SOP 11
Vegetation

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PROTOCOL REFERENCE

TBF. 2021. Vegetation Cover Surveys Standard Operating Procedures. Unpublished protocols. The Bay Foundation, Los Angeles, CA. https://cms.santamonicabay.org/wp-content/uploads/2021/03/L3-Estuarine-Wetland-Manual-V.2_FINAL_web.pdf

EMAP 2002. West coast pilot. Intertidal assessment: California intensification. Environmental Monitoring and Assessment Program. https://www.sfei.org/sites/default/files/biblio_files/3_EMAP_Quality_Assuranc~000.pdf

Moore, K.A., et al. 2020. NERRS SWMP Vegetation Monitoring Protocol, Long-term Monitoring of Estuarine Vegetation Communities. National Estuarine Research Reserve System Technical Report, Gloucester Point, VA. 41pp.

OBJECTIVE

Evaluating habitat change of vegetation communities can be accomplished at various levels of detail in the landscape. Comprehensive, broad evaluation of habitats typically requires the use of airborne or satellite remote sensing tools and imagery. Ground surveys, although not a replacement for remote imagery, provide a level of detail for assessing community composition and change that is complementary to broader scale remote surveys. Additionally, the implementation of statistically rigorous ground surveys can provide a foundation for other monitoring activities related to quantifying the process of change in these communities (Moore et al. 2020).

This monitoring protocol for emergent vegetation communities has the following objectives:

1. Quantify vegetation patterns and their change over space and time;
2. Maintain consistency with other monitoring protocols used nationally and worldwide;
3. Apply over a wide range of estuarine sites and habitats;
4. Quantify relationships among the various edaphic factors and the processes that are regulating the patterns of distribution and abundance in these communities;
5. Used as ground truthing to support comprehensive remotely sensed mapping of vegetation communities
6. Evaluate condition of endangered Ridgway's Rail habitat using standardized *Spartina foliosa* surveys

This SOP provides a standard approach to evaluate three important plant community parameters in tidal marshes: 1) plant species diversity, 2) community structure, and 3) the invasion of non-native species. This protocol is to be used for estuarine wetland habitats including the backshore (i.e., upland transition zone), marsh plains, channel margins, tidal pannes and ponds, and foreshore (i.e., channel-ward transition zones from the marsh plain to open tidal mud flats).

The recommended survey will use **across elevation methods** utilizing fixed transects that cross multiple elevation zones in the marsh to 1) quantify species composition and 2) track shifts in the vegetation community. For example, with sea level-rise, we might expect to see a shift in the low marsh vegetation community to higher elevations.

However, in some marsh evaluation frameworks, within elevation (parallel to elevation) have been implemented. In contrast to across elevation methods discussed above, within elevation methods utilize randomly assigned transects that run within a single elevation marsh platform. This method better characterizes the marsh community within each elevation. While not all frameworks/programs use this method, comparison with across elevation data is possible if within elevation methods include 1) fixed points that use real-time kinematic positioning (RTK) elevation, 2) assignment of data within habitat assemblage zones (discussed below), and 3) fixed points can be added through time to capture changes in vegetation.

For monitoring questions that focus specifically on Spartina foliosa, methods from Page et al. 2022 are also discussed in this SOP.

MATERIALS

1. 100-m transect tape
2. PVC or wooden stakes (left in field to mark fixed points)
3. Hammer or mallet
4. Meter stick or measuring tape (for vegetation canopy heights)
5. Percent cover quadrats (1m^2 quadrat divided into 16 smaller squares using string, PVC pipes, and elbow joints)
6. 35 cm sampling hoop
7. RTK GPS

SURVEY DESIGN – ACROSS ELEVATION

Across elevation transect methods will follow protocols as outlined in Moore et al. 2020, the NERRS SWMP Vegetation Monitoring Protocol. The protocol has been adapted for the purposes of Bight ’23 and the EMPA programs.

