Unified Monitoring Protocols for the Multi-Agency Rocky Intertidal Network
(2022)

John M. Engle, Laura Anderson, Jennifer L. Burnaford, Melissa Douglas, David P. Lohse, Avrey Parsons-Field

BOEM
Bureau of Ocean Energy Management

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This document is intended for an audience familiar with marine ecology and with prior knowledge of MARINe. Following are resources for aid and clarification. Many MARINe resources are stored on Egnyte, a cloud-based file storage site. Access to shared MARINe files on Egnyte can be requested via email (see Key Contacts below). Appendices, datasheets, examples, guides, and protocols (including National Park Service protocols) can be found on Egnyte in the Handbook Resources Folder (Figure 1). Throughout the remainder of this document, the referenced links will have the beginning omitted for brevity but share the same URL beginning as the link below:
https://marine.egnyte.com/app/index.do#storage/files/1/Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources

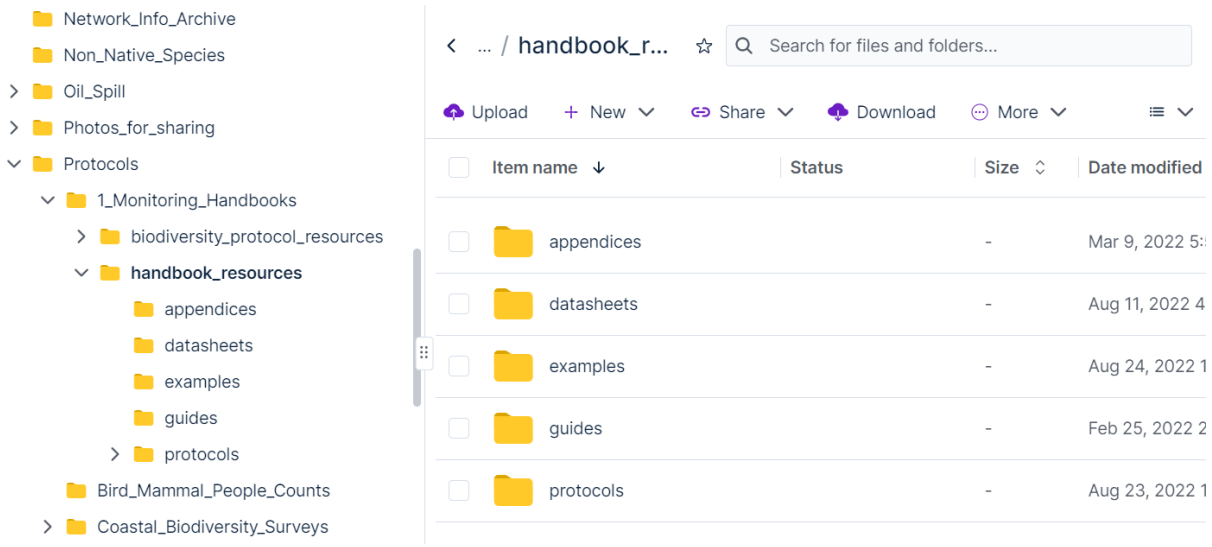

Figure 1. Screenshot of the handbook resources folder on Egnyte

The MARINe website (www.pacificrockyintertidal.org) contains detailed and frequently updated information on all aspects of the network, including funding partners, research groups, study sites, and data summaries.

For a detailed history of the MARINe network, refer to:

Gilbane L, RF Ambrose, JL Burnaford, ME Helix, CM Miner, SN Murray, KM Sullivan, SG Whitaker. 2021. Long-term sustainability of ecological monitoring: perspectives from the Multi-Agency Rocky Intertidal Network (MARINe). *Chapter 7 In: Partnerships in Marine Science: Policy Implications, Lessons Learned, and Recipes. Editors: G. Auad and FK Wise. Elsevier Publishing.*

KEY CONTACTS

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LIST OF APPENDICES

(available on Egnyte: Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources/appendices):

Appendix 1: Monitoring information for MARINe sites

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1. INTRODUCTION

1.1 Multi-Agency Rocky Intertidal Network Monitoring Program

The Multi-Agency Rocky Intertidal Network (MARINe) was created as a result of a workshop held at the University of California Santa Barbara (UCSB) in 1997, when several existing monitoring programs using similar but not identical protocols agreed to standardize protocols and enter data into a shared database. MARINe is composed of partner organizations and monitoring groups including federal and state agencies, academic institutions, and non-profit groups. Gilbane et al. (2021) provide a detailed history of the collaborative network, and specific information on funding partners, research groups, and study sites which can be found on the MARINe website (www.pacificrockyintertidal.org). As of 2021, MARINe covers 145 core monitoring locations.

1.2 Handbook Purpose

The purpose of this Handbook is to articulate a standard set of monitoring protocols for use at all MARINe monitoring sites. These standard procedures should not be modified without network agreement. Agreed-upon changes will be communicated to monitoring groups and incorporated into periodic updates of the Handbook and website (www.pacificrockyintertidal.org).

MARINe methods can be divided into two tiers. **Core protocols** cover procedures that are done by all groups at all sites. **Supplemental protocols** (formerly labelled 'optional' protocols) cover procedures that are done by groups with funding & staffing to support additional work.

Monitoring groups can opt to employ variations of core protocols in consultation with MARINe database managers. Consultation is essential in order to ensure that variations a) are backward compatible with historical data, b) are compatible with and eligible for entry into the database and c) have clearly defined protocols for database managers when they are organizing data for comparison across sampling groups. For example, *Codium fragile* is lumped into the group 'other green algae' for photoplot sampling under MARINe core protocols. If a group wanted to record abundance of *Codium fragile* separately from other green algal species, they would need to consult with the database manager first to ensure specific definitions and compatibility. In addition, the group would need to make a commitment to this variation for the long term, because there is little value in changing protocols on an occasional basis (e.g., only when a particular person is available in the field to identify that species).

Monitoring groups can also opt to implement supplemental protocols beyond the core monitoring, again in consultation with MARINe database managers. For example, a group may decide to install Robomussel temperature dataloggers at one of their field sites (section 3.11). This protocol would be undertaken and maintained in addition to the core sampling at that field site. Groups that decide to add supplemental protocols to their sampling regime at a site must make a commitment to the supplemental protocol for the long term, because (as with variations to core procedures mentioned above) there is little value in collecting data on a short-term or occasional basis.

This Handbook describes current protocols. Documentation of historical changes to and details on approved protocol variations (for specific sampling groups) are included in Appendix 2 to provide a long-term perspective that is useful for data analysis. Additional information on protocols can be found in monitoring group study plans and handbooks (Ambrose et al. 1992, Engle & Davis 200b, Engle et al. 1994a,b, Richards & Davis 1988, Richards & Lerma 2003), as well as in data reports (Ambrose et al. 1995a,b, Davis & Engle 1991, Engle 2000, 2001, 2002, Engle & Adams 2003, Engle & Davis 2000a,c, Engle & Farrar 1999, Engle et al. 1998a,b, 2001, Miner et al. 2005, Raimondi et al. 1999, Richards 1986, 1988, 1998, Richards & Lerma 2000, 2002).

This Handbook provides descriptions of standardized protocols that are incorporated into each monitoring group's site-specific field protocols. Each field team should maintain documentation

such as directions to the site; a site description that includes the site size, boundaries, and GPS coordinates; site maps showing prominent features and plot locations; printed photos of plot locations; site safety considerations, and useful notes to efficiently locate and consistently sample the plots. Site-specific coordinates and sensitive species information should not be made available to the public, in order to minimize collecting or other activities that may impact the sites.

2. TARGET SPECIES ASSEMBLAGE LONG TERM MONITORING SURVEYS

2.1 Monitoring Sites

Long-term MARINe monitoring sites have been established at representative rocky intertidal reefs along the North American West Coast. Selecting sites for long-term monitoring is a process that must include consideration of a large number of factors such as monitoring objectives, available funding, and long-term site access. It is recommended that sampling teams communicate with MARINe database managers (see Key Contacts) to discuss site characteristics during the site selection process. An example datasheet for scouting potential monitoring sites can be found on Egnyte.

Current MARINe sites are listed on the website (www.pacificrockyintertidal.org). Information on monitoring for each site (plot types and GPS coordinates) is available in Appendix 1 (see List of Appendices in the Table of Contents). Information about specific site locations (e.g., directions, site maps) can be found on Egnyte in Shared/MARINe_Internal_Resources/Sites).

It is MARINe policy not to provide site location details to the public, in order to minimize collecting of species in these areas.

2.2 Sampling Design: Target Species Assemblage / Fixed Plot Methodology

Target species (Table 1) **are species or species groups specifically chosen for MARINe long-term monitoring**. Criteria for selecting target species are listed on the MARINe website (https://marine.ucsc.edu/target/selection-criteria.html). One key factor in target species selection is that these species / groups can be accurately identified with high consistency across all MARINe groups

2.2.1 Establishing Fixed Plots / Transects: Priority and Supplemental Target "Species"

The number of and identity of target species monitored at any given site is determined by the relevant sampling team in consultation with MARINe database managers. Decisions are based on the abundance of species and the logistics of repeated monitoring of target plots or transects for that sampling team at that location.

Priority target species have the highest priority for monitoring and are monitored at as many sites as possible. After consultation with MARINe database managers, some monitoring groups have established fixed plots or transects to monitor **approved supplemental target "species"** (we here use the term "species" for ease of comparison while recognizing that many of the supplemental fixed plot sampling types are not focused on single biological species).

PRIORITY TARGET SPECIES: MACROPHYTES

1. *Fucus distichus*
2. *Hesperophycus californica (Pelvetiopsis californicus)*
3. *Pelvetiopsis limitata / arborescens*
4. *Silvetia compressa*
5. *Endocladia muricata*
6. *Phyllospadix scouleri/torreyi*

PRIORITY TARGET SPECIES: INVERTEBRATES

7. *Anthopleura elegantissima/sola*
8. *Mytilus californianus*
9. *Lottia gigantea*
10. *Haliotis cracherodii*

11. *Haliotis rufescens*
12. *Chthamalus dalli/fissus/Balanus glandula*
13. *Semibalanus cariosus*
14. *Tetraclita rubescens*
15. *Pollicipes polymerus*
16. *Pisaster ochraceus*

APPROVED SUPPLEMENTAL TARGET "SPECIES"

- *Egregia menziesii*
- *Hedophyllum sessile*
- *Neorhodomela larix*
- *Caulacanthus okamurae*
- *Zostera marina*
- *Postelsia palmaeformis*
- *Mastocarpus* spp
- *Mazzaella* spp
- Red Algae (includes plots targeting *Gelidium spp* and "red algae," and transects targeting "turf")
- *Balanus glandula* (separated from *Chthamalus fissus/dalli*)
- *Katharina tunicata*
- *Cryptochiton stelleri*
- *Strongylocentrotus purpuratus*
- Tar
- Recovery
- Rock (= plots above the barnacle zone to monitor shifts due to Sea Level Rise).

2.2.2 Data Collection: Core and Supplemental Species

Core Species: **Core species, species groups, or substrates are scored by everyone in MARINe** (Table 2, 3). **Scorers in all monitoring groups must be able to identify all core species. Data sheets and iPad data collection templates must include all core species, although core species that are absent or rarely occur at a site can be de-emphasized** (e.g., smaller font size or last page of a template). **All priority target species are also core species**. Core species were deemed reasonably and consistently identifiable using the designated scoring protocol and important enough to warrant scoring for abundance trends. Entries for all core species, including zeros where species are not observed, are required for data submission to the MARINe database.

Supplemental Species: **Supplemental species are non-core species or species groups that one or more monitoring groups choose to score at their sites (in consultation with MARINe database managers) in addition to the core species**. Before a monitoring group decides to score supplemental species, they must contact the MARINe data manager and work out an agreement regarding category definitions. Choosing to add a supplemental species requires a commitment to monitor the species consistently for a long period of time.

Example: In the MARINe Photoplot Core Species List (Table 2), the barnacles *Balanus glandula* and *Chthamalus dalli/fissus* are combined into the single category CHTBAL. However, after consultation with MARINe database managers, CSUF / CPP score these taxa separately (codes = BALGLA and CHTDAL, respectively). When the data are used to make comparisons across all MARINe sites, BALGLA and CHTDAL are lumped together into the CHTBAL category.

2.2.3 Fixed Plot Sampling Design and Site Set-up

Background for Fixed Plot Sampling: Fixed plots are permanent areas of rocky intertidal habitat which are variable in size and shape. The objective of MARINe core protocols is to monitor changes in abundances of the target species over time. Fixed plots were chosen instead of randomly located plots (placed in different locations for each survey) because intertidal assemblages are so heterogeneous that an impractically high number of replicate plots would be necessary to adequately detect temporal changes in species abundances in the midst of variability due to different plot placements for each sample season. The size and number of plots sampled with limited available effort is a compromise between gathering more detailed information about a limited segment of the resource versus sampling a wider range of resources (see Ambrose et al. 1992, 1995b; Drummond & Connell 2005; Murray et al. 2002). Fixed plots reduce the high variability inherent in random plots and can be monitored relatively easily and inexpensively. However, it is important to note that the dynamics of fixed plots cannot be extrapolated to larger areas (e.g., site-wide) without gathering additional larger-scale information. For in-depth discussion of the rationale and pros/cons of MARINe fixed plot sampling, see Ambrose et al. (1992, 1995b) and Murray et al. (2002).

Photoplots: **Rectangular (50 x 75 cm; 0.375 m²) photoplots** were established to monitor the cover of relatively small, densely spaced, sessile target species. To maximize efficiency during limited low-tide time and provide a permanent visual record, these plots were originally designed to be photographed in the field, with photos later scored in the lab (hence the name 'photoplots'). The plot size was the largest area that could be captured reliably with a rectangular 35 mm film frame, allowed a comfortable camera working height, and provided sufficient detail to identify target species. The original data collection protocol recorded data for a single biological 'layer.'

As of 2020, the **preferred photoplot monitoring protocol** is to score plots in the field and take (and store) archival photos. A **supplemental protocol for photoplots** is to collect data on multiple species layers. Layering protocols were constructed to be backward compatible with older 'top-layer' data. The MARINe standard is to monitor **5 replicate plots** per target species, placed in a stratified manner throughout the zone in which the relevant target species has its maximum abundance, within the limits set by stable substrate suitable for sampling permanent photoplots and sufficient (relatively high) cover of the target species.

Point-Intercept Transects: **Linear transects (10 m in length)** are primarily used to monitor the cover of surfgrass, although at some sites transects are also used to monitor red algal turf, *Egregia*, *Zostera*, and/or *Saccharina*. The MARINe standard is to monitor **3 replicate transects** per target species, placed throughout the target species zone of maximum abundance, within the limits set by stable substrate suitable for sampling permanent transects and sufficient (relatively high) cover of the target species.

Circular Plots: The number and size of **owl limpets** are monitored within permanent circular plots (**1 m radius, 3.14 m² area**), marked with a central bolt. The size of the plot was designed to encompass enough owl limpets for size-frequency comparisons. The MARINe standard is to monitor **5 replicate plots** per site within the owl limpet zone of maximum abundance, placed in areas with stable substrate suitable for sampling permanent circular plots, with minimal (initial) cover of mussels, and sufficient (relatively high) density of the target species.

Band Transects and Irregular Plots: The number and size of **sea stars, abalone (black and/or red), and urchins** are monitored within band transects or irregularly sized / shaped plots. Plot type and size should be chosen based on the area containing sufficient numbers of the target species for monitoring consistently. At sites with extremely low abundance of these target species, whole site searches or timed searches may be more appropriate. The MARINe standard is to monitor **3 replicate plots** per site within

the target species zone of maximum abundance, placed in areas with stable substrate suitable for sampling permanent band transects or irregular plots and sufficient (relatively high) density of the target species. Abalone and sea stars are monitored in the same set of transects/plots at some sites.

Plot Markers: Every plot or transect needs a set of markers (herein 'plot markers') to identify the boundaries / corners and allow the sampling team to locate the plot during subsequent sampling events.

- **Plot markers should be placed in prominent locations to maximize ease of relocating plots during annual sampling.** This is especially important in mussel beds to minimize disruption to the mussels (if mussels grow over plot markers, the mussels are disturbed as sampling teams attempt to find the markers on each sampling trip).
- **The best plot markers are stainless steel hex head bolts** epoxied into holes drilled into the rock. Bolt length and diameter depend on ease of rock drilling as well as bolt conspicuousness versus public safety (tripping hazard) and aesthetic considerations. If bolts eventually become overgrown (with algae, mussels, etc.), large bolts (e.g., 4-6 inch long, 3/8-inch diameter) can be relatively easily found using a metal detector. If the rock is soft, use large, long bolts for best anchorage so they are not easily lost if the rock erodes or flakes away. In remote areas (few visitors) or in mussel beds (where mussels can overgrow bolts) bolts should ideally extend several inches out from the rock surface to aid in relocation (attaching brightly colored cable-ties can also help). However, on reefs with a lot of public access, bolts may need to be small or inconspicuous (even flush with the substrate). If drilling holes for bolts is not feasible, use epoxy blobs (consider encasing something metal like a washer in the epoxy to allow detection with metal detectors) instead of bolts (but relocation and maintenance efforts will be greater than for bolts because of the higher potential for overgrowth of flat plot markers).

