Standard Operating Procedures (3.1): Algae and Submerged Aquatic Vegetation

March 2021

Prepared for the United States Environmental Protection Agency

The Bay Foundation
8334 Lincoln Blvd. #310, Los Angeles, CA 90045
(888) 301-2527
www.santamonicabay.org

Standard Operating Procedures:
Algae and Submerged Aquatic Vegetation

SOP Identification: SOP 3.1 Algae and SAV
Date of Original Issue: 20 June 2015
Date of Last Revision: 30 March 2021
Developed by: The Bay Foundation, Southern California Coastal Water Research Project, California State University, Long Beach

Protocols reviewed by:

Christine Whitcraft, California State University, Long Beach
Karina Johnston, The Bay Foundation
Jeff Crooks, Tijuana River National Estuarine Research Reserve
Ivan Medel, Integral Ecology Research Center
Charles Piechowski

Suggested citation: TBF. 2021. Algae and Submerged Aquatic Vegetation Standard Operating Procedures. Unpublished protocols. The Bay Foundation, Los Angeles, CA.

Protocol Suitability Evaluation

A habitat suitability table containing appropriate estuarine wetland habitat types (of those evaluated) to implement macroalgae and submerged aquatic vegetation (SAV) protocols is displayed in Table 1. A comparative assessment of cost, effort, and data quality are shown in Table 2. A matrix of additional detailed categorical evaluations of implemented macroalgae and SAV protocols can be found in Appendix 3.1A.

Table 1. Appropriate habitat types for algae and submerged aquatic vegetation survey protocols.

	Habitat Types					
Survey Protocol	**Tidal Channel**	**Mud / sand flat**	**Emergent salt marsh**	**Non-tidal salt marsh**	**Salt pan**	**'Degraded' / fill**
Algae	X	X	X	X	X	X
SAV (subtidal)	X	X				

Table 2. Categorical assessment of cost/effort and data quality for algae and submerged aquatic vegetation survey protocols.

	Evaluation Metric	Algae	SAV (subtidal)	Notes
Time / Effort	Office Preparation Time	10-30 minutes	10-30 minutes	Site selection and any GPS locations
	Equipment Construction Time (one time)	30-60 minutes	30-60 minutes	Will need to construct quadrat with PVC and twine
	Field Time (per transect)	10-30 minutes	3-4 hours	----
	Laboratory Time (per transect)	30-60 minutes	0 minutes	Cleaning and weighing algae biomass
	Post-Survey Processing / QAQC Time	10-30 minutes	10-30 minutes	----
	Minimum Repetition (site-dependent)	Few Repetitions	Few Repetitions	Algal cover may vary across tidal channel areas; SAV may be patchy
	Relative Cost (equipment and supplies)	< $15	< $1,000	Significant costs associated with subtidal surveys (boat, SCUBA, etc.)
Survey / Data Quality	Accuracy (at a survey area level)	Medium	Medium	----
	Precision (at a survey area level)	High	High	----
	Qualitative-Quantitative Score	Quantitative	Quantitative	----
	Subjectivity-Objectivity Score	Objective	Objective	----

Resulting Data Types

The application of macroalgae and SAV survey protocols will yield quantitative data displayed in species-specific percent cover along individual transects or extrapolated to a habitat type or wetland. The application of subtidal SAV mapping survey protocols will yield quantitative data displayed in aerial cover along areas or as a Geospatial Information Systems (GIS) map. Additionally, biomass data result in grams per meter squared data that may be extrapolated up to a transect-level, habitat type, or wetland. These data are useful to identify algae and SAV cover trends over multiple time scales and may assist in identifying potential areas of eutrophication within estuaries or locations of subtidal SAV beds.

Objective

Macroalgae (or visible larger algae) and submerged aquatic vegetation surveys provide important information about primary productivity within a system, essential fish habitat, and given trophic structure. Algae abundance and growth can also be useful indicators of eutrophication and tidal flushing (Zedler 2001, Hughes et al. 2010). This document interchangeably refers to macroalgae or algae, but always means visible larger species (Figure 1).

Figure 1. Green algae and *Ruppia sp.* in a wetland tidal channel.

