Coastal Biodiversity Survey Protocols

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MARINe Research Group at
University of California, Santa Cruz

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RESOURCES

Many MARINe resources are stored on Egnyte, a cloud-based file storage site. Access to shared MARINe files on Egnyte can be requested by emailing one of the contacts listed under "Key Contacts" below. Datasheets, examples, guides, protocols, and instructions for suggesting edits/updates to this CBS protocol can be found on Egnyte here: https://marine.egnyte.com/app/index.do#storage/files/1/Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/biodiversity_protocol_resources

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Coastal Biodiversity Survey Protocols

Selecting an appropriate location

The ideal location to establish a Coastal Biodiversity Survey (CBS) is on a bedrock intertidal bench that 1) is at least 30m wide, 2) slopes from the high to low zone, and most importantly, 3) contains a representative sample of the intertidal community of the entire site. If it is not possible to find a contiguous 30m stretch of coastline, the survey can either be split between two benches (sections) or set up along a contiguous 20m stretch of coastline. When split, the survey area should be divided as evenly as possible between the two sections (e.g., 5 transect lines on one bench, 6 transect lines on the other: see set-up below).

Set-Up

Once an appropriate area of shoreline has been selected, it is sampled using a series of eleven parallel transect lines extending from the high zone to the low zone of the intertidal. To facilitate the setup of these lines, two permanent 30m horizontal baselines (parallel to the ocean) are established. The upper baseline is placed in the high zone, ideally just above the upper limit of organisms, while the lower baseline, which should be parallel to the upper baseline, is established closer to the ocean. Depending on the level of beach traffic and site regulations, the ends of each baseline are permanently marked with either hex or carriage (preferred) stainless steel bolts and marine epoxy. The 0 end of the transect tape should always be placed upcoast (to the right when facing seaward), and the 30 meter end of the tape should always be downcoast (to the left when facing seaward). The upcoast onshore marker is named OT1, downcoast onshore marker is OT2, upcoast offshore marker is OT3, and downcoast offshore marker is OT4. “OT” stands for “one time” and is a relic of past surveys that were intended to be sampled just one time (which is no longer the case). Naming of markers may vary depending on the site (e.g., a site where it is helpful to have a third marker along the upper baseline to help set it up due to a bend in the contour of the bench). When setting up a site, write the bolt name in the not yet dry marine epoxy for future surveys. Always clearly notate bolt names on the site map and site notes.

Once these two baselines have been established, parallel transect lines are run down the shore every three meters along the upper baseline (or every two meters if using a 20m baseline). In some (rare) cases, the transect lines may be offset along the baseline; for example, transect 18 could be offset to 19 to avoid running through a deep channel (again, this is not common and clear notes should be made about this exception for consistent repetition at the particular site). If this is done, the subsequent transects are still positioned normally; for example, run lines at 12, 15, 19, 21, 24, etc.). To ensure that these transect lines are parallel, they should intersect the appropriate corresponding meter mark on the lower baseline. In general, the transect lines drape to follow the contours of the bench. When necessary, rocks are placed along the lines to prevent them from being shifted by heavy winds. The meter mark on each transect where it crosses the lower baseline (when draped) is noted to aid in consistent placement during subsequent surveys.

To facilitate resurveying the site, a map is drawn, and other key information is recorded. The site map should show the location of the upper and lower baseline bolts relative to notable landmarks and/or pre-existing permanent plots. If the biodiversity transects overlay or are adjacent to an established Long Term Monitoring (LTM) site, the baseline locations and other key site information can be added to the existing LTM site map. GPS coordinates are recorded in decimal degrees for the location of each baseline bolt, and the GPS unit and datum used (preferably NAD83 or WGS84) should be noted. A Site Log datasheet with all set up information is filled out. Overview photos showing bolts (both close-up photos and those showing prominent site features to help with relocation) and set-up of lines are taken, as well as a set of panoramic photos which are repeated during each subsequent survey (see Panoramic section below). The distance and bearing between the baseline end bolts are recorded. When possible, measurements are also taken from end bolts to any pre-existing permanent plots (for triangulation purposes when relocating bolts). Other information such as the compass heading (angle) of the vertical transects, coastal orientation, primary bench type, surrounding coast, slope, relief, and the sampling interval are also recorded. A rock sample is collected (and stored at the University of California, Santa Cruz Long Marine Laboratory) for determining the geology of the bench. Information from the completed site log datasheet should be used post-field to create a site notes document, which should be updated after every subsequent survey. See resources folder on Egnyte for an example site notes document.