Site Delineation

The wetland boundaries should be defined *a priori*. A general base map should be developed providing the fundamental features of the site. The degree of detail of this reference map will be dependent on the extent of the geographical detail of the region. Typically, topographic quadrangles, digital orthophoto quarter quadrangles, vertical or oblique photographs can be used.

Within each sampling station/zone at a site (as established in Walker et al. 2023. Estuary Marine Protected Area Monitoring Protocol), a minimum of three transects should be established to represent the dominant environmental and elevation gradients with the sampling zone. If a different or notable habitat type/assemblage (e.g., vegetated brackish marsh or unvegetated salt panne) exists within the sampling zone but not on a transect, an additional transect should be added to capture that habitat type (Figure 1, Figure 2).

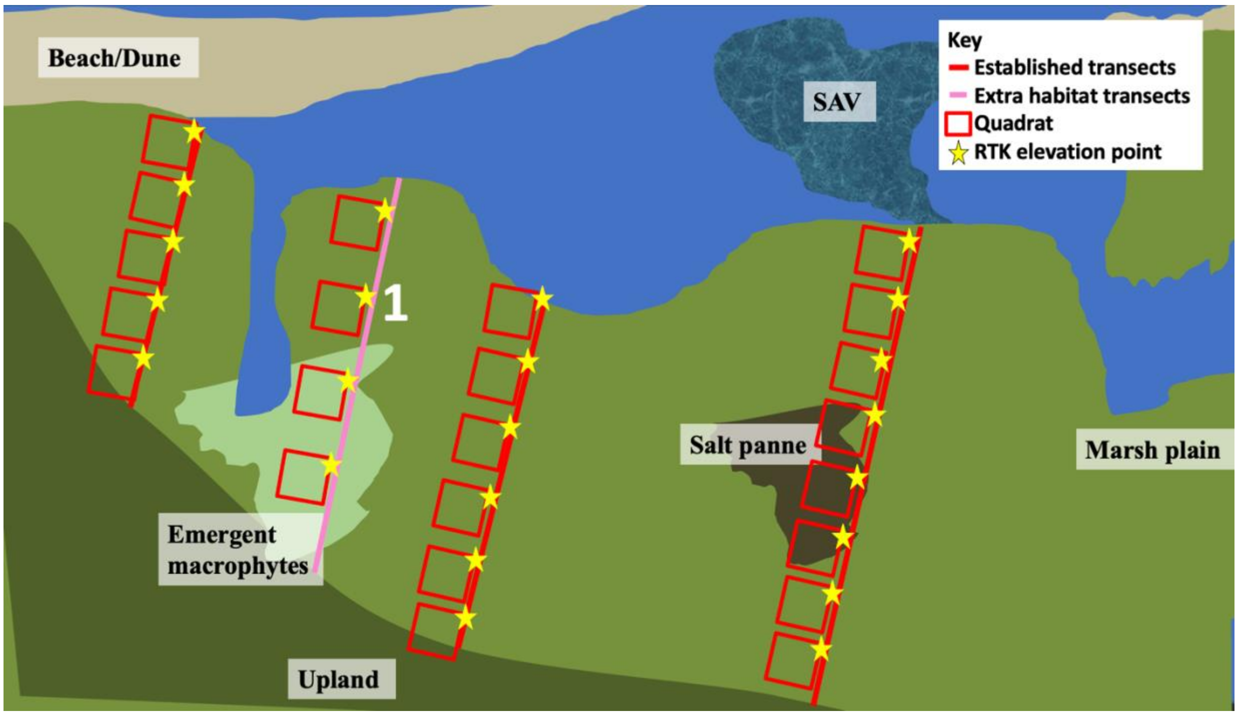

Figure 1. Marsh sampling design for across elevation surveys. The map represents a sampling zone/station with three established transects and an extra transect running through the emergent macrophyte habitat.

