



SAM Programme Reef Monitoring Protocol

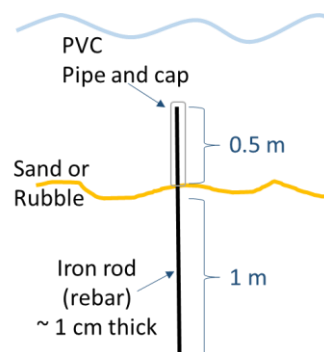
Site Selection

- Initially, at each MPA (park or reserve), set up a minimum of three sites in the closed zone (or reserve) and three sites either outside the reserve (in a fished area) OR in the general or specified use zone. Overtime, we will want to have a total of 9 sites in the parks with 3 in each zone; and 6 site total for reserves with 3 inside and 3 outside.
- Try to have the 3 sites within a zone distributed across different parts of the zone (not close together). However, if not enough coral areas exist it is ok to put two transects relatively near each other, but they must be at least 10 m apart.
- Select shallow areas (1-3 m deep at low tide) with moderate cover of live corals stretching over at least 40 m of substrate that includes other hard surfaces (e.g. dead coral or granitic rock).

Marking Permanent Coral Reef Transect Sites

To mark each site, use either rebar pounded into sand or building blocks cemented to bare rock. Note that it is NOT ok to simply have heavy stones on the ground that are not fixed to the reef. The ocean can move anything, so even a stone you cannot move underwater can and will be moved by the ocean. This is very dangerous, as these will move and break corals. Also, they will not be fixed in place and will migrate over time.

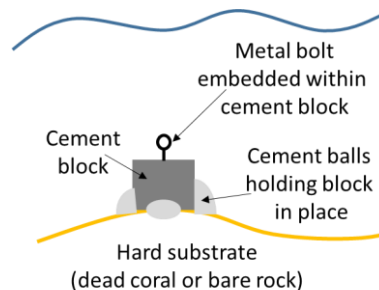
- Rebar Method



- Cut lengths of rebar (iron bars) that are 1 cm diameter to 1.5 m long (2 per site).
- At the site, first position your transect tape over coral habitat to make sure you are satisfied with the location and that the line is straight and covers 40 m of mostly hard substrate. Make sure the line follows the contour of the bottom going up and down over rocks and corals (do not stretch the line tightly so that it is suspended).

- The ends of your 40 m on each side must be next to hard reef, but in soft substrate (e.g. sand or rubble substrate).
- Pound 1 meter into the sand using a mallet or hammer, leaving 0.5 m of rebar exposed.
- Cover the top of the rebar (the part sticking out of the sand) with a PVC pipe and cap to prevent injury.
- Extend the line ~41-42 meters from the first point and insert second rebar with flagging. Note that you do not want exactly 40 m between the two rebars – leave space so that you can tie your rope (thus the distance between the bars – including the line going up and down over the bottom contour – should be around 41-42 m).
- Make sure you get GPS coordinates of each rebar as these may become hard to find. Also record landmarks on shore that will help you locate the site.
 - It is not advisable to attach buoys to the rebar as this will dislodge them. Better to use GPS (all SMART phones can do GPS with apps) or have somebody who knows the sites.
 - This method may not work in areas where theft is high.
- You might consider using cement to fix the rebar even more firmly in place. Even if you don't use cement, the rebar will not move, but if you are worried about theft, you might want to add cement in a big ball around the rebar to make it harder to take.
 - To do this, mix cement 50/50 with sand and add seawater until it can be formed into balls (not too soft). Swim with the balls in your hand quickly to the bottom and place firmly around the base of the rebar (probably 5-6 balls per rebar).

- Building Block method



- Use this method in sites where there is no loose sand substrate to insert rebar into or in areas where rebar will get stolen.
- Create a concrete block using a small bucket (e.g. 2L paint bucket). As it starts to dry, insert a metal bolt into the top so that you have a place to tie your transect line. Make sure the cement dries firmly around the bolt so that it cannot be removed when dry. (Alternatively, you can use building blocks that have a hole in the center so that you can tie your transect line through the hole).