Point-Contact Surveys

The diversity and abundance of invertebrates and algae along each vertical transect are sampled using the point intercept method. Tar and other non-biological substances are also included (see species list at https://marine.ucsc.edu/biodiversity-species-list.pdf). The goal is to have a total of 1,100 sampling points per site. Ideally, 100 points are sampled on each of the eleven parallel transect lines. The interval between points is determined by the length of the transect lines (20cm for a 20m long transect, 10cm for a 10m long transect, etc.). If the topography of the bench is such that lines cannot be equal in length and some lines have fewer than 100 points (e.g. if there is a steep drop-off at one end of the bench) then some lines can be extended out further (to have more than 100 points) such that the goal of 1,100 total sampling points per site can still be met. Whatever interval and length are selected during set-up is what will continue to be used for subsequent sampling efforts.

At each sampling point, two types of data are collected: 1) data that are used to determine relative abundance (% cover), and 2) data that are used to describe spatial distributions.

1) Relative abundance (% cover) data are collected by identifying taxa/substrata that fall directly under each point, including categories such as rock, sand, and tar.
    a) If layers of species occur under a point, up to three layers of taxa/substrata are identified and assigned a letter: A for the top-most layer, B for the second layer, and C for the third. If there are only two layers, “C” will not be used. If there are no layers present under a point, “A” “B” and “C” are not recorded.

Each layer must be a different taxon. If the point falls on an epibiont living on a recognized host species (see Table 1), the epibiont is denoted by EPI (and the letter indicating the layer) and the host by HOST (and the letter indicating the layer). If the point directly hits an epibiotic alga, it is recorded as both a layer (A) and as an epibiont (EPI); if its host is the next direct layer, it is recorded as (B) and host (HOST). Note that it is possible for a species to be a host and an epibiont. For example, in the case of a *Chthamalus* on a *Balanus* on a *Mytilus*, the *Balanus* will be recorded as both an epibiont and a host. A total of up to three taxa are identified under each point, even if there are more than 3 layers; only the first 3 are identified. If a HOST is not one of these 3 points, any associated EPI is still recorded but not as an EPI. If an epiphyte occurs on a species that is not a recognized host, then that epiphyte cannot be recorded. Although many species have the potential to be a host to epibiotic species, for this survey, only those species upon which a multitude of epibiotic species live are considered hosts.

Table 1: List of recognized hosts.

Barnacles (e.g., *Balanus*, *Pollicipes*)	*Lottia gigantea*
Bivalves (e.g., *Mytilus*)	Polychaete worms
Coralline algae	Worm snails

b) If the point falls in a pool, on a cobble, or on a boulder, these are recorded individually for each species. For example, Rock - boulder, *Lottia scabra* - cobble, Crustose Coralline - cobble, pool. Cobbles are defined as <25.6cm (smaller than 10 inches) and boulders are ≥25.6cm (10 inches or "head size" and larger). Do not spend time measuring every rock; estimation is acceptable.

2) If fewer than three taxa (including substratum if first point) are recorded directly under a point, then data are collected on the identity of the next one or two species closest to that point (Table 2). These data are used to describe the spatial distribution of species and factor into diversity indices but are not used when calculating site-wide abundances. If the substratum is a layer, there still need to be 3 biotic points resulting in four points total. For example: *Silvetia compressa* - A, Rock - B, *Lottia scabra*, *Littorina keenae*.

Table 2: Number of 'nearby' species recorded.

Recorded Under Point	Number of 'Nearby' Species
One layer: either an attached organism or substratum*	Two additional species
Two layers: bottom layer substratum*	Two additional species
Two layers: both organisms (includes cases of epibiont and host)	One additional species
Three layers: bottom layer substratum*	One additional species
Three layers: all organisms	No additional species

* substratum = rock or sand: treated as organisms for these protocol rules.

'Nearby' species must be different from those found under the point and must fall within a circle centered over the point with a radius of half the length of the sampling interval (Figure 1). Closeness is determined by attachment location on the primary substratum. For example, if a frond of *Silvetia* is closer to the point than a barnacle, but the alga's holdfast is farther away, the barnacle is considered the closer species. If all 'nearby' individuals are the same taxa as that found under the point, or there are no other 'nearby' species, 'none' is recorded (this can be recorded twice if needed). As with taxa under the sampled point, if the 'nearby' species is an epibiont, it is only recorded if it is on a recognized host (Table 1); the host is denoted by HOST and the epibiont by EPI. Note: In cases with two layers in which one of the layers is an epibiont on a recognized host, and the host would be counted as a nearby species, then the epibiont is recorded and denoted as EPI with the appropriate letter to indicate the layer, and the host is later recorded as the nearby species and denoted as HOST (without a layer). Also, as with taxa under the sampled point, record if these 'nearby' species are found in pools, on cobble, or on boulders.

