, detailed collections are made of macroalgal species because identification resources for algae are limited compared to other taxa. In addition to being an identification resource, a reference collection provides material for future taxonomic and biogeographic studies of Victorian marine flora and fauna.

6.2 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 this 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 speciment 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 the brittle specimens are not broken;
11. The muslin is soaked in bleach or another 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 relevent 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; and
19. Specimens are stored in a cool, dark, dry place, free of insects.

6.3 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 cm^2 tissue fragment from a healthy portion of the plant (note: do not sample from sporophylls for *Undaria*);
3. Place label in bag/tube and seal tightly;
4. Check drying process is adequate, if not change the drying beads; and
5. Record specimens in the appropriate catalogue.

6.4 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 include some tube feet, a piece of the test or the tip of an arm;
4. Write details on label and place in tube; and
5. Record specimens in the appropriate catalogue.

6.5 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; and
8. Monitor fluid levels in containers and top up when necessary.

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

7.0 Training and Calibration

7.1 CENSUS TRAINING

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

7.1.1 Syllabus for Novice Observers

1. Ensure the trainee has fulfilled all qualification and experience requirements (Chapter 3);
2. Familiarise the 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 experienced divers using reference texts, whiteboard diagrams and land simulations;
5. Practice of methods in the field, alongside actual survey operations;
6. Comparison of practice data with real data, practice continues until size and abundance measurements concur with actual survey data;
7. Commencement of actual invertebrate census - the method requiring the least amount of taxonomic knowledge as unknown species can be brought back to the surface. This method is also the most robust to dive observer biases and imprecision. Practice transects for fish census techniques are also done during the dive, once actual fish surveys are finished;
8. Once dive observers are comfortable and familiar with the invertebrate census techniques, and fish census data concurs with actual census data, the dive observer may commence formal census of fish transects;
9. New dive observers are closely monitored by experienced personnel while in the water, correcting non-conformance to the standard operating procedure where necessary;
10. Data collected by novice dive observers are closely scrutinised for mistakes or anomalies;
11. Training in macrophyte quadrat techniques does not commence until dive observers are very familiar with the invertebrate and fish census techniques. The macrophyte census requires familiarity with a much larger number of species and diagnostic features. This

method is generally more demanding of dive observer-concentration as well as being more time consuming;

12. Training for the macrophyte census technique involves practice quadrats in the field, collection of samples for identification and comparison in the laboratory. Reference texts and material such as Edmunds, McDonald and Tran (2001) and Edmunds (2002) are studied to become familiar with diagnostic features, in addition to tutoring from trained and experienced dive observers; and
13. Training, demonstration and close supervision of novices also occurs during data entry, checking and management tasks.

7.2 ON-GOING CALIBRATION

On-going training and calibration of dive observers occurs through discussion and comparison of data at the end of every dive and every dive-day. Training and standardisation also occurs through regular revision of species identification texts, specimen collections and the standard operating procedure. Techniques are currently being developed for in-water dive observer-calibration, as well as measurement of biases and precision.

8.0 References and Identification Guides

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8.2 FURTHER READING – IDENTIFICATION GUIDES AND MATERIALS

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9.0 Forms

Examples of the forms required for this standard operating procedure are listed below and presented on the following pages.

1. Underwater data sheet;
2. Data correction sheet; and
3. Specimen labels

These forms are over an above the documentation and reporting requirements for occupational health and safety policies and procedures, diving operations and quality management systems.

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

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

DATA CORRECTION SHEET

Project title: ..... Task No: .....…….. - ...……...

Location: ..... Survey: .....…….....…..….

Entry Officer: ..... Sheet: ……..... of ……..…..

Check Officer(s): ..... Date: ...…….....…….....

Sighted: ..... Date: .....……...…….....

Information on this form is only for the purposes database management and training of staff for reducing data entry errors. This information is not for disclosure or disciplinary action of any kind.

Notes: .....

.....