Plot/Transect Establishment Procedures: Permanent plots or transects are established during the initial set-up of a new monitoring site (or may be added to expand surveys at an existing site). For maximum comparability among sites, **all MARINe priority target species that occur in sufficient abundance for adequate sampling should be monitored at each site if possible** (except for those sites established for a particular species, such as black abalone). However, resource availability might limit the number of target assemblages that can be consistently monitored over the long term at some sites.

Plot/transect establishment procedures may vary among sites depending on the nature of the site and preferences of the monitoring group. The following are guidelines for standard practices that can increase efficiency, enhance compatibility across MARINe sites and facilitate data entry into the MARINe Database:

- **For each target species: a) identify multiple good plot/transect locations within the optimal zone (area of high abundance of that species / assemblage), b) stratify plot locations by differing physical conditions/locations.** For example, if two surfgrass areas (one twice as large as the other) occur at the site, identify all good transect locations within the two areas, then place two transects in the large area and one transect in the small area to establish the MARINe standard of three replicate transects per site. Transects and plots are usually spatially distinct but may run end to end (transects) or have adjacent sides (plots) if necessary: the layout depends on the shape and expanse of the target species' habitat at a site.
- **Make sure to locate plots in areas that are accessible for frequent monitoring over the long term.** Be aware that if you are setting up on an exceptionally low tide (or during unusually calm conditions) plots/transects established in the low intertidal zone may not be easily accessible during future surveys with different tidal or weather conditions. **Photoplots need to be relatively flat (though not necessarily horizontal) so that the entire plot falls within a similar focal plane,**

with minimal shadowing from crevices or projections. Also, remember that the plots/transects you set up are permanent, so consider factors such as sampler movement between plots, etc.

- **For each target species / assemblage, plots / transects must be marked to identify the boundaries for repeated sampling. There are two standard types of plot markers: a) stainless steel hex-head bolts sunk into the rock, and b) epoxy markers secured to the rock surface. To install a plot marker**, clear an area of about 5 cm by 5 cm to bare rock using scrapers and wire brushes, then rinse the rock surface to remove dust and debris. Clean rock is important for good adhesion, but it does not have to be dry. For bolts, drill a central hole and epoxy the bolt firmly in the hole. For epoxy markers, press a blob of well-mixed epoxy onto the rock and form it into a smooth mound approximately 4-cm in diameter. Embedding a stainless-steel washer into the blob can facilitate relocation as it will trigger a metal detector. Waterproof pinpoint metal detectors are extremely useful for locating plot markers, especially if they have been overgrown. Epoxy blob markers can be inscribed with helpful markings (see below).
- **For each target species / assemblage, plots / transects should be numbered from #1 to #5, ideally from upcoast to downcoast. For each plot/transect, one marker will be designated as the primary plot marker and marked with the plot number. Assigning a primary plot marker is essential for repeated sampling of plots in a consistent orientation (photoplots) or direction (transects). The other plot markers may be marked or not depending on marker type.**
    - Each sampling team should identify a standard location for the primary plot marker for each type of plot (e.g., in the upper left-hand corner of each photoplot as you face the water, on the upcoast end of each transect, on the most land-ward marker for each irregular plot, etc.).
    - Epoxy blob primary plot markers can be inscribed with the plot type and number in the epoxy before it is dry (e.g., mussel plot 1 = M1, mussel plot 2 = M2, etc.). Stainless steel bolt primary plot markers can be notched on the top using a saw or Dremel tool with a cutting wheel attachment (e.g., plot 1 primary plot marker has 1 notch… plot 2 has 2 notches, etc.: Figure 2). Combinations of epoxy markers and bolts can also be used: e.g., epoxy for the 'regular' markers with etchings such as 'M 1 LR' (mussel 1 lower right) and a stainless-steel bolt (with notches) for the primary plot marker. Note that if bolts are used exclusively, careful mapping may be necessary to distinguish plots / transects for different target species (e.g., to distinguish Mussel Plot #1 from Gooseneck Barnacle Plot #1).

Figure 2. Examples of notched bolts used for marking permanent plots. Left bolt has 3 notches, right bolt has 1 notch. A maximum of 6 notches is recommended for hex head bolts.

    - For photoplots, a good standard is to put markers at 3 corners, designating the primary plot marker as the one in the upper left corner as you stand to take the photo and the remaining 2 markers in the upper right and lower left corners. Photoplots are photographed in horizontal orientation, and each sampling team should identify a standard for photography (e.g., photographer faces the water or photographer's back is to the water) at the start, so that the primary plot marker can be placed in the upper left-hand corner of the photo as the plot is photographed (Figure 3).

Figure 3. Example photo plot showing ideal placement of plot markers. The primary plot marker (in this case, a notched stainless-steel bolt) is in the upper left corner, and the other markers (in this case, unnotched bolts) are visible in the upper right and lower left corners of plot. This marker placement ensures consistent orientation of the photographs across repeated surveys.

  - For transects, install the primary marker at the upcoast end and mark the mid marker (if one is used) and end marker in a way that will allow you to distinguish them. For example, "/" or "MID" for mid and "X" for end.

- After all plots and transects are set up, identify several prominent spots around the site for installation of **reference markers** that can be useful for relocating plots in the future (particularly at sites where plot markers are likely to be overgrown by mussels, etc.) and for fixed panoramic photographs (see below). These reference markers should be placed centrally among groups of plots/transects on easily visible surfaces to facilitate relocation and allow overview photo pans to include nearby plots/transects. The number of reference/photopoint markers will depend on site size and plot/transect distributions. An abalone-only site may need only 1 reference marker, while a large site with multiple target species assemblages may need 5 or more reference markers. The best type of reference markers may depend on the site: if large hex bolts (e.g., 6 inch long by ½ inch diameter) are not feasible, epoxy blobs are an option, as reference markers are generally placed in high areas that are less likely to be overgrown and are more visible to the public.

Site Mapping: It is important to document the site location and the boundaries (for site-wide searches) as well as the specific location of each plot and transect (Figure 4). Each plot marker should be identified on the site map, and the primary plot marker should be distinguished from

other plot markers. For example: on the site map, a team could use circles at the corners of photoplots to identify 'regular' plot markers, and an x to identify the primary plot marker. Site maps can include directions to the site, GPS coordinates, inter-plot measurements, sketch maps, plot overview photos, and aerial photos.

Site Directions: Briefly record how to get to the site (by car, boat, or on foot) from the monitoring team institution or city/base station closest to the site. Include waypoint mileages and estimated travel time. Consult your agency or university guidelines regarding site safety procedures such as listing local hospitals/urgent care centers, etc. Examples of site direction documents can be found on Egnyte (see List of Resources in this Handbook for the link).

GPS Coordinates: Record at minimum, **3 principal GPS coordinates** for each site. First **a single latitude/longitude coordinate pair that defines the location.** This should be close to the physical center of the site: ideally at a BLM marker or site reference marker. Alternatively, one can use the location of a specific target species plot. Second, **the two boundaries of the site (north/south or east/west) should be documented.** These are ideally spots centered between high and low tide zones, but they could be the positions of the northern- or western-most plot and the southern- or eastern-most plot. Use the most accurate GPS unit available. Be sure to document who took the reading and when, the specific location (e.g., BLM Ref 1, MARINe Ref 2, MYT Plot 5, PHY Transect 3 Center Bolt, etc.), the type of GPS unit used and its accuracy, and the datum used (preferably NAD83 or WGS84). If possible, record latitude/longitude as decimal degrees.

Measurements: These measurements are valuable for site mapping and to aid in relocation of plots on future samplings. Measurements should be entered into a spreadsheet after sampling, which will allow for easy reversal of location measurements and calculation of the reverse compass bearings. For example, if the measurements from M1 to M3 are 5.7m and 150º, the reverse measurements from M3 to M1 are 5.7m and 330º. Having both original measurements and reverse measurements is helpful for finding plots during future surveys (see Egnyte for example "bolt to bolt" measurement files).

- For each plot/transect, **record at least 3 pairs of distances** (to nearest 0.1 m) **and bearings** (to nearest 5°) **which document the location of the primary plot/transect marker relative to reference markers and primary markers of other plots/transects.** It is preferable to use markers in several different directions to allow for triangulation.
- For transects: record the measurement and bearings from the primary marker to mid marker (if present) and end marker.
- For irregular plots: record measurements and bearings between the primary marker and all other markers, and between markers for other plots and reference markers.
- For reference markers: record measurements and bearings between each reference marker and at least two other reference markers or plot markers.
- For the site: measure the distance between upcoast and downcoast boundaries of the site (defined as upcoast-most plot to downcoast-most plot). An example can be found on Egnyte (see List of Resources for link).

Sketch Maps: From as much of an overhead perspective as possible, sketch the prominent features of the site (e.g., pinnacles, ridges, pools, boulders), with approximate **plot/transect locations shown relative to each other and to the physical features**. Scale relationships on sketch maps can be improved by incorporating the inter-plot measurements in a second draft of the maps. Indicate the notched (e.g., upper left-hand corner) marker location for quadrats and transects (e.g., by using an x to mark that corner). For large sites, separate maps can be prepared for different sub-areas. Always make sure to identify 'North' on the map, as well as the location of the ocean and land. Maps can be scanned into digital format for labeling and other enhancements. Digital maps can be loaded onto a tablet and brought in the field. See Egnyte for an example map (see List of Resources for link).

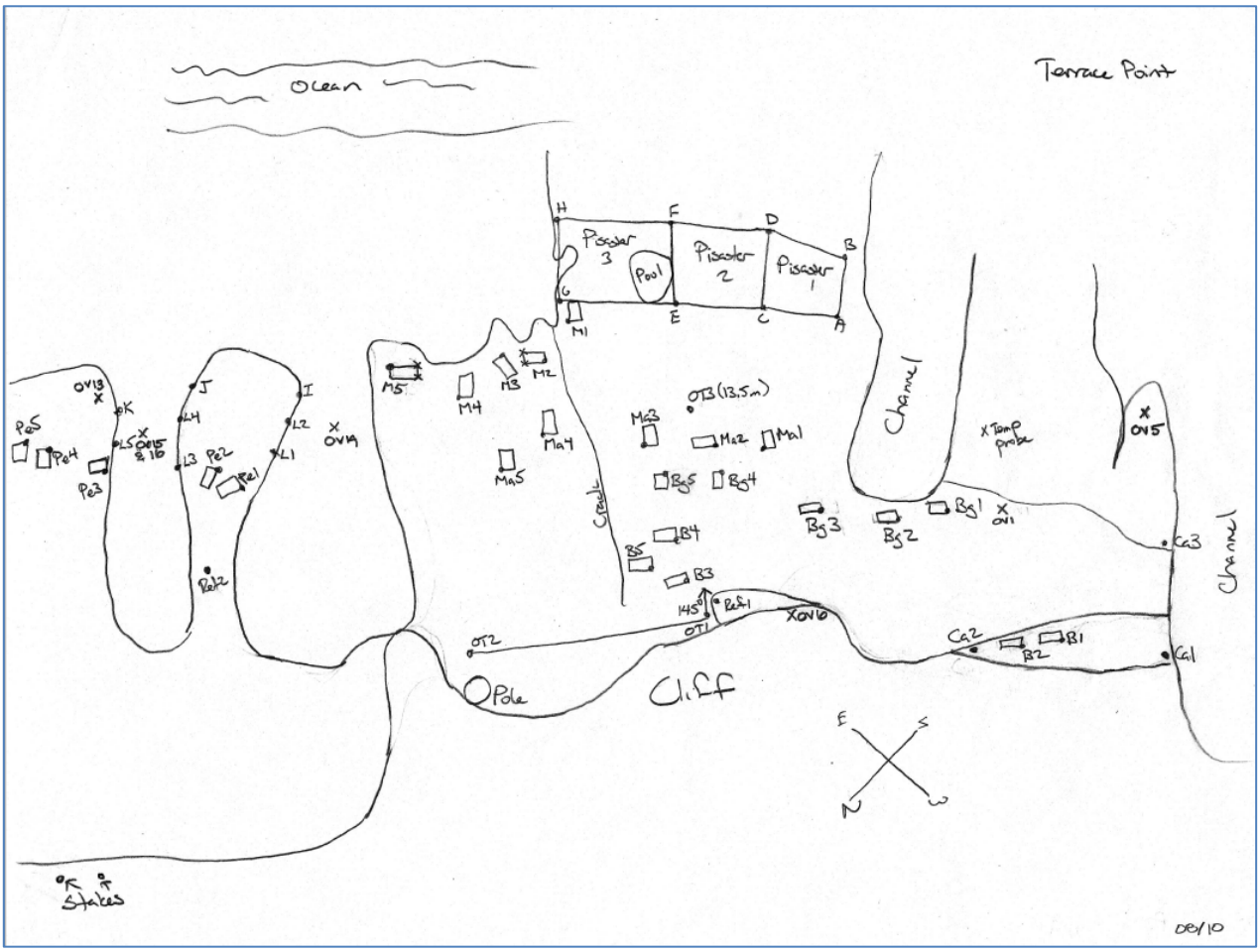


Figure 4: Example Site Map.

Plot/Transect Overview Photos: Take many site overview photos with photoplot PVC frames or flagging (see 3.3.1) and transect meter tapes in position. It is helpful to put orange cones on reference markers to help with orienting the photos (cutting vents in the cones helps to prevent weather-based cone movement). Photos can range from **broad views of large portions of the site to individual views of each plot and transect**. For the latter, include the area around each plot/transect to document location relative to nearby, prominent or distinct features. It is useful to print and laminate photo guides, or print photos on waterproof paper to assist with plot location during surveys. Photos can also be loaded onto a tablet and brought in the field. An example of overview photos can be found on Egnyte here: /Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources/examples/overviews_example

Aerial Site Photos: If possible, take aerial photos of the site during low tide, with photoplot PVC frames or flagging and transect meter tapes in position. Put orange cones on reference markers. This may be accomplished easily if the site abuts a high cliff. Another option is a camera on a drone. A good aerial photo can greatly complement the site map and facilitate plot re-location.

2.2.4 Plot / Transect Maintenance

Criteria for Adding or Dropping Plots/Transects: Target species abundances occasionally decline dramatically in one or more plots or transects, due to changes in the biological community (e.g.,

ecological changes or zone shifts) or due to substrate disturbance from storm swells (including rock breakouts and boulder movements). When target species abundance drops severely and stays low for a long period, the plot or transect is no longer actually helping to monitor the target species (except for its paucity in the plots), especially when that species is still present elsewhere at the site. The following are recommendations for how to deal with these types of situations:

- **All originally established plots / transects should continue to be monitored (and should retain their original names and numbers).** For example: Mussel Plot #1 will always be Mussel Plot #1, and will continue to be monitored, even if a storm removes all of the mussels from that plot and other species subsequently dominate in that plot. Continued monitoring is important to confirm this major loss over time or perhaps document later recovery.

- **If the target species remains low/absent in its targeted plot(s) for an extended period of time (perhaps 3 years), but shows reasonable cover elsewhere at the site, the standard is to <u>add</u> new plot(s) in areas with good cover. This applies to large countable target species (e.g. abalone or seastars) as well as smaller species.** For example, if Rockweed Plots #1, #2, and #5 lose all rockweed for 3 years (apparently due to a zone shift) and Plots #3 and #4 still have good rockweed cover, in the 4th year, establish 3 additional plots (#6, #7, and #8) in areas with similar cover to Plots #3 and #4. From this point on, all 8 plots will be monitored. It is important to avoid changing the plot numbers so that original plots can be followed over the long term.

- **If large countable target species such as abalone or sea stars become low in the targeted plots <u>and</u> throughout the site, continue monitoring the plots, but <u>also</u> institute a site-wide timed search** (see below) during each survey (akin to having the entire site as one plot).

- The above plan also is recommended for situations where one or more plots have been subject to physical disturbance such as breakout of the rock surface or movement of a previously stable rock. Typically, this results in major reductions in key species cover that may or may not recover over time. Disturbed plots should continue to be monitored to document recovery or lack of recovery over time (replace any missing markers). If the disturbance has substantially changed the microhabitat or tidal height zone such that it is unlikely that recovery of the key species will occur, then <u>add</u> a plot (or plots) with cover of the target species that is higher / similar to the remaining undisturbed plots. In very rare cases, disturbance to a plot is so extreme (e.g., complete loss of rock) that it no longer makes sense to continue monitoring. If a plot is abandoned, it is important to convey this to the database managers so that it can be designated as "inactive."

<u>2.2.5 Data Collection: Timing and Frequency of Surveys</u>

Due to the nature of our sampling schedules (including limited # of adequate low tide periods, site access limitations, and weather delays), MARINe has 3 sampling seasons, each 4 months long, defined as follows: **Fall = October-January, Spring = February-May, and Summer = June-September** (Note that this does not quite match the calendar year; thus a sample in January 2005 would be listed as a Fall 2004 sample).

Historically, core protocols called for MARINe sampling semi-annually, in Fall and Spring. In 2018, after an analysis of temporal trends in long-term monitoring data, the protocol was changed to recommend annual sampling of long-term monitoring sites in Fall.

Variations from and Additions to Core Protocols:

- It is critical that at any single site, annual sampling is conducted routinely within the same season each year. While the recommendation is for teams to sample in the Fall, for sites which are difficult for sampling teams to access regularly in Fall, annual sampling during the summer may be the best option. **Note that the decision to deviate from the recommended Fall sampling

regime must be made in consultation with MARINe database managers.

- For sites which are easy to access semi-annually, some sampling teams complete the full suite of annual monitoring protocols in Fall and return to repeat a subset of protocols in Spring (typically sea star and limpet plots).

