ATRC

Australian Temperate Reef Collaboration

Standardised Survey Procedures For Monitoring Shallow Temperate Rocky Reef Communities

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INTRODUCTION



This manual describes the Underwater Visual Census (UVC) methods for estimating densities of fishes, large macroinvertebrates, sessile invertebrates, and seaweeds on rocky reefs adopted by the Australian Temperate Reef Collaboration (ATRC, https://atrc.org.au/). This survey technique was established by Graham Edgar and Neville Barrett, has been utilised for annual surveys of Marine Protected Areas since 1992, undertaken by University of Tasmania staff in collaboration with government conservation and fishery agencies in Tasmania, Victoria, New South Wales, South Australia and Western Australia. Over 680 sites have now been surveyed using the ATRC methods (Edgar & Barrett 1997, 1999, Barrett & Buxton 2002), some with more than 30 years of annual replicate data. The data continues to inform government reporting and research regarding Marine Protected Areas, long-term changes in biodiversity, reef health, and key species with respect to climate change, fishing, and other anthropogenic impacts (Stuart-Smith et. al, 2017, Edgar et. al, 2020). Compatible methods are now applied globally by Reef Life Survey, a non-profit citizen science program (https://reeflifesurvey.com/) and data from both programs are collated by the National Reef Monitoring Network (NRMN), providing the most extensive and comprehensive marine species dataset of this kind in the world.

INTRODUCTION



Underwater Visual Census (UVC) techniques provide an effective, non-destructive way to monitor species at shallow-water sites because large amounts of data on a broad range of species can be collected within a short dive period, with little post-processing time required. The broad taxonomic range covered allows detection of human impacts affecting different levels of the food web, making these methods ideal for assessing and monitoring the effectiveness of management actions such as the declaration of Marine Protected Areas (MPAs), or the ecological consequences of localised pollution or ocean warming.

Monitoring programs associated with marine protected areas (MPAs), such as this one, need to cover a range of taxa because, in addition to heavily exploited species that are predicted to recover in new sanctuary zones, significant flow on effects of fishing associated with increased predator numbers may occur that would otherwise go undetected. For MPAs, the same sites should be investigated during different survey periods, with sampling repeated whenever possible in the same month in different years to minimise seasonal effects.

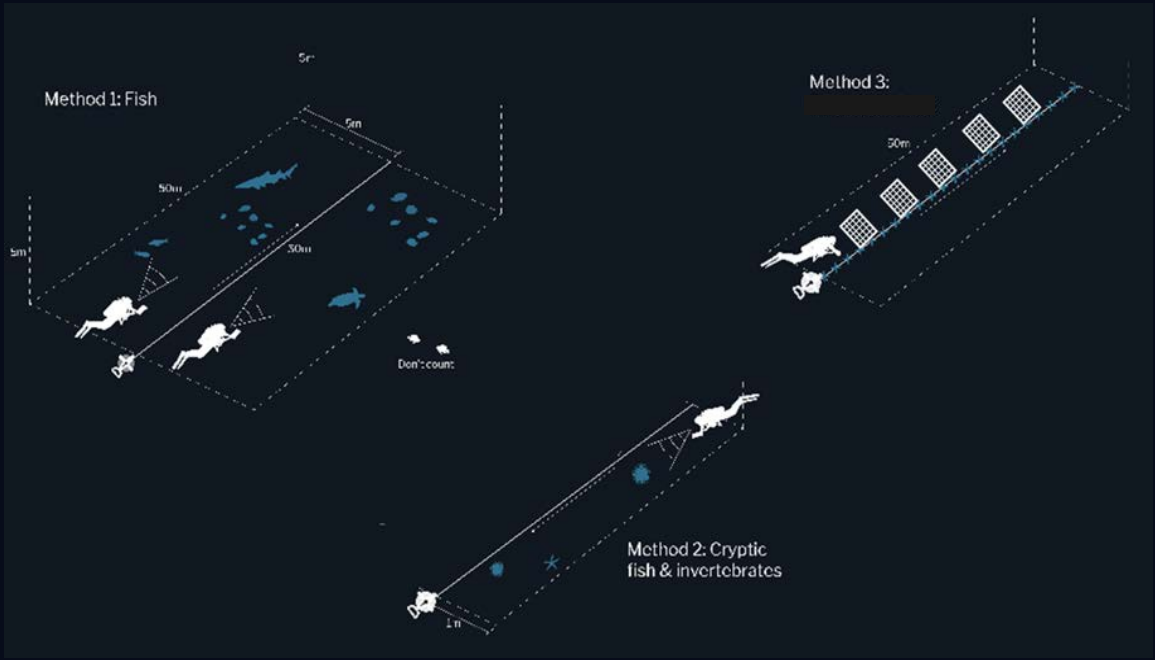
INTRODUCTION

These survey methods were designed to maximise the amount of ecological information related to all conspicuous taxa that can be obtained during a dive with a single tank of air, based on a 2 - 4 person dive team.

Typically, sites are surveyed at 5m and/or 10m contour depths. At core sites, visited every 1-2 years, the same depth(s) are surveyed every time, starting from the same GPS point. For MPAs there will be number of sites within protected zones and some nearby where fishing is permitted.

A trained dive team usually surveys three sites per day comfortably, depending on the biological complexity of the sites and the weather conditions. Tasks are divided between divers based on biological knowledge of the area, survey skills and experience.

INTRODUCTION



The basic unit monitored at each site is a 200 m long transect line, subdivided into four 50 m lengths, that is set along a defined depth contour. Along the transect line three core survey methods are applied, each focusing on different major taxonomic groupings (Method 1 for fish, Method 2 for macro-invertebrates and cryptic fish, and Method 3 for sessile invertebrates and seaweeds). The width of survey area is different for Method 1 and Method 2, and Method 3.
Because data can vary with relatively slight modifications to protocols (e.g. with different transect band-width or diver swimming speed for fishes), it is important that these methods are consistently applied. Data generated are most usefully applied in a relative sense (i.e. for comparing sites or times when data are collected using the same methods). Data collected by different divers on a field trip should be compared for consistency between divers as soon as possible, particularly during early surveys.

SURVEY EQUIPMENT

- 2 x 100 m lead core transect line (better for sites with surge), or 4x50 m fibreglass transect lines, marked with distance measures
- 2 quadrats, 50 x 50 cm with 7 stainless wires each direction
- Calipers (plus spare) for measuring abalone and lobster sizes
- Camera for identification/reference photos
- Either catch bag or clips on BC to hold slate & transect line. *(It is very important to be able to clip your slate onto your BC to allow the use of two hands during the invertebrate/cryptic fish survey when surveying in kelp).*
- Slate, pencil (and a spare pencil) and waterproof paper.
- GPS to record site position.
- Marker float for GPS position when not anchoring on site.

BEFORE THE SURVEY

Prior to all surveys, dive teams need to be clear on dive safety procedures, both to minimize the risk of problems developing, and so that participants all know what actions are required if an accident does occur. Safety margins should be factored into all dive plans, and buddy checks completed before entering the water. Each diver must be certain of what they are doing and where they are going.

It is essential that all members of the group collaborate and record the same general site details on each datasheet, and that datasheets of buddy pairs have all survey details exactly matching (i.e. Site Name, Site Number, Latitude, Longitude, date, Depth, and Direction). If this information is not recorded before the dive, then it must happen directly after the dive.

For example:

- Assess the site for conditions needed for a successful survey i.e. swell, visibility, diver safety. Complete relevant on-site Assessment and Hazard Checklist.
- Dive briefing: ensure team members are aware of the dive plan, tasks, risks associated, and clear on the relevant dive safety procedures.
- Ensure the field team and trip plan has been lodged and approved by relevant safety officers, and that all staff and volunteers are aptly qualified and able, and that the appropriate equipment is available prior to leaving.
- Be sure that all relevant site information (i.e. date, depth, site name, site code, time, GPS, transect direction, buddy, is recorded on each diver's data sheet).
- Conduct relevant dive safety checks, as per protocol, including buddy systems and risk mitigation/safety margins relevant to the dive.

SURVEYING A NEW SITE



Transects should be positioned on hard substratum (patches of sand or silt are acceptable, but aim for at least 90% hard substratum).

Select reefs that extend for at least 200 m along a given depth contour, usually 5 or 10 metres however other depths may be chosen due to reef structure or exposure to prevailing swell conditions. Anchor, or place a surface marker buoy, in the middle of the reef (or midpoint of where you want the transect to run).