Repeated monitoring of macroalgal abundance provides information on when algal blooms occur and how long they endure as an indicator of primary productivity in each system. Macroalgal abundance is determined by measuring percent cover and algal biomass. The Southern California Bight 2008 Regional Monitoring Program (Bight '08) was part of an effort to provide an integrated assessment of environmental conditions through cooperative regional-scale monitoring and developed these protocols. One purpose of this sampling method is to continue to collect eutrophication data using the same regional collection methods from the Bight '08 program to assess long-term data trends over time. In southern California estuaries, some SAV will be intertidal especially if *Ruppia* (ditch grass) species are present. However, in some systems, much of the SAV is subtidal, requiring additional monitoring protocols including SCUBA (see SAV subtidal mapping protocols).

The macroalgae cover SOP is described based on standardized methods conducted by Johnston et al. (2011, 2012) and developed by the Bight '08 Program. The subtidal SAV cover SOP is described based on standardized methods conducted by Paua Marine Group (A. Obaza, A. Bird). However, more in-depth SAV measurements (e.g., turion density, invertebrates, etc.) are often required or important to understand. Those methods have been documented in other protocols (e.g., MarineGEO 2020, SCCWRP 2020, NOAA 2014) and are not included in SOP 3.1.

Equipment

Equipment and supplies needed for both survey types include:

1. GPS

Additional supplies needed for the macroalgae SOP:

1. Transect tape

2. 0.25 m² PVC quadrat (0.5 x 0.5 m) with 7x7 squares delineated using string to make 49 points of intersection (Figure 2)
3. Sealable bags
4. Small PVC cylinder (6 in diameter)
5. Data sheet (Appendix 3.1B)

Figure 2. Quadrat placement in a wetland tidal channel.

Additional supplies needed for the subtidal SAV SOP:

1. Boogie board
2. SCUBA gear (Figure 3)
3. Data sheet (preliminary map or location)

Field Preparation

Equipment described above should be collected prior to the field shift. Batteries for all electronic devices should be checked and replaced as needed, and relevant data sheets should be printed.

Figure 3. SCUBA gear is required for subtidal SAV surveys.

Field Methods

Macroalgae protocols:

Surveys should be conducted once quarterly in March, June, September, and December. Surveys should begin approximately one and a half hours before a low spring tide to obtain the maximum mudflat exposure and conclude after approximately three hours.

A minimum of three, 30 m transects should be laid out in the intertidal area parallel to the water's edge and along the same elevational contour (Figure 4; Bight 08, Johnston et al. 2011, 2012). Transects may be placed along the edge of the vegetation to reduce impact to the mudflat and channel bottom, but the quadrats should be placed at approximately three quarters of the distance from the mean lowest low water line to the downslope end of vascular vegetation on the mid-to-upper mudflat (Figure 5). This area has been demonstrated to be representative of macroalgae accumulation in southern California estuaries (Kennison et al. 2003).

Figure 4. Transect deployment adjacent to a tide channel.