3. SURVEY PROTOCOLS

3.1 Field Log and Site Reconnaissance Protocol

During each site monitoring survey, the field team should complete a field log (with information on field team members, timing of sampling, etc.) and observe and record general physical and biological conditions at the site. Additional site-wide categorization of target and other core species conditions is useful whenever time permits. These observations, along with panoramic photographs, provide valuable perspective on site dynamics that aid interpretation of data from the fixed plots and transects.

3.1.1 Completing the Field Log and Conducting Site-Wide Reconnaissance

Core Protocol: Field log information and site reconnaissance characterization are recorded on the two-page field log data form (see Egnyte for datasheets and Form 1 for relevant definitions). **Field log data that must be recorded (because they are required for data entry into the database) include site, date, survey time, and names of survey team members participating that day.** Core physical data should also be recorded, including weather and sea conditions (swell/surge, wind, rain, recent rain, and water temperature), substratum changes since the last survey (sediment level, scour, rock movement), and debris/pollutants presence (plant wrack, driftwood, shells, dead animals, trash, and oil/tar).

To facilitate standardization and data management, many data entries are restricted to specific category codes (e.g., low, med, high). **All data entry blanks on the field log should be filled in with a code, actual value, notes, or a dashed line indicating "no data."**

Physical Conditions: Emphasis is placed on **conditions that could affect quality of sampling or help to interpret data trends (e.g., low tide event coincided with a heatwave)**.

Birds and Mammals: Core categories should always be documented. **Record species and maximum number of individuals within the defined MARINe sampling site, either onshore or within 50 m or shore, seen at any one time during the sampling, preferably upon arrival at site prior to sampler disturbance.** If recording for permitting requirements, keep track of the time of disturbance, how many were disturbed, how great a disturbance it was, and age/sex of species disturbed (if possible).

If a sampling group wishes to define more specific categories or species than the core categories listed on the field log, they should consult with MARINe database managers. More specific information can always be recorded in the notes.

Humans: **Record maximum number of people seen at any one time during the sampling**. Separate counts for people within the boundaries of the defined MARINe sampling site from counts of people on nearby sandy beaches. Note relevant behaviors such as fishing, collecting (including information about the taxon collected if possible), walking with buckets, etc.

Guidelines:

- On a descending tide, it may be practical to start the field log and site reconnaissance upon first arrival at the site because many observations can be recorded before the tide is low enough for performing other tasks. Additional notes can be added later during monitoring, or at the conclusion of monitoring, when more time is available to organize thoughts or confer with others.
- Things to note include: general appearance of algae and encrusting animals, physical damage / disturbance, signs of disease, changes since last visit (e.g., absence of animals or algae that typically occur at the site), any methods that were done differently from the standard protocols, and problems encountered with equipment or locating plots.

Variations from and Additions to Core Protocols: These are approved **supplemental categories** that provide additional information. Groups can add this information to the field log:

- Sea Star Information: If the group does not perform dedicated sea star surveys, observations on abundance and health conditions of encountered individuals (identified to species) can be noted. This information can be entered into the sea star observation log (https://marinedb.ucsc.edu/ssd/public/observation-log/create)
- Collections: If collections are made by the MARINe sampling group, note the species, number collected, who did the collecting and for what purpose. This information is useful when filling out required collection reports.
- Non-Native Species Presence: Record the presence (or absence) of *Sargassum hornerii*, *Sargassum muticum*, *Undaria pinnatifida*, *Watersipora*, *Caulacanthus okamurae*, *Didenum vexillum*, *Lomentaria hakadotensis*. **If you are unsure (i.e., the team did not actively look for a species, record as ND - no data)**. If you encounter a non-native species not on this list, there is space to write it in.
- Plot Marker Loss/Repair: Note any problems with lost markers or difficult to find plots, and record any repairs completed or newly installed bolts or plots. Identify problems that need to be fixed on the next visit. This section does not need to be entered in the database but can be checked when planning the next sampling trip.
- Other Notes: Notes on physical and biological conditions contain useful information as noted in the introduction to this section. These notes should be entered in the database (as text entries) if possible.
- Survey Checklist: The survey checklist (on the back of the datasheet along with definitions and instructions) is used by some monitoring groups to mark off procedures done at a site to ensure that all tasks were completed.

3.2 Panoramic (Pan) Photograph Protocol

During each survey, panorama pictures should be taken to a) provide a photographic record of the overall condition of the site, b) document the relationship of the fixed plots to their surrounding area, and c) document changes occurring over time at site. Additional photographs should be taken to document anything unusual, such as rock breakouts or reef damage, evidence of poor organism health (e.g., 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.

Panorama pictures are taken to document the condition of regions of the study site. They typically encompass 180° or 360° fields of view but can be smaller if targeting specific plots or transects. Each set of panoramic (pan) photos is numbered and, to ensure repeatability, taken from a specific, marked location. Ideal locations to take panoramas are reference markers, specific photoplots, or markers used to mark irregular plots. The location of all pan photo sets should be labeled on the site map and described in detail on the sheet with printed pan photos that are used for reference while in the field (see below). Ideally, pan photos are taken after all plots have been located and marked with either quadrats or transect tapes.

3.2.1 Photographing Panoramas

- Check to make sure the camera settings (e.g., white balance, resolution, type of metering, etc.) are correct. Check the shutter speed on the camera. Although it is always desirable to choose the lowest ISO (=ASA) setting possible, if the shutter speed is too slow (e.g., <1/60 sec), increase the ISO setting. The best quality photos are obtained by optimizing ASA (low

requires more light while high becomes increasingly grainy), Aperture (small needs more light while large has poor depth of field), and Shutter Speed (slow increases likelihood of blurring while fast needs more light).

- Find the specific location from where the set of panoramic photos is taken. Every attempt should be made to replicate earlier versions of the panorama. Having printed copies of previously taken panoramas, along with notes of where and how they were taken, is helpful. If there is no marker to indicate the location for the panorama, it can be helpful to have a printed overview photo showing the location (with a written description of where it was taken). Panoramas are typically taken with photos in portrait orientation to capture more of the intertidal zone. However, in some cases a horizontal (landscape) orientation is more appropriate. See an example of a site pan overview here: /Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources/examples/pans_example.

- **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.** Panoramas that span a 360° field of view can be taken as 2 separate 180° pans. Be aware that the sun reflecting off the ocean or tidepools can cause the rest of the picture to be underexposed; if possible, adjust the exposure to compensate. When done, and before moving on to the next panorama, take a picture of some standard object (e.g., your foot, hand, clipboard); this will help distinguish one set of panorama 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 form (which can be found on Egnyte).

3.2.2 Labeling Panorama Digital Images

After downloading the photographs, with the aid of the photolog form, label each picture as **site code_pan#_seasonyear**. For example, the first picture of pan# 2 at Stairs taken in fall 2019 would be labeled sta_pan2_fa19. Historically, each photo number of a pan was labeled manually: but now, 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 sta_pan2_fa19 (1), sta_pan2_fa19 (2), etc. If desired, panoramas can be stitched together using standard programs such as Microsoft ICE (Image Composite Editor).

3.3 Photoplot Protocol

Historically, plots were sampled (photographed) twice per year at most sites, and photos or slides of the plots were scored in the lab. Post 2020, there are two major updates to this historic protocol: a) most sampling groups sample photoplots once per year (usually in Fall), and b) plots are scored in the field. Scoring plots in the field is preferred by most teams whenever possible for the following reasons: 1) Field scoring is more accurate than scoring from photos, 2) Office demands made it difficult to find time for lab scoring, 3) Data on species layering that is impossible to see in photos can be collected in field. For consistency, it is preferable to use the same sampling method (either field or lab scoring) at any given site over time. Occasionally, conditions do not allow for field scoring of all plots. In these cases, plots can be scored from photos in the lab. **If a team is field scoring, plot photos should still be taken and archived** in case photos need to be referenced during QA/QC (to verify presence of an uncommon species, for example). Archived photos have also been useful for addressing research questions outside the scope of the MARINe monitoring program.

3.3.1 Photographing Photoplots

Core protocol: Waterproof digital cameras are used. A **photo framer apparatus is used to support the camera at a constant height (1 m with a 35 mm lens) and orientation to ensure consistent framing of each plot**. The photo framer, usually constructed of PVC pipe, consists of a bottom photoplot-sized frame (50 x 75 cm internal dimensions) connected to a smaller camera frame by poles. Painting the white PVC gray or using gray Schedule 80 PVC for the bottom photo frame reduces glare that may over-expose plot margins. The lens of the camera is aligned to provide coverage of the entire plot. **The photo framer is placed over each plot in a consistent orientation, typically with the primary plot marker in the upper left corner**. Site, date, target species, and plot number are written on a label which is placed on the edge of the frame so that it is recorded by the plot photo (Figure 3). Plot labels are typically grey PVC (written on with dry-erase marker) or grey vinyl (written on with black china marking pencil). Ensure that the writing is thick enough to be legible in the photos. Care should be taken to ensure that the plot label does not obscure material inside the plot.

Specific photographic procedures vary depending on camera and **should be established by each monitoring team**. Photos must be of sufficient quality to allow teams to zoom in and consistently recognize target and core species when scoring in the lab.

Photoplots are primarily intended to document the abundance /percent cover of sessile and sedentary organisms. **Unattached drift plants (e.g., giant kelp blades), large motile invertebrates that are not scored in photoplots (e.g., *Aplysia*; record count if doing motile invertebrate protocol), invertebrate debris (e.g., lobster exoskeleton or loose mollusk shell), and flotsam (e.g., driftwood) should be removed prior to photographing and scoring plots**. These items are removed because they obscure the sessile / sedentary organisms that are the focus of the sampling effort in these plots. Otherwise, plot photos are taken "as is" without moving live organisms. **Do not remove small mobile invertebrates** (snails, crabs, etc.) **or sedentary motile invertebrates** (chitons, limpets, black abalone, ochre sea stars, purple urchins, etc.), particularly since sedentary invertebrates may be harmed by removal and displacement.

Variations from and Additions to Core Protocols: These are approved **supplemental protocols** that provide additional information.

- In plots with high abundance of barnacles (e.g., Barnacle plots, *Endocladia* plots, and Rock plots) some groups take both whole-plot photos AND close-up photos of portions of the plot. For example: CSUF / CPP take four close-up supplemental photos, each covering ¼ of the photoplot (upper left, upper right, lower left, and lower right). Close-up photos provide higher resolution when zooming-in and allow the identification of barnacles to species.

Guidelines:

- Before departing for the field, all photographic equipment (camera, memory cards, photoframer, batteries, etc.) should be in good working order and properly packed. Ensure that rechargeable batteries are fully charged, and memory cards are operational and have sufficient available space. Packing extra batteries and memory cards is recommended.

- It can save time, especially if personnel are unfamiliar with the site, to have one person locate all of the photoplots at the start of the sampling day and place temporary markers to make them easy for samplers to find (and to make them visible in panoramic photographs). Plots can be temporarily marked with PVC frames (many groups use partial frames, with one short and one long piece of PVC and a single corner piece) or with flagging tape placed at the corners. Extra-large brightly-colored rubber bands can be used to mark plots with bolts that protrude from the rock. Metal detectors can be helpful

for locating plots: some groups use a large metal detector to identify the general location of a plot and then switch to a pinpoint metal detector to identify the specific locations of individual plot markers.

- **It is important to ensure that photos of each plot are taken with consistent orientation and quality over time**. A field guide with photos of each plot (with PVC frame or flagging in place), site map, and marker-to-marker measurements aid plot location and ensure consistent placement of the photoframer if plot corner markers are obscured or missing. A metal detector may be helpful in locating obscured bolts, especially those overgrown in a mussel bed. If plot markers are missing, replace them in the exact same location if possible.

- Cleaning plot corner markers regularly aids in minimizing overgrowth so plots can more easily be located during the next survey. In some locations, it may be appropriate to attach a brightly colored cable-tie to the notched corner marker, especially in mussel beds where mussels may eventually cover bolts (however, this is not recommended for sites with high human visitation).

- **If algae such as rockweed must be moved to locate plot markers, be sure to return them to their original position (as best you can).** Photos should be taken – and plots should be scored – with the natural orientation and arrangement of canopy algae. **If you are scoring in the field, photos need to be taken BEFORE plots with canopy algae are scored**, as field scoring requires the movement of canopy algae to document the species or substratum that is underneath.

- Camera setting guidelines are the same for photoplots as for panoramic photos (3.2). For photoplots, bracketing exposures helps ensure a good exposure for scoring and provides back-up photographs of each plot. Take two pictures, bracketing the exposure value (-2/3 EV, 0EV). If necessary, take a third picture using the flash (especially when bright out).

- An umbrella (e.g., a golf umbrella) or other type of large shade can help reduce shadowing or glare and improve potential to identify items in photographs. When using an umbrella, ensure that the entire plot, the bottom of the photo framer, and the plot label are shaded (and be careful when windy, etc.).

<u>Sketching Plots and Taking Notes</u> **(Done only for Core legacy photo-scoring protocol. Sketches are not necessary if plots are scored in the field).**

Core (Legacy) Protocol: If time and resources permit, rough field sketches and notes are made of the distribution of organisms and substrata in each plot to aid species identifications when the photos are scored in the lab (blank and example datasheets are available on Egnyte). Note that the purpose of the sketches is to facilitate species identification from photographs; and the purpose of scoring from photographs is to save time in the field. It can be tempting to get very detailed and thus one can spend quite a bit of time sketching plots and taking notes…but keep in mind that this is just an aid for scoring. If someone spends only 3 min sketching each plot, at a site with 25 plots it will still take over an hour to complete the plot sketches. If too much time is devoted to this task, then one might as well score the plot in the field, with more accurate results.

Guidelines:
- It is preferable that the person who will score the photos makes the sketches and takes notes.
- It is not necessary to sketch obvious target or other distinct species.
- Things to sketch/note include rock surfaces that may be confused with tar or crusts, tar spots and/or oil sheen, coralline and non-coralline crusts, sand (and what is below the sand if there is only a thin layer), obviously dead invertebrate parts (e.g., shells, barnacle tests, *Phragmatopoma* tube fragments), bleached coralline algae, species recruits (especially barnacles), closed anemones, motile invertebrates, small/fine algae, uncommon species, unusual conditions, and obvious

epibionts and layering – particularly if they affect the target and core species (e.g., algae on mussels). Species that seem reddish in the field may look black in photos, and lighter-colored species like crustose corallines may not be obvious in photos.

- Species scattered throughout the plot can be noted but not sketched.
- If possible, estimate the extent of cover for sketched species or substrates.
- For barnacle plots where *Chthamalus* and *Balanus* are not distinguished in digital image scoring, record a quick visual estimate of % cover of each of these barnacle species (nearest 5%) whenever possible.
- The sketches are a good place to record plot corner marker conditions.

3.3.2 Scoring Cover in Photoplots

Each of the 100 points within each photoplot is identified and scored as one of 51 approved categories (which include core species, lumped taxa, and substrata). Category definitions are available on Egnyte: /Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources/PhotoplotDefinitions_2019_0405.pdf).

Monitoring groups can opt to score photoplots in *greater* taxonomic detail (e.g., some sampling groups identify all organisms to the lowest level possible instead of using the approved lumped taxa categories: see Section 1.2 for an example). **However, these supplemental specific categories must be developed in consultation with MARINe database managers** (and require a commitment to consistently utilize this protocol: see Section 1.2).

Basic field scoring (preferred core protocol): Plots are field scored using a 50 cm x 75 cm frame strung with 10 evenly spaced horizontal lines and 10 evenly spaced vertical lines to create 100 intersection points under which organisms are identified and recorded. Layers are not scored separately, so the total percent cover is constrained to 100%: specific instructions for collecting these data are found on Egnyte. Data can be recorded on paper datasheets or with a custom-developed iPad app which allows the user to enter data directly in the field and subsequently send the data file to the MARINe database managers. Datasheet examples and specific instructions for using the photoplot iPad app for data collection are available on Egnyte.

Digital image scoring (legacy core protocol): There is no layering protocol for digital image scoring. Photoplots are scored from digital images in the laboratory and plot sketches and notes are used to facilitate identification of species and substrata. **A grid of one hundred evenly spaced points (10 x 10) is created on the computer and overlaid onto the plot photo.** The grid size is manipulated to provide complete coverage of the plot within the photo framer frame.

Historically, Adobe Photoshop has been used to create a separate layer of points on top of the plot photo. As of 2020, the new program PhotoQuad is preferred over Adobe Photoshop because PhotoQuad saves each point with the associated species, has time-saving functions such as a lasso tool, and allows the scorer to easily remove the dot to see what lies beneath. The image can then be saved with the "grid layer," clearly documenting the exact points scored. The PhotoQuad protocol can be found on Egnyte here: /Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources/protocols/photoquad_protocol

Variations from and Additions to Core Protocols:

- **Field Scoring with Layering and Location: Teams can choose to score in the field using an approved supplemental protocol which includes layering and location information**. If the sampling team is using the layering protocols, more than 100 records may be generated (with up to 2 records per data point). Data can be recorded on paper datasheets or with the custom-developed iPad app for data entry in the field. **Specific instructions on the MARINe Photoplot Layering Protocol, example layering protocol datasheets, and instructions for using the photoplot app for layering and location data collection are available on Egnyte.** (Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources/protocols/photoplot_layering_protocol).