Error Codes: C = Coding; F = Filldown (site, survey, date, diver, etc.); D = Displacement; S = Species coding; SF = size frequency; N = Count; X = Sex

Site	Meth	Tran	Sp	Error	Before Change	After Change:

SPECIMEN LABELS

Specimen:	Specimen:	Specimen: ....
Date:	Date:	Date: ....
Loc:	Loc:	Loc: ....
Site:	Site:	Site: ....
Lat:	Lat:	Lat: ....
Lon:	Lon:	Lon: ....
Depth:	Depth:	Depth: ....
Notes:	Notes:	Notes: ....
....	....	....
....	....	....
....	....	....

Specimen:	Specimen:	Specimen: ....
Date:	Date:	Date: ....
Loc:	Loc:	Loc: ....
Site:	Site:	Site: ....
Lat:	Lat:	Lat: ....
Lon:	Lon:	Lon: ....
Depth:	Depth:	Depth: ....
Notes:	Notes:	Notes: ....
....	....	....
....	....	....
....	....	....

Specimen:	Specimen:	Specimen: ....
Date:	Date:	Date: ....
Loc:	Loc:	Loc: ....
Site:	Site:	Site: ....
Lat:	Lat:	Lat: ....
Lon:	Lon:	Lon: ....
Depth:	Depth:	Depth: ....
Notes:	Notes:	Notes: ....
....	....	....
....	....	....
....	....	....

10.0 Data Codes and Species Lists

Table 10.1. Census method codes.

Code	Method	Measurement unit	Replicates per site
1	Mobile fishes and cephalopods	Abundance per 500 m^2	4
2	Invertebrates and cryptic fishes	Abundance per 50 m^2	4
3	Macroalgae and seagrasses	Points covered of 50 per 0.25 m^2	20
4	*Macrocystis* abundance	Abundance per 100 m^2 section	20
5	Grazing invertebrate abundance	Abundance per 0.25 m^2	20

Table 10.2. Monitoring site details to 2002. (: (Depth) depth, metres; (T1) direction of Transect 1; (CMS) core monitoring site – yes or no; and (Ab100) site with at least 100 abalone measured. Note: further locations were added in 2003 (Hart et al. 2003) and more are to be added in 2004.

Location	Site No.	Site Name	Latitude	Longitude	Depth	T1	CMS	Ab 100
Port Phillip Heads	2801	Point Franklin	38° 19.128’	144° 42.955’	2	W	Y	N
	2804	South Channel Fort	38° 18.505’	144° 47.982’	2	E	Y	N
	2812	Annulus (Popes Eye)	38° 16.692’	144° 41.777’	5	E	Y	N
	2802	Nepean Offshore	38° 18.215’	144° 39.441’	2	W	Y	N
	2803	Nepean Inner West	38° 18.337’	144° 39.271’	2	W	Y	N
	2808	Nepean Inner East	38° 18.345’	144° 39.458’	2	W	Y	N
	2805	Shortland Bluff	38° 16.607’	144° 39.250’	5	E	Y	N
	2806	Victory Shoal	38° 16.900’	144° 37.424’	5	N	Y	N
	2807	Merlan Inner	38° 17.330’	144° 37.120’	5	N	Y	N
	2810	Merlan Outer	38° 17.497’	144° 37.275’	5	N	Y	N
	2809	Lonsdale Kelp Outer	38° 17.272’	144° 37.698’	7	N	Y	N
	2811	Lonsdale Kelp Inner	38° 17.212’	144° 37.570’	7	N	Y	N
	2813	Lonsdale Point	38° 17.890’	144° 36.700’	7	E	Y	Y
	2814	Lonsdale Back Beach	38° 17.502’	144° 35.250’	5	E	Y	N
	2815	Lonsdale Pt SW	38° 17.734’	144° 35.816’	7	E	Y	N
Phillip Island	2901	Nobbies North	38° 31.143’	145° 06.515’	6	W	Y	Y
	2902	Pyramid Rock West	38° 31.622’	145°12.639’	6	E	Y	Y
	2903	Pyramid Rock North	38° 31.817’	145° 13.287’	4	N	Y	N
	2904	Washing Machine	38° 33.617’	145° 20.370’	6	E	Y	Y
	2905	Cape Woolamai Mid	38° 34.115’	145° 21.437’	6	E	Y	N
	2906	Cape Woolamai East	38° 33.994’	145° 21.622’	4	N	Y	N
Bunurong	3001	Cape Patterson	38° 40.911’	145° 36.499’	4	N	Y	N
	3002	Cape Patterson Boat Ramp	38° 40.732’	145° 36.938’	6	E	Y	Y
	3015	Boat Ramp East	38° 40.666’	145° 37.173’	7	E	Y	Y