Record the position where the transect line is to start in decimal degrees to 5 decimal places using WGS 84. [Note: a boat at anchor will sit away from the anchor], and a local site name based on geographical features.

A hand drawn “mud map” can be useful, indicating reference points in relation to the shore and the layout of the transect line where the reef contour is convoluted. If relevant, it is important that the direction of the lines from the midpoint or the GPS point is recorded so that if the transect is resurveyed at a later date then the line will be placed in the same direction.

RE-SURVEYING AN EXISTING SITE

Most ATRC surveys resurvey an existing site, in order to gather data to compare over time. If resurveying an existing site, the site code and name and the GPS coordinates should be obtained from the program data officer.

If conducting a re-survey of an existing site it is crucial to go to the EXACT GPS coordinates associated with that site. If safe to do so anchor on it. If it is not safe to do so, leave a weighted marker float at the GPS point. If the GPS coordinates are incorrect and the site location is adjusted, record new coordinates on the dive data sheet for that site. Consider any large tidal variations when assessing the depth of the site, as compared to the original surveys.

SURVEY METHODS

A single complete 50 m survey consists of the following components:

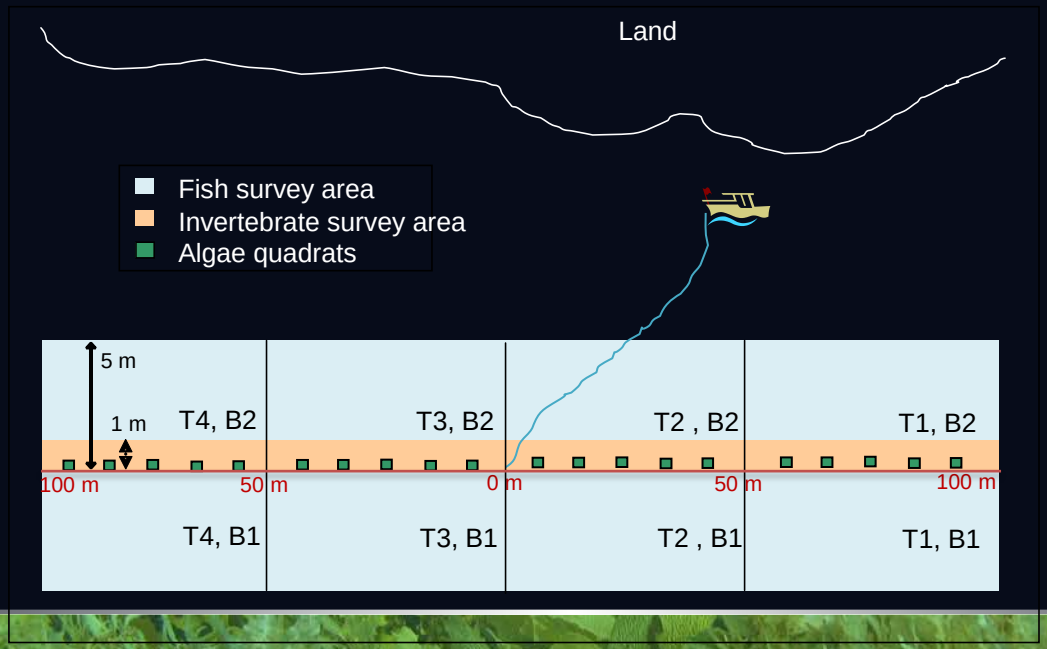
- **METHOD 1: Fishes** are surveyed in two 5 m wide by 5 m high bands or (“blocks”), parallel with each 50 m transect length.
- **METHOD 2: Invertebrates and cryptic fishes** are surveyed in a 1 m wide by 2 m high band on one side of the transect line.
- **METHOD 3: Sessile invertebrates and macroaglae** are surveyed in-situ using 50x50cm quadrats, completed at 10m intervals along the transect line (i.e. 5 per transect)

SURVEYING A SITE – Recording data

Record the following header information: date, depth of transect, diver name, site name, time, direction, buddy, and visibility (measure this out along the line during dive)

Four 50m transects, laid end to end along a depth contour, are surveyed at each site. As well as dividing the data into transects, the fish data are separated into blocks either side of the line. It is important to ensure both buddies have the appropriate transect number and block number next to their recorded data, and that all transects and blocks are accounted for. Record what method, transect (T1, T2, T3, T4) and block (B1, B2) you are working on and make a clear distinction (draw a line) between data for different transects and blocks.

If you have only done part of a transect make a clear note about where you are up to and who (if anyone) has done the rest. Add the extra data for the transect from the other persons sheet as soon as you get into the boat if possible.



SURVEYING A SITE – Laying the transect

Lay the transect along the reef contour, as close as possible to the agreed depth (note most divers swim approximately 1 m off the bottom when laying the line, so the depth gauge of the diver should read 1 m less than the desired depth or the transect will end up too deep). On steep surfaces, to hold the line in position you may have to wrap the transect line around an algal holdfast or rock in some places. This is particularly important where there is a wall or drop off.

If you run into extensive sand or soft sediment then change direction, following inside the reef edge (keeping 2.5 m inside the reef edge if possible so that the full width searched for fish remains over reef substratum). In these circumstances avoid sharp angles and if the line ends up parallel to itself make sure there is a least a 6 m gap. In some cases the reef edge will become progressively shallower, in which case it is best to stay inside the reef rather than extend the transect over sand. The actual depth range of the transect should then be recorded on data sheets (e.g. 3.8-5.0 m rather than 5 m).

If the reef is very flat it may be necessary to take a bearing of the coastline before descending from the surface, or take notice of the sun angle. Check the depth and then lay the transect line along the bearing, in order to avoid inadvertently swimming in an arch or circle

SURVEYING A SITE – Division of labour

Workload is divided between members of the dive team in a way that optimises efficiency.

Division of tasks thus depends largely on the size of the team, who is skilled in what disciplines, depth and survey location (some locations take longer for particular taxa). It is also optimal to avoid only one person collecting the data for a method at a site, to minimise any diver-bias.

Figure 2 show a possible division of labour for a four person dive team with 2 people competent at surveying macroalgae and sessile invertebrates (M3) and fish (M1), and 2 divers competent at surveying fish (M1) and invertebrates and cryptic fish (M2).