3.3.3 Labeling Photoplot Digital Images

MARINe photoplot file names contain 6 main types of information. This hierarchy (from general to specific) is as follows:

1) **Site**: use our standardized 3-5 letter site codes (lowercase) to conform with the database. A site code list is available on Egnyte in (Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources\appendices/MARINe_Handbook_Appendix_1_20200806).

2) **Target Species**: Use the first 3 letters (lowercase) of the target species plot names in the database (see Table 1). Using fewer than 3 letters leads to ambiguities, while more letters unnecessarily lengthen the file name. For barnacle plots, make sure to use the same species code consistently through time, since there are two options ("cht" for "typical" barnacle plots that target a mixture of *Chthamalus/Balanus* and "bal" that target Balanus).

3) **Plot Number**: Plot identifiers should conform to consecutive #'s starting with "1" if possible (e.g., 1, 2, 3, 4, 5 ...). Other unique and consistently applied plot #'s can be used (e.g., 212, 213, …); however, for simplicity in labeling, mapping, and database operations, use the "1, 2, 3, 4, 5" format when feasible.

4) **Date (Season/Year)**: Use the standard MARINe season definitions (see 2.2.3): Fall = October-January, Spring = February-May, and Summer = June- September. Abbreviate the season as a lowercase 2-letter code (Fall = fa, Spring = sp, Summer = su). Abbreviate the year as the final 2 digits (e.g., 1997 = 97, 2004 = 04). Using these codes means the file names are listed in alphanumeric order and therefore photos will be grouped by season within a year (Fall, then Spring, then Summer). Note that years in the new century (2000s) will sort out before the 1990s. This partial breakdown of chronological order was not considered significant enough to change to lengthier and less intuitive file names since the MARINe photo database allows for all kinds of sorting, including chronological.

5) **Photo Replicate:** In the field, most teams take multiple replicate photos of each plot (see section 3.3.1). In the lab, the scorer should select the best photo to use for scoring (or to be archived, if the team is sampling plots in the field). The scorer may wish to keep a second photo if that second photo provides additional resolution (e.g., the second photo may have been taken with a different exposure and may provide resolution on a few points that are underexposed in the 'best' photo).

If the photos are going to be used for scoring, then depending on the software used to layer the grid onto the photo (see 3.3.2), there may be one additional photo (the 'best' photo overlaid with the grid of 100 dots). If using Adobe software, for example, the user will need to save a copy of the photo with the grid layer. PhotoQuad software stores the layer file (with the grid) in a separate format so there is only one photo to save and store.

To differentiate the photo replicates for a given plot, add a single lowercase letter after the year in the

file name:

"a" = highest quality photo to be scored (no dot grid)

"b" = additional photo that can be used to provide additional resolution (e.g., with a different exposure)

"g" = scored photo overlain with dot grid

Historically**,** the standard protocol was to keep ALL photos of every plot, labeling the 'extra' photos (not the best [=a] or second best [=b]) with sequential letters of the alphabet through f (because g = the scored photo with dot grid). As of 2020, in order to save data storage space, the recommendation is that photos that are unlikely to be used (additional photos with the same exposures or poor quality or mis-framed photos) should be deleted.

6) **Photo Variants**: For some plots, there may be photos taken from different perspectives or of different subsections of the plot. For example, if the plot lies over a ledge, one photo may be taken with the frame mostly horizontal and another photo taken more vertically. Another example: CSUF takes separate photos of each ¼ of the barnacle plots to get better resolution for scoring (see 3.3.1). UCSC takes a separate photo of the upper left ¼ of each barnacle plot to have a high-resolution photo to be able to look at demography. To differentiate these types of photos in the relatively few circumstances when they occur, add an appropriate code at the end of the file name, such as (these example codes could be changed if other designations are found to be more appropriate):

"horiz" = horizontal or "vert" = vertical

"ul" = upper left, "ur" = upper right, "ll" = lower left, or "ul" = lower right quadrants

Based on the above criteria, the MARINe photoplot digital photo name standard is:

site code_target species code & plot#_season code & year_replicate

Or for "variant" photos:

site code_target species code & plot#_season code & year_replicate_variant

NOTE that only lower-case letters should be used in the file name.

Photoplot File Name Examples (see photo_naming_worksheet document on Egnyte for a list of example photo names by site):

psn_maz2_fa04.jpg = Pt Sierra Nevada, Mazzaella Plot #2, Fall 2004, (field-scored image)

psn_maz2_fa04a.jpg = Pt Sierra Nevada, Mazzaella Plot #2, Fall 2004, Replicate "a" (lab-scored image)

psn_maz2_fa04b.jpg = Pt Sierra Nevada, Mazzaella Plot #2, Fall 2004, Replicate "b" (different exposure of lab-scored image)

psn_maz2_fa04g.jpg = Pt Sierra Nevada, Mazzaella Plot #2, Fall 2004, Replicate "g" (dot grid lab-scored image)

shco_sil5_sp05a.jpg = Shaws Cove, Silvetia Plot #5, Spring 2005, Replicate "a" (lab-scored scored image)

shco_cht3_sp05a_ul.jpg = Shaws Cove, Chthamalus/Balanus Plot #3, Spring 2005, Replicate "a" (lab-scored image), upper left quadrant

care_pol4_fa03b_vert.jpg = Cardiff Reef, Pollicipes Plot #4, Fall 2003, Replicate "b" (lab-scored image), vertical emphasis

bml_myt1_su04g.jpg = Bodega, Mytilus Plot #1, Summer 2004, Replicate "g" (dot grid lab-scored image)

3.4 Point-Intercept Transect Protocol

Permanent point-intercept transects are employed to **monitor the cover of 4 target species: *Phyllospadix scouleri/torreyi* (= surfgrass), *Egregia menziesii*, *Hedophyllum sessile*, and Red Algae (turf algae, including articulated corallines and other red algae).** Transects are established at sites with sufficient cover of the target species for monitoring.

3.4.1 Scoring Cover on Point-Intercept Transects

Core Protocol: Cover of designated target species (see section 2.2.1) is assessed by the point-intercept method along 3 permanent 10 m long transects. Each transect is sampled by scoring 100 points uniformly distributed at 10 cm intervals (10 cm, 20 cm, 30 cm …1000 cm) along a meter tape laid out between marker end bolts. **Each of the 100 points along the transect meter tape is recorded as a single category** of core species, higher taxa, or substrata. The topmost (visible) layer that is attached to the substrate (i.e., not an obvious epibiont) is recorded. Underlying layers are not recorded unless there is surfgrass under that top visible non-epibiont layer. In this case only, the point is also recorded in the 'surfgrass under top layer' category (which allows sampling teams to get a good estimate of the abundance of surfgrass over the long term while still constraining the top-layer data to 100% cover). An example datasheet is available on Egnyte.

Variations from and Additions to Core Protocols:

Surfgrass Conditions: In the general area of the surfgrass transects (not at the whole site level, but not limited to the area directly under the transect line) estimate the cover of the following, using the categories none, low, medium, or high: *Smithora* on *Phyllospadix, Melobesia* on *Phyllospadix*, bleached / brown *Phyllospadix* present, abraded (shortened and jagged blades) *Phyllospadix*, and the abundance of *Phyllospadix* flowers.

Surfgrass Thickness. Each transect is divided into ten 1 m long segments. If the entire segment is covered by surfgrass, surfgrass layer thickness is measured in the middle of that segment. If surfgrass covers only a portion of the segment, thickness is measured in the middle of the covered portion. If there are two separate portions of surfgrass within the one-meter sampling area, take the thickness measurement in the middle of one of the patches (to avoid an edge effect). The most common choice is to take the thickness measurement in the middle of the larger patch. For each transect, there will be 10 thickness measurements (one per segment). To measure surfgrass thickness, all surfgrass layers are lightly compressed together (not tightly bunched), and the thickness is measured with calipers to the nearest mm. Sampling should begin at the primary marker and end at the other marker.

Surfgrass Species Separation: UCSC records the percent cover of *Phyllospadix torreyi* and *Phyllospadix scouleri* along each transect by estimating the proportion of each species in surfgrass covered areas. Overlapping morphological characters (e.g., leaf width 1-2 mm for *P. torreyi* vs. 2-4 mm for *P. scouleri*) and paucity of flower stalks (which can distinguish the 2 species) make species separation difficult. If transect sections contain surfgrass that is difficult to identify, the percentage of each species is based on the proportion of the transect that can be confidently identified. These data have not yet been entered in the MARINe database.

Surfgrass Transect Length: UCSC monitors surfgrass at 2 sites where the standard 10m long transects could not be established. At these sites, transects are shorter than 10m, or bend in the middle to fit within the surfgrass habitat. For transects <10m, sampling still occurs at 10mm intervals, except for on one transect with a 5mm interval. Fewer than 100 points are recorded.

Guidelines:

- Minimize disturbance of surfgrass and algae along transects when laying out meter tapes. If vegetation must be moved to locate marker bolts, be sure to return it to its original position as best as possible.
- Wave surge can rearrange surfgrass and other algae along the transect while sampling (depending on the extent of low tide and sea conditions). Try to survey the entire transect during a period when the tape and grass are undisturbed. If this is not possible, get help to hold the tape in place and record during the calm periods.
- "Surfgrass" is recorded under a point no matter what its appearance (bleached, abraded, etc.). Leaves, flowers, and rhizomes all are recorded as "surfgrass."
- If possible, site panorama photos should include each transect (lengthwise) to document seasonal species assemblages and appearance.

3.5 Owl Limpet Plot Protocol

Permanent plots are established at MARINe sites with sufficient densities of owl limpets (*Lottia gigantea*).

3.5.1 Counting and Measuring Owl Limpets in Plots

Core Protocol: At each site, five circular plots are established in areas of high owl limpet density to obtain as many counts and measurements for size-frequency as possible (preferably >20 individuals/plot for a total of >100 per site). Therefore, plot densities do not reflect average densities at a site. Plots are marked with one center marker, and since there is only one marker per plot, this is the primary plot marker. Limpets are measured within a circle (of 1 m radius) around each bolt.

To survey a plot, a 1 m length of line or tape is attached to the center marker and arced around to form a circle. **The maximum length of any owl limpet ≥ 15 mm found within that circle (including those touched by the 1 m mark) is measured with calipers to the nearest millimeter.** Measured owl limpets are temporarily marked with a lumber crayon to avoid measuring duplication. If a limpet cannot be measured directly by the calipers (due to tight crevices or other irregularities), its size is estimated. **Limpets are never removed from the rock**.

There are two widely used methods regarding the exact use of the line or tape: a) the line/tape is pulled taut along the topography of the substrate (i.e., if a limpet can be touched by the end of the line, it is included) or b) the line / tape is laid loosely along the topographic contours to determine which limpets lie within the plot outline. **Sampling groups should document their specific**

method (taut or contour) and ensure that it is used consistently at the site.

With each survey, the percent cover of mussels (and *Pollicipes* if the species are intermixed) in each plot should be visually estimated and the value should be entered on the datasheet.

Guidelines:

- To ease decisions about plot boundaries for plots on irregular rock surfaces, it is helpful to print a photo of each plot and annotate the photo with a line or series of markers to indicate the plot boundary. Add notes about plot irregularities if necessary. This guide can be used in the field to confirm plot edges.

- Observers must refine their search image to locate owl limpets and should search the plot from multiple angles. Owl limpets are often located in narrow crevices, underneath rock ledges, or on top of mussels, and may be covered with barnacles or algae. A flashlight should be used to see in cracks and dark areas. It is good practice to go over the plot more than once (from different angles) and/or to have a second person search the plot for limpets possibly missed by the first person. This is especially important with inexperienced team members. If there are substantial differences in the *L. gigantea* count between samplers, the plot should be resampled before the end of the field day. It is important to note that *L. gigantea* may be confused with other large limpets (especially *L. paradigitalis, L. pelta, and L. digitalis/austrodigitalis*). Photo guides which distinguish between small *L. gigantea,* and these other species are helpful for teams in the field.

- If possible, photograph owl limpet plots at least once a year to document the nearby species assemblages and overall appearance. This can be accomplished using site panoramic photographs (depending on the placement of the panoramic photos and the limpet plots).

Variations from and Additions to Core Protocols

- Small owl limpets: The standard 15 mm minimum size for counting and measuring owl limpets was implemented during the initial design of this monitoring to reduce variability among sampling teams and seasons associated with the difficulty in locating and identifying small *L. gigantea.* Small owl limpets can be hidden in tiny crevices and may look similar to other limpet species to inexperienced samplers. If groups feel confident and have consistent/experienced samplers, after consultation with the MARINe database managers, *L. gigantea* individuals smaller than 15mm may be recorded. **However, as with all supplements / additions to core protocols, a sampling group must make a long-term commitment to this option.** A juvenile *Lottia gigantea* identification guide is on Egnyte in (Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources/guides).

- At a small number of sites, owl limpet plots have a radius of 1.5 m.

- Very rarely owl limpet plots are rectangular rather than circular. All *L. gigantea* occurring within or touching the rectangle boundaries (delineated by marker bolts) are counted/measured.

3.6 Abalone, Sea star, and Urchin Monitoring Protocols

Permanent plots and transects are employed at sites with sufficient densities to monitor abundance and size distribution of abalone (black - *Haliotis cracherodii* and red - *Haliotis rufescens*), sea stars (*Pisaster ochraceus* and *Evasterias troschelii*), and urchins (*Strongylocentrotus purpuratus*). Other species of abalone, sea stars, and urchins may be monitored but are typically not measured (no size structure data are gathered). At sites with very low densities of these species, timed or site searches are used to assess abundance.

3.6.1 Counting and Measuring Abalone, Sea stars, and Urchins in Fixed Plots

Core Protocol: Number, size, and health of abalone, sea stars, and urchins are monitored within irregularly shaped plots or belt transects, depending on site topography. **Three to five plots/transects are generally established in areas of high density to obtain as many counts and measurements for size-frequency as possible** (preferably >20 individuals/plot for a total of > 60-100 animals per site). At some sites, the same plots or transects are used to monitor multiple species. Historically, most plots were sampled twice per year, in spring and fall. Currently, most plots are sampled once per year in either spring or fall, and season varies by sampling group.

Irregular plots are typically delineated by four or more "corner" markers, one of which is marked as the primary plot marker. Because markers are placed on conspicuous rock features whenever possible to ease relocation efforts, plot boundaries may include habitat unsuitable for abalone or sea stars. For this reason, **irregular plots are not intended to provide densities for comparison between sites: they are designed to monitor temporal trends within a site.**

Standard belt transect dimensions are different for sea stars (2 x 5 m) and abalone (1 x 10 m). There is no designated 'standard' belt transect size for urchins. Belt transects are marked at both ends (and often in the center). Each sampling team should designate a standard location for the primary (marked) marker for their belt transects.

To survey a plot or transect, once the tide is low enough, a meter tape (or line) is laid out along the center of the belt transect or around the irregular plot perimeter. Belt transects are surveyed by moving a 1 m rod (usually a meter stick or a piece of PVC pipe) down each side of the central line (for 2 x 5 m transects) or centered on that central line (for 1 x 10 m transects). All sea stars or abalone present (wholly or in part) under the path of the rod are recorded and measured. For irregular plots, the entire area encompassed by the boundary tape (or line) is searched carefully. Sea stars and abalone are counted and recorded if any part of the animal is inside the plot. **None of these organisms (abalone, sea stars, or urchins) should be removed from the rock for sampling.**

Abalone sampling: Shell lengths of individuals *in situ* (not removed from the rock) are measured with calipers or a ruler to the nearest 5 mm for animals <40 mm and to the nearest 10 mm for animals > 41 mm. Sometimes it is necessary to estimate lengths for abalone which are lodged deeply in cracks or otherwise inaccessible. To avoid duplicate counting, it is helpful to use lumber crayons to temporarily mark the rock next to the abalone. Make a note if any individuals have characteristics of Withering Syndrome (i.e., shrunken foot). Empty abalone shells are also documented: record the species, size, and whether the shell appears fresh or old. Echinoderm abundance in abalone belt transects is estimated using the following categories: 1-5, 6-10, 11-20, >20, 21-50, 51-100, 101-500, 501-1000, 1001+.

Sea star sampling: Sea stars (*P. ochraceus* and *E. troschelii* only) are measured *in situ* (not removed from the rock) from the center of the disc to the tip of the longest ray with calipers or a ruler to the nearest 5 mm for animals < 10 mm and to the nearest 10 mm for individuals > 10 mm. Sizes must be estimated when sea stars are wedged in tight places. Sea stars should never be "straightened" or removed from the rock. Sea star wasting disease category should be recorded for each star using the categories described in the guides on Egnyte. Notes should be made documenting any evidence of arm regrowth. Species other than *Pisaster ochraceus* and *Evasterias troschelii:* individuals should be counted but are not measured; disease condition (healthy, mildly diseased, severely diseased) should be noted; and notes should give a rough indication of whether many juveniles are present. For all species, unusual observations should be recorded in the notes section of the datasheet. Examples of unusual observations include "abnormal" sea star behavior such as "twisting" and falling off rocks. Signs of potential recovery from wasting should also be recorded, such as arm regrowth and lesion healing. A juvenile sea star guide can be helpful in telling very small sea stars apart (available on Egnyte). To avoid duplicate counting, it is helpful to use lumber crayons to mark the rock adjacent to sea stars after they

have been measured/counted. Sea stars should not be directly marked, as it is not known whether this can contribute to sea star wastingndisease transmission. A datasheet for sea star plots can be found on Egnyte.