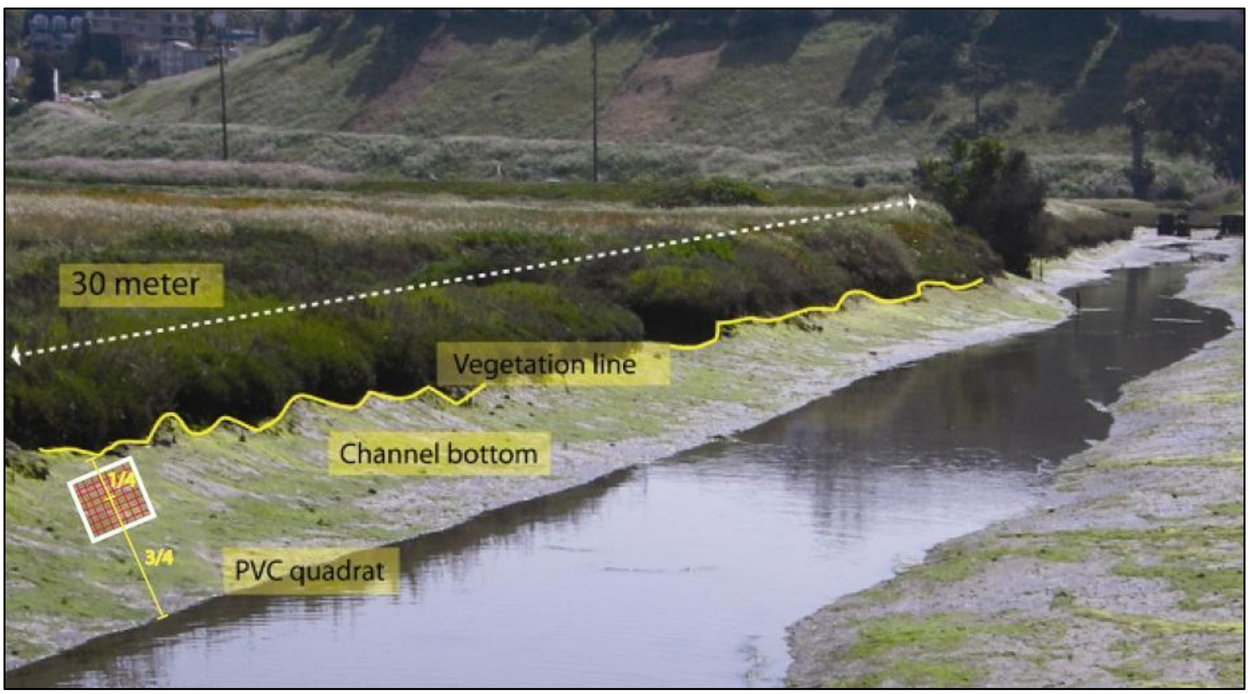

Figure 5. Diagram of algae/SAV transect showing placement of quadrat and vegetation line (replicated from Johnston et al. 2011). Note: diagram is not drawn to scale.

Percent cover should be measured at ten randomly chosen points along the transect using a random number generator. Place the 0.25 m^2 quadrat with 49 intercepts (Figure 2) on the benthos at each random transect point, and record the presence or absence of each macroalgae (e.g., *Ulva sp.*) or submerged vegetation (e.g., *Ruppia sp.*) species under each intercept point (see Appendix 3.1B for datasheet). Only one species per intercept point should be recorded. Intersecting points occurring over bare soil or mud should be recorded as 'bare'. The estimated maximum and minimum mat thicknesses should also be noted in millimeters on the datasheet (Appendix 3.1B). Thickness can be measured by using the transect tape as a reference or a handheld ruler.

Biomass should be randomly collected at five of the quadrat locations using a 6-inch diameter PVC cylinder placed in the middle of the quadrat. Biomass samples should be collected from within the circumference of the PVC cylinder and placed into a labeled bag and sealed. Each biomass sample should be refrigerated until analysis and processed within 24-hours of collection (see laboratory methods).

Note: The additional "other" categories on the algae datasheet may be used for notating supplementary invertebrates (e.g., Cerithidea californica*) and trash presence or absence.*

SAV subtidal mapping protocols:
Surveys should be conducted twice yearly in June, September, (end of growing season) in line with regional monitoring efforts and NOAA California Eelgrass Mitigation Policy (CEMP) protocol. Aerial cover should be measured and mapped by divers on SCUBA using a Trimble R1 Global Navigation Satellite System receiver linked with a smartphone (or similar setup) (Figure 6). This mapping is done by having a single diver swim the outline of the eelgrass bed perimeter towing a Pelican float, while a second diver follows this path with the Trimble R1. This receiver, enabled with real-time Satellite-based Augmentation System correction, provides sub-meter accuracy during mapping. Data are then exported to the Trimble Terraflex cloud system for review and are available as shapefiles.

Figure 6. Biologist with Paua Marine Research Group outfitted with Trimble R1 GNSS Receiver used to map an eelgrass bed (photo: Paua Marine Research Group).

Laboratory Methods

In the laboratory, for biomass calculations, algal samples should be cleaned of macroscopic debris, mud, and animals, and sorted to genus level. Excess water should be shed from each sample, then weighed wet, and subsequently dried at 60°C to a constant weight, then weighed dry. During data analysis, all macroalgae genus weights should be summed for each quadrat to give a total macroalgae wet and dry weight by quadrat.

Data Entry and QAQC Procedures

Data should be entered in the field using the appropriate data sheet (Appendix 3.1B). All required fields should be completed in full, and the data recorder should assign their name at the top of the document(s). Data should be transferred to the appropriate electronic database within three days, and the hard copies filed in labeled binders. Electronic copies of all data should be housed on an in-house dedicated server and backed up to a cloud-based or off-site server nightly. Hard copies should be saved for five years. Electronic copies should be saved indefinitely.

Quality Assurance and Quality Control (QAQC) procedures should be conducted on all data. QAQC procedures should be conducted by the QA Officer and include a thorough review of all entries, double checking of all formulas or macros, and a confirmation that all data sheets and field notes are filed appropriately with electronic back-up copies available. QAQC should verify that the entered data match the hard copies of the field data sheets. Any discrepancies should be corrected, and the initial data entry technician notified.