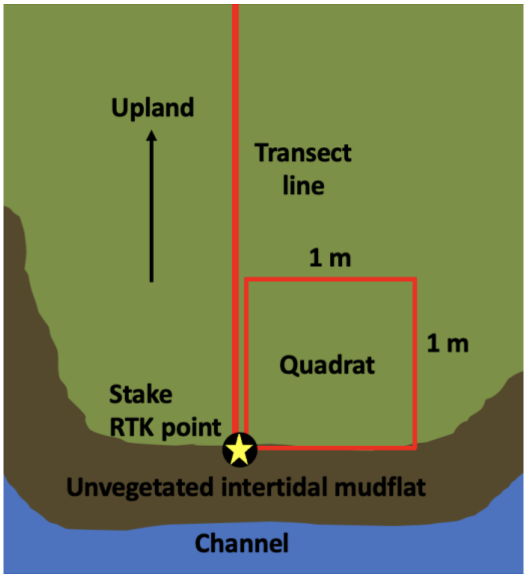

Figure 2. A zoomed in depiction of the first quadrat on the transect line. The beginning and end of the transect is marked with a stake and an elevation point is captured using RTK at each quadrat.

Survey Design

Each sampling zone (also referred to as a "station") may then be systematically divided into equal sized sections, if necessary (e.g., for large study systems), to achieve good interspersion of transects throughout the area.

1. Designate transects. At least three transects are then placed so that a minimum of three transects will be located in a sampling zone. Transects should be representative of the marshplain.
   a. Setting the location of the sampling transects within a zone can be accomplished by dividing the shoreline of each section into equal-sized intervals, numbering each interval and then randomly choosing interval numbers for transect establishment using tables or computer random number generation.
   b. Individual transects should be at least 10 m apart to maintain independence and should cover an area that is representative of the sampling station.
   c. A transect added to capture a unique habitat assemblage can be closer than 10 m apart.
   d. Each transect should traverse the elevation gradient from the foreshore to the upland without sampling in the upland itself. A detailed description of transect establishment for an emergent wetland study site using this approach is provided in Roman et al. (2001)

(https://coast.noaa.gov/data/docs/nerrs/Research_TechSeries_TechReportSWMPBio-MonitoringProtocol.pdf).

2. Assign first plot or quadrat to the vegetated marsh zone just above the unvegetated intertidal zone.
    a. Each "permanent plot" is an area immediately adjacent to a specific point along the transect that is used for repeated vegetation sampling (Figure 2).
    b. Mark the corner of the first permanent plot with PVC or wooden stake so that this can be found for subsequent sampling.
    c. All plots should be located with the same corner on the distance marker of the transect tape (Figure 1 and Figure 2). The orientation does not matter but should be kept consistent within each site and throughout the sampling time points (e.g., lefthand corner of the quadrat is always on the 10m mark).
3. Determine the length of the entire transect from first permanent plot to the upland edge by running a transect from the first plot to the edge.
4. Assign additional plots. The remaining permanent plots are then located at regular intervals along each transect.
    a. A total of approximately 6 – 7 quadrats per transect to establish 15 - 20 plots per sampling zone are suggested for adequate sampling power (Roman et al. 2001), therefore the permanent plot intervals should be adjusted for the overall length of the transects to achieve this replication. Quadrats should be distributed equally across the transect.
    b. If the marsh plain is large (> 60 m wide), no permanent plots should be more than 10 m apart.
    c. However, scaling of placement of the plots across the landscape will depend on the scale of the study area.
        i. For example, a larger marsh could have permanent plots placed at 20 m intervals along each transect with individual transects 50 m apart.
        ii. Alternatively, a smaller creek marsh could have permanent plots placed at 10 m intervals, with transects 10 m apart.
    d. Each permanent plot is then permanently marked with PVC or wooden labeled stakes driven into the marsh. If this is not possible then a GPS point using RTK should be taken at the plot corner so it can be returned to during the next sampling period.
5. Measure elevation at each quadrat in the same location as the corner of the quadrat (as discussed above). Elevation (or more technically "height") of each plot should be measured to the highest vertical resolution possible given survey equipment/resources (ideally mm level accuracy through leveling/RTK to nearby benchmark(s).
    a. The ellipsoid height is a simplified mathematical representation of the Earth's shape and the ellipsoid datum is a good reference system for