Urchin sampling: Sample units vary widely across sites, depending on topography, urchin population size, and other factors. When possible, a sampling team should establish 3 replicate sample units at each site. In many places, use of established sea star plots is the best approach as these are typically areas where urchins are present, and this does not require establishment of new plots nor installation of new markers. In some cases, establishment of dedicated urchin sampling plots may be necessary. In other cases, whole-site searches, or timed searches (e.g., 30-minute searches, recording the number of samplers) can be established that specifically focus on urchin appropriate habitat at the site. No single protocol is a best fit for all cases, thus sampling design decisions should be made on a site-by-site basis.

Urchins are sampled *in situ* (not removed from the rock). Record the size of the first 20 purple urchins encountered OR a minimum of 60 urchins measured across all plots. Size is determined using calipers or a ruler to measure the diameter of the test (not including the spines). Sizes are lumped into bins: ≤ 5 mm and subsequent bins of 10 mm (10, 20, 30, etc.). If there is unusually high recruitment resulting in a dominance of urchins <10 mm, double the number of individuals for which size is recorded (120 individuals for the entire site, 40 per plot). After the appropriate number of urchins in a sample unit have been measured, record the remaining number of unmeasured urchins, separating the count of 'healthy' and 'diseased' urchins.

Without removing urchins from the rock surface, examine whether each urchin is healthy or is showing signs of disease using the categories described in the urchin disease ID guide available on Egnyte. If disease symptoms are present, note the type of symptom (e.g., black rings, red lesions, etc.) and algal growth in bald spots. Also record information about the presence of urchin tests and signs of disease on tests. For species other than *S. purpuratus*, record the total number only (no sizes). The urchin datasheet can be found on Egnyte.

Guidelines:

- Each monitoring group should document its rules for delineating abalone/sea star/urchin plots or transects so that areas are surveyed consistently.

- Observers must refine their search image to locate abalone and sea stars (sometimes very small) in deep and narrow crevices. Use a waterproof flashlight to see into dark areas. It helps to look through the plot from different angles; for example, sometimes going outside of the plot in order to look under a boulder. It is helpful to have two samplers looking and communicating at the same time from different places and utilizing flashlights and sticks/rulers (as pointing devices) to make sure organisms are not double counted. Lumber crayon marks on the rock next to organisms reduce duplicate counting. It is good practice to go over the plot more than once and/or to have a second sampler search the plot for organisms possibly missed by the first sampler. This is especially important with inexperienced samplers. If there are substantial differences in the organism count between samplers, the plot should be recounted before the end of the field day.

- At some sites, sea star counts may be variable over time within a single plot because these motile invertebrates move in and out of the plots/transects. If plot/transect boundaries are extended to reduce this temporal variability, separate counts for old and new search areas are necessary to maintain backward compatibility.

- If possible, photograph each abalone / sea star / urchin sampling unit at least once a year to document the species assemblage and appearance. This may be accomplished by the panoramic photos

for the site, but if not, dedicated photos can be added to the list of archival photos taken during sampling.

Variations from and Additions to Core Protocols:

- *For Abalone: Nearest neighbor protocol*: In this supplemental protocol, the sampler places each individual into a category based on the distance from that individual to the nearest individual of the same species. There are 5 possible categories: A = touching, B = ≤10cm apart (but not touching), C = ≤1m apart (but greater than 10cm), D = ≤5m apart (but greater than 1m), and E = >5m apart. An example datasheet for nearest neighbor protocol can be found on Egnyte.

- *Other abalone and sea star species*: In this supplemental protocol, groups record numbers of individuals of every abalone and sea star species and the Gumboot chiton (*Cryptochiton stelleri*). A modification is to also record size data for abalone and *Cryptochiton*.

- *Katharina tunicata*: In this supplemental protocol, some groups measure the first 15 individuals (anterior to posterior length to the nearest 10mm), and record total # of individuals in each sea star plot.

- *Cryptochiton stelleri*: In this supplemental protocol, groups measure the first 15 individuals (anterior to posterior length to the nearest 10mm), and record total # of individuals in each sea star plot.

- *Ochre Sea star Color*: In this supplemental protocol, groups record color categories (e.g. 'orange' vs. 'not orange' or 'orange' vs. 'brilliant purple' vs. 'other') of *Pisaster ochraceus.*

3.6.2 Counting and Measuring Abalone, Sea stars, and Urchins using Timed or Site Searches

Core Protocol: Site-wide and timed searches are employed at locations where abalone, sea stars, or urchins have been historically absent or exist in numbers too low to monitor within replicated plots or transects. The purpose of site-wide and timed searches is to document absence/rarity and to have records that will capture a population increase which may lead to the establishment of replicated plots for abundance surveys.

Timed search: **This method is primarily qualitative because time limitations prevent a thorough search of the entire site and low tide/swell conditions affect the lower boundary accessible for searching.** Timed searches should be conducted around the time of the lowest point of low tide. One person spends 30 min (or 2 persons 15 min. each, etc.) searching for abalone / sea star / urchins in the appropriate habitat (e.g., crevices and pools) along the low intertidal zone throughout the defined site (between up-coast and down-coast boundaries). Samplers should use flashlights to look into crevices and under boulders and should look under algal canopies (returning canopies to original location). Numbers of target species individuals and sometimes size measurements are recorded. A timed search datasheet can be found on Egnyte.

Site-wide search: **The boundaries of the search area must be clearly delineated and documented before the first sampling event, ideally using permanent site markers or landscape elements (e.g., crevices or outcroppings).** Particular care must be taken during establishment of the lower boundary in order to ensure that low tide/swell conditions do not affect the size of the sampling area. The boundaries should be clearly described and marked on site maps to ensure consistency over time.

Surveys should be conducted around the time of the lowest point of low tide. Samplers search for abalone / sea stars / urchins in the appropriate habitats (e.g., crevices, pools, under algal canopies) along the low intertidal zone throughout the defined site (between predetermined up-coast and down-coast boundaries). Samplers should use flashlights to look into crevices and under boulders and should look under algal canopies (returning canopies to original location). Numbers encountered and sometimes size

measurements are recorded.

Guidelines:

- If abalone or sea stars show up in moderate numbers during site or timed searches over several sampling seasons, consider setting up fixed irregular plots (3 replicate plots) of sufficient size for adequate long-term quantitative monitoring.

Variations from and Additions to Core Protocols:

- *Other abalone and sea star species:* In this supplemental protocol, sampling groups record the number of individuals of all abalone and sea star species, and the Gumboot chiton (*Cryptochiton stelleri*). Another modification is to also record size data for abalone and *Cryptochiton*.
- *Ochre Sea star Color*: In this supplemental protocol, groups record color categories ('orange' or 'not orange') of *Pisaster ochraceus.*

3.7 Sea Palm *(Postelsia palmaeformis*) Monitoring Protocol (SUPPLEMENTAL)

Abundances of the Sea Palm (*Postelsia palmaeformis*) are monitored in bands centered over permanent transects at sites from central California to central Oregon. These transects were established in areas of the shore with abundant *Postelsia*, and their endpoints are marked with permanent markers. There are typically 3 transects per site ranging in length from 5 to 10 m, depending on the extent of the *Postelsia* patch. The bands extend out to a distance of 1m on each side of the transect. Surveys are usually conducted annually in spring/early summer: within a region, all sites are sampled at the same time of the year (e.g. Central CA sites in spring, Northern CA sites in summer).

Standard Protocol: Sampling is done by dividing each transect into 1m segments. Data are recorded in a spatially explicit manner: the number of *Postelsia* stipes are counted and recorded for each 1x1m section (resulting in 10 to 20 sections per swath). To be counted, a *Postelsia* stipe must have at least one frond. Because of occasional site-specific variations on the standard protocols, specific datasheets are created for each site (see example on Egnyte).

3.8 Motile Invertebrate Monitoring Protocol (SUPPLEMENTAL)

The number, and in some cases, sizes of select motile invertebrates are monitored in photoplots at sites where the monitoring group has sufficiently experienced samplers and time to conduct these surveys. This is a supplemental protocol which has been tested and standardized for those monitoring groups choosing to use it. Within a sampling group, the protocol should be conducted consistently in time (Fall, Spring, or both) and space (in terms of the photoplot type(s) chosen for motile invert sampling). Many groups choose to conduct the sampling in only a subset of photoplots (often but not always the highest tidal elevation plots: e.g., Rock, Barnacle, and *Endocladia*).

3.8.1 Counting and Measuring Motile Invertebrates in Photoplots

Standard Protocol: **The densities of 16 types of mobile invertebrates are monitored in permanent 50 x 75 cm photoplots at each site** (see Egnyte for example datasheet). These monitored motile invertebrate groups are: the gastropods *Acanthina* spp., *Fissurella volcano*, *Lottia gigantea*, other limpets (excluding *Lottia gigantea*), *Littorina* spp., *Nucella emarginata/ostrina*, *N. canaliculata*,

Ocenebra circumtexta, *Tegula brunnea*, *T. funebralis*, and *T. gallina;* the chitons *Lepidochitona hartwegii*, *Mopalia* spp., and *Nuttalina* spp., and the crabs *Pachygrapsus crassipes*, and *Pagurus* spp.

Small limpets (< 5 mm) and medium limpets (5-15 mm) are sub-sampled in three 20 x 20 cm quadrats (=sub-plots or miniquads), placed in (respectively) the upper left, middle, and lower right corner of each photoplot (relative to the primary plot marker in the upper left-hand corner of the plot). Counts are facilitated by dividing the 20 x 20 cm quadrat frames into 4 equal subsections with string. If limpets are super-abundant (as commonly occurs with the < 5 mm category), they can be sub-sampled in a 10 x 10 cm sub-section of the 20 x 20 cm quadrat. If no medium limpets are counted in the 20 x 20 cm areas but medium limpets are present in the plot, then medium limpets should be counted in the entire photoplot (note: it is too onerous to do this for small limpets). The specific size of sub-plot in which each type of organism is counted (20 x 20 cm or 10 x 10 cm) must be noted on the data sheet for each plot during each sampling event because sub-sampled counts will be extrapolated to the full 50 x 75 cm photoplot area (counts in 20 x 20 cm areas are summed and multiplied by 3.125, counts in 10 x 10 cm areas are summed and multiplied by 12.5).

Littorines are sub-sampled in the upper left 10 x 10 cm section of each of the three 20 x 20 cm sub-sampling ("mini") quadrats. If no littorines are found in the first upper left 10 x 10 cm area (of the upper left 20 x 20 sub-plot), then counts should be done in the entire 20 x 20 cm quadrat for all three "mini-quadrats" (even if the other two mini-quadrats have littorines in the upper left section). If this is done, a note should be made about it on the datasheet in the field because counts from sub-sampled areas will be extrapolated to the full 50 x 75 cm photoplot area.

Sizes of the first 10 individuals encountered in each plot are measured to the nearest mm for the following 7 gastropod species: *Acanthina* spp., *Lottia gigantea*, *Nucella emarginata/ostrina*, *N. canaliculata*, *Tegula brunnea*, *T. funebralis*, and *T. gallina*. The exact species measured in each plot will vary slightly among regions since only those that are abundant enough to get useful size data should be measured.

Guidelines:

- **Sampling in plots with foliose / canopy-forming algae that need to be rearranged to find motile invertebrates should be done after plot photos and photo notes (if photo-scoring) have been taken and after plots have been scored (if field-scoring).**

- Some motile invertebrates can be removed from plots and placed in a container for counting/measuring but should be returned to the plot when sampling is completed. Forceps are useful for extracting whelks from crevices and from amongst mussels.

- It is not possible to locate all cryptic or tiny individuals in complex plots. Practical time limits should be placed on search efforts.

- A tally counter can be used to keep track of counts.

- Sampling often works best by conducting multiple searches through the plot, concentrating your search image on one or two species during each search.

Variations from and Additions to Standard Protocols:

- *Supplemental Species:* The following species can be counted in addition to the standard species: the gastropods *Amphissa versicolor, Epitonium tinctum, Ceratostoma nuttalii, Haliotis cracherodii, H. fulgens,* and *Mexacanthina lugubris*, the chitons *Lepidochitona* spp., *Lepidozona* spp., *Stenoplax* spp., and *Tonicella lineata*, the sea stars *Patiria miniata*, *Leptasterias hexactis*, *Pisaster ochraceus*, and *P. giganteus*, and the sea urchins *Strongylocentrotus purpuratus* and *S. franciscanus*.

- Pagurus *species identification*: Identify 1st 10 *Pagurus* to species and multiply the ratio out for the total # counted.

- *Identify limpet substratum*: Record limpets according to substratum (rock, *Mytilus* or *Pollicipes*).

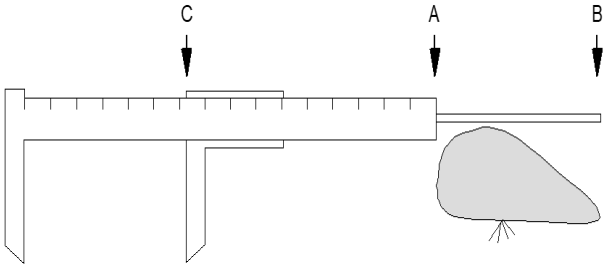
3.9 Mussel Measurement Protocol (SUPPLEMENTAL)

The mussel measurement protocol may be important for Natural Resource Damage Assessment (NRDA) in the case of disasters such as oil spills. **Measurements are conducted *in situ* (without removing mussels from the substratum) in Mussel Photoplots** and provide information on mussel size distribution and approximate population biomass (to complement cover data) that can be compared throughout the network of monitoring sites.

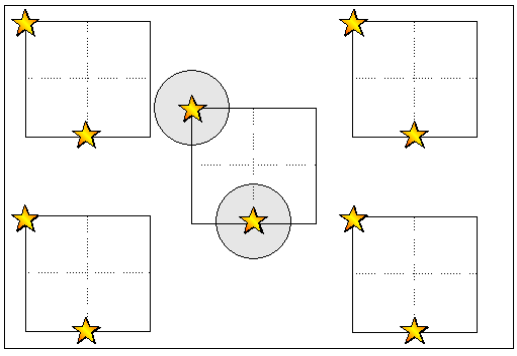
Standard protocol:

Examine the 50 X 75 cm plot to quickly determine if there are >10 mussels present. If it appears there are 10 or fewer mussels, search carefully for cryptic mussels, but do not spend excessive time searching for the tiniest possible mussels.

If you confirm there are 10 or fewer mussels in the plot measure the length (to the nearest cm) of all existing mussels in the plot and you are done (do not make any mussel bed/patch depth measurements).



To measure a mussel, rest the end of the caliper (A, in sketch) against one end of the mussel. Slide the caliper open until the tip of the rod (B, in sketch) reaches the other end of the mussel (the umbo). Read mussel length on the scale (C, in sketch) to the nearest centimeter. For extra thick mussel beds, a long rod and ruler can be used in place of the caliper. Mark each mussel with a lumber crayon after measurement to avoid double-measuring.



If there are >10 mussels present, place a 20 X 20 cm mini quad in each of the 5 locations indicated in the diagram. In each mini quad location, measure length (to nearest cm) of mussel(s) visible directly under each of the 2 designated points (indicated by stars in the diagram). For each designated point: A) Measure the length of the mussel directly under the designated point (this will be the 'top' - put a tick mark in the 'top' column to indicate the appropriate size). If this is a multi-layered bed/patch, also measure any mussels under the point that can be reasonably measured without undue disturbance to the bed (put tick mark(s) in column labeled "Under" – there can be more than 10 "Under" measurements but never more than 10 "Top" measurements). There is no need to indicate whether a mussel is attached to another mussel or to the substrate. B) Measure the depth (to nearest centimeter) of mussel or mussels (if multilayered) directly under the upper left point of the mini quad, resulting in 5 depth measurements per 50 X 75 cm plot. This measurement is the distance from the substratum to the highest point on the mussel that lies directly under the point, at an angle that is perpendicular to the orientation of the substratum at that location. There is no need to record layering information. Since the measuring rod cannot go through the

mussel(s), you can place it in a nearby gap and project across to the sample point location (a small ruler can help with this projection).

If there is no mussel under a designated point, measure the length of the mussel nearest to the point that is within the 50 X 75 cm plot and record the bed depth at this mussel. If there are 10 or fewer mussels in the 50 X 75 cm plot, depth measurements do not need to be taken.

If the entire plot is an "obvious" monolayer, then put a check mark in the monolayer box, if not, leave it blank, but still measure the bed depth.

Guidelines:

- Do not search for or measure any mussels outside the plot.
- Each mussel is only measured once, so if a measured mussel is also closest to another designated point, the next closest non-measured mussel should be chosen. For example, if there are only 16 single-layer mussels in one clump in the 50 X 75 cm plot, 10 of these 16 mussels would be measured no matter where the clump occurred in the plot.
- For plots in which mussels are rare or absent, there may be <10 (even zero) measurements. For plots containing 10 or more mussels, a total of at least 10 length measurements will be recorded (more if multiple measurable mussels occur below any of the 10 designated points).
- For a single-layer mussel oriented vertically by longest length, the mussel length and bed/patch depth measurements would be the same; however, since mussels vary in orientation, and multi-layering may occur, the 2 measurements will rarely be the same.