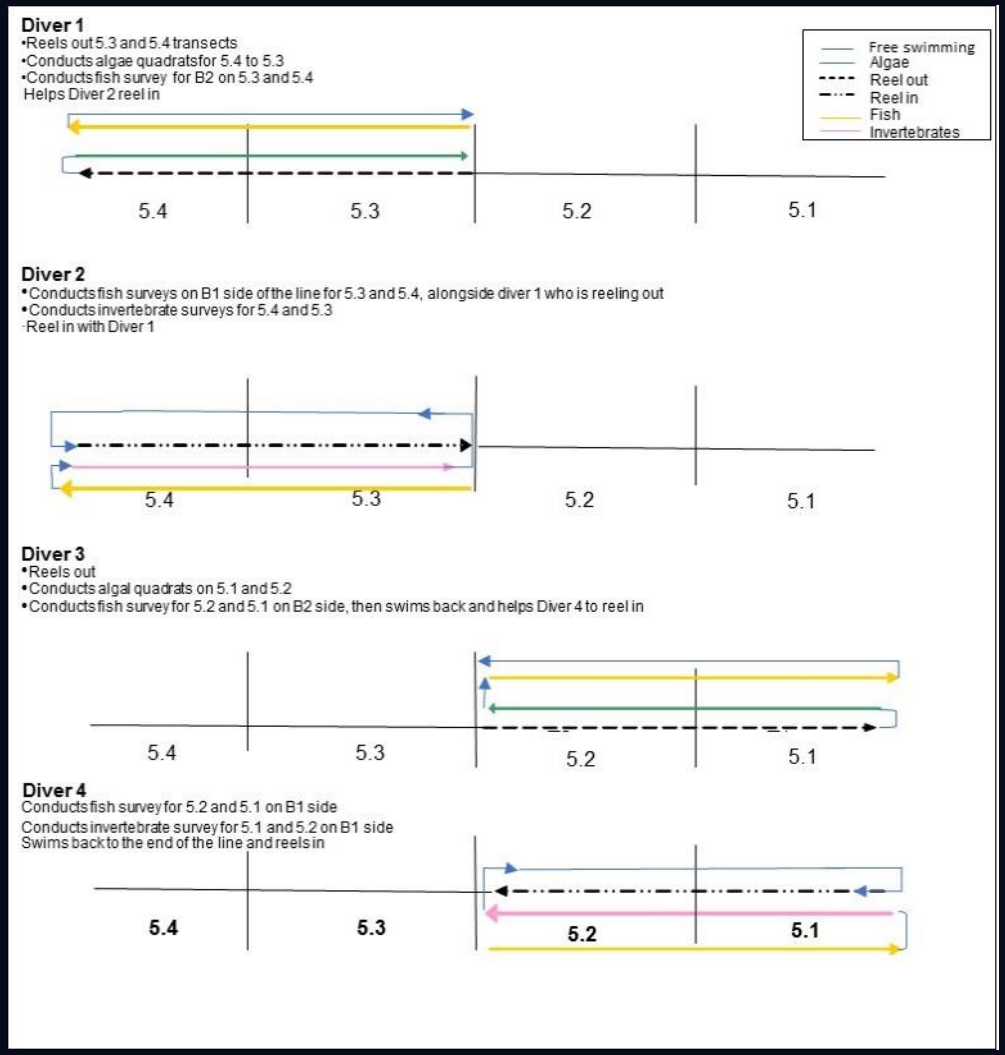


Figure 2: Possible division of labour for a 4 person dive team.

METHOD 1 – FISH SURVEYS (M1)

TARGET GROUP: *All fishes* and other large swimming animals (e.g. squid, octopus, jellyfish, seals, turtles, whales etc.)

During the fish survey, the number and estimated size-category of all fishes sighted within 5 m blocks either side of the transect line, and within a 5 m high ceiling (and 5 m deep floor if applicable, see section on methods for surveying walls in appendix 2) is recorded as the divers swim slowly along the block. The deeper side of the line is referred to as “Block 1” or “B1”, and the shallower side, “B2”. Data for the two blocks are collected and recorded separately whether done by one or two divers.

Size-classes of total fish length (from snout to tip of tail, or longest distance, including for stingrays) used are 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 50.0, 62.5 cm, and above. Lengths of fish larger than 62.5 cm should be estimated to the nearest 12.5 cm and individually recorded.

Fish species sighted outside of the 5 m blocks, or at a time other than during the fish swim should be recorded separately—particularly if they are rare or may be outside of their usual distributional range. These species when seen “off-line” should be recorded as “method 0” (see page 20).

METHOD 1 - TECHNIQUE

Visualise a 5 m wide and high “tunnel” (bordered along one edge by the transect line). Divers swim along the middle of this about 1 metre from the seabed, but can move to the right or left to search the entrances to caves and under ledges (see figure 2). [As a reference, the distance of 2.5 m is approximately the length of a tall diver with arm outstretched in front from fin tip to finger tip, but you should measure this on yourself to become familiar with this distance]. Divers should practise estimating distances underwater under varying visibilities.

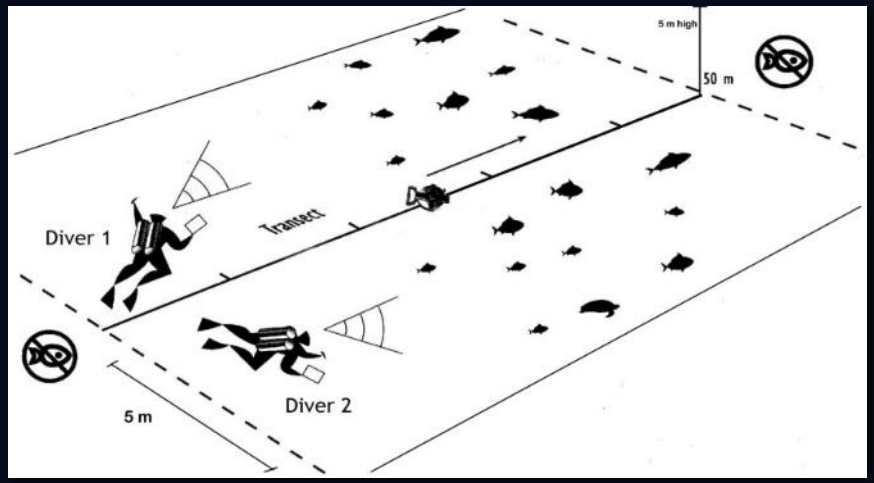


Figure 2. Stylised representation of method 1 survey technique

Record the size and number of individuals of all fish species seen within the block.

If identification is not possible, then take a photograph, draw a picture, and/or write a descriptive note (the more information the better). Be sure to ask others/check books at the end of the dive. Do NOT ignore unidentified species. Make a record of any fish you see that you can’t identify but are sure is different from other species recorded. It is much better to include (e.g. as unidentified member of a particular genus or family) than make no record at all – it is still important species richness information.

METHOD 1 - TECHNIQUE



- Where fish are schooling, estimate abundance by counting a subset and then multiplying by the number of similar subsets you would estimate to fit into the school.
- Don’t count fish that overtake you.
- If you recognise the same fish that has been recorded in the other block (i.e. see a fish that has obviously moved across the transect line), still record this animal (this balances out other fish that moved across the line in the opposite direction, and were not counted), but don’t re-record one that you know you have already counted within the same block.
- As best as possible, avoid counting fish when there are other divers in close proximity as this can affect fish counts (plan dives so fish counts can be done with minimal disturbance). If sea lions or other large marine mammals are around, then make sure that their presence is noted on data sheets since this can greatly affect the fish survey.

METHOD 1 – HOW TO DEAL WITH HIGH DIVERSITY AREAS

Surveys of high diversity areas, such coral reefs, requires substantially more survey experience, preparation and attention to detail. In such areas, when it is impossible to record counts for all fishes seen, there is a defined order of priority for accuracy of information.

- Priority (1): get an accurate species list; i.e. record the names of every new species seen before worrying about anything else
- Priority (2): individually record the abundance and size of large or rare species
- Priority (3): estimate of abundance of other species
- Priority (4): partition abundance estimates among estimated size classes for other species

Note that all of these components must still be undertaken by the end of the fish survey (*before* starting Method 2), but that they should be done in this order, often with the last two priorities done at intervals along the line or at the end of the line if necessary.

METHOD 2 – MACROINVERTEBRATE & CRYPTIC FISH SURVEYS (M2)

TARGET GROUP: Mobile invertebrates and fishes in families likely to be overlooked in M1 (see next slide for details on the target group)

Large macro-invertebrates (large molluscs, echinoderms and crustaceans) and cryptic fishes (i.e. inconspicuous species closely associated with the seabed) are censused along the same transect lines set for fish surveys. During M2 searches, divers swim along the bottom, counting all mobile macro-invertebrates within 1 m horizontal distance of the line, to a maximum of 2 m height above or below the line on steeply-sloping reefs. Data for the two blocks (either side of the line) are recorded separately.

A mental tally of the number of the most common two or three species can be kept to minimise the number of times you need to stop to make a record on the slate, but at locations where large numbers of macro-invertebrates (particularly sea urchins) are present, divers should write down data on the underwater slate at least each 5 m along the transect line.

Size information is not required for invertebrate species, with the exception of lobsters and abalone, for which the carapace length and shell width should be estimated, respectively.

Record size information for all cryptic fish.

The invertebrate and cryptic fish data are analysed separately from the fish survey, so any cryptic fishes that may have already been recorded on the M1 fish survey should still be re-recorded in M2.

METHOD 2 – MACROINVERTEBRATE & CRYPTIC FISH SURVEYS (M2)

Target group details (also see Appendix 1)

- ‘Large’ invertebrates refers to those that are more than 2.5 cm (approximately 1 thumb tip) when mature.
- Invertebrates counted include large molluscs (e.g. nudibranchs, abalone and whelks, giant clams, scallops), echinoderms (e.g. feather stars, sea cucumbers, sea stars, sea urchins) and crustaceans (e.g. lobsters, large crabs and hermit crabs).
- Cryptic fishes are those closely associated with seaweeds or the seabed such as gobies, blennies, triplefins, cardinal fishes, scorpionfishes, frogfishes (anglerfishes), cat sharks, rays, and moray eels. All families considered cryptic and to include in M2 are listed in Appendix 1.
- Fishes **not** regarded as cryptic, hence not generally counted in M2, include wrasses and damselfishes, for which method 1 provides better density estimates. If such species are seen during M2, but were not recorded during M1, they can be recorded as “Method 0” (see slide 20) – but *never* added to M1 datasheets afterwards.
- Invertebrates *not* counted include any species permanently attached to the seabed other than scallops, pearl oysters or giant clams. Thus, edible oysters, mussels, sponges, anemones (other than the large ‘swimming’ anemones), barnacles and corals are not counted. Small (<2.5 cm) molluscs also are not counted, as these can occur in very high abundance and take up too much dive time. Small abundant shrimps (<2.5 cm) are also not counted, nor are brittlestars and chitons, even if they grow larger than 2.5 cm.