monitoring vertical stability of the benchmark over time. Since NOAA's NGS will release new geometric (horizontal – replacing NAD83) and geopotential (vertical – replacing NAVD88) datums in 2022, it will be important to collect and store information referenced to the current ellipsoid in order to easily transform between the new and old datums.

b. Repeat RTK surveys (to check for changes in elevation on the reference benchmarks as well as from the reference benchmark to the vegetation plots) should be conducted as often as possible but at least on a five-year interval.

At sites where there is a high potential for vegetative community migration due to sea level rise or other driving forces, additional elective sampling should be implemented to allow for monitoring of future shifts. In instances such as this at least one permanent plot should be assessed on either end of the current habitat assemblage boundaries, with the same spacing between plots as is used in the rest of the transect.

Each 1 m^2 vegetation sampling plot is sampled non-destructively for visual estimates of cover (%) for each species and for unvegetated cover. A variety of methods for plant cover estimates are available. We recommend following the methods as outlined below.

Percent Cover Methods

1. Within each quadrat or plot, the following data should be collected. Definitions of each type of cover are explained here.
    a. **Assign habitat assemblage** (**type;** e.g., low marsh)
        i. Based on the topography and characteristic plant assemblages, saltmarshes can be divided into zones/habitat assemblages. This classification is related to the number of tidal submergences per year (Adam 1990) as well as vegetation present (Sawyer and Keeler-Wolf 1995, Zedler et al. 1999). Some classifications also include divisions on the basis of substrate texture—some species are able to grow at lower elevations on well-drained sand than on silt (Randerson 1979) so substrate will be noted in metadata.
        ii. Only assign one habitat assemblage per quadrat.
        iii. Habitat assemblage definitions
            1. **Unvegetated salt panne**
                a. Definition: Salt pannes (or pans, salinas, alkali flats, playas) are unvegetated seasonal wetlands characteristic of arid, semi-arid, and Mediterranean climate coastal environments such as Southern California, disconnected from regular tidal inundation and where water ponds, usually hypersaline and unvegetated with soil cracks.
            2. **Unvegetated mudflat**

a. Definition: unvegetated areas of fine-grained sediment (mud) that are sometimes flooded
b. It is unlikely that quadrats will be placed in the mudflat. However, there may be instances where restoration sites could be conducting pre-restoration monitoring, and mudflat sites may be planted for vegetation.

3. **Vegetated low marsh**
   a. Definition: The 'low marshes' typically extend from the mean tidal level to the mean high water spring tide. The low marshes are drained by tidal creeks that convey flood and ebb flow; ebb flow generally dominates because flood water also inundates the marsh directly from the main channels. The bayward portion of the marsh plain and lower elevations
   b. Plants (often present but does not have to be present to be low marsh)
      i. *Spartina foliosa* alliance (cordgrass marsh – Zedler et al. 1999)
      ii. *Salticornia bigelovii* (absent from some marshes and seasonally)
4. **Vegetated mid marsh plain**
   a. Definition: a 30-cm elevation range with heterogeneous topography and up to nine common species
   b. Plants
      i. *Distichlis spicata*
      ii. *Frankenia salina*
      iii. *Sarcocornia pacifica*
      iv. Batis maritima
      v. Triglochin concinna
      vi. Jaumea carnosa
      vii. Sueda esteroa
      viii. Limonium californicum
5. **Vegetated high marsh plain**
   a. Definition: The 'high marshes' extend from the mean high water level to the highest springtide level. Flooded only by the highest tides and during storms, they are more like a terrestrial than a true marine environment. Specifically, a 30- to 70-cm elevation range (Zedler et al. 1999)
   b. Plants:
      i. *Salicornia subterminalis*