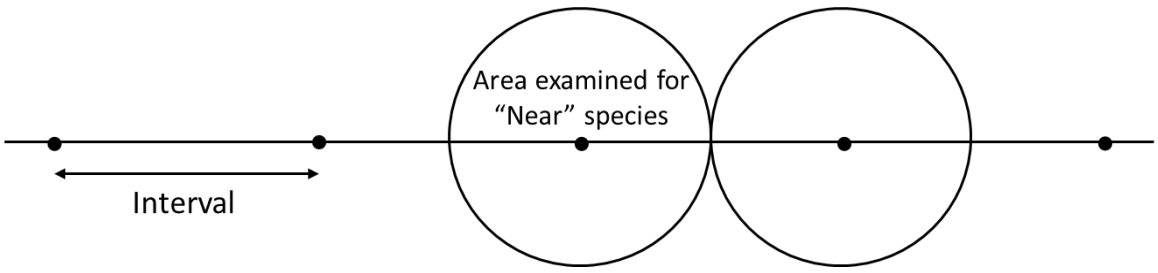

Figure 1: Diagram showing area examined for 'nearby' species.

Point contact data are collected using an iPad app developed specifically for this project that has built in error-checking features and allows survey teams to upload regional species templates. Data collected in the field are stored as CSV files and uploaded to the database on the local file server at UC Santa Cruz. In-depth instructions for how to download and use the app can be found on Egnyte at the link listed in the "Resources" section above.

Species Identification (ID) Best Practices

Upon arrival at a site and while sampling, it is important to take note of any species that seem difficult to identify (ID) and ask other samplers for ID help. It is best to convene with the other samplers early during the sampling day, if possible, to make sure that everyone is in agreement on how unknown or unusual species are being ID'ed and recorded. For example, one person may collect a voucher or take a photo for later identification, and other samplers can note on their iPad or datasheet that they are also calling those specimens the same thing. When in doubt, ask for ID help. It is important to check in with other samplers on a regular basis to avoid ID drift.

Vouchers

When a species cannot be identified in the field, it is assigned a unique unknown number (example: unk001) and a sample is collected for each site. If multiple samplers are using the same voucher, it still needs a unique unknown number for each sampler. Samples are labeled with the date, site, name of sampler, transect line on which it was found, zone in which it was found (i.e. high, mid, low), defining features (i.e. slippery, stinky, etc.), surrounding species (if applicable), and the unknown number assigned to it. Anything collected must be assigned an unknown number (even if it is a known species that is just being collected for an example). Samples are either immediately pressed (algae), or desiccated or preserved in alcohol (invertebrates), and cataloged and stored at the UC Santa Cruz Long Marine Laboratory. When collection is impossible, photo vouchers can be taken and stored on the local file server. Vouchers are reviewed and identified (if possible) by taxonomic specialists.

Mobile Invertebrate Quadrat Surveys

Because the abundances of mobile species are not captured well by point-contact surveys, mobile invertebrate abundances are determined using 50 x 50 cm quadrats placed at three locations along each transect. Each transect is divided into three zones: generally, the low zone is the area below the mussels, the mid-zone includes mussels and rockweeds (e.g., *Silvetia*, *Fucus*), and the high zone is the area dominated by barnacles and littorine snails. When one of the sampling zones is not present on a transect (e.g. due to the topography of the site, a transect never extends into the high zone), one of the following protocols is followed: (in order of preference) 1) an extra quadrat in the missing zone is sampled on another transect, 2) the quadrat may be placed elsewhere in association with the line in order to capture the missing zone (e.g., placed just above the upper baseline in the high zone with the distance above the upper baseline noted as a negative number for the location on the datasheet), 3) only two quadrats are sampled on the particular transect. For example, on a transect where no true high zone exists: 1) two high zone quadrats may be sampled on another transect that has sufficient area in the high zone, 2) the quadrat may be placed above the upper baseline in the high zone on the original transect, or 3) quadrats are sampled in only the mid and low zones on that transect.

Within each zone the quadrat location on the transect is determined using a stratified random approach (Figure 2). A random number table or other random number generator is used to identify three numbers to indicate the location on the transect at 10 cm increments. For example, 094 = 9.4 m, 194 = 19.4 m. Unique random numbers must be used for each transect.

After location on the transect is determined, the sampler faces onshore and positions the upper left corner of the quadrat at the determined location (e.g., 9.4 m) on the downcoast side of the transect tape. In some cases, random generation of quadrat location results in a quadrat placement that contains "non-target" habitat (e.g. an area of sand that is greater than 50% of the quadrat or a pool that covers more than 50% of the quadrat or a pool that is less than 50% but very deep) which would result in data that are not representative of the site or that are not accurate (if the observer cannot thoroughly view the quadrat area). In these rare events, the following options should be used to reposition the quadrat: 1) flip the quadrat UP the transect tape so that the randomly generated location is now the lower left corner of the quadrat, 2) flip the quadrat DOWN the transect tape, 3) flip the quadrat ACROSS the transect tape (and note "flipped to upcoast" on datasheet), or 4) if none of the flipping options above alleviate the situation, then pick a new random location. See decision tree in appendix for more details on quadrat placement for mobile invertebrate sampling.