Location	Site No.	Site Name	Latitude	Longitude	Depth	T1	CMS	Ab 100
	3014	The Oaks Beach	38° 40.650’	145° 38.465’	6	E	Y	N
	3003	Oaks East	38° 40.707’	145° 38.740’	6	E	Y	N
	3004	Twin Reefs	38° 40.827’	145° 39.172’	6	E	Y	N
	3005	Shack Bay West	38° 40.691’	145° 39.442’	5	N	Y	Y
	3012	Shack Bay Beach	38° 40.607’	145° 39.556’	5	E	Y	Y
	3006	Shack Bay East	38° 40.397’	145° 39.796’	6	E	Y	N
	3007	The Caves	38° 39.948’	145° 40.907’	6	E	Y	N
	3013	Petrel Rock West	38° 39.713’	145° 41.199’	4	E	Y	N
	3008	Petrel Rock East	38° 39.389’	145° 41.629’	5	E	Y	N
Wilsons Promontory	3101	North Shellback Is	38° 58.083’	146° 13.622’	10	W	Y	N
	3102	North Tongue Pt	38° 59.590’	146° 15.199’	10	W	Y	N
	3103	Northwest Norman Is	39° 08.382’	146° 19.065’	10	SW	N	N
	3104	West Norman Is	39° 01.568’	146° 14.425’	10	S	Y	Y
	3105	Leonard Pt	39° 01.489’	146° 16.954’	10	SW	N	Y
	3106	Pillar Pt	39° 02.467’	146° 18.202’	10	SE	Y	Y
	3107	South Norman Pt	39° 03.318’	146° 19.152’	10	E	Y	Y
	3108	Oberon Pt	39° 04.676’	146° 19.391’	10	SW	Y	N
	3109	East Glennie Is	39° 05.123’	146° 14.001’	10	N	Y	N
	3110	West Glennie Is	39° 05.464’	146° 13.853’	10	SE	N	Y
	3111	North of Sea Eagle Bay	39° 06.232’	146° 19.948’	10	SE	Y	N
	3112	Sea Eagle Bay	39° 06.799’	146° 20.470’	10	S	Y	Y
	3113	North Anser Is	39° 08.362’	146° 19.067’	10	NW	Y	N
	3114	South Pt	39° 08.139’	146° 22.161’	10	E	N	N
	3115	Roaring Meg Bight	39° 07.892’	146° 22.854’	10	E	Y	Y
	3116	West of West Landing	39° 07.858’	146° 24.384’	10	E	N	N
	3117	East landing	39° 07.537’	146° 25.353’	10	NW	Y	N
	3118	Fenwick Pt	39° 06.876’	146° 25.741’	10	NW	Y	N
	3119	Waterloo Pt	39° 05.354’	146° 26.364’	10	W	N	N
	3120	Central Waterloo Bay	39° 03.802’	146° 26.600’	10	N	Y	N
	3121	North Waterloo Bay	39° 03.943’	146° 28.081’	10	E	Y	N
	3122	North Cape Wellington	39° 03.439’	146° 28.716’	10	N	Y	Y
	3123	Bareback Bay	39° 03.220’	146° 28.444’	10	NE	Y	N
	3124	South Refuge	39° 02.831’	146° 28.614’	10	N	Y	N
	3125	North Refuge	39° 02.257’	146° 28.148’	10	E	Y	N
	3126	Horn Bay	39° 01.841’	146° 27.955’	10	NE	N	N
	3127	North Horn Pt	39° 01.585’	146° 28.202’	10	NW	Y	N
	3128	The Hat	38° 59.923’	146° 26.764’	10	N	N	N