            ii. *Atriplex* spp. (e.g. *watsonii, triangularis)*
            iii. *Cressa truxillensis*
            iv. *Distichlis littoralis* (prior name - *Monanthochloe)*
            v. *Frankenia palmeri* (usually just in Baja marshes, rare further north)
    6. **Vegetated brackish marsh**
        a. Definition: An area typically characterized by sedges, such as bulrush, and typically experiences freshwater input
        b. Plants
            i. *Bolboschoenus maritimus* alliance
            ii. *Carex lyngbyei* provisional alliance
    7. **Scrub/Shrub**
        a. Definition: An area typically characterized by shrubs, such as willows, and may experience freshwater input
        b. Plants
            i. *Salix spp.* alliance

b. **Percent vegetated cover** – the total vegetated cover; the area of the plot with vegetated cover (upright, rooted, live or dead plants)
c. **Percent non-vegetated cover** – the amount of the plot that is not covered with vegetated material (upright, rooted, live or dead plants); this can include other cover types, such as algae, detritus, and debris
    i. **Note** – Non-vegetated and vegetated cover should add to 100%
d. **Percent cover by species**, distinguishing between live and dead species as separate estimates of cover
e. **Percent cover of other cover classes**
    i. <u>Detritus on sediment surface</u> (e.g., thatch) - newly dead or decaying organic matter on sediment surface (below plant canopy)
    ii. <u>Detritus on plant canopy</u> (e.g., wrack) - newly dead or decaying organic matter on top of the plant canopy
    iii. <u>Trash</u> – non-natural material on either sediment surface or plant canopy
    iv. <u>Woody debris</u> - single or multiple pieces of woody material
    v. <u>Algal mat</u> - macroalgae occurring on the sediment surface of a wetland (attached or detached).
f. **Height of the tallest plant of each species** (both living and dead)
g. **Epifauna species and abundance**
    i. Benthic *epifauna* are animals found to be living on or attached to the sediment surface (visible to the naked eye; e.g., horn snails, crabs). We do not include terrestrial insects (e.g., bees, leafhoppers, scales) in the epifauna counts.

2. Collect percent cover using above definitions

a. Surveys should be conducted using 1 m^2 PVC quadrats
    i. To increase the accuracy of the $1m^2$ estimate, use a quadrat subdivided into squares (Figure 3)
b. When first arriving at the plot, the surveyor should observe if there is any detritus on the plant canopy in the plot. If so, the surveyor should record the estimated cover and then remove the detritus from the plant canopy in the plot
c. Next, surveyors should estimate the percent vegetated cover and percent non-vegetated cover. These numbers should equal 100%.
    i. The total vegetated cover is the area of the plot with vegetated cover (upright, rooted, live or dead plants). If there is vegetated cover that overhangs the plot and is significantly influencing the plant canopy then this can be included in the cover estimate (plants taller than 1.5m should be excluded).
d. Surveyors should then estimate percent cover by species
    i. Because canopies of different strata (e.g., grasses, shrubs) may overlap, individual species cover estimates may total more than 100%
    ii. Each species (and whether it is alive or dead) should be recorded.
    iii. Visual estimates of cover are made to exact cover estimates. Multiple data recorders should calibrate their cover estimates before making measurements in the field.
    iv. These more precise cover estimates can be scored back in the laboratory using a modified Daubenmire cover class system with 7-point scale.
    v. If there are plant species that overhang the plot and are significantly influencing the plant canopy then these species can be included in the cover estimates (plants taller than 1.5m should be excluded).
e. Finally, the surveyors should record the cover estimates of each ‘other’ cover class, as defined above.