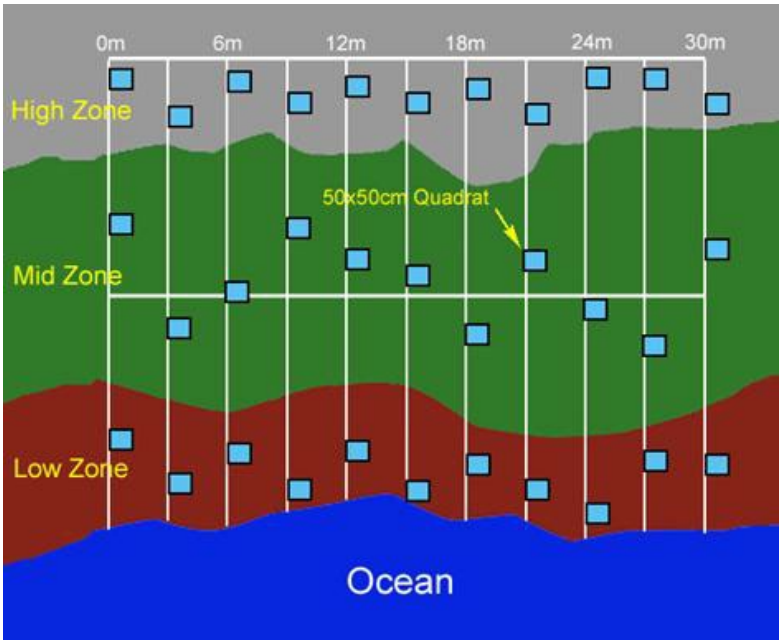

Figure 2: Biodiversity grid with example of possible distribution of mobile quadrats in high, mid, and low zones.

In each quadrat, all mobile species visible with the naked eye (using non-destructive sampling) are counted with the exception of worms, *Neomolgus littoralis* (red mites), and amphipods. Using a flashlight for looking in cracks and crevices is recommended. Because of our non-destructive sampling approach, organisms living within the

interstices (the spaces between the substrate and sessile organisms such as mussels) are likely underrepresented. Data are recorded using a waterproof paper datasheet and entered into a spreadsheet saved on the UC Santa Cruz server.

If a species is exceptionally abundant in a given quadrat (exceptionally abundant is defined here as ~100 or more individuals) then the abundance of that species in that quadrat may be counted in a reduced area (= sub-sampling).

The method used by the UC Santa Cruz team for subsampling utilizes the ecological judgment of the sampler. The sampler should assess the entire quadrat and then choose an area to subsample that is most representative of the quadrat as a whole (for examples, see Figures 3 and 4). The sampler estimates the proportion of the quadrat taken up by that subsampled area, and notes the appropriate multiplier on the data sheet for that species (for example, if the subsampled area is ½ of the quadrat, and 62 individuals are counted in that area, then the notation on the data sheet will be "62 x 2").

If a species is exceptionally abundant but the distribution within the plot is such that there is no representative way to divide the plot for a subsample, count that species within the entire plot.

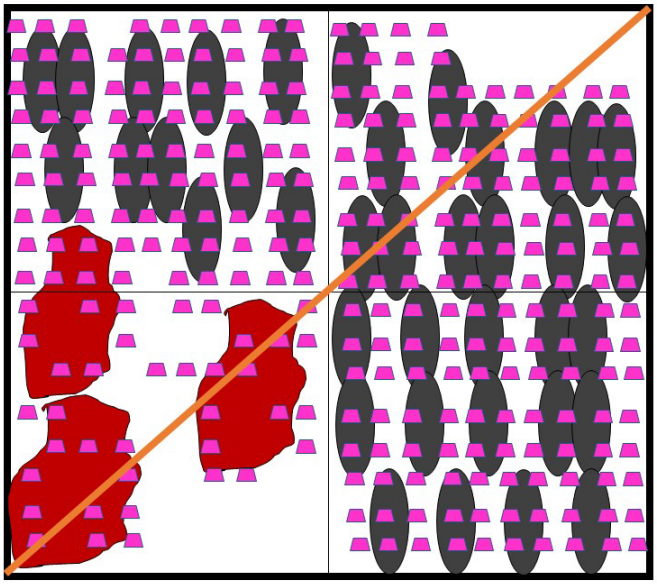

Figure 3: This plot is mostly mussels with some red crusts. The targeted invertebrate is pink. In this instance, mentally split this plot in half (orange line), count the targeted species on one side then write the count and the appropriate multiplier (in this case, x 2) on the data sheet.