METHOD 2 - TECHNIQUE

- Stay close to the bottom and push aside any seaweeds to reveal the substratum. If large seaweeds are present, it usually helps to clip your slate off to your BC and use both arms in a “breaststroke” fashion to part the seaweed for this (this also helps ensure that the full 1 m width can be effectively searched). In coral dominated areas, care should be exercised to maintain good buoyancy to stay as close to the bottom without touching it and breaking the coral (and likewise avoid any gear dangling and breaking coral).

- Some urchins and gatropods live curled up in seaweeds and can be felt as the seaweeds are moved aside. These should be counted.

- Record abundance and size of all invertebrates and cryptic fishes on all surfaces of the substrate in 2 m high and 1 m wide bands on each side of the transect line (see figure 3). This includes the top and bottom of some overhangs, or at least the portion of them within 1 m of the line. Search all crevices, cracks and walls for animals visible from the entrance but do not turn over rocks or boulders.

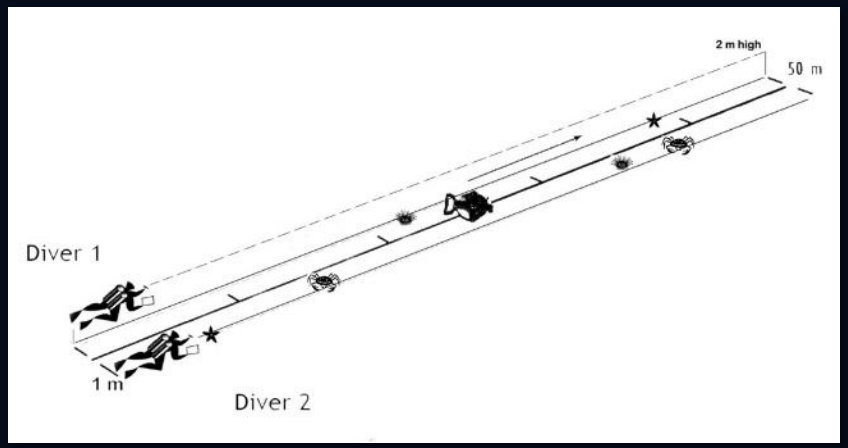


Figure 3. Stylised representation of method 2 survey technique

METHOD 2 - TECHNIQUE

- Rock lobsters and abalone need to be counted and also measured vernier callipers to at least 5mm accuracy. If you cannot catch the animal, estimate the size as best you can and note that you have made an estimate on your data sheet by writing an E after the size. Abalone size is measured across the widest part of the shell and rock lobster size is measured from the antennal horns to the rear edge of the carapace.

- Estimate and record size of cryptic fishes using the same size categories as for M1

- Some programs require divers to also measure all other M2 invertebrates using the same size categories as for M1, except for lobsters and abalone. Starfish sizes are estimated from the centre to the tip of the arm (radius), urchins are estimated by the widest part of the test (excluding spines), gastropods by shell length, and crabs are measured using carapace width.

- Only measure the first 20 or each species per 50 m transect but make sure to count the abundance of all thereafter.

METHOD 2 - TECHNIQUE

- It is easy to accidentally “narrow” your focus and search a band less than 1 m wide when in dense kelp. Conversely, it is also easy to accidentally “broaden” your focus to wider than 1 m when in areas of bare rock or coral and when not swimming close enough to the substrate. To avoid this, using the transect markings as a ruler, measure where on your body 1 m reaches from fingertips across your outstretched arm and chest. Then, whilst searching, regularly reach out to the tape to calibrate the outer boundary of the band. This is particularly important when deciding whether to count an animal that is close to 1 m away from the tape.

- Where numbers of large macroinvertebrates are extremely dense, such as beds of screw shells or turbo shells, numbers can be estimated in a patch by counting a subset and multiplying by the estimated area along the transect line (in the 1m search-band).

- If identification is not possible, take a photograph (of both the upper and lower views for molluscs) and make a note on your data sheet.

Count “swimming anemones”

Photograph both sides of unknown gastropods

Non-sessile bivalves can be counted

METHOD 3: In Situ quadrats

TARGET GROUP: All algae, sessile invertebrates (including corals) and substratum categories (e.g. sand).

TECHNIQUE:

- Five quadrats are sampled per 50 m transect segment, making 20 per site
- Quadrats are placed at 10 m intervals, marked on the transect line.
- Record how many contact points the algae (inverts or substratum) has with the 50 quadrat points. Contact points consists of the 49 quadrat intersection points plus one corner

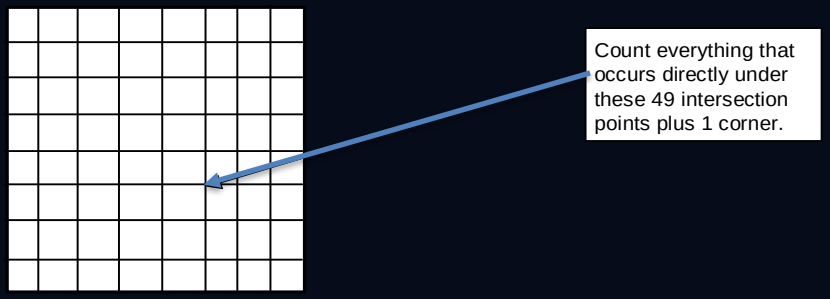


Figure 4. Diagram of quadrat used in algae surveys.

METHOD 3: In Situ quadrats

TECHNIQUE Continued:

- Count all layers of algae. This is done by counting the canopy species, then brushing these aside to count what is underneath, keep going through the layers until you reach the substratum, then finally record the composition of the substratum layer. NOTE: the lowest layer recorded is often a mixture of substrate, encrusting or turf forming species.

- Try to identify algae to species, if not possible then to genus, or accepted categories as per the tables in Appendix 2. Sponges, ascidians and others sessile invertebrates are often lumped into broad categories such as: “encrusting sponge”, “massive sponge” etc.

- If identification to species or genus is not possible while underwater then make a note on your data sheet, take a sample (try and get an entire plant) and/or photo and ask others/check books at the end of the dive. You may also press the alga for future reference. Ensure you have marked on your data sheet the result of your queries by the end of the trip so that it may be entered affectively into the database.
- Urchin barren identifiers are recorded, where the quadrat is situated on more than 75% urchin barren. This is done by recording 50 points of the code for barrens, “BRB”. In addition to this, the normal quadrat procedure is conducted, including scoring all points of bare rock in the substratum under the normal code for bare rock “BRN”.

ADDITIONAL METHODS

METHOD 4 – Macrocystis M4

TARGET GROUP: Macrocystis pyrifera plants

TECHNIQUE:

- In areas where Macrocystis occurs we add an additional survey count. This is done by counting the number of Macrocystis plants that are taller than 1m in a 2 m wide swathe (1 m on either side of the line) in 10 m long blocks. Count each 10 m block while swimming between successive algal quadrats. A total of 20 counts per site. If you are using this method be sure to make a clear note on your data sheet.

ADDITIONAL METHODS

METHOD “0” - M0

This method is not a defined part of an ATRC transect, but rather a way of recording species that were not included within the time and space boundaries of M1 and M2.

This can be done at any stage of the dive and for any species, and serves two main purposes:

1. To allow a mechanism for recording the presence of species which were not recorded in M1 or M2 (this is particularly important for rare species, or those that are outside of their usual distributional range, or a large school of pelagic fish off-transect).
2. To allow people to record more species without ‘cheating’ by including those only seen beyond the 5 m or 1 m boundary for M1 or M2, or during a part of the dive in which they were not specifically undertaking the method designed to record those species (e.g. if a non-cryptic fish species, like a wrasse, was not seen during the fish survey (M1), but is seen whilst doing the invertebrate survey (M2)).

- **It is critical not to include such species in M1 or M2 as this will bias results**.

M0 observations can be recorded at any time, and on any part of the datasheet, provided it is clear that these are separate from the remainder of the data (usually the bottom of the page is best if there is space).