Location	Site No.	Site Name	Latitude	Longitude	Depth	T1	CMS	Ab 100
Point Hicks	3201	Bemm Reef	37° 47.405'	149° 03.485'	14	E		
	3202	Cloke Rock, Clinton Rocks	37° 47.063'	149° 11.508'	5	E		
	3203	Sensation Reef	37° 47.833'	149° 14.903'	16	E		
	3204	Old Jetty Bay	37° 47.839'	149° 15.898'	4	S		
	3205	Hicks Front Reef	37° 48.304'	149° 16.146'	11	E		
	3206	Hicks Light House	37° 48.215'	149° 16.566'	5	NE		
	3207	Krafts Garden	37° 47.942'	149° 17.196'	7	E		
Cape Howe	3208	Tullaberga Deep	37° 47.942'	149° 17.196'	6	S		
	3209	Tullaberga Shallow	37° 33.554'	149° 50.464'	3	S		
	3210	Gabo Monument	37° 33.934'	149° 54.217'	6	S		
	3211	Gabo Harbour	37° 33.432'	149° 54.384'	5	S		
	3212	Iron Prince	37° 31.254'	149° 57.703'	5	E		
	3213	Howe West	37° 30.685'	149° 58.335'	10	E		
	3214	Howe Central	37° 30.564'	149° 58.491'	8	NE		
	3215	Howe Border	37° 30.520'	149° 58.640'	10	NE		

Table 10.4. List of fish species commonly encountered in Victoria and their codes.

Sp. Code	Species	Sp. Code	Species
1	*Heterodontus portusjacksoni*	53	*Latridopsis forsteri*
105	*Parascyllium variolatum*	55	*Sphyraena novaehollandiae*
3	*Cephaloscyllium laticeps*	169	*Achoerodus viridis*
107	*Dasyatis brevicaudata*	192	*Coris sandageri*
5	*Myliobatis australis*	111	*Ophthalmolepis lineolata*
108	*Urolophus paucimaculatus*	56	*Dotalabrus aurantiacus*
11	*Genypterus tigerinus*	171	*Notolabrus gymnogenis*
17	*Hippocampus abdominalis*	60	*Notolabrus tetricus*
18	*Phyllopteryx taeniolatus*	58	*Notolabrus fucicola*
24	*Caesioperca lepidoptera*	59	*Pseudolabrus psittaculus*
25	*Caesioperca rasor*	57	*Pictilabrus laticlavius*
962	*Paraplesiops meleagris*	2548	*Suezichthys aylingi*
27	*Trachinops caudimaculatus*	61	*Odax acroptilus*
154	*Trachinops taeniatus*	66	*Odax cyanomelas*
28	*Dinolestes lewini*	62	*Siphonognathus attenuatus*
2327	*Sillaginodes punctata*	956	*Siphonognathus radiatus*
31	*Trachurus declivis*	113	*Siphonognathus tanyourus*
32	*Arripis spp.*	64	*Siphonognathus beddomei*
33	*Parequula melbournensis*	63	*Neoodax balteatus*
184	*Chrysophrys auratus*	65	*Haletta semifasciata*