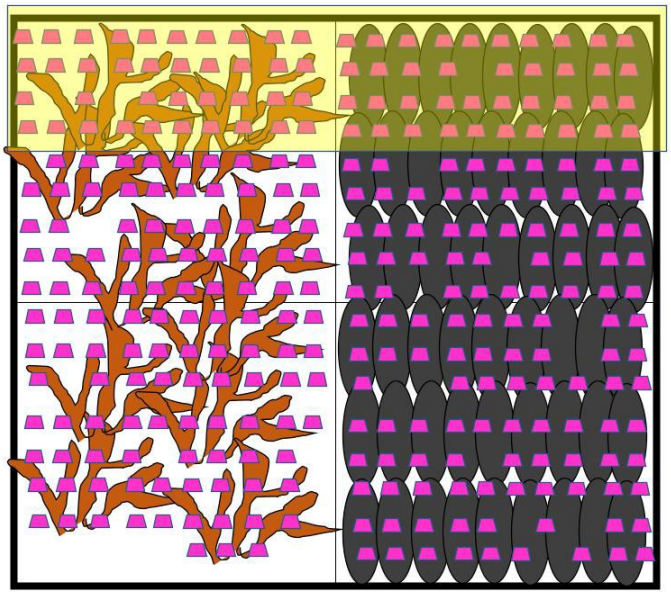

Figure 4: This plot is half *Silvetia* and half mussels. The targeted invertebrate is pink. In this instance, mentally split the plot in quarters, count the pink individuals in the shaded area, and write the count and the appropriate multiplier (in this case, x 4) on the data sheet.

Swath Counts

Sea stars play an important role in the intertidal community but are often patchy in distribution and/or occur under ledges or in crevices that are under-sampled by our point-contact protocols. Their abundances are therefore measured in two-meter-wide swaths centered over each vertical transect. At sites with a 20m baseline, the sea star swaths for neighboring transects will be adjacent, so using chalk (or another method) for marking the rock nearby counted individuals in order to avoid double counting is important.

Within each swath, the focus is on sea stars > 25mm radius (measured from the center of the disc to the length of the longest arm). The abundance, size (to the nearest 10mm), health, and location along the transect (to the nearest 0.5m) of *Pisaster ochraceu*s and *Evasterias troschelii* (> 25mm radius) are recorded. For other sea star species, abundance, health, and location along the transect are recorded in the same way but these sea stars are not sized. If stars <25mm radius are observed, record species, presence of disease, and notes at the base of the data sheet; this information is entered into the MARINe sea star tracking map at seastarwasting.org. For each swath, we also record abundance, size (total length), and location (to the nearest 0.5m) for individuals of *Cryptochiton stelleri* and any species of *Haliotis*.

Sea star disease categories are always recorded as follows: Healthy = no visible lesions, Mild = lesion(s) on no more than 2 arms or 1 arm and body and/or deteriorating arm(s); and Severe = lesions on most of body and/or missing arms, or severe tissue deterioration/death (death only counted as disease if there are signs of wasting, so that

death from other causes is not misidentified as disease). Sea star disease guides may be found at seastarwasting.org.

For each swath, the locations of any surge channels or pools that cannot be searched are noted. The distance along the vertical transects to which the swath surveys were conducted should also be noted. This is important for calculating densities for a given survey. Transect length may be different for a point contact and a swath survey if, for example, the tide comes in before swaths are completed, or if a time restriction dictates that swaths are only completed below the lower baseline (etc.). Data are recorded on a waterproof paper datasheet and entered into a spreadsheet saved on the UC Santa Cruz server.

GPS Measurements

GPS measurements of latitude and longitude (WGS84) and height above mean sea level (meters above MSL GEOID03 Conus) are recorded at each permanent marker bolt using Trimble survey equipment with a Zephyr antenna, ProXRT receiver, and Nomad computer running Terrasync software, all mounted upon a leveled bipod. The bipod is placed directly beside each bolt, and GPS measurements are recorded. Measurements are post-processed on a computer using GPS Pathfinder Office software to increase precision. One bolt is selected as a "benchmark bolt," to which all topography measurements are referenced. (See GPS Field Protocols document on Egnyte for detailed protocols).

Stillwater Measurement

For sites that do not have GPS measurements, the height of the sea level at low tide is used instead. Three locations are selected that are at the water's edge and are exposed to the open coast. The height of these 3 locations and the time each measurement was taken is recorded and used as a reference for the topography measurements.