3. Measure the height of the tallest plant of each species
    a. The height of the tallest plant (to the nearest cm) is recorded for each species in each quadrat. Do this for both living and dead plants.
        i. From these data, the height of the tallest plant in each plot can be extracted
        ii. In addition, the number of plant layers (estimate of complexity) can also be determined.
        iii. If complexity is a key question for a monitoring framework, additional complexity methods are discussed in Zedler. 2015. Handbook for Restoring Tidal Wetlands
4. Within each plot that contains *Spartina foliosa*, place a 35 cm diameter sampling hoop within the established quadrat where *Spartina* occurs (non-randomly), and record the stem height of all stems within the sampling hoop. This will also provide a stem count (calculated later).

a. Stem height should be measured to the top of the stem but below any inflorescence.
    i. Note: If the top leaf reaches past the inflorescence, *S. foliosa* height is recorded until the very end of the top leaf (i.e., past inflorescence).

5. Identify epifauna species and determine abundance
    a. For each quadrat, count and record the total abundance for each epifauna species
    b. Crab burrows should also be counted to record evidence of crabs
    c. If 1m^2 quadrats are too large to count epifauna, then 0.25m^2 quadrats can be used to count a subset of individuals
        i. Epifauna abundance can be scaled on data sheets multiplying the abundance by 4
6. On the field datasheet record the following: Estuary name, sampling zone, transect #, transect length, date, time, data collectors, quadrat #, location of quadrat on transect (meter #), GPS location, elevation, habitat assemblage, total cover, cover class, species, live or dead, % cover, max height, epifauna species, epifauna abundance, and epifauna quadrat size

Figure 3. 1m^2 PVC quadrat, divided into squares.

SURVEY DESIGN – WITHIN ELEVATION

1. Locations for vegetation surveys are critical in assessing overall plant community parameters
    a. Survey areas will be pre-selected on sampling maps and marked with lines
    b. Transects should be within one of the three designated sampling zones of the estuary
    c. Transects should include multiple habitat zones in the marsh platform -
        i. the backshore (i.e., upland transition zone)
        ii. marsh plains
        iii. channel margins
        iv. tidal pannes and ponds
        v. foreshore
2. The number and direction of transect lines will follow the EMAP 2002 protocols (Figure 5). Each transect is placed parallel to the channel along a uniform elevation.
    a. 1 transect – 25 m transect, parallel to the mainstem channel along the foreshore (low marsh), but not in the water or on a mudflat.
    b. 1 transect – 25 m transect, parallel to the mainstem channel, 20 m back from the foreshore (mid marsh), 10 m from any other channel
    c. 1 transect – 25 m transect, along the backshore in the high marsh.
    d. *Additional transects can be added based on the number of marsh platforms
3. For each transect –
    a. Every 5 m along the 25 m transect, lay the $1m^2$ quadrat next to the transect (Figure 3)
        i. Alternate sides of the transect when laying the quadrat (Figure 5)