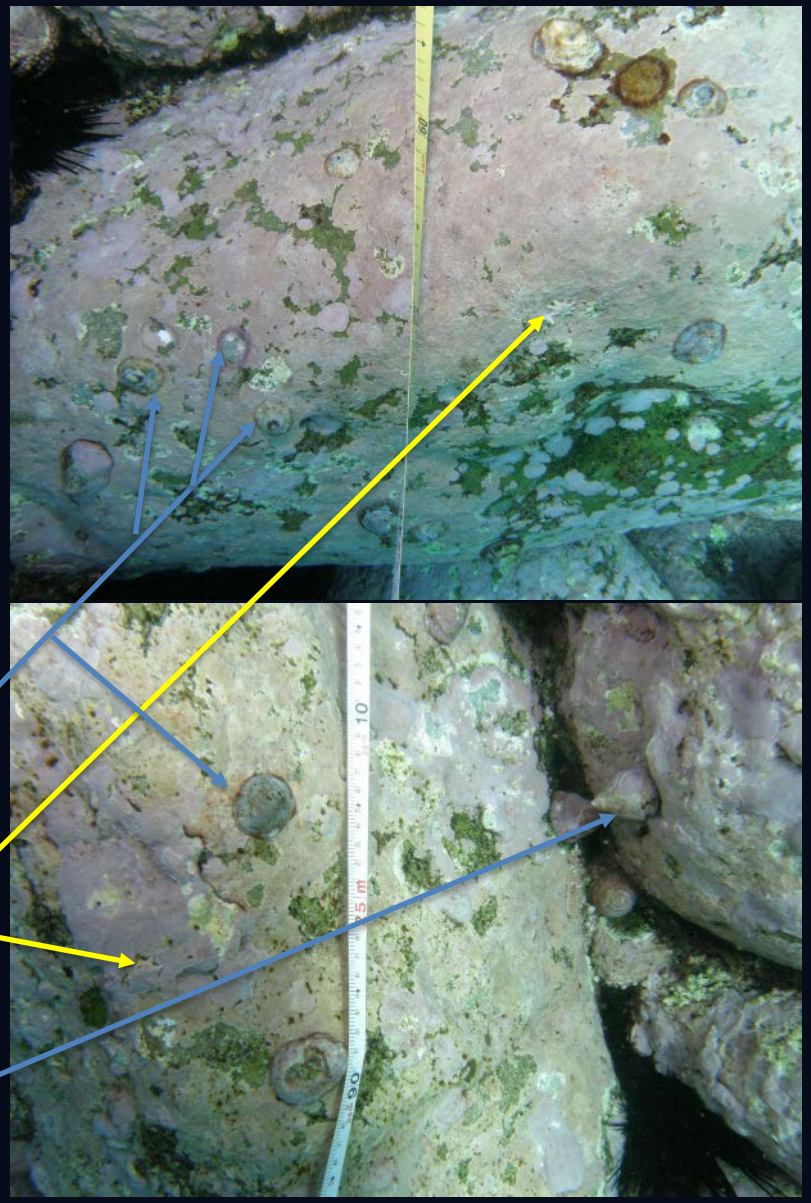

ADDITIONAL METHODS

METHOD 5 – Limpet counts

TARGET GROUP: Limpets

TECHNIQUE:

- In NSW additional counts of turban shells (*Astralium tentoriformis and A.squamiferum*) and limpets (*Scutellastra chapmani*) as a total count under each quadrat. Again if you are using this method make a clear note on your data sheet saying what you have done. Other, difficult to identify limpets are recorded as “unidentified limpets” and still counted.



ADDITIONAL METHODS

PHOTOQUADRATS (PQs)

TARGET GROUP: All algae, sessile invertebrates (including corals) and substratum categories (e.g. sand).

In instances where a lack of resources dictate that Method 3 cannot be completed, this method can be replaced with photoquadrats. The percentage cover of different macroalgal, coral, sponge and other attached invertebrate species in photoquadrats is later assessed using specialised computer software and is thus not part of the survey.

Digital photoquadrats are taken directly downwards from approximately 50 cm above the seabed (usually sufficient to encompass an area of approximately 0.3 m x 0.3 m).

ADDITIONAL METHODS

PHOTOQUADRATS (PQs) - TECHNIQUE

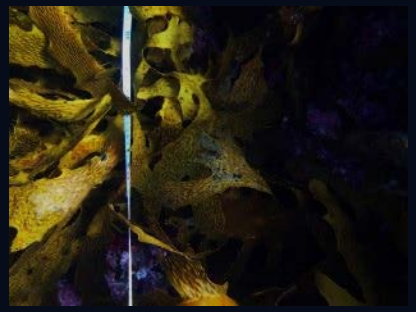
Using a digital camera, 20 quadrats are photographed along each 50 m transect, at distances of 2.5, 5, 7.5, 10, 12.5, 15, 17.5 m, and so on up to 45m, then at 47.5 and 49 m positions as marked on the transect line.

A photo showing the divers depth gauge or dive computer should be taken at the start and end of the photo-quadrat run along each transect (to 'bookmark the photo-quadrats), and a single shot should also be taken at the start of the line, looking along the line to show the general habitat (unless experienced with wide-angle photography, it is best to turn the flash off for this shot, but then turn it back on for the PQs).

Photo-quadrats are usually centred on the transect line, with the line running across the shortest axis of the picture (see examples below).

If the survey tape is not lying on the bottom, don't worry about trying to get the tape in the photo, and instead lower the camera to 50 cm from the bottom to ensure a clear photo of the substrate.

GOOD – In focus and sufficiently lit. Transect line vertical across shortest axis



NOT SO GOOD – Seaweed in focus, but large dark areas

BAD – Too much back-scatter, seaweeds not easily identifiable

ADDITIONAL METHODS

PHOTO QUADRATS (PQs) - TECHNIQUE

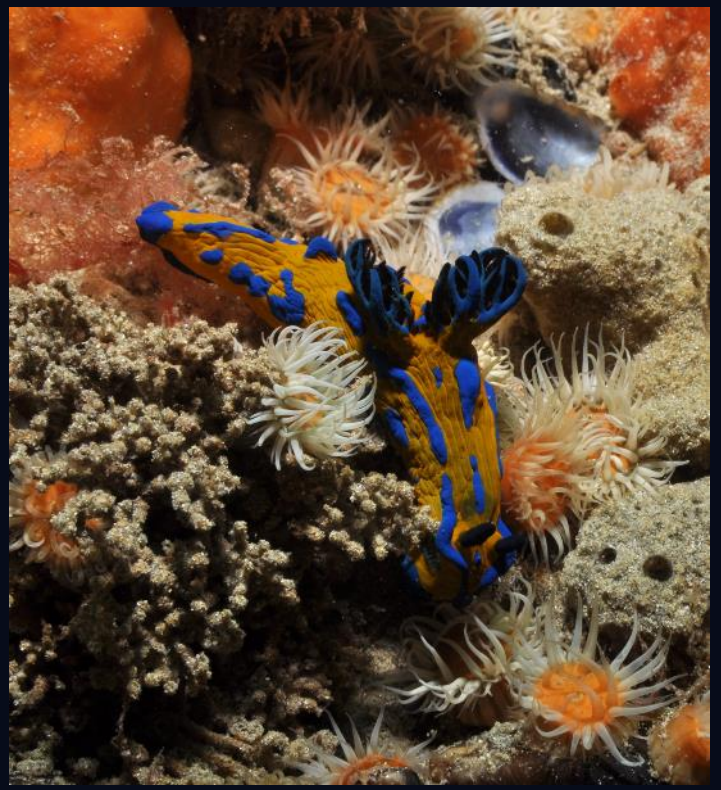
A flash should generally be used. If a separate strobe is not available and the camera's in-built flash is used, a closer shot that encompasses a smaller area of the seabed, but more clearly shows the seabed, is preferred over a larger quadrat in which the substratum is unclear due to turbidity or backscatter.

The exact area photographed is not critical because information is calculated from each image as a percentage, not total density. It is more important to take a sharp image without dark areas or too much backscatter than to worry too much about the size of image. If you need to go closer to take good clear images, then increase the number of photos taken (for example, take 40 pictures if they are only 15 cm x 15 cm each).

Use wide angle lens or zoom at widest angle when available. Use highest digital resolution and largest recorded image size possible. Save images in highest resolution .jpg rather than raw.