Topography

When each new site is established, a three-dimensional map of the study area is created from topography measurements along each vertical transect line (Figure 5). A rotating laser leveler (on a tripod) and a stadia rod (mounted with a laser sensor) are used to take the measurements. Ideally, the laser leveler is positioned in a location from which the topography of all eleven transects can be measured (typically in the high zone or on a high point within the site). Where this is not possible (due to a bend in the bench, etc.), and the laser leveler must be placed in two or more locations, it is necessary to record measurements for several of the same reference points (i.e., OT bolts) for each tripod location. Tripod location must be clearly indicated on the topographic measurement data sheets and ideally a new datasheet will be started when the leveler is moved (i.e., tripod location 1 vs. tripod location 2 written on top of separate datasheets). This will ensure that the staff heights (the height of the stadia rod when the laser triggers the sensor) can be distinguished. Measurements are taken along each transect wherever there is a notable

change in height (Figure 6). Changes in height of a few centimeters should not be recorded. Thus, measurements are taken infrequently (every few meters) for gradual slopes, but more frequently (tens of centimeters) at more topographically complex sites in order to capture the presence of ridges, pools, and channels, etc.

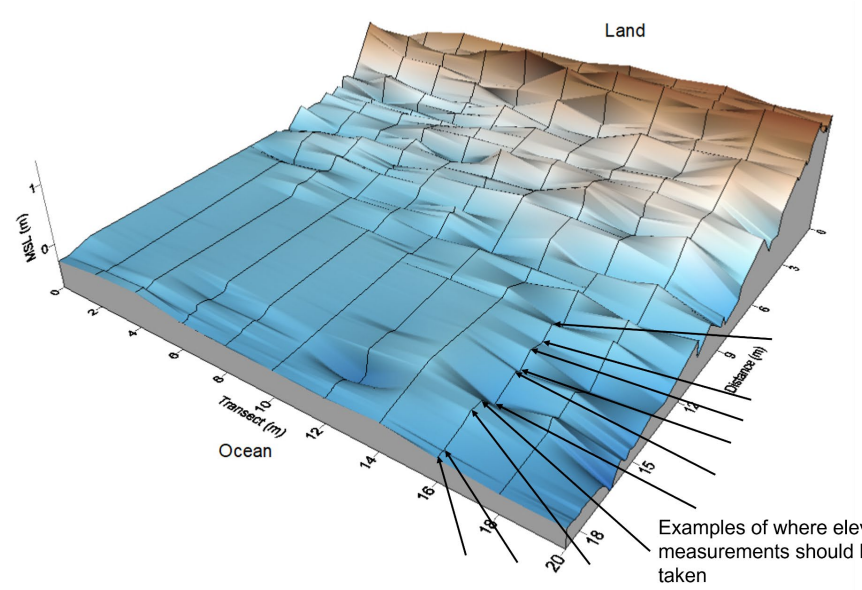

Figure 5: Example topographic map for a site with a 20 m baseline. Brown is high intertidal and blue is low intertidal (MSL = mean sea level in meters).

Figure 6: Examples of where elevation measurements should be taken.

Slope Measurements

When the site is established, measure the slope of the bench by using a separate transect tape, stretched taut, and recording distance measurements from the lower baseline bolts to the end of their respective draped/unstretched lines. For example, OT3 to end of line 0 (Figures 7 and 8) and OT4 to end of line 30. These paired sets of transect measurements (taut vs. draped), along with bolt-to-bolt (e.g., OT1 to OT3; OT2 to OT4) and elevation measurements, are used to calculate bench slope. Slope measurements should be done on a meter mark on the draped line where an elevation measurement was also taken. Slope measurements only need to be done once at a site (as they should not change over time).

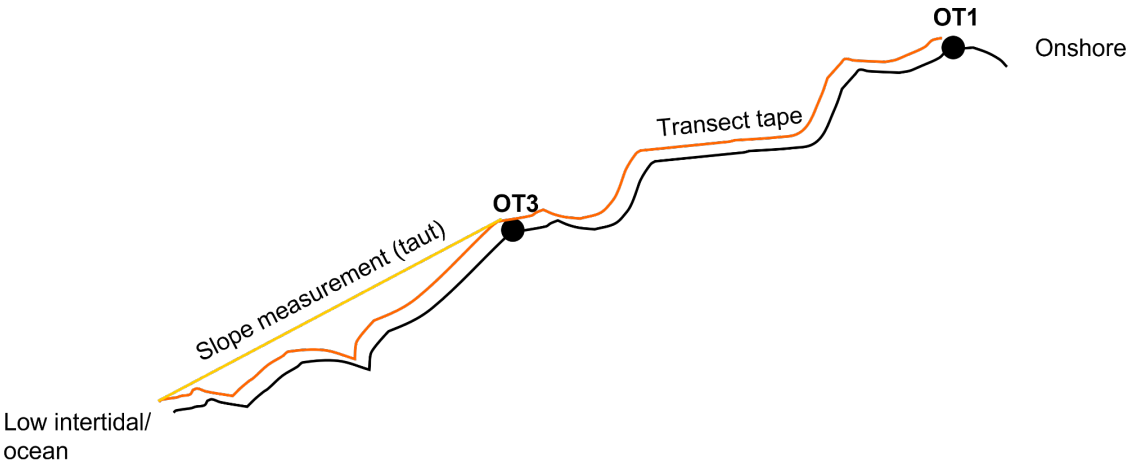

Figure 7: Diagram showing how slope measurements are taken.