Data Analyses

Algae and intertidal SAV surveys can be analyzed by determining percent cover for each quadrat (i.e., number of points for a species / 49 x 100) by species or summed as one value for algae and one for submerged aquatic vegetation. Quadrats can be averaged by transect, and standard error used to determine variability. Graphs can be created using averages and standard errors by season, transect, or estuary.

Biomass data can be calculated for both wet and dry weight. Biomass data can also be evaluated at the transect level or up to habitat type or wetland. For biomass data, one, 6-inch PVC pipe equates to an area of 0.072963725 m^2. To extrapolate up to grams per meter squared, enter the resulting individual weight (g) of each biomass sample into the following equation:

$$\text{Weight of sample (g)} \times (1 / 0.072963725\ m^2) = \text{grams per } m^2$$

For subtidal SAV, data outputs are in the form of mapping GIS polygons (Figure 7), which can include specific attributes such as percent cover, number of turions, etc., as determined by the monitoring program.

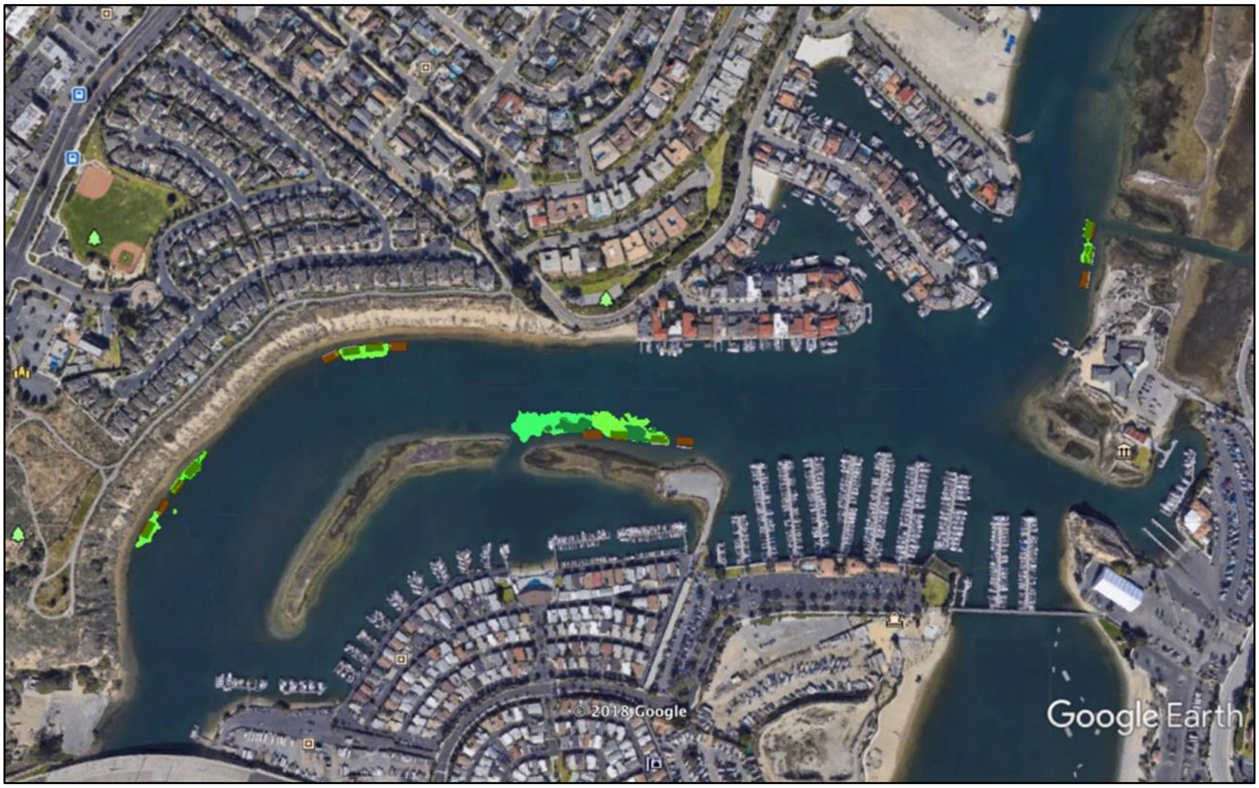

Figure 7. Upper Newport Bay subtidal SAV map (Zacherl et al. 2018, unpublished data).

Health and Safety Precautions

Not applicable.