- Once your blocks are ready, make sure you plan to put them in the field on a neap low tide (not a spring tide) because the water motion will be less, which is important for the cement you will add in the field to hold the blocks in place.
- At the site, first position your transect tape or line over 40 m of coral habitat to make sure you are satisfied with the location and that the line is straight. Make sure the line follows the contour of the bottom going up and down over rocks and corals (do not stretch the line tightly so that it is suspended).
- At the start of the transect, find an area of bare rock and scrape clean of all algae and sediment with a knife.
- Position the building block in this cleared area so that it is stable.
- On the boat, you should have sand and cement premixed (50:50) with no gravel in the mixture. In a separate basin, mix the cement with seawater so that it is a very dry mixture that can be formed into balls larger than your fist. Make about 9 of these per cement block you are fixing in place.
- Hold a ball in your hand and dive to the block. Quickly slap the ball onto the side of the block where it touches the bottom. Once the ball is in place, do NOT attempt to mold the cement – just leave it as is – it will dry underwater as cement drying is a chemical reaction.
- Place 6-9 blocks around the building block connecting the block to the substrate.
- Leave in place (DO NOT TOUCH BLOCK OR CEMENT) for 24 hours. DO NOT tie transect to this block while cement is wet or put a float on the block.
- Follow the same procedure at the other side of the transect line at about 41-42 m.
- After 24 hours, return to the site and check blocks for stability. If needed, add more cement balls to stabilize.
- **EVERY MONTH – make sure you check blocks for stability. If loose, it is VERY important you re-fix these in place as loose blocks can slide around with currents and break corals. Blocks MUST be cemented into place or they will move and kill corals.**
- Make sure you get GPS coordinates of each block as these may become hard to find. Also record landmarks on shore that will help you locate the site.
- It is not advisable to attach buoys to the blocks as this will dislodge them. Better to use GPS (all SMART phones can do GPS with apps) or have somebody who knows the sites.

Preparation for Field Monitoring

Before going to the field, you should go over all the gear using the provided checklist (see Dropbox folder). Make sure you have everything and it is all in working order. Check to make sure pencils are sharp. Carry paper copies of the data sheets in addition to the slates so that IMMEDIATELY after you get out of the water, you can record the data on the paper data sheet. Leaving data on the slates is not a good idea because it can rub off. When recording the data from the slate onto the paper, after it is transferred, be sure somebody double checks it for mistakes. This is a critical step.

Helpful Tip: Masks fog easily underwater. When you buy new masks, before use, clean them with toothpaste and rub into glass on both sides with your fingers to remove film. After this first use, prior to entering the water, use a little liquid soap on the inside of your mask to prevent fogging. This will help you collect accurate fish and secchi data, which require good vision.

Monitoring

You should carry out your monitoring using the following order of operations:

BEFORE ANYBODY GETS IN THE WATER:

- 1) Complete the entire header of the data sheet on paper and on the slates
- 2) Do the counts of human use (e.g. fishing boats & gears, snorklers)

ONLY 2 PEOPLE IN WATER

3) Next have 2 people ONLY go into the water to do secchi. Do not have the whole group enter the water as it will reduce visibility and also scare away the fish you will count next.