Sp. Code	Species	Sp. Code	Species
159	*Upeneichthys lineatus*	78	*Seriolella brama*
34	*Upeneichthys vlaminghii*	2325	*Thyristes atun*
35	*Pempheris multiradiata*	85	*Acanthaluteres spilomelanurus*
38	*Kyphosus sydneyanus*	93	*Acanthaluteres vittiger*
37	*Girella tricuspidata*	86	*Brachaluteres jacksonianus*
36	*Girella elevata*	94	*Thamnaconus degeni*
39	*Girella zebra*	946	*Monacanthus chinensis*
40	*Scorpis aequipinnis*	126	*Scobinichthys granulatus*
41	*Scorpis lineolata*	88	*Meuschenia australis*
42	*Atypichthys strigatus*	89	*Meuschenia flavolineata*
938	*Tilodon sexfasciatus*	90	*Meuschenia freycineti*
43	*Enoplosus armatus*	947	*Meuschenia galii*
44	*Pentaceropsis recurvirostris*	91	*Meuschenia hippocrepis*
47	*Parma victoriae*	116	*Meuschenia venusta*
46	*Parma microlepis*	92	*Meuschenia scaber*
45	*Chromis hypsilepis*	175	*Nelusetta ayraudi*
48	*Aplodactylus arctidens*	902	*Eubalichthys bucephalus*
166	*Crinodus lophodon*	87	*Eubalichthys gunnii*
167	*Cheilodactylus fuscus*	906	*Eubalichthys mosaicus*
49	*Cheilodactylus nigripes*	95	*Aracana aurita*
50	*Cheilodactylus spectabilis*	96	*Aracana ornata*
52	*Nemadactylus macropterus*	714	*Contusus richei*
168	*Nemadactylus douglasi*	97	*Tetractenos glaber*
941	*Nemadactylus valenciennesi*	98	*Diodon nichthemerus*
51	*Dactylophora nigricans*	2324	*Arctocephalus pusillus*

Table 10.5. List of invertebrate and cryptic fish species commonly encountered in Victoria and their codes.

Sp. Code	Species	Sp. Code	Species
	Invertebrates		**Invertebrates**
270	*Jasus edwardsii*	565	*Anthaster valvulatus*
277	*Jasus verreauxi*	2515	*Anthenea sidneyensis*
572	*Paguristes frontalis*	210	*Nectria ocellata*
273	*Strigopagurus strigimanus*	224	*Nectria macrobranchia*
275	*Diogenid (purple leg)*	552	*Nectria multispina*
274	*Pagurid (grey)*	559	*Nectria wilsoni*
569	*Pagurid unidentified*	212	*Petricia vernicina*
271	*Nectocarcinus tuberculatus*	208	*Fromia polypora*
272	*Plagusia chabrus*	214	*Plectaster decanus*
2312	*Petrocheles australiensis*	223	*Echinaster arcystatus*

Sp. Code	Species	Sp. Code	Species
	Invertebrates		**Invertebrates**
241	*Haliotis rubra*	222	*Nepanthia troughtoni*
240	*Haliotis laevigata*	2517	*Pateriella exigua*
252	*Haliotis scalaris*	221	*Pateriella calcar*
266	*Scutus antipodes*	238	*Patiriella gunnii*
2304	*Phasianotrochus eximius*	211	*Patiriella brevispina*
571	*Phasianella australis*	209	*Coscinasterias muricata*
717	*Phasianella ventricosa*	217	*Uniophora granifera*
243	*Turbo undulatus*	206	*Goniocidaris tubaria*
264	*Astralium tentoriformis*	234	*Phyllacanthus parvispinus*
2313	*Cypraea angustata*	557	*Phyllacanthus irregularis*
246	*Charonia lampas rubicunda*	203	*Centrostephanus rodgersii*
247	*Cabestana tabulata*	205	*Amblypneustes spp.*
257	*Cabestana spengleri*	225	*Holopneustes porossimus*
262	*Cymatium parthenopeum*	204	*Holopneustes inflatus*
256	*Argobuccinium vexillum*	233	*Holopneustes pycnotilus*
253	*Ranella australasia*	202	*Heliocidaris erythrogramma*
255	*Sassia subdistorta*	218	*Stichopus mollis*
250	*Dicathais orbita*	558	*Echinoderms unidentified*
268	*Agnewia tritoniformis*		**Cryptic Fishes**
242	*Pleuroploca australasia*	105	*Parascyllium variolatum*
244	*Penion mandarinus*	17	*Hippocampus abdominalis*
245	*Penion maxima*	21	*Scorpaena papillosa*
713	*Conus anemone*	920	*Glyptauchen panduratus*
715	*Mitra glabra*	23	*Gnathanacanthus goetzii*
279	*Cymbiola magnifica*	29	*Vincentia conspersa*
2588	*Sagaminopteron ornatum*	35	*Pempheris multiradiata*
2351	*Ceratosoma brevicaudatum*	47	*Parma victoriae (juv)*
2321	*Tambja verconis*	46	*Parma microlepis (juv)*
2326	*Perplex digidentis*	68	*Bovichtus angustifrons*
2316	*Hypselodoris bennetti*	75	*Parablennius tasmanianus*
280	*Mytilus edulis*	70	*Norfolkia clarkei*
260	*Equichlamys bifrons*	69	*Forsterygion varium*
249	*Chlamys asperimus*	74	*Heteroclinus perspicillatus*
283	*Ostrea angasi*	103	*Heteroclinus wilsoni*
2333	*Octopus maorum*	921	*Heteroclinus whiteleggei*
251	*Sepia apama*	72	*Heteroclinus tristis*
261	*Sepioteuthis australis*	73	*Heteroclinus johnstoni*
200	*Cenolia trichoptera*	77	*Nesogobius sp.*