3.10 Invertebrate Recruitment Protocol (SUPPLEMENTAL)

Acorn barnacle (*Chthamalus dalli/fissus/Balanus glandula*) recruitment has been monitored at many MARINe sites. Barnacle recruitment is monitored by scoring settlement on five 10 x 10 cm PVC plates, covered in textured safety-walk, screwed into the substrate next to barnacle photoplots. The PVC plates are retrieved during each field survey (replaced with clean plates) and sampled in the lab. Barnacle recruitment can also be monitored in 10 x 10 cm clearings (cleared with a scraper and/or wire-brush to expose bare rock, including a 1-2 cm border around each plot). For clearings, recruits are counted in the field during each survey, then the 10x10 plot and the border are re-cleared.

3.10.1 Field scoring barnacle clearings and collecting barnacle plates

Clearings:

- When density is high, use the subsampling method: divide the plot into fractions (i.e., ½, ¼, etc: but no smaller than ¼) and count all barnacles in that fraction (assuming it is representative of the plot as a whole). The decision to sub-sample is made separately for each species and developmental stage (i.e. cyprids vs. metamorphosed barnacles). If there are too many individuals of one species or stage to be counted in full, this species or stage can be sub-sampled while other species and/or stages are counted in the whole clearing.
- If the density of any species or developmental stage is low and the field of view and sub-sampling methods do not reflect actual density, count the entire plot. A hand lens or magnifying glass is useful for finding barnacles.
- Once you have determined your sampling area (whole plot, field of view, or subsample) use a field

dissecting scope or hand lens (magnifying glass) to count (by species) all barnacles and cyprids.

- Randomly measure 10 *Chthamalus* and 10 *Balanus* per clearing. Preferably, measure 2 from each field of view or subsample of the plot. It is best to measure individuals throughout the plot (not clumped together).
- Measure one cyprid of each species per clearing (if present).
- Use a metal brush and thin metal probe to clear the plot of all barnacles when you have finished counting. A squeezable water bottle full of sea water can be helpful.
- See Egnyte for example datasheet.

Plates:

- Replicate plates should be marked with the site code and replicate number on the underside (side facing rock) by either engraving (e.g. with a Dremel tool) or (less preferable) with a Sharpie. Deployment locations for each replicate plate should be identified on the site map.
- Remove each plate with a nut driver and store in a "plate rack" (4" long bolt with 4 "spacer" nuts of larger diameter than bolt threading (so they slide easily) and one fitting nut to secure plates on "rack"). This protects barnacles that have settled on each plate from being scraped off.
- It is a good idea to verify that the plate you are picking up is the replicate you think it is (i.e., it was deployed in the proper place). For example, if you are at the location on the map where it says plate 4 is located and the plate you remove is labeled #3, write the correct number on the underside of the plate before combining it with the others on the plate rack.
- Replace each plate with a clean plate using a nut driver.

3.10.2 Lab scoring barnacle plates

Using a dissecting scope, scan the whole plate, looking for adult and cyprid stages of barnacles. If the plate needs to be sub-sampled, divide it into 100 squares using a Sharpie and choose 25 squares at random for counting. Sub-sampling is done for each species and developmental stage separately (i.e., if there are too many individuals of one species or stage to be counted in full, this species or stage is sub-sampled while the other species and stages are counted on the whole plate). Counters / clickers can be very useful for tallying different species and stages. In addition to counting settled barnacles, record the following information: percent sand/algae cover, proportion of plate sampled, number of cyprids (identified to species), and the number of barnacle adults (identified to species). See Egnyte for example datasheet.

3.11 Water Temperature Protocol (SUPPLEMENTAL)

Commercially available small autonomous loggers have been deployed at many MARINe sites to record nearshore seawater temperature at pre-set logging intervals (typically 15 minutes). Although data are collected continuously, temperatures collected by loggers during emersion are not comparable among sites (because of differences in logger placement e.g. shading vs. no shading) nor within a single site over time (as cages become fouled between sampler visits). In contrast, temperatures collected while the logger is submerged (= water temperatures) are comparable among sites and within a single site over time. Temperatures during submersion, and are extracted from downloaded raw data files using tidal height cut-offs specific to each site.. The list of sites with water temperature loggers can be found on Egnyte here:
/Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources/append

ices/MARINe_Handbook_Appendix_1_20200806.xlsx.

Standard protocol: **Deploy one water temperature logger per site** (redundant loggers may be deployed to guard against equipment loss or failure during deployment if the sampling team has funds to cover this). Typically, sampling groups deploy loggers manufactured by Onset Corporation (www.onsetcomp.com). Logger models change as technology advances, and thus groups may be deploying a mix of newer and older models, however all have factory calibrated accuracy of ± 0.2 °C. As of 2022, the preferred model recommended by MARINe is the "Pendant MX Temp" (model #MX2201). The "TidbiT MX Temp 400" (model #MX2203) is recommended as a secondary option. **All loggers used must be maintained at a minimum accuracy level of ± 0.5 °C**. Temperature loggers are launched and downloaded using the appropriate hardware and software (check the company website to determine the specific accessories and software for the type of logger you are using). If your team is using a logger from a company other than Onset, please contact the MARINe database manager before the first deployment to discuss the appropriate file types for submission to MARINe.

Water temperature loggers are typically deployed in a central location at the low end of the mussel/mid zone but may be deployed at lower tidal heights if needed (e.g., if the site has heavy human visitation, deploying loggers in the lower intertidal zone may reduce the chance of tampering). There are many different options for securing loggers to the substratum. Some groups use a small stainless-steel mesh cage which is bolted to the rock: the logger is attached to the underside of the cage with cable ties. Some groups deploy loggers in PVC tubes or caps which are bolted or epoxied to the rock.

Because the goal is to create a continuous series of temperature recordings at each site, deployment duration for a single logger will depend on battery and memory life for that unit. Onset loggers have battery life and memory capacity sufficient to collect and retain data for over a year with a 15-minute logging interval. Thus, teams which use Onset loggers typically swap them out (the previously deployed logger is collected and a calibrated, launched replacement logger is deployed into the same cage) on an annual basis as part of the Long-Term Monitoring at the site.

Logger Calibration: **All loggers must be maintained at a minimum accuracy level of ± 0.5 °C by calibrating prior to, and following, every deployment**. Calibration can be performed in one of three ways (may be performed with multiple loggers at a time):

A. *Ice bath calibration (preferred method):* Launch the logger/s to be calibrated with a logging interval of 1 minute. Prepare an ice bath by filling a small container (insulated container recommended) with ice and filling with water to the top of the ice. There should always be more ice than water in the ice bath during the entire procedure (replace water with more ice as needed). Stir well. Place the logger/s in the ice bath and place the entire ice bath into a refrigerator. Remove the loggers after ten minutes and download the data for review. At least three consecutive recorded temperatures during the calibration period must be 0 ± 0.5 °C in order to pass. The calibration procedure may be repeated, however loggers that do not pass at least one calibration cannot be used and should be sent in for factory calibration (may be under warranty or a fee may be charged) or retired from service. If a logger does not pass calibration following a deployment, you must contact the database manager prior to uploading the data from the deployment to Egnyte to determine if the data will be flagged or deleted. Calibration records are maintained according to the logger serial number in the file "MARINe_temperature_reference" found on Egnyte here: /Shared/MARINe_Data/MARINe_Database/Temperature.
B. *Known temperature bath calibration:* Follow the ice bath procedure above substituting the ice bath for a water bath of stable temperature. In this procedure you must also use a NIST (National Institute of Standards and Technology) calibrated reference thermometer. Deploy the logger/s to be calibrated in the water bath with the reference thermometer and record reference temperature readings each minute for 10 minutes (on the same logging interval as the logger).

C. *Factory calibration:* Loggers may be sent to the factory for calibration. Contact the manufacturer to determine associated costs and shipping procedures.

Battery replacement: The recommended Onset loggers have user-replaceable batteries. Model #MX2201 must have the battery replaced annually (CR2032 battery), model #MX2203 must have the battery replaced at minimum every three years (CR2477 battery). Name brand batteries should be used (such as Sony or Duracell) and expired batteries cannot be used because they are likely to give out before the end of the deployment period. Be sure to lightly grease the O-ring on logger with a silicone grease and dispose of used batteries safely.

Configuring Water Temperature Loggers: Refer to the user manual for information on how to configure your particular model. Complete the calibration procedure (above) prior to each deployment. Loggers should be **launched in UTC** (Universal Coordinated Time). Set the logger to begin recording temperature at the top of the hour at some time prior to deployment at the site. In general, loggers are set to record temperatures **every 15 minutes.** However, loggers may be set to record temperatures at shorter or longer intervals depending on the logger memory available and the intended length of deployment. The chosen interval should be compatible with the 15 min interval, therefore alternative intervals are 1 min, 5 min, 30 min, 45 min or 60 min (maximum interval of 60 minutes). Ideally, loggers should be deployed such that the battery will last longer than the intended deployment period and the memory will not fill prior to the end of the intended deployment period.

Water Temperature Data Uploading: Procedures for uploading temperature data may be updated frequently, therefore please refer to the most current temperature data instructions which are maintained in the "temperature_data_processing" file found on Egnyte here: /Shared/MARINe_Data/MARINe_Database/Temperature. Data files from Onset loggers should always be downloaded from the loggers as **".hobo"** files and named using the following naming convention:

sitecode-zonecode-localcode-downloaddate (example file name: KIB-sm1-TV2-20180706)

Note that dashes (-) are used, NOT underscores (_), because of how the post-processing script works. Refer to the "zone_codes" and "loggercodes" tabs in the file "MARINe_temperature_reference" to determine the correct zone code and local code for your particular files. Correctly named files, which have passed post-deployment calibration, should be saved in the appropriate group folder on Egnyte here: /Shared/MARINe_Data/MARINe_Database/Temperature. Metadata for each logger and each deployment are maintained in the "MARINe_temperature_reference" file on Egnyte in the same location. Novel sites and/or novel logger models must first be added to the file by the MARINe database manager.

Water Temperature Metadata Entry: Procedures for entering the associated metadata may be updated frequently, therefore please refer to the most current temperature data instructions which are maintained in the "temperature_data_processing" file found on Egnyte here: /Shared/MARINe_Data/MARINe_Database/Temperature. Follow these steps:

A. Download the file "MARINe_temperature_reference" from Egnyte
B. Confirm that the "temperature_site_reference" and "logger_information" tabs include your site and logger serial numbers. If not, contact the database manager.
C. Enter the deployment and retrieval dates for each logger in the "temperature_log" tab
D. Enter the calibration_passed date on the "logger_info" tab
E. Save the file with a new name reflecting the date you made the changes and your initials
F. Upload the file to your group folder on Egnyte here: /Shared/MARINe_Data/MARINe_Database/Temperature.

Water Temperature Data Processing: The database manager will periodically review, process and merge files that have been uploaded. This procedure generally includes the removal of tips (time period

between launch and deployment in the field) and tails (the time period after collection from the field prior to downloading) and the tagging of water temperature values (de-tiding). Time points representative of logger submersion are tagged based on tidal height referenced to the nearest tidal station for each particular site. If the tidal height of the logger position has been measured in the field, this is used to determine a cut-off height and is listed in the "temperature_site_reference" tab of the "MARINe_temperature_reference" file. If no height cutoff is provided, only values from the highest high tide of each day will be tagged as water temperatures. Daily water temperature means are calculated from water temperatures and used for further analysis.

3.12 Robomussel Protocol (SUPPLEMENTAL)

In 2015, the Marine Temperature Committee convened to evaluate the potential for coordinated collection of temperatures during emersion across the MARINe network. Water temperature loggers are deployed inside cages which are infrequently maintained (and thus become fouled over time), thus the temperatures that they collect during emersion are not useful for comparison within sites over time or across sites. In addition, the temperatures collected by water temperature loggers during emersion are not biologically relevant as the loggers themselves are not thermodynamically similar to any organism. Biomimetic data loggers address this issue by specifically mimicking the thermal properties of specific organisms in order to provide biologically relevant temperature data. While no biomimetic logger can mimic every organism, mussels are a species of interest for MARINe and a verified biomimetic logger (the robomussel, developed by Brian Helmuth), already exists for *Mytilus spp.* After a period of pilot testing at several MARINe sites, the committee recommended the deployment of robomussels at sites for measurement of biologically relevant temperatures during emersion as a supplemental protocol.

As of 2019, MARINe groups are using robomussels which are manufactured in coordination with the Helmuth Lab at Northeastern University and which incorporate EnvLogger temperature loggers from Electric Blue (https://www.electricblue.eu/products/). Most of the loggers currently deployed are built with the 27mm EnvLogger with enlarged battery, however as technology advances we expect to use updated models. Product manuals are available from the company website. Field calibration testing was conducted by UCSB in 2018 which confirmed that the thermal properties of the epoxy used for casting these loggers matches the epoxy used historically by the Helmuth Lab. Thus, all data collected with these next-generation loggers can be considered comparable to all historically collected robomussel data.

Robomussel temperature loggers are launched and downloaded using a smartphone with NFC (Near-Field Communication) technology. The software used is specifically developed for the EnvLoggers and is a free app available from any App store (available for both Android and iOS operating systems). A close connection must be made between the smartphone and the face of the logger, which can be made easier by using an optional NFC extension wire (available from retailers such as Amazon.com).

Standard protocol: Deploy six robomussels per site. Procedures and troubleshooting tips may be updated frequently, therefore please refer to the most current "MARINe_robomussel_manual" found on Egnyte here: /Shared/MARINe_Data/MARINe_Database/Temperature.

Acquiring robomussel loggers: Robomussels are not commercially available for purchase. Sampling groups interested in adding this supplemental protocol at their field sites should contact the Temperature Committee to discuss the purchase of robomussels for new sites. Each specific location within a site receives a unique code (microsite_id) that is used to tag all data collected at that location. Before deploying robomussels at any site, work with the Temperature Committee to identify available microsite_id codes and determine the best locations for robomussel placement.

Smartphone preparation: From the app store, download the free "EnvLogger Logger" app to your smartphone. Note that the app store search bar is case sensitive. Android and iOS versions are available. Launch the app and enable permissions to access the phone's storage and location so that the app can save downloaded data files. You will be prompted to "turn on NFC" when launching the app if NFC is not already turned on. Determine the physical location of the NFC antenna in your smartphone to know how to position the loggers /antenna extension for the best connection. The communicating face of the logger must be placed within ~ 1 cm or less of the antenna to connect. Note that the strength of the NFC antenna appears to vary between smartphone models, as of 2022 the iPhone appears to have the strongest antenna. Use this website to determine the location of the NFC antenna on your device:

http://support.sytravelmaster.com/support/solutions/articles/36000183018-locate-your-nfc-reader-on-your-smartphone-device

Every smartphone is different; therefore, it is recommended that time be spent testing and troubleshooting connecting to loggers with your particular device in the lab and field. It is also recommended that a backup NFC device be prepared and tested so that multiple devices are available for field downloads.

Logger preparation: For the most current instructions on using the EnvLogger App, please refer to the user manual provided by the manufacturer which is updated frequently which is named "EnvLogger_documentation" and can be found on Egnyte here: /Shared/MARINe_Data/MARINe_Database/Temperature.

Connect to the logger with your smartphone using the EnvLogger App. Enter the microsite_id to the "custom name" field for each logger. This unique code will automatically be included in the metadata portion of all downloaded data. Loggers are set to record at 30-minute intervals, with a sampling resolution of 0.1 degrees Celsius. As of 2022, because of limitations on memory (to ensure that loggers retain data for a full year) the standard is to keep this 30-minute logging setting. All loggers automatically record data in UTC. Additionally, every downloaded data file is tagged with the GPS coordinate provided by the smartphone at the time of download. Location accuracy is based on the accuracy of the smartphone at that time.

Site Layout:

- If robomussels have been deployed at the site in the past, loggers should be located in exactly the same locations as historical loggers. An existing microsite_id code can only be used when the location of a logger is within 20 cm of the historical location. If there is uncertainty about the exact location for previous deployments, a new microsite_id code, and a new custom name, must be assigned to each logger.
- For new sites, if the exact locations of historical loggers cannot be determined, or if you are adding robomussels to a site (e.g. if the site historically has had only 4 robomussels) deploy 2 loggers near the lower edge of the mussel be (least amount of emersion time), 2 in the vertical middle of the mussel bed, and 2 near the upper edge of the mussel bed (most emersion time).

Logger Deployment in the Field: **Robomussels should be placed within a patch of live mussels and oriented in a vertical "growth position."** Robomussels should be surrounded on all sides by live mussels, but do not need to be deployed in a continuous bed if the mussels do not form continuous beds at the site. Robomussels are 6 cm in length. Make every effort to deploy the robomussels in patches of similarly sized mussels OR in 'divots' or on 'mounds' in the rock so that the top of the robomussel is roughly at the same height as the top of the natural mussels. (Robomussels may not be an option for sites with extremely small or scarce mussels). Robomussels should not be exposed to more direct solar radiation than a "typical" mussel at that site. Robomussels are attached to the rock surface using marine epoxy putty. Details and tips for secure attachment can be found in the "MARINe_robomussel_manual" on Egnyte.