Figure 8: Example of slope measurement.

Panoramic Photograph Protocol

During each survey, panoramic (pan) photographs should be taken to 1) provide a photographic record of the overall condition of the site, 2) document the placement of the transects relative to their surrounding area, and 3) document changes occurring over time at the site. Additional photographs should be taken to document anything unusual, such as rock breakouts or reef damage, evidence of poor organism health (bleaching, gaping mussels, etc.), sand scour, noticeable recruitment events, the presence and extent of oil/tar, or evidence of pollution and/or other human impacts. Pan pictures typically encompass 180° or 360° fields of view but can be smaller if targeting specific transects. Each set of pan photos is numbered and, to ensure repeatability, taken from a specific marked location. Ideal locations to take panoramas include reference markers, OT bolts, or specific locations along transect lines. The location from which each pan photo set should be taken is described in detail on the pan sheet. In the lab, pan photos should be stitched and printed in order to facilitate photo consistency during site re-surveys (see below). Ideally, pan photos are taken after all bolts have been located and the grid has been marked with transect tapes, and close to low tide (if possible).

Check to make sure the camera settings are appropriate for taking pans (not in macro mode, turn off flash, etc.). For site re-surveys, find the specific location from which each pan photo was taken. Every attempt should be made to exactly replicate earlier versions of the pan. Having printed copies of previously taken pans, along with notes of where and how they were taken, is helpful. If there is no marker to indicate the location for the pan, it can be helpful to have a printed overview photo showing the location. Pans are typically taken with photos in portrait orientation to capture more of the intertidal zone. However, in some cases, a horizontal (landscape) orientation is appropriate. See an example of a site pan overview on Egnyte (at the link listed in the “Resources” section above).

Hold the camera vertically (portrait orientation) and, turning clockwise (from left to right), take a series of overlapping pictures of the desired region of the shoreline. The camera should be kept level, with the horizon just below the top edge of the photo. Successive pictures should overlap by at least 1/4 of the frame. Pans that span a 360° field of view should be taken as 2 separate 180° pans (because pans taken as a single 360° tend to create a distorted view). Be aware that the sun reflecting off the ocean or tidepools can cause the picture to be underexposed; if possible, adjust the exposure to compensate. When done, and before moving on to the next pan, take a picture of some standard object (e.g., your foot, hand, clipboard, etc.); this will help distinguish one set of pan pictures from another when they are downloaded from the camera and labeled. Record the number of the pan, how many pictures were taken, and any special notes on the photolog datasheet. A single, landscape orientation photo showing the entire grid should also be taken if possible. This photo can be used on the MARINe website. See an example in the overview photos example on Egnyte (at the link listed in the “Resources” section above).

Labeling Pan Digital Images

After downloading the photographs, with the aid of the photolog form, label each picture as filename_pan#_yyyy_mmdd. The 'filename' for each site can be found in the file "intertidal_master_site_table" on the UC Santa Cruz server. For example, the photos for pan# 2 at Stairs taken October 29, 2019, would be labeled stairs_pan2_2019_1029. Computer software will automatically differentiate the photos with the number in parentheses, and thus the sequential photos for a single 'pan' set will appear as stairs_pan2_2019_1029 (1), stairs_pan2_2019_1029 (2), etc. If desired, panoramas can be stitched together using standard programs such as Microsoft ICE (Image Composite Editor).

Modifications to Biodiversity Surveys

There are 6 'official' options for modifications of Coastal Biodiversity Surveys (Table A1 in Appendix). Modifications may need to be made for reasons including limited personnel, inclement weather (and thus a reduced number of days in the field or amount of time at a site on a given day) or because a specific project has limited funding, etc. Species resolution remains the same regardless of which modified methods are employed.

In addition to the modified surveys described above, alternative surveys have been done by other groups outside of UC Santa Cruz using the same grid set-up. These surveys may use a different number of transects and/or locations, different layering rules, and a simplified species list. Please note that these alternative surveys are not covered in this protocol.

Project Specific Protocols

ASBS
ASBS (areas of special biological significance) sampling uses modified survey method #4 (CBS first point no layering) or #6 (CBS reduced first point no layering), see Table A1 in Appendix. Mussels are of particular interest, so layers over mussels are ignored and the mussel is recorded as the point.