SAMPLING TEAM IN WATER

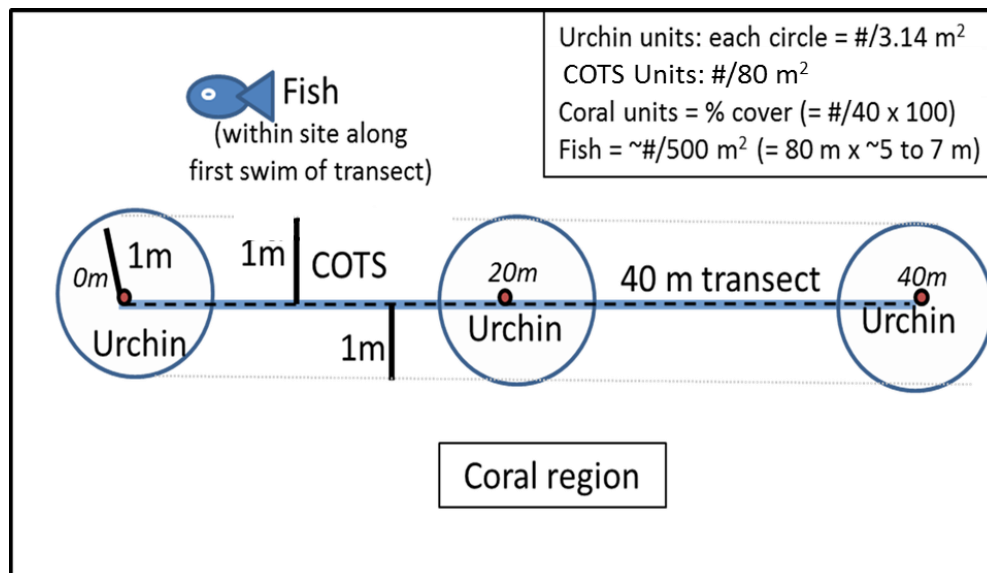
- 4) Locate the transect location and tie end of transect tape to block or metal bar.
- 5) Lay out weighted transect line (should be laying on bottom) and search for fish to end
- 6) Do benthic counts, COTS, sea urchin circles, and coral health
- 7) Return to boat and transfer data to paper datasheet. Have somebody check for errors.
- 8) Make sure your data makes sense. For example, if you had 30% coral cover last month, it is unlikely you have 50% this month. Discuss the data with the whole team prior to leaving the site.

Secchi Disc for Water Clarity

- Conduct the secchi measurement as soon as you get to the site (e.g. before ANYBODY gets into the water)
- Do NOT do this right over the transect area as the splashing of people will scare away fish.
- Make sure there are no knots in the rope of the secchi disc
- Have 2 people get into the water with the secchi. The person with the best vision should be the one looking at the secchi.
- The person looking at the secchi disc stays in place.
- The person who will be looking at the secchi should have the sun behind them (because looking into the sun will affect the measurement).
- The person holding the secchi disc should have the disc in the water so that their partner can see the black and white surface. The person holding the disc then should slowly start swimming backward away from their partner.
- The person watching the secchi disc holds the rope and allows it to run out through their hand.

- At the second when the person watching the disc can NO LONGER see the disc, hold the rope firmly so that the person with the disc stops moving away. Move forward and backward to make sure you are at the exact distance where the disc disappears.
- Tie a knot at that point in the rope.
- Take the secchi disc back to the boat and measure the length of the line from the disc to the knot. Record this to the nearest centimeter.
- In the beginning as you are learning, it is a good idea to compare what 2-3 people get for the secchi distance to make sure everybody understands how to do it.

Conducting Benthic Transects



Fish Survey

- Always start at the same side of the transect, so that the 0 mark is approximately in the same place each time.
- Tie off the line to the first transect marker. It is important to have a long enough rope before the 0 point on your transect line or rope so that you have space to tie off without covering your 0 mark.
- As one person is reeling out the line, the other person should be counting fish. At this time, we are only counting orange strip triggerfish (and the star-eye parrotfish as males, females, and juveniles if the MPA is ready to do this). Make sure that the person laying out the line is not getting ahead of the person counting fish as this will scare away the fish. Remain SIDE BY SIDE and go slowly.
- When you reach the 2nd transect marker at 40 m, the fish count is over. No further fish can be counted even if seen.
- Tie off the transect to the 2nd transect marker, but make sure the line is draped over the bottom, following it up and down. DO NOT tie the line tight so that it is held above the bottom. IT IS VERY IMPORTANT THE TRANSECT BE ADEQUATELY WEIGHTED SO IT SITS ON THE BOTTOM.

- As you move from the 40 m point to the 0 m point, one person can do the sea urchins, the crown of thorns sea stars (COTS). The second person can do the point counts at each of the 40 points. Or, you can stay together as a team.