PQs should be downloaded and labelled as soon as possible, following the naming convention on the next page.

PQs can be sent to RLS via email, Dropbox, or post.



ADDITIONAL METHODS

LABELLING PHOTO QUADRATS

PQs should be labelled consistently to include all of the following 5 bits of information:

- Site code (e.g. NSW12)
- The initials of the photographer/RLS diver who is submitting the PQs.
- Transect depth (followed by 'm' for metres)
- Date (6 digits, e.g. 021108 for 2 November 2008)
- Site name (this can be abbreviated, but should be easily identifiable)

Underscores can be used to separate numbers from two of these naming components.

e.g. for PQs taken by Rick Stuart-Smith at site number NSW12 at 7 m depth on 25 January 2010 at Bushranger Bay, Bass Point, the labels would be:

NSW12_RSS7m250110BushrangerBay

Photo-quadrats should be labelled as a batch for each transect, using the *rename* function if you use Windows. This involves highlighting all photos for one transect, leaving the cursor on the first of these highlighted quadrats, right-clicking and going down the bottom of the scroll list to the *rename* function. This highlights the title of the first photo-quadrat and details should then be typed in. The rename function will apply this code to all PQs for that transect followed by (1), (2) etc.

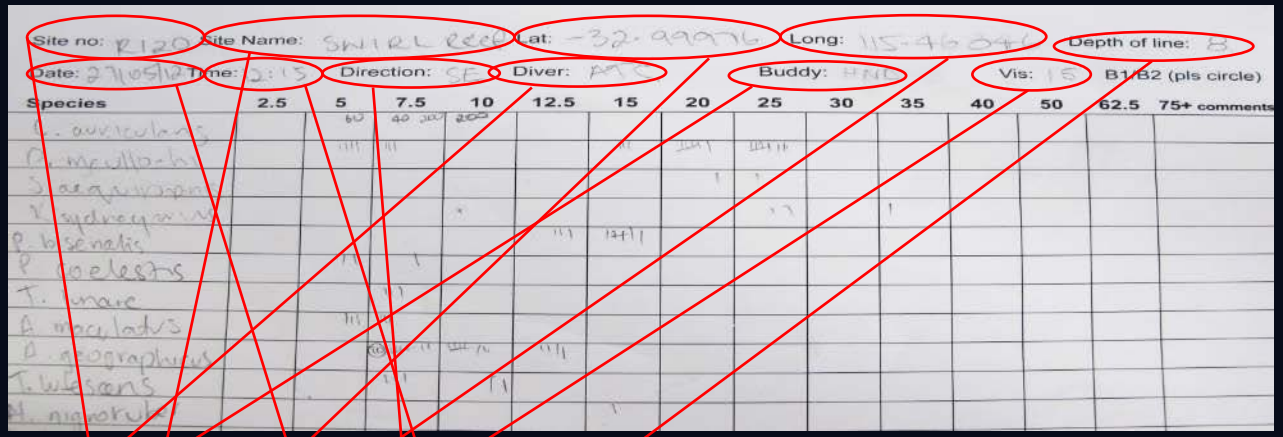
It is very important that the details in the PQ labels match the details for that survey in the datasheet exactly to allow these two parts to be matched up in the RLS database – so cross check depth and site codes in particular, to ensure they match what you have entered into excel and what your buddy has entered.

All images for each transect should be put in a folder for that transect, with the folder labelled with the same format.

DATA ENTRY

Data should be entered onto specifically-designed ATRC Excel templates, which can be obtained from the data officer. Numerous surveys can be entered onto these templates, one below another, but be careful to ensure the appropriate site numbers, depths etc. are changed when new transects are started.

On data entry the four 50m transects from a site will use the same depth integer, but will differentiated by their depth's decimal values (i.e for a five-metre site transect 2 will have a depth of 5.2m, and transect 1 will have a depth of 5.1 m); this is because in the NRMN database it is the site code x depth x date combination that distinguishes different 50 m surveys.



ID	Diver	Buddy	Site	Site Name	Latitude	Longitude	Date	vis	Directi	Time	P-Qs	Depth	Meth	Block	Code	Species	Total	Inverts	2.5	5	7.5	10	12.5	15	20	25	30	35	40	50	62.5	75	87.5	100	112.5
										12:00			0-2	0-2					1	2	3	4	5	6	8	10	12	14	16	20	25	30	35	40	45
##	ATC	HND	RI20	Swirl Reef	-32.9998	115.4605	27/05/2012	15	SE	12:15	ATC	8	1	1	cau	Cons aunculanis	500	0		60	240	200													
##	ATC	HND	RI20	Swirl Reef	-32.9998	115.4605	27/05/2012	15	SE	12:15	ATC	8	1	1	pmc	Parma mcculloch	23	0		4	3			3	6	7										
##	ATC	HND	RI20	Swirl Reef	-32.9998	115.4605	27/05/2012	15	SE	12:15	ATC	8	1	1	sae	Scorpis aequipinnis	2	0								1	1									
##	ATC	HND	RI20	Swirl Reef	-32.9998	115.4605	27/05/2012	15	SE	12:15	ATC	8	1	1	ksy	Kyphosus sydneyanus	3	0									2		1						
##	ATC	HND	RI20	Swirl Reef	-32.9998	115.4605	27/05/2012	15	SE	12:15	ATC	8	1	1	pbi	Pseudolabrus biserialis	9	0						3	6											
##	ATC	HND	RI20	Swirl Reef	-32.9998	115.4605	27/05/2012	15	SE	12:15	ATC	8	1	1	pco	Pomacentrus coelestis	3	0		2	1															
##	ATC	HND	RI20	Swirl Reef	-32.9998	115.4605	27/05/2012	15	SE	12:15	ATC	8	1	1	tlu	Thalassoma lunare	3	0			3															
##	ATC	HND	RI20	Swirl Reef	-32.9998	115.4605	27/05/2012	15	SE	12:15	ATC	8	1	1	ama	Austrolabrus maculatus	6	0		3	3															
##	ATC	HND	RI20	Swirl Reef	-32.9998	115.4605	27/05/2012	15	SE	12:15	ATC	8	1	1	age	Arripis georgianus	29	0			17	8	4													
##	ATC	HND	RI20	Swirl Reef	-32.9998	115.4605	27/05/2012	15	SE	12:15	ATC	8	1	1	tlut	Thalassoma lutescens	5	0			3	2														
##	ATC	HND	RI20	Swirl Reef	-32.9998	115.4605	27/05/2012	15	SE	12:15	ATC	8	1	1	hni	Hypoplectrodes nigroruf	1	0						1												

Figure 4. Example of how underwater data sheets relate to the Excel data entry template.

TIPS FOR ACCURATE TRANSCRIPTION OF SURVEY DATA

- When underwater, write words on the underwater data sheets as clearly as possible with printed letters. Don't forget that others may need to read your entries down the track to crosscheck.
- Record which block you are working on and make a clear distinction (draw a line) between data belonging to different blocks and between data from methods 1 & 2.
- Record abundance information as either a written number or by using tally lines in groups of 5. Always distinguish between groups of numbers with commas or by underlining (e.g. avoid 32 being interpreted as a 3+2) and take particular care with written 11 (eleven) as this looks identical to two tally strokes.
- Try and use recognised names for animals (preferably scientific but common names are fine) underwater. It is o.k. to make up your own naming conventions or codes for species but consistency is key and correct names must be added clearly in PEN (preferably red so it stands out) at the end of the line after the data sheet is dry.
- Data should be entered onto the template as soon as possible after the dive to improve accuracy and prevent loss of important information (i.e. before memory becomes fuzzy!) see figure 4.
- Method 0 observations should be given a value of "0" in the block column of the data entry template as they don't relate to a specific survey component.
- If a survey is done, but no species were in that block (sometimes happens for fish), enter the blocks method, block number and the species "No species found" with a total of "0"

HOW TO DEAL WITH UNIDENTIFIED SPECIES

In some cases, you may come across species which aren't in any identification book and you just can't identify it to species level. If this happens:

1.) Email a photo of the unknown species - if you don't have a photo then it is probably most accurate to record it to genus level if known (i.e. *Genus* spp.), or even family level if genus is unknown (i.e. Family spp.)

2.) If a species level identification cannot be provided then the photo should be labelled according to the following syntax:

Scenario a.) *Genus ?species*

This naming convention is used when you are sure of the genus and you believe your species may be a form or variant or another described species. E.g. *Pomacentrus ?coelestis* would be a *Pomacentrus* species which may be *coelestis* or an undescribed species closely resembling *P. coelestis*

Scenario b.) *Genus species* [?]