Sp. Code	Species	Sp. Code	Species
	Invertebrates		**Cryptic Fishes**
201	*Cenolia tasmaniae*	86	*Brachaluteres jacksonianus*
216	*Tosia australis*	98	*Diodon nichthemerus*
215	*Tosia magnifica*		
213	*Pentagonaster dubeni*		

Table 10.6. List of macroalgal species commonly encountered in Victoria and their codes.

Sp. Code	Species	Sp. Code	Species
	Macroalgae		**Macroalgae**
365	*Ulva* spp	329	*Macrocystis angustifolia*
514	*Chaetomorpha* sp	322	*Ecklonia radiata*
521	*Abjohnia laetevirens*	321	*Durvillaea potatorum*
850	*Cladophora prolifera*	340	*Xiphophora chondrophylla*
361	*Cladophora* spp	333	*Phyllospora comosa*
525	*Codium dimorphum*	338	*Seirococcus axillaris*
719	*Codium lucasi*	337	*Scaberia agardhii*
364	*Codium pomoides*	303	*Caulocystis cephalornithos*
523	*Codium duthieae*	300	*Acrocarpia paniculata*
528	*Caulerpa remotifolia*	311	*Cystophora platylobium*
357	*Caulerpa scalpelliformis*	310	*Cystophora moniliformis*
355	*Caulerpa longifolia*	508	*Cystophora grevillei*
359	*Caulerpa trifaria*	840	*Cystophora pectinata*
351	*Caulerpa brownii*	309	*Cystophora monilifera*
366	*Caulerpa obscura*	308	*Cystophora expansa*
353	*Caulerpa flexilis*	313	*Cystophora retorta*
369	*Caulerpa flexilis var. muelleri*	315	*Cystophora siliquosa*
354	*Caulerpa geminata*	314	*Cystophora retroflexa*
368	*Caulerpa annulata*	316	*Cystophora subfarcinata*
352	*Caulerpa cactoides*	302	*Carpoglossum confluens*
358	*Caulerpa simplisciuscula*	347	*Sargassum decipiens*
506	Filamentous browns	350	*Sargassum sonderi*
324	*Halopteris* spp	349	*Sargassum varians*
416	*Cladostephus spongiosus*	336	*Sargassum verruculosum*
2392	*Dictyota diemensis*	334	*Sargassum fallax*
320	*Dictyota dichotoma*	335	*Sargassum vestitum*
2397	*Dilophus angustus*	857	*Sargassum linearifolium*
2401	*Dilophus gunnianus*	858	*Sargassum spinuligerum*
812	*Dilophus marginatus*	344	*Sargassum* spp
862	*Pachydictyon paniculatum*	843	Brown algae unidentified