Data Collection: Robomussels are downloaded in the field, *in situ* (without removal from the rock surface) before the memory banks are full. If technical difficulties with downloading data in the field require the removal of the logger (for downloading in the lab), the logger must be replaced within 20 cm of the original location when it is returned to the field. If the new location is > 20 cm from the original location, then the logger must be renumbered with a microsite_id (and thus given a new custom name). Note that there is a video tutorial available on Egnyte here: /Shared/Marine_Data/Marine_Database/Temperature/Robomussel: filename: "Video tutorial_downloading_robomussel_data"

Logger Metadata: Metadata for each logger are maintained in the "MARINe_Robomussel_Deployment_Log" file (Shared/MARINe_Data/MARINe_Database/Temperature/ Robomussel directory). In order to enter metadata for a new logger or one you have just downloaded a) download the deployment log file from Egnyte; b) check the deployment_log and logger_info tabs to make sure the site and logger info are present (including the unique microsite_id); c) enter the metadata in the deployment_log and logger_info tabs; d) save the file with a new name reflecting the date you made the changes and your initials*; e) upload the file to Egnyte . The database manager will periodically review and merge the individual files.*Example file name: MARINe_Robomussel_Deployment_Log_2020_0506_HS.xls

<u>*Logger Data:*</u> Logger files should be downloaded and named using the following naming conventions (note that these are underscores (_) NOT dashes).

"microsite_id"_"download year and three letter month"

*Example file name: USCACP341_2020MAR

Files should be saved on Egnyte in the appropriate site folder in the Shared/Marine_Data/Marine_Database/Temperature/Robomussel/raw_data directory.

Raw data files should be saved on Egnyte in the appropriate site folder in the /Shared/MARINe_Data/MARINe_Database/Temperature directory.

3.13 Vertical Distribution Surveys (SUPPLEMENTAL)

These surveys measure the vertical distribution of the species listed below using transects which run

from the high intertidal zone to the low intertidal zone. They are conducted along permanent transects established for MARINe Biodiversity Surveys (https://marine.ucsc.edu/methods/biodiversity-methods.html). It is recommended that sampling groups establish permanent transects using the criteria for Biodiversity Surveys if these transects do not already exist at the field site. Vertical distribution surveys use every other biodiversity transect line (i.e., lines 0, 6, 12, 18, 24, and 30m), for a total of six transects per site. An "ideal" bench is one that is topographically simple, and slopes downward continuously from high to low zone (think of a boat ramp). At sites that are more topographically complex than this, rather than sample every other SWAT line, an option is to select those that are the most "ideal".

Vertical Distribution Surveys have been conducted in Oregon (O), central CA (CA), and Washington (WA) for the following taxa:

Primary taxa	Optional taxa
Invertebrates *Anthopleura elegantissima* (WA) *Balanus glandula* (O, CA, WA) *Chthamalus fissus/dalli* (O, CA, WA) *Crassostrea gigas* (WA) *Mytilus californianus* (O, CA) *Mytilus trossulus* (O, WA) *Pollicipes polymerus* (O) *Semibalanus cariosus* (O, WA) **Algae** *Caulacanthus okamurae* (WA) *Endocladia muricata* (O, CA, WA) *Egregia menziesii (CA)* *Fucus distichus* (O, CA, WA) *Gelidium/Pterocladia* spp. (WA) *Mastocarpus* spp. (CA, WA) *Mazzaella parksii* (O) *Mazzaella splendens/flaccida* (O, CA) *Odonthallia flocossa/oregona* (O) *Pelvetiopsis limitata* (O, CA) *Saccharina sessilis* (O) *Silvetia compressa* (CA)	**Invertebrates** *Tetraclita rubescens* (CA) **Algae** *Analipus japonica* (CA) *Cladophora columbiana* (CA) *Gloiopeltis furcata* (O) *Mastocarpus* spp. (O) *Neorhodemela larix* (O) *Odonthallia flocossa/oregona* (CA) *Phyllospadix* spp. (O, CA) *Postelsia palmaeformis* (O)

Two aspects of vertical distribution are determined for each taxon: 1) its upper and lower distributional limits, and 2) the region of the shore where it was the most spatially common (zonation patterns).

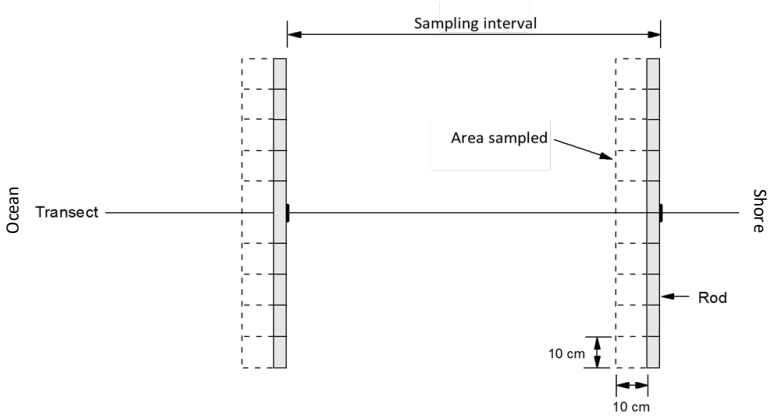
Standard protocol: Upper and Lower Distributional Limits

Upper and lower limits are determined by noting the location (distance along transect) of the uppermost and lowermost 3 individuals of each species within a 2m wide band centered over each transect. The location of any individual found above the upper Biodiversity Transect baseline is recorded as a negative distance. Individuals found in places where environmental conditions may be different than exposed surfaces (e.g., standing pools of water, or in cracks/crevices) are not included, but epibiotic

individuals are counted. Since there are often irregularities in elevation across the width of the 2m band, individuals found >10cm (vertical height) above or below where the transect line touches the substrate are not included.

Standard protocol: Zonation Patterns

Data are collected using a 1m sampling rod which is placed along the vertical transect at regular sampling intervals, the length of which are determined by the length of the bench. The goal is to obtain approximately 20 sampling locations per transect. Thus, for benches around 10m long, the sampling interval is 50 cm; for benches around 20m long, the sampling interval is 1m and for benches 40 m long or longer, the sampling interval is 2m.

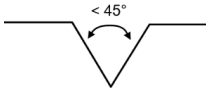


The sampling rod is divided into 10 segments (each 10cm long). By projecting (dashed lines in figure) the sampling team uses the rod to define 10 sampling squares (each 10 cm x 10 cm). The goal is to sample uniform exposed substratum (not pools, cracks, or especially rugose areas in which the rock surface is more than 10 vertical cm above or below the point of contact on the transect line: see 'Guidelines' below). In each square with uniform exposed substratum, the presence (or absence) of each of the primary or optional species is recorded. Epibiotic individuals are counted, as are individuals located beneath canopy species. As necessary, the rod is shifted left or right (but not beyond the transect line) to avoid sampling in pools/cracks. If that is not successful, the rod can be rotated (with the middle as the pivot) to achieve more uniform substratum, or moved up or down the transect up to 10cm for the 50cm sampling interval or 20 cm for longer sampling intervals. If 'acceptable' sampling habitat is still not encountered, the number of squares deemed unacceptable (pools/cracks, or substratum 10 cm above or below the transect line) is recorded, and the remaining squares are sampled.

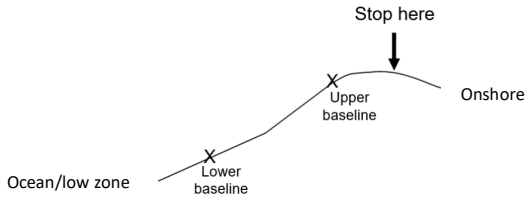
Guidelines:

Upper and Lower Distributional Limits:

- Do not sample areas that are more than 10cm in vertical height above or below the point where the transect line contacts the rock surface.
- Do not sample in cracks and crevices. These are defined as areas where the angle of the substrate is less than 45°.



- If the bench drops in elevation before the vertical upper limit of the species has been reached, stop sampling at the point where the decline begins. Note the location of this point and that the species was found up to this point.



Zonation Patterns:

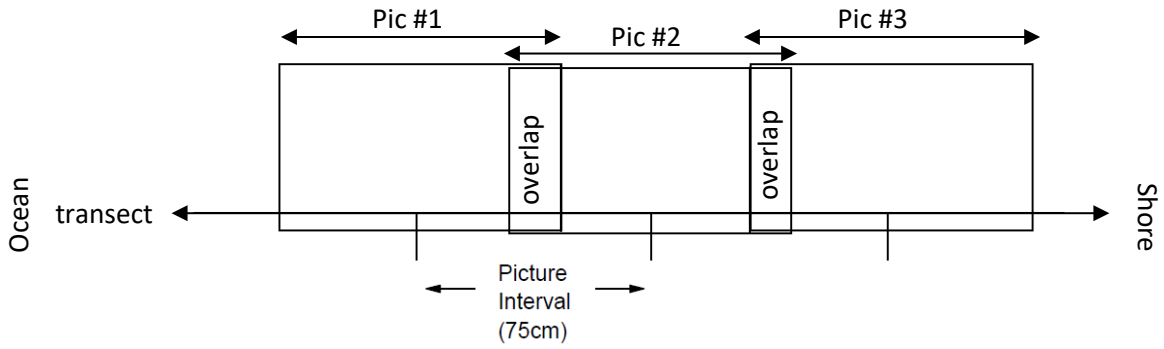
- When the areas to the left and right of the transect line are higher or lower than the specified location on the transect line, shift the rod to the left or right to attempt to sample the same elevation (differences of 10cm or less are okay). If that does not work, rotate the rod.

- Depending upon the length of the transect line, adjust the sampling interval so that around 20 measurements per transect are taken. For example, measurements should be taken every 0.5m where the transects are around 10m long, but every other meter where transects are around 60m in length.

3.14 Pansects (SUPPLEMENTAL)

This procedure was developed to photographically document the vertical distribution of species at each site at the same resolution used to sample the MARINe photoplots. Ideally pansects are conducted along permanent transects established for MARINe Biodiversity Surveys (https://marine.ucsc.edu/methods/biodiversity-methods.html). For sites without permanent biodiversity survey transects, the sampling group can follow Biodiversity Survey protocols to establish permanent transects or identify and mark other permanent transects for use with pansects.

After laying out the vertical transect, stand on the 0 m mark (= upper baseline) with the camera about 1m above the substrate (if possible, also take pictures above the upper baseline). From this point, take a picture every 75cm down the length of the vertical transect. Since the width of the picture is about 1m when the camera is about 1m above the substrate, this distance allows neighboring pictures to overlap. (Note: this assumes the camera being used has the equivalent of a 35mm wide angle lens. If it does not, then the picture interval can be changed). A 1m rod (e.g., a leg from a photoframer) can be used to ensure the height of the camera above the transect stays constant. Make sure to include the transect line along the bottom of each picture. At every 5m mark, place a small PVC plate inscribed with the site, date, transect, and location. When possible, take pansects on both sides of the transect line.



4. MARINe DATA MANAGEMENT

4.1 Data Recording, Data Backups, Data Entry / Uploads

Data Recording: Most data are recorded on data sheets. Prototype data sheets can be found on Egnyte: they can be used "as is" or may be slightly modified to meet specific needs of monitoring groups so long as they capture the core data and maintain an order consistent with database entry. For Photoplot scoring, as an alternative to data sheets, there is a custom iPad app that can be used for direct data entry while scoring Photoplots in the field. The photoplot app records the spatial location (e.g., column 3, row 7) as well as up to two species or substrate layers per sampled point. The app is available at the Apple app store: https://itunes.apple.com/us/app/photo-plot-layers-ltm/id1219374808?mt=8. Recording data using the app is preferred because data are automatically saved in a .CSV file format eliminating the need to enter data from datasheets, and built-in error checks reduce errors in data collection in the field. Detailed instructions on how to use the Photo Plot app can be found on Egnyte here: /Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources/protocols/photoplot_app_instructions

Data backups: At the end of each sampling day, it is recommended that data sheets are scanned as high-quality (e.g. 600 dpi) PDFs and archived on the sampling group's local file server. In addition, all images should be downloaded from the camera memory chip to a computer for later organization and labeling. Sampling groups should ensure that they have a secure off-site server (e.g. Egynte or Dropbox) on which to store archived data, which should include all labeled photographs, field datasheet scans, and .CSV files. If a file server and backup option is not available for a particular research group, they can contact the database managers (see Key Contacts) to discuss storing files on the MARINe Egnyte server.

Data processing / entry / uploads: Most data are entered into the MARINe MySQL database via web entry forms (on Egnyte in /Shared/MARINe_Internal_Resources/Protocols/1_Monitoring_Handbooks/handbook_resources/protocols/web_data_entry_instructions). Data should be entered into the database entry template as soon as possible after sampling, while memories are fresh, and questions can be resolved. MARINe practitioners have two deadlines for data entry each year (March 1 and October 1). Motile invertebrate data are entered into MARINe spreadsheets (not into the MySQL database) which are subsequently uploaded to Egnyte. iPad Photoplot data files from each site survey are concatenated and uploaded to Egnyte (see instructions on Egnyte). Temperature data are uploaded to Egnyte (see 3.11 Water Temperature Protocol and 3.12 Robomussel Protocol). Photographs are labeled (see 3.2.2 Labeling Panorama Digital Images and 3.3.3 Labeling Photoplot Digital Images) and stored in the sampling group's folder on Egnyte. As of 09/2022, photographs are subsequently uploaded at intervals from Egnyte to the ViQi photo database.

4.2 MARINe Database

The primary MARINe Database contains Long-Term Monitoring data (percent cover, counts, and size structure within fixed plots) from sites ranging from Alaska to Mexico. Separate databases are maintained for Biodiversity (site-wide percent cover and density; site topography), abalone habitat assessment, and Temperature (seawater and biomimic) data. Unless otherwise referenced below, all database outputs are updated after QC checks have been completed. This typically happens 2x/year in April/November after each data deadline (in March/October). Database 'outputs' include publishing new data and updating trend graphs and data summary files available for viewing and downloading from the MARINe website.

4.3 Data and Metadata Format

Data are organized into separate data sets (data packages) based on the survey methods used. All

data and metadata are stored in machine readable formats. Data files are stored as comma-separated value/CSV files and associated metadata are documented using the Ecological Metadata Language (EML) format. For more information about EML see: https://eml.ecoinformatics.org/). Survey methods and protocol documents are included in each data package, typically in PDF format.

4.4 Data Accessibility

All data packages are published with a Digital Object Identifier (DOI). This ensures that data are available across multiple data repositories (see https://www.doi.org/). MARINe data are typically replicated on one or more DataONE Member Nodes to increase accessibility. In addition, data requests can be made, and data downloaded directly from our website at https://pacificrockyintertidal.org. Data for species of concern can only be obtained through a data request; however, metadata for these data packages are still publicly viewable on DataONE.

4.5 Data Repositories Utilized by MARINe

DataONE Network: https://search.dataone.org/data
PISCO Member Node: https://data.piscoweb.org/metacatui
OPC Hosted Repository: https://opc.dataone.org/

4.6 MARINe Database Outputs

Database Dump (sql): A complete export of the MARINe database in .sql format, including all table structure and data files.

Raw Data Tables (csv): Data and lookup tables exported from the MARINe database in the exact format that they are entered/referenced within the database.

Summary Data Tables (csv): Summary data tables either by plot or means/totals for each site. These are the versions of the files available for download from our website or by request (specifically for species of concern and NPS and Navy sites).

Related Research: The MARINe database also contains data from additional research projects that can be accessed via data request from our website. This includes community-based monitoring programs, educational programs, restoration projects, and observations of sea stars, invasive species, and human activity (e.g. tide pooling, harvesting) along the coast (in development).

Additional Data Products: Information and links to additional data products can be found on our website here: https://marine.ucsc.edu/explore-the-data/index.html

4.7 MARINe Metadata

Database Schema View (HTML): The web viewable database schema for the MARINe database are updated 2x/year (https://marinedb.ucsc.edu/marine/schema/). This provides an easy way to view the structure of the MARINe database including the relationship between the database tables.

Metadata file (xml): The full set of metadata in Ecological Metadata Language (EML) format for each data set (data package). For more information about EML see: https://knb.ecoinformatics.org/#external//emlparser/docs/index.html)

DataONE Metadata View (html): A user-friendly interface via web to view the XML metadata for each data set. See example here: https://search.dataone.org/#view/doi:10.6085/AA/marine_ltm.1.2

4.8 MARINe Data Display

Static Trend Graphs: Trend graphs showing changes in species abundance, size structure or percent cover are updated on individual site pages on our website 2x/year; see example below:

https://marine.ucsc.edu/sitepages/boathouse-lt.html

User Generated Graphs: This graphics tool can be used to create customized, downloadable graphs using data from Biodiversity Surveys (site-wide percent cover and density), Long-Term Surveys (percent cover, counts, and size structure within fixed plots), or intertidal Temperature loggers (https://intertidalgraphs.org).

GIS Interactive Map and Data Display: The GIS map allows users to create visual summaries of data from our two primary survey types (Biodiversity and Long-Term) across all MARINe sites (https://intertidalmap.org)

5. GLOSSARY

Core protocols: Protocols that are completed by all groups at all sites. In some cases, technological advances have led to slight adjustments in core protocols over time. In these situations, the **legacy core protocol** is the original core protocol, and the **preferred core protocol** is the newer version (which has been designed in order to be backward compatible with data taken using the legacy core protocol).

Core species: Species, species groups, or substrates (Table 2, Table 3) that are scored by everyone in MARINe. Scorers in all monitoring groups must be able to identify all core species. Data sheets and iPad data collection templates must include all core species, although core species that are absent or rarely occur at a site can be de-emphasized (e.g., smaller font size or last page of a template). All priority target species are also core species. Core species were deemed to be reasonably and consistently identifiable using the designated scoring protocol and important enough to warrant scoring for abundance trends. Entries for all core species are required for data submission to the MARINe database.

Defined MARINe sampling site: The area in which MARINe sampling is conducted at a given location (field site). This encompasses all photoplots, transects, reference markers, and locations for timed or site-searches. It may or may not include all of the rocky habitat at that field site.