This is for when you are unsure of both the genus and the species but you believe your species may be a form or variant or a particular described species. E.g. *Pomacentrus coelestis* [?] would be used for a damselfish which you believed may be a variant of *Pomacentrus coelestis* but could still possibly belong to a different genus. This is the same as the general scientific protocol of adding preceding the genus name with the question mark (but is easier to sort and search)

Scenario c.) *Genus sp.* [identifying character]

When you are sure of the genus (or family) but the species can't be determined with confidence, a qualifier can be placed in the square brackets. E.g. *Pomacentrus sp*. [blue ear spot]

It is critical that the photo of the unknown species receives the same naming convention and that the photo is sent in at the same time as the data.

APPENDIX 1. – GROUPS OF INVERTEBRATES & FISH FAMILIES COUNTED IN METHOD 2

Table 1. Invertebrate groups counted in the Method 2 search

PHYLA/GROUPS	ORDER/SUB-GROUPS	RULES/EXCEPTIONS
Echinoderms	Echinoids	Count all
	Crinoids	Count all
	Holothurians	Count all
	Asteroids	Count all
	Ophiuroids	ONLY count basket stars (because they are exposed)
Crustaceans	Crabs & hermit crabs	Count only if they grow bigger than 2.5cm
	Lobsters	Count and size all
	Shrimps	Cleaner shrimps only (Don't count small shrimps such as hinge-beak shrimps).
	Barnacles	DON'T count any
	All others	Count only if: (1) grow bigger than 2.5cm
Molluscs	Gastropods	Count only if: (1) mobile, AND (2) grow bigger than 2.5cm. Also NOT Patellidae, Polyplacophora
	Bivalves	Count giant clams (e.g. Tridacna spp.), razor clams (e.g. Pinna spp.), scallops (e.g. Pecten spp.) and pearl oysters (e.g. Pinctada spp.). Don't count other bivalves including edible oysters.
	Cephalopods	Count all
	All others	Count only if: (1) mobile, AND (2) grow bigger than 2.5cm
Worms (including Polychaetes)	All	DON'T count any
Sessile groups	Ascidians	DON'T count any
	Sponges	DON'T count any
	Bryozoans	DON'T count any
	Hydroids	DON'T count any

Table 2. Families considered to be cryptic and should be recorded if found during a method 2 swim.

FAMILY	COMMON NAME	FAMILY	COMMON NAME	FAMILY	COMMON NAME
Agonidae	Poachers	Cyclopteridae	Lumpsucker	Pempheridae	Bullseye
Ambassidae	Glassfishes	Cynoglossidae	Tonguefish	Pholidae	Gunnels
Anarhichadidae	Wolf eels	Dasyatidae	Stingrays	Pinguipedidae	Grubfishes
Antennariidae	Anglerfishes	Diodontidae	Porcupinefish	Platycephalidae	Flatheads
Aploactinidae	Velvetfishes	Eleotridae	Gudgeons	*Plesiopidae – excluding Trachinops	Longfins
Apogonidae	Cardinalfishes	Gnathanacanthidae	Red velvetfish	Pleuronectidae	Righteye flounder
Ariidae	Catfishes	Gobiesocidae	Clingfishes	Plotosidae	Catfishes
Aulopidae	Sergeant bakers	Gobiidae	Gobies	Priacanthidae	Bigeyes
Bathymasteridae	Ronquils	Grammistidae	Soapfishes	Pseudochromidae	Dottybacks
Batrachoididae	Frogfishes	Hemiscylliidae	Longtail carpet sharks	Psychrolutidae	Fatheads
Blenniidae	Blennies	Heterodontidae	Bullhead sharks	Rajidae	Skates
Bothidae	Lefteye flounder	Holocentridae	Squirrel and soldier fishes	Rhinobatidae	Shovelnose rays
Bovichtidae	Thornfish	Hypnidae	Coffin rays	Scorpaenidae	Scorpionfish, orbicular velvetfish
Brachaeluridae	Blind sharks	Labrisomidae	Tropical blennies	*Serranidae - excluding “Anthias”, Caesioperca, and Lepidoperca	Rockcods & Seaperches
Brachionichthyidae	Handfishes	Leptoscopidae	Pygmy stargazers	Scyliorhinidae	Catsharks
Bythitidae	Blindfishes and cuskeels	Liparidae	Snailfishes	Soleidae	Soles
Callionymidae	Dragonets	Lotidae	Burbots	Solenostomidae	Ghostpipefishes
Caracanthidae	Crouchers	Monocentridae	Pineapplefishes	Stichaeidae	Prickleback
Carapidae	Pearlfish	Moridae	Beardies	Synanceiidae	Stonefish
Centriscidae	Razorfish	Muraenidae	Moray eels	Syngnathidae	Pipefish & Seahorses
Chaenopsidae	Tubeblennies, flagblennies	Nototheniidae	Icefishes	Synodontidae	Lizardfishes and Sauries
Chironemidae	Kelpfishes	Ophichthidae	Snake and worm eels	Tetrabrachiidae	Anglerfishes
Cirrhitidae	Hawkfishes	Ophidiidae	Lings	Tetrarogidae	Waspfishes
Clinidae	Weedfishes	Opistognathidae	Jawfishes	Torpedinidae	Numbfish
Congridae	Conger eels	Orectolobidae	Wobbegongs	Trachichthyidae	Roughies
Congrogadidae	Eel blennies	Paralichthyidae	Large-tooth flounder	Tripterygiidae	Threefins
Cottidae	Sculpins	Parascylliidae	Catsharks	Uranoscopidae	Stargazers
Creediidae	Sand divers	Pataecidae	Prowfishes	Urolophidae	Stingarees
Cryptacanthodidae	Wrymouths	Pegasidae	Seamoths	Zaproridae	Prowfish
				Zoarcidae	Eelpouts

APPENDIX 2. – METHOD 3 GROUPINGS TO BE USED FOR SUBSTRATUM, ALGAE AND SESSILE INVERTEBRATES

Substratum categories	Description
Bare rock	Urchin barrens - rocks grazed bare of macroalgae and most invertebrates, large numbers of urchins present.
Bare rock - barrens	Bare rock cleared by action other than urchin grazing: possibilities include waterflow, wave action, sand scour.
Cobble	Loose rock from 80mm to 200mm in diameter or measured across the longest axis.
Pebbles	Loose rock from 25mm to 80mm in diameter or measured across the longest axis.
Gravel	Loose rock from 5mm to 25mm in diameter or measured across the longest axis.
Sand	Sand, shell grit, sediment or silt less than 5mm in diameter.
Silt on reef	Sand, shell grit, sediment or silt less than 5mm in diameter that rests on a hard substratum, silt depth less than 5cm.

APPENDIX 2. – METHOD 3 GROUPINGS TO BE USED FOR SUBSTRATUM, ALGAE AND SESSILE INVERTEBRATES

Algae categories	Description
Browns	
Filamentous browns	Long chains, threads, or filaments of brown algae. These filaments often intertwine forming a mat.
Foliose browns	Flat leafy brown algae that cannot be identified to genus or species
Encrusting algae	
Caulerpa rhizomes	Green rhizomes forming random 'net' like structure over substratum; when obvious, Caulerpa flexilis is generally responsible, so if that species is present best to use species name
Crustose coralline algae	Calcareous pink encrusting algae; “pink paint”
Encrusting brown algae	Unidentified brown algae that adhere closely to substratum
Encrusting green algae	Unidentified green algae that adhere closely to substratum
Hildenbrandia spp.	Medium to dark red brown to purplish 3-80cm across, tightly bound to substratum, smooth to warty or knobby surface, with very fine felt of hairs
Peyssonnelia flat	Hard red rubbery encrusting algae
Greens	
Filamentous greens	Long chains, threads, or filaments of green algae. These filaments often intertwine forming a mat.
Foliose greens	Flat leafy red algae that cannot be identified to genus or species
Other	
Drift	Unattached algae of any type, sometimes common in depressions on reef.
Reds	
Filamentous red algae	Long chains, threads, or filaments of red algae. These filaments often intertwine forming a mat.
Foliose reds	Flat leafy red algae that cannot be identified to genus or species
Turf	
Brown Turf	Dense unidentified brown algae that attain a canopy height of only 1 to 10 mm.
Green Turf	Dense unidentified green algae that attain a height of only 1 to 10 mm.
Red turf	Dense unidentified red algae that attain a canopy height of only 1 to 10 mm.
Turf/sand/sediment matrix	Matrix formed by organic sessile structures that trap sand, shell grit, sediment or silt into a matrix on a hard substratum, usually less than 5mm deep.