Sp. Code	Species	Sp. Code	Species
	Macroalgae		**Macroalgae**
702	*Lobospira bicuspidata*	515	*Gelidium australe*
809	*Padina* sp.	512	*Gelidium asperum*
319	*Dictyopteris muelleri*	409	*Pterocladia lucida*
705	*Chlanidophora microphylla*	396	*Pterocladiella capillacea*
502	*Distromium* spp	2306	*Delisea pulchra*
328	*Homeostrichus olsenii*	415	*Ptilonia australasica*
704	*Homeostrichus sinclairii*	438	*Asparagopsis* spp.
342	*Zonaria angustata*	2458	*Mastophoropsis canaliculata*
2408	*Zonaria crenata*	805	*Amphiroa anceps*
842	*Zonaria spiralis*	518	*Corallina officinalis*
343	*Zonaria turneriana*	806	*Haliptilon roseum*
2508	*Zonaria* sp nov	837	*Cheilosporum sagittatum*
509	*Lobophora variegata*	833	*Metagoniolithon radiatum*
345	*Carpomitra costata*	2559	*Arthrocardia wardii*
339	*Sporochnus* sp	2556	Encrusting corallines
332	*Perithalia cordata*	398	Corallines unidentified
301	*Bellotia eriophorum*	429	*Sonderopelta coriacea*
346	*Colpomenia peregrina*	430	*Peyssonelia novaehollandiae*
371	*Callophyllis rangiferinus*	391	*Sonderopelta/Peyssonelia*
452	*Stenogramme interrupta*	532	*Champia* sp
2307	*Rhodoglossum* sp	710	*Botrocladia leptopoda*
405	*Gigartina* sp	421	*Erythremenia minuta*
2439	*Callophycus laxus*	2463	*Rhodymenia australis*
834	*Erythroclonium* spp	2465	*Rhodymenia obtusa*
441	*Areschougia* spp	2466	*Rhodymenia prolificans*
860	*Areschougia congesta*	394	*Rhodymenia* spp
2443	*Acrotylus australis*	2569	*Hymenocladia chondricola*
384	*Plocamium angustum*	2570	*Hymenocladia usnea*
386	*Plocamium costatum*	721	*Ceramium* spp
387	*Plocamium dilatatum*	815	*Giriffithsia* sp
390	*Plocamium potagium*	370	*Ballia callitricha*
389	*Plocamium mertensii*	423	*Ballia scoparia*
412	*Plocamium preissianum*	410	*Euptilota articulata*
385	*Plocamium cartilagineum*	376	*Hemineura frondosa*
388	*Plocamium leptophyllum*	414	*Dictymenia harveyana*
395	*Phacelocarpus alatus*	378	*Jeannerettia lobata*
2444	*Phacelocarpus complanatus*	380	*Lenormandia marginata*
383	*Phacelocarpus peperocarpus*	408	*Lenormandia smithiae*

Sp. Code	Species	Sp. Code	Species
	Macroalgae		**Macroalgae**
2447	*Nizymenia australis*	605	*Laurencia clavata*
393	*Rhodophyllis membranacea*	448	*Laurencia elata*
2449	*Rhodophyllis multipartita*	593	*Laurencia filiformis*
2432	*Halymenia plana*	2477	*Laurencia tumida*
377	*Hypnea ramentacea*	379	*Laurencia* spp
2434	*Gelinaria ulvoidea*	374	*Echinothamnion hystrix*
2314	*Polyopes constrictus*	400	Filamentous red algae
392	*Thamnoclonium dichotomum*	399	Other thallose red alga
2311	*Gracilaria secundata*	808	*Halophila ovata*
2322	*Curdiea angustata*	402	*Amphibolis antarctica*
382	*Melanthalia obtusata*	401	*Heterozostera tasmanica*
2589	*Melanthalia abcissa*	461	Sand (exposed)

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

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

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

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