Sea Urchin and COTS Surveys (*person 1*)

- For the person doing the sea urchins and COTS, start at the 40 m mark. Place your urchin stone (with 1 m line attached) on top of the 40 m mark. Swim in a circle holding the line and count all the sea urchins between the stone and the tip of the line in the whole 360° circle. **Make sure you look under any ledges or overhanging corals.** Count urchins in separate categories as large (size of a dinner plate = typically the species *D. savignyi* and *D. setosum*) and small (size of a teacup = typically the species *Echinometra mathaei*). If any part of a sea urchin is under the 1 m line, count that urchin.
- As you swim from the 40 m mark to the 20 m mark, look for and count COTS on 1 m on either side of the transect. If you see a COTS, you can use your 1 m line attached to the stone to determine if it is inside or outside the 1 meter distance from the transect. If any part of the sea star is under the 1 meter line, count it. **Make sure you look under all ledges or overhanging corals** for COTS within 1 m of either side of the transect line.
- At the 20 m mark, do the same procedure as above (step 7) for sea urchins, searching in a circle with the 1 m line as the radius and the weight on the mark. Make sure you search under coral or rock ledges.
- As you swim from the 20 m mark to the 0 m mark, repeat the procedure as above (steps 8 and 9) for COTS (searching 1 m on either side of the transect line) and for coral damage (searching 2 m on either side of the transect). When you reach the 0 m mark, record the total number of COTS you saw between the 40 m mark and the 0 m mark and record the total number of damaged corals. Because you are searching a 40 m x 2 m area for COTS, your COTS density will be #/80 m². Because you are searching a 40 m x 4 m area for damaged corals, your damaged coral density will be #/160 m².
- At the 0 m mark, repeat the procedure above (step 7) for sea urchins, searching in a circle. For each sea urchin circle, your area searched is 3.14 m² (based on the area of a circle with a 1 m radius = $\pi r^2 = 3.14 \times 1^2$). After the 0 mark, you should have recorded sea urchin data from 3 circles.

Benthic (Substrate) Point Count (*person 2*)

- For the person doing the benthic point counts, you can start at the 40 m mark. At each meter mark along the line, record a tick for what is on the bottom of the ocean (the bottom of the ocean is called the benthic substrate). Make sure you look at the point directly under (touching) the meter mark. Actually TOUCH the point under the mark to be sure what it is.
- The categories are (see identification sheet for photographs):
 - Live coral
 - Bare Rock (= Dead Coral)
 - Soft coral
 - Seaweed (=fleshy macroalgae)
 - Coralline algae (pink, orange, or yellowish – covers rocks like paint).

- Halimeda (bright green algae that has a crunchy skeleton inside)
 - Rubble
 - Sand
 - Seagrass
 - Other (includes anything not on the list that is attached to the bottom of the ocean. If you find something mobile like a sea urchin or a COTS, move it and look at what is under it.)
- As you record each point, leave your clothes peg at that point so that you know where you left off. Without doing this, it is easy to lose track of where you are.
 - When you reach the 20 m mark, make sure you have 20 points. If not, go back and repeat to avoid mistakes.
 - When you reach the 1 m mark, that is your last point. Make sure you have a total of 40 points. If you have 39-41, it is ok, but try to avoid having more or less than 40 points. If you have less than 39 points or more than 41 points, please redo the point count along the transect.

Coral Health

- Have one person start at the 0 m mark and swim to the 20 m mark (make sure you always start at the same side of the transect – this is very important).
- For EVERY coral under the line, record (with a tick) if it is healthy (brown or green in color), fully bleached (coral is completely white – not pale, but white), or partly bleached (some part of the coral is completely white – not pale, but white). It does not matter if the coral is big or small, each coral colony gets 1 tick.
- At the end of the 20 m, you can total the ticks to get the total number of corals you surveyed by summing the ticks in the 3 categories (healthy, fully bleached, partly bleached).
- To calculate percent corals bleached, divided the number of corals you ticked as fully bleached by the total number of corals. Then multiply this number by 100. You can do the same calculation to determine the percent of corals partly bleached.

With any questions, please email Dr. Jennifer O'Leary: jkoleary@calpoly.edu