APPENDIX 2. – METHOD 3 GROUPINGS TO BE USED FOR SUBSTRATUM, ALGAE AND SESSILE INVERTEBRATES

Invertebrates	Description
Ascidians	
Encrusting ascidians	Ascidians that adhere to substratum closely.
Ascidians	Ascidians that do not adhere to substratum closely
Bryozoans	
Encrusting bryozoans	Bryozoans that adhere to substratum closely
Hard bryozoans	Bryozoans that are erect but do not bend if touched.
Soft bryozoa	Bryozoans that are erect but do bend if touched.
Coral	
Encrusting soft coral	Soft coral that adheres closely to substratum.
Soft coral species	Soft coral that does not adhere to substratum closely
Brain coral	Brain coral
Bramble coral	Bramble coral
Plate coral	Plate coral
Coral (other than plate)	Hard coral that does not form plate structure
Sponges	
Erect sponges	Erect or plate like sponges that do not adhere to substratum closely
Sponge (encrusting)	Sponges that adhere to substratum closely.

APPENDIX 3. – SURVEYS IN SPECIAL CIRCUMSTANCES

SURVEYING WALLS

Vertical walls can be surveyed using the RLS methodology, but extra consideration needs to be paid to how the survey works, given that the methodology requires fishes to be surveyed in 5 m wide bands out *horizontally* from the transect line. A ceiling of 5 m should be applied to all transects (see fish survey methods above), but for wall surveys a floor of 5 m below the transect line should also be applied. For the invertebrate survey, the standard vertical height limits of 2 m above (for block 2) and below (for block 1) apply.

A number of scenarios exist, depending on whether the wall reaches the surface and where on the wall the transect line is laid (see the diagrams in the following pages). If the wall does not reach the surface (or very close to it), and the line is in a depth of 5 m or less, then the survey can go ahead using the standard method, with a maximum of 5 m vertical distance of wall below the transect line surveyed for fishes in B1, and 5 m out from the transect in both B1 and B2. If the wall does reach the surface, or the transect line is laid more than 5 m deeper than the top of the wall, then the “wall method” needs to be used for fishes.

THE WALL METHOD

For near vertical surfaces, B1 encompasses all fishes below a plane extending 5 m out from the transect line to a maximum depth of 5 m below the transect line, while all fishes within 5 m above it are in B2. This is essentially the same as the standard method, but with blocks placed one on top of the other instead of side by side. It is essential to always follow one or the other method, with no intermediate configuration, although switching between methods on a single transect will be necessary in some cases (i.e. when a wall is only present along part of the transect).

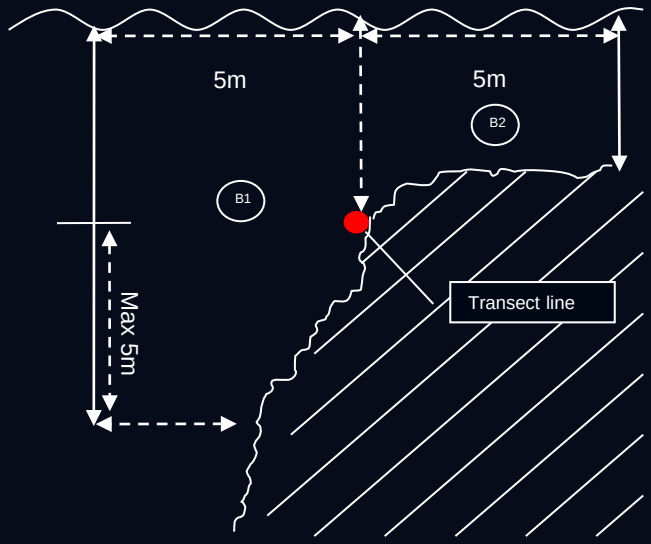


Figure 5. Representation of standard method on a wall that doesn't reach the surface.

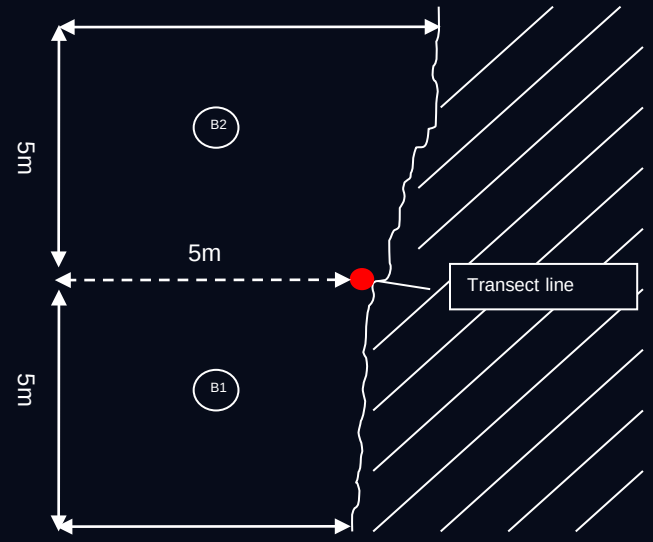


Figure 6. Representation of wall method for walls that reach the surface, or when transect line is set > 5 m below the top of a wall.

THE WALL METHOD

a.) Standard Method

b.) Wall Method

Figure 7. When to use wall method. A decision needs to made as to when to switch to the wall method. Generally, somewhere between these two scenarios would be most appropriate, before the area covered in B2 becomes too small using the standard method. In Figure a.) the standard method can still be used but in Figure b.) The Wall methodology would need to be adopted. Divers need to be consistent with their decisions for using the wall methodology.

SURVEYING NARROW REEF

A survey may still be undertaken on a wall that reaches the surface, but is less than 10 m high above sand (and is thus too short for the wall method to be applied), as is the case for many breakwaters or shallow rocky shores. In this case, only one block should be surveyed along the line (for both fishes and invertebrates/cryptic fishes). A second line should then be subsequently set, so that two blocks are still surveyed, “end on end” (N.B. please ensure they are still labeled as “block 1’ and ‘block 2’ in the data entry). Photo-quadrats should be taken on both lines. If you have any queries regarding the application of this method, please feel free to contact RLS organisers for clarification.

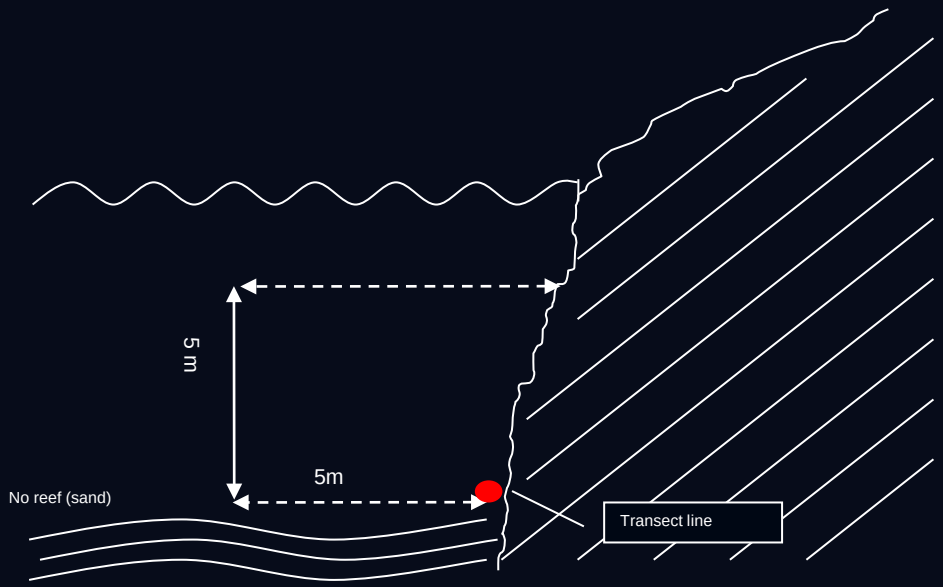


Figure 8. Reef less than 10 m wide and/or wall less than 10 m high (e.g. groyne). Only 1 block is surveyed and a second line should be surveyed on one end in the same manner.

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