References and Applicable Literature

2nd Nature. July 2008 (revised May 2010). Malibu Lagoon Restoration Monitoring Plan (MLRMP) Baseline Conditions Report.

Abbot, I.A., and Hollenberg, J.G. 1976. *Marine Algae of California*. California: Stanford University Press.

Ambrose, R.F. and Diaz, N. 2008. "Integrated Wetlands Regional Assessment Program (IWRAP) DRAFT Data Collection Protocol – Tidal Wetland Vegetation." *Prepared for the Southern California Wetland Recovery Project.*

(Bight '08) Bight '08 Coastal Ecology Committee Wetlands Subcommittee. 2009. "Estuarine Eutrophication Assessment Field Operations Manual DRAFT (Version 9). *Prepared for Commission of Southern California Coastal Water Research Project.*

Hughes, B., Haskins, J., Wasson, K. 2010. Assessment of the effects of nutrient loading in estuarine wetlands of the Elkhorn Slough watershed: a regional eutrophication report card. Elhorn Slough Technical Report Series 2010:1.

Johnston, K.K., E. Del Giudice-Tuttle, I.D. Medel, C. Piechowski, D.S. Cooper, J. Dorsey, and S. Anderson. 2012. "The Ballona Wetlands Ecological Reserve Baseline Assessment Program: 2010-2011 Report." Santa Monica Bay Restoration Commission. Report Prepared for the California State Coastal Conservancy, Los Angeles, California. 215 pp.

Johnston, K.K., E. Del Giudice-Tuttle, I.D. Medel, S. Bergquist, D.S. Cooper, J. Dorsey, and S. Anderson. 2011. "The Ballona Wetlands Ecological Reserve Baseline Assessment Program: 2009-2010 Report." Santa Monica Bay Restoration Commission. Report Prepared for the California State Coastal Conservancy, Los Angeles, California. 446 pp.

Kennison, R., Kamer, K., Fong, P., 2003. Nutrient dynamics and macroalgal blooms: a comparison of five southern California estuaries. Southern California Coastal Water Research Project Technical Report #416, Westminster, California.

(MarineGEO) 2020. Protocol: Seagrass Cover and Density (2020) Tennenbaum Marine Observatories Network, MarineGEO. Smithsonian Institution. 4 pp.

McCune, K., D.J. Gillett, and E.D. Stein. Methods and Guidance on Assessing the Ecological Functioning of Submerged Aquatic Vegetation in Southern California Estuaries and Embayments. Southern California Coastal Water Research Project: Technical Report 1136. 57 pp.

McLaughlin K., M. Sutula, L. Busse, S. Anderson, J. Crooks, D. Gibson, K. Johnston, L. Stratton, L. Tiefenthaler 2012. Southern California Bight 2008 Regional Monitoring Program: Estuarine Eutrophication Assessment. Southern California Coastal Water Research Project. Costa Mesa, CA.

(NOAA) 2014. National Oceanic and Atmospheric Administration. California Eelgrass Mitigation Policy nd Implementing Guidelines. 48 pp.

Zacherl, Nichols, Whitcraft, Obaza, and Bird. 2018. Unpublished data.

Zedler, J.B., ed. 2001. *Handbook for Restoring Tidal Wetlands.* Baton Rouge*:* CRC Press.

Contact Information

Karina Johnston, The Bay Foundation
kjohnston@santamonicabay.org

APPENDIX 3.1A

	Evaluation Metric	Macroalgae	SAV (subtidal)	Notes
	Correlation to L2 CRAM	Not Applicable (at the Attribute-level)	Not Applicable (at the Attribute-level)	Loosely tied to the patch size metric as one potential type of patch
Personnel Requirements	Specialty Equipment or Clothing Required	Few Specialty Items	Many Specialty Items	Hard-soled wetsuit booties work well in tidal channels; subtidal requires full SCUBA
	Ease of Transport (amount or weight of supplies)	Few Items / Easy	Few Items / Easy	----
	Ease of Implementation	Easy	Easy	----
	Expertise / Skill Level	Some Technical Knowledge	Some Technical Knowledge	Familiarity with species identification is recommended
	Number of Personnel	2	2	Includes one data recorder and one surveyor
	Training Requirements	None	None	----
	Seasonality of Survey Time	Every season	Late summer	Macroalgae: spring, summer, fall, winter
	Suggested Frequency	Quarterly	Annually	----
Survey / Data Quality	Type of Output	Numerical	Numerical	----