MARINe sampling season: MARINe has 3 sampling seasons, each 4 months long, defined as follows: Fall = October-January, Spring = February-May, and Summer = June- September (Note that this does not quite match the calendar year; thus, a sample in January 2005 would be listed as a Fall 2004 sample).

Miniquad: A small (mini) quadrat, 20 cm x 20 cm, used in Motile Invertebrate Monitoring and Mussel Measurement (supplemental) protocols.

Nearest neighbor: A supplemental protocol used for abalone sampling in which the sampler places each individual abalone into a category based on the distance from that individual to the nearest individual of the same species.

Panoramic (Pan) photos: Pictures OR overlapping sets of pictures taken to document the condition of regions of the study site. They can be comprised of overlapping sets of photos that encompass 180° or 360° fields of view from a single location (referred to as '180 Pans' or '360 Pans') but can be single photographs that target specific plots or transects.

Photoplots: Permanent (fixed) rectangular (50 x 75 cm; 0.375 m^2) established to monitor the cover of relatively small, densely spaced, sessile target species. Historically data were collected from photoplots by photographing the plots in the field and scoring cover of target organisms in the lab (hence the name photoplots). As of 2020, most teams score these plots in the field, but the name photoplot has been retained.

Photoplot PVC frame: A temporary PVC frame used to demarcate the edges of photoplots during low tide on a sampling date. These frames help scorers to rapidly locate plots and show the locations of photoplots in panoramic photos. Many teams use partial frames (e.g., one long and one short piece of PVC connected by a single joint) to reduce weight during travel to the field site.

Plot / transect marker: A permanent marker on the rock surface used to delineate the boundaries / corners or a plot or transect and allow the sampling team to locate the precise sampling location during subsequent sampling events. For each sampling unit, one marker is designated as the **primary plot marker** and marked with the plot or transect number.

Priority target species: Species or species groups that have the highest priority for monitoring and are monitored at as many sites as possible. All priority target species are also core species.

Reference marker: A permanent marker (usually a bolt or putty blob) which is in a central location at a

field site on an easily visible surface. Each MARINe sampling site has one or more reference markers, which can be used as tools to locate plots (with directions and compass heading to the plot) and as the location of panoramic photos. overview photo pans to include nearby plots/transects.

Supplemental protocols (formerly 'optional' protocols): Protocols that are completed by groups with funding & staffing to support additional work. Note that adding supplemental protocols at a site requires consultation with a MARINe database manager and long-term commitment to the supplemental protocol.

Supplemental target "species": Non-core species, species groups, or plot types that one or more monitoring groups choose to score at their sites (in consultation with MARINe database managers) in addition to the core species. Before a monitoring group decides to score supplemental target "species", they must contact the MARINe data manager and work out an agreement regarding category definitions. Choosing to add a supplemental target species requires a commitment to monitor the species consistently for a long period of time.

Target species: Species or species groups specifically chosen for MARINe long-term monitoring (Table 1).

Table 1. Standardized Names for Target Species Plots

Official MARINe Target Species				
Plot Name	**Plot Type**	**Scientific Name**	**6-Letter Code**	**3-Letter Brief**
Plants and Algae				
Egregia	Transect	*Egregia menziesii*	EGRMEN	EGR
Fucus	Photoplot	*Fucus distichus*	FUCSPP	FUC
Hedophyllum	Transect	*Hedophyllum sessile*	HEDSES	HED
Hesperophycus	Photoplot	*Hesperophycus californica* *NEW: Pelvetiopsis californicus*	HESCAL	HES
Pelvetiopsis	Photoplot	*Pelvetiopsis limitata/arborescens*	PELLIM	PEL
Silvetia	Photoplot	*Silvetia compressa*	SILCOM	SIL
Endocladia	Photoplot	*Endocladia muricata*	ENDMUR	END
Neorhodomela	Photoplot	*Neorhodomela larix*	NEOLAR	NEO
Caulacanthus	Photoplot	*Caulacanthus okamurae*	CAUUST	CAU
Phyllospadix	Transect Transect	*Phyllospadix scouleri/torreyi*	PHYSPP PHYUND	PHY
Zostera	Transect	*Zostera marina*	ZOSMAR	ZOS
Invertebrates				
Anthopleura	Photoplot	*Anthopleura elegantissima/sola*	ANTELE	ANT
Mytilus	Photoplot	*Mytilus californianus*	MYTCAL	MYT
Lottia	Size/Count	*Lottia gigantea*	LOTGIG	LOT
Haliotis	Size/Count	*Haliotis cracherodii*	HALCRA	HAL
Haliotis	Size/Count	*Haliotis rufescens*	HALRUF	*no code*
Chthamalus/Balanus	Photoplot	*Chthamalus dalli/fissus/Balanus glandula*	CHTBAL	CHT
Semibalanus	Photoplot	*Semibalanus cariosus*	SEMCAR	SEM
Tetraclita	Photoplot	*Tetraclita rubescens*	TETRUB	TET
Pollicipes	Photoplot	*Pollicipes polymerus*	POLPOL	POL
Pisaster	Size/Count	*Pisaster ochraceus*	PISOCH	PIS
Katharina	Size/Count	*Katharina tunicata*	KATTUN	KAT
Cryptochiton	Size/Count	*Cryptochiton stelleri*	CRYSTE	CRY
Strongylocentrotus	Size/Count	*Strongylocentrotus purpuratus*	STRPUR	STR
Supplemental Plot Types				
Plot Name		**Scientific Name**	**6-Letter Code**	**3-Letter Brief**
Plants and Algae				
Mastocarpus	Photoplot	*Mastocarpus spp*	MASSPP	MAS
Mazzaella	Photoplot	*Mazzaella spp*	MAZSPP	MAZ
Postelsia	Size/Count	*Postelsia palmaeformis*	POSPAL	POS
Red Algae	Photoplot Transect	(Includes plots targeting *Gelidium* & Red Algal & transects targeting Turf)	REDALG	RED
Invertebrates				
Balanus	Photoplot	*Balanus glandula*	BALGLA	BAL
Other				
Tar	Photoplot		TAR	TAR
Recovery	Photoplot		RECOV	REC
Rock	Photoplot		ROCK	ROC

Table 2. MARINe Photoplot Core Species List with Definitions

Code	"Species" name	Definition
ANTELE	*Anthopleura elegantissima; Anthopleura sola*	*Anthopleura elegantissima/sola*, may also include *A. xanthogrammica* at some sites
ARTCOR	articulated corallines	erect, jointed, calcified, red algae of the Family Corallinaceae, with flexible, articulate fronds arising from crustose bases
CAUUST	*Caulacanthus okamurae*	*Caulacanthus ustulatus*
CHITON	chitons	any species of chiton
CHOCAN	*Chondracanthus canaliculatus*	*Chondracanthus canaliculatus*
CHTBAL	*Chthamalus dalli / fissus; Balanus glandula*	*Chthamalus dalli/fissus* and *Balanus glandula*, used for photoplots scored in the lab
CLACOL	*Cladophora columbiana*	*Cladophora columbiana*
CRUCOR	crustose corallines	thin, flattened, calcified, crust-like red algae of the Family Corallinaceae, having no erect, articulated fronds. Bleached crustose corallines (white) are scored as well because they may be alive
DEADCB	dead *Chthamalus dalli / fissus; Balanus glandula*	dead *Chthamalus dalli/fissus; Balanus glandula*
DEAINV	other dead invertebrate	other dead invertebrate
DEAMCA	dead *Mytilus californianus*	dead *Mytilus californianus*
DEASEM	dead *Semibalanus cariosus*	dead *Semibalanus cariosus*
DEATET	dead *Tetraclita*	dead *Tetraclita*
EGRMEN	*Egregia menziesii*	*Egregia menziesii*
EISARB	*Eisenia arborea*	*Eisenia arborea*
ENDMUR	*Endocladia muricata*	*Endocladia muricata*
ENPEPH	*Endarachne spp; Petalonia spp; Phaeostrophion spp*	*Endarachne/Petalonia/Phaeostrophion* spp
FUCGAR	*Fucus distichus*	*Fucus gardneri*
HALSTE	*Stephanocystis* spp	*Halidrys dioica/Cystoseira* spp
HEDSES	*Hedophyllum sessile*	*Hedophyllum sessile*
HESCAL	*Hesperophycus californicus*	*Hesperophycus californicus / Pelvetiopsis californica*

Table 2 (Photoplot Core Species List) Continued

Code	"Species" name	Definition
LIMPET	limpets	all species of limpets through spring 2002, all limpets other than *Lottia gigantea* from fall 2002 to present
LOTGIG	*Lottia gigantea*	*Lottia gigantea*
MASSPP	*Mastocarpus* spp	*Mastocarpus papillatus/jardinii*
MAZAFF	*Mazzaella affinis*	*Mazzaella affinis*
MAZSPP	*Mazzaella* spp	*Mazzaella* spp (= *Iridaea* spp)
MYTCAL	*Mytilus californianus*	primarily *Mytilus californianus*, but may include M. *trossulus/galloprovincialis*, *Septifer*, and *Brachydontes* where photoplots scored in lab or where juvenile species were too small to ID in the field
NEOLAR	*Neorhodomela larix*	*Neorhodomela larix*
NONCRU	non-coralline crusts	any thin, flattened, crust-like algae other than coralline crusts
OTHALG	other algae; other plants	algae/plants that cannot be identified to species or group
OTHBAR	other barnacle	barnacle other than *Chthamalus spp, Balanus glandula, Pollicipes*, *Tetraclita*, or *Semibalanus*
OTHBRO	other brown algae	brown algae other than those scored separately (varies by group and over time)
OTHGRE	other green algae	green algae other than those scored separately (varies by group and over time)
OTHINV	other invertebrates	invertebrates other than those scored separately (varies by group and over time)
OTHRED	other red algae	red algae other than those scored separately (varies by group and over time)
PELLIM	*Pelvetiopsis limitata*	*Pelvetiopsis limitata*
PHRSAB	*Phragmatopoma* spp; *Sabellaria* spp	*Phragmatopoma californica* at sites south of Bodega, but may include other species of *Sabellaridae* at more northern sites
PHYSPP	*Phyllospadix* spp	primarily *Phyllospadix scouleri / torreyi* overstory but includes *P. serrulatus* at northern sites
PISOCH	*Pisaster ochraceus*	*Pisaster ochraceus*
POLPOL	*Pollicipes polymerus*	*Pollicipes polymerus*
PORSPP	*Pyropia* spp	*Porphyra* spp

Table 2 (Photoplot Core Species List) Continued

Code	"Species" name	Definition
ROCK	rock	bare, unconsolidated substrates larger than sand/gravel (including cobble, rocks, and boulders) and all consolidated substrates (i.e., bedrock) that contain no obvious living organisms or tar (epoxy corner markers and blue-green algal films are scored as
SAND	sand	granular, particulate (fine sand to gravel) substrate. Photoplots: score
SARMUT	*Sargassum muticum*	*Sargassum muticum*
SCYSPP	*Scytosiphon* spp; *Melanosiphon* spp	*Scytosiphon* spp; *Melanosiphon* spp
SEMCAR	*Semibalanus cariosus*	*Semibalanus cariosus*
SILCOM	*Silvetia compressa*	*Silvetia compressa*
TAR	tar	fresh or weathered oil or tar coating on the substrate
TETRUB	*Tetraclita rubescens*	*Tetraclita rubescens*
ULVENT	*Ulva* spp; *Kornmannia* spp; *Monostroma* spp	*Ulva* spp / *Enteromorpha* spp; *Kornmannia* spp; *Monostroma* spp
UNIDEN	unidentified	cannot tell if plant, invertebrate, or substrate

Table 3. MARINe Transect Core Species List with Definitions

Code	"Species" name	Definition
ANTELE	*Anthopleura elegantissima; Anthopleura sola*	*Anthopleura elegantissima / sola*, may also include *A. xanthogrammica* at some sites
ARTCOR	articulated corallines	erect, jointed, calcified, red algae of the Family Corallinaceae, with flexible, articulate fronds arising from crustose bases
BARNAC	barnacles	any species of barnacle, used for transects where species are not distinguished, also used in early photoplot data?
CRUCOR	crustose corallines	thin, flattened, calcified, crust-like red algae in Family Corallinaceae with no erect, articulated fronds. Bleached crustose corallines (white) are scored as well because they may be alive
EGRMEN	*Egregia menziesii*	*Egregia menziesii*
EISARB	*Eisenia arborea*	*Eisenia arborea*
HALSTE	*Stephanocystis* spp	*Halidrys dioica / Cystoseira* spp
MYTCAL	*Mytilus californianus*	primarily *Mytilus californianus*, but may include *M. trossulus / galloprovincialis, Septifer*, and *Brachydontes* where photoplots scored in lab or where juvenile species were too small to id in the field
NONCRU	non-coralline crusts	any thin, flattened, crust-like algae other than coralline crusts
OTHALG	other algae; other plants	algae/plants that cannot be identified to species or group
OTHBRO	other brown algae	brown algae other than those scored separately (varies by group and over time)
OTHGRE	other green algae	green algae other than those scored separately (varies by group and over time)
OTHINV	other invertebrates	invertebrates other than those scored separately (varies by group and over time)
OTHRED	other red algae	red algae other than those scored separately (varies by group and over time)
OTHSUB	other substrate	substrate other than rock or sand; includes dead barnacles, mussels, etc. where these are not scored separately
PHRSAB	*Phragmatopoma* spp; *Sabellaria* spp	*Phragmatopoma californica* at sites south of Bodega, but may include other species of *Sabellaridae* at more northern sites
PHYSPP	*Phyllospadix* spp	primarily *Phyllospadix scouleri / torreyi* overstory but includes *P. serrulatus* at northern sites
PHYUND	*Phyllospadix* spp understory	*Phyllospadix* spp occurring under other species of algae/plants

Table 3 (Transect Core Species List), continued

Code	"Species" name	Definition
ROCK	rock	bare, unconsolidated substrates larger than sand/gravel (including cobble, rocks, and boulders) and all consolidated substrates (i.e., bedrock) that contain no obvious living organisms or tar (epoxy corner markers and blue-green algal films are scored as
SAND	sand	granular, particulate (fine sand to gravel) substrate
SARMUT	*Sargassum muticum*	*Sargassum muticum*
TAR	tar	fresh or weathered oil or tar coating on the substrate
ULVENT	*Ulva* spp; *Kornmannia* spp; *Monostroma* spp	*Ulva* spp / *Enteromorpha* spp
UNIDEN	unidentified	cannot tell if plant, invertebrate, or substrate

Form 1: MARINe Rocky Intertidal Field Log Definitions

Codes

No Data (----): Draw a horizontal line through any blank area to indicate that this category was not evaluated or does not apply.

None (0): None were found within the defined site boundaries.

Low (L): Relatively few or low levels were found within the defined site boundaries.

Med (M): Medium numbers or moderate levels were found within the defined site boundaries.

High (H): High numbers or high levels were found within the defined site boundaries.

Weather and Sea Conditions

Swell/Surge: L/M/H relative levels of water movement over seaward portion of site.

Wind: L = ≤10 knots M = 11-20 knots H => 20 knots

Rain: L/M/H relative amounts of precipitation at the site during the survey.

Recent Rain: Evidence or knowledge of L/M/H amounts rain at the site within the past few days.

Water Temp: Actual seawater temperature (°C) or L: ≤14°C (57°F) M: 15-18°C H: >18°C (64°F).

Substratum Changes

Sediment Level: L/M/H relative levels of unconsolidated sand/gravel/cobble along reef/sediment interfaces.

Scour: L/M/H relative extent of scoured reef surfaces within the defined site boundaries.

Rock Movement: L/M/H relative extent of overturned boulders or bedrock breakouts.

Debris and Pollutants

Plant Wrack: L/M/H levels of unattached algae or other drift plants within the site.

Driftwood: L/M/H levels of sticks, branches, and logs within the site.

Shells: L/M/H levels of dead shells, especially mussel shells.

Dead Animals: L/M/H levels of dead invertebrates, fish, birds, or mammals.

Trash: L/M/H levels of human debris including cans, bottles, plastics, and metal items.

Oil/Tar: L/M/H relative extent of fresh or weathered oil/tar within the site.

Supplemental Field Log Definitions

Birds and Mammals
Core categories are listed and must be recorded. Record maximum number seen at any one time during the sampling, preferably upon arrival at site. Other more specific categories or species may be added but must define linkage to core taxa. Only record species within the defined site, either onshore or within 50 m of shore. Note relevant behaviors.

Marine Mammal Observations and Disturbances
For each species, record total # of individuals observed/disturbed by category. Record time of the event, sex/age of the individuals when possible, and any notes (location relative to site, injuries, etc.). Categories are:

0 = observation by researchers, no reaction by pinniped
1 = pinniped reacted to presence of researchers with movement <1 meter
2 = pinniped reacted to presence of researchers with short movement of 1-3 meters
3 = pinniped flushed to the water or moved >3 meters in retreat

Collections
For any collections made, record species, number collected, collector's name, and any notes (project, purpose, etc.)

Humans
Record maximum number of people seen at any one time during the sampling. Especially check at low tide. Separate counts for people on rock and on sand. Note relevant behaviors (e.g., fishing, etc.). Note also if people are present upcoast or downcoast of the site.

Plot Marker Loss/Repair, Other Notes, and Survey Checklist
These are optional categories. Information may or may not be added to the database as text entries.

Non-Native Species
For each species listed, note whether they are present (yes) or not observed (no)