MPA Baseline Monitoring
MPA baseline monitoring sampling uses survey method #1 (CBS standard) or #2 (CBS reduced). See Table A1 in Appendix.

APPENDIX

Mobile Invertebrate Sampling Decision Tree

Quadrat placement

1. Begin the survey by conferring with other samplers to identify the limits of the zones (high, mid, low) at this particular site.
    a. generally, the low zone is the area below the mussels, the mid-zone includes the mussels and the rockweeds (e.g., *Silvetia*, *Fucus*), and the high zone is the area dominated by barnacles and littorine snails.
2. For each transect: first define the zone you are sampling. The zone may be one area (i.e., high zone = 0 to 4.5m) or may be composed of multiple areas on the transect (i.e., high zone = 0 to 4.5m AND 10.2 to 14.7m) due to topographic complexity. If these different areas represent distinct habitats (i.e. one mid zone area is dominated by *Fucus* and another by mussels), be sure to sample mobile quadrats in both areas in a way that corresponds to each area's relative proportion of the zone (e.g., if the overall mid zone area is equally divided between *Fucus* and mussels at this site, choose random quadrat locations within the *Fucus* zone for transects 0, 6, 12, etc. and within the mussel zone for transects 3, 9, 15, etc.).
    a. If a transect does not pass through a particular zone:
        i. If a re-survey: refer to the existing site notes from previous surveys as to what has been done previously AND assess the current situation with the survey team in case conditions have changed since the last survey. When appropriate, do what has been done before.
        ii. First priority: sample an extra quadrat on a different line with this zone present (maintains replication of 11 quads per zone).
        iii. Second priority: specific to the high zone, the quadrat may be placed ABOVE the upper baseline with the random location recorded as a negative distance above the baseline.
        iv. Third Priority: reduce the replication for that zone at this site (i.e., less than 11 high zone quadrats). Always confer with the entire survey team before making this decision.
3. Identify three randomly chosen integers.
    a. The three digits represent your random location as: XX.X m (i.e., 015 = 01.5m, 256 = 25.6m).
    b. If your random location does not fall within your defined zone (from step 2), then pick a new number, repeating until the location falls in your zone.
4. If your random location falls within the defined zone, place the quadrat on the location with the upper left corner of the quad on the random location (when facing onshore, i.e., quadrat is on the right/down coast side of the tape)
5. If the quadrat is dominated by pool (i.e., > 50% or <50% pool but unable to see in pool) or sand (> 50%) then:
    a. First priority: flip the quad UP the transect tape so that the random location is now the lower left corner of the quadrat.
    b. Second priority: flip the quad DOWN the transect tape.

   c. Third priority: flip the quad ACROSS the transect tape (and note "flipped to left" on datasheet)
   d. Fourth priority: if none of the flipping options above alleviate the situation, then pick a new random location (i.e., return to step 3)
6. If you made it this far then please enjoy sampling your perfectly placed quad (but remember, if subsampling, you have lots more decisions to make)!

Table A1: Survey Method Descriptions

Survey Method	Description
1) CBS standard (no modification)	CBS surveys are completed as described in the above survey protocols, with the full number of transects surveyed for all methods
2) CBS reduced	CBS surveys are completed as described in the survey protocols, with a reduced number of transects surveyed for one or more methods. If reduced sampling is necessary, the priority is to sample every other line (e.g., 0, 6, 12, 18, 24, 30) in order to retain maximum spatial coverage of the site.
3) CBS first point layering (not recommended)	CBS point contact surveys are modified. Only the first point is recorded at each location, but all layering and epi/host relationships on that point are also recorded. The full number of transects are surveyed for all methods. This method was only used once and is not a recommended method.
4) CBS first point no layering	CBS point contact surveys are modified. Only the first point is recorded at each location and layering, and epi/host relationships are not recorded. If layering occurs, the top species is the organism recorded at this point unless otherwise desired for a specific project. For example, if mussels are specifically of interest, layers over mussels may be ignored and mussels will be recorded at that point. In this case, the modification will be detailed in the project report and site notes. If epi/host relationships occur, epibionts are ignored and the species attached to the substratum is the organism recorded at this point. The full number of transects are surveyed for all methods.
5) CBS reduced first point layering (not recommended)	CBS point contact surveys are modified. Only the first point is recorded at each location, but all layering and epi/host relationships on that point are also recorded. A reduced number of transects are surveyed for one or more methods. This method was only used once and is not a recommended method.
6) CBS reduced first point no layering	CBS point contact surveys are modified. Only the first point is recorded at each location and layering, and epi/host relationships are not recorded. If layering occurs, the top species is the organism recorded at this point (except if otherwise desired for a specific project as described in #4 above). If epi/host relationships occur, epibionts are ignored and the host species (the species attached to the substratum) is the organism recorded at this point. A reduced number of transects are surveyed for one or more methods.