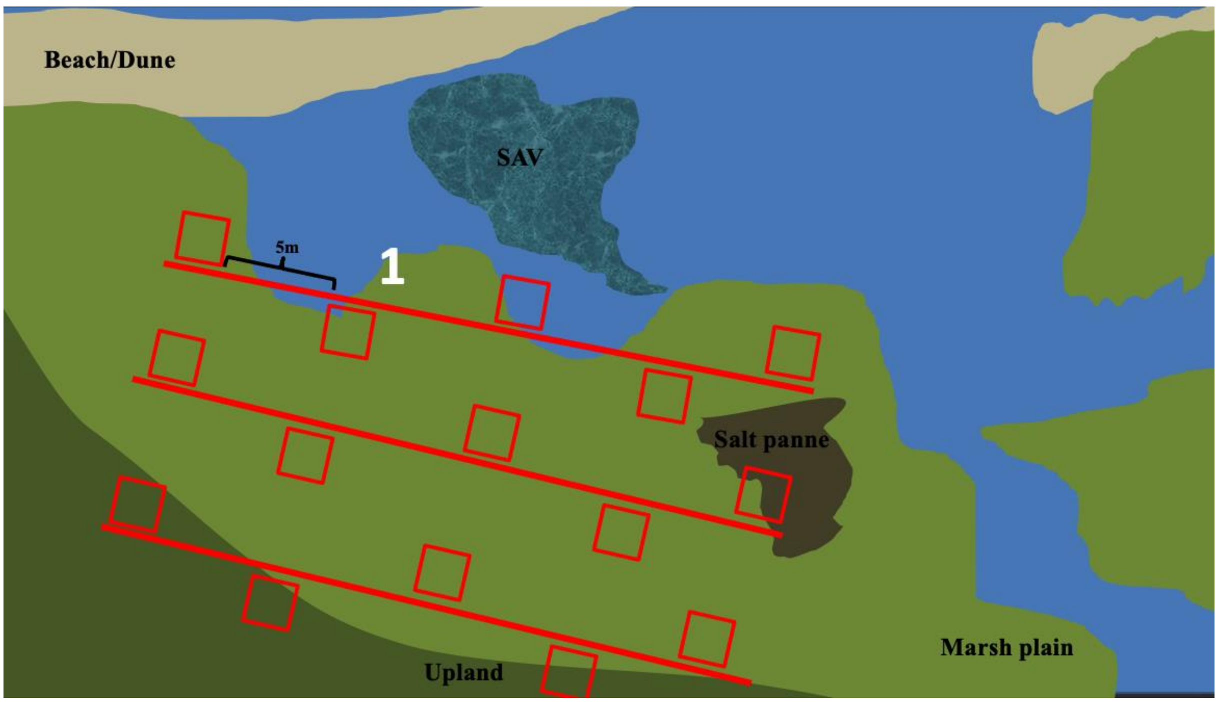

Figure 5. Example lagoon with three vegetation transects (foreshore, mid, and backshore) and five quadrats every 5 m along each 25 m transect line. This configuration would be focused at 1 sampling zone. Similar transect lines could be set up at the other zones.

FIELD METHODS – SPARTINA SURVEYS

We encourage surveys located in estuaries with sufficient densities of *Spartina foliosa* (Pacific cordgrass) to conduct these additional in-depth surveys.

1. In quadrats with cordgrass present, randomly place a 35 cm diameter sampling hoop in the quadrat.
2. Count the total number of live and dead cordgrass stems.
3. Measure the stem height of all live stems within the sampling hoop.
    a. Stem height should be measured to the top of the stem but below any inflorescence.
        i. Note: If the top leaf reaches past the inflorescence, *S. foliosa* height is recorded until the very end of the top leaf (i.e., past inflorescence).

QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC)

The Lead Scientist from each organization will be responsible for ensuring that their field personnel have been trained properly on all field methods and procedures that will be used during the survey. It will be their responsibility to review the Field Operations Manual with their field crews, and to make sure that each person understands that these procedures must be followed during the survey. Personnel that cannot perform a required operation will not participate in conducting that operation.

While it is expected that the lead taxonomists of each organization will have a wide range of knowledge of the common seine caught species, it is not expected that all persons making field identifications will know every species. *It is, therefore, very important to avoid guessing when finalizing any identification*. An error made in the identification of an organism may result in an irretrievable error in the database because most of the organisms that are identified in the field are returned to the estuary. If there is any question regarding the identity of a specimen, that specimen shall be returned to the laboratory for final identification and a voucher should be collected. Once the final identity of any specimen has been ascertained in the organization's laboratory, that change will be made on the data sheets by crossing out the original name (do not erase the original name) and writing the correct name.

All data collected on the data sheet should be entered clearly. Field crews should double check that all final calculated vegetation data are accurate. Team Leaders should also double check that the Data sheets have been completely filled out before leaving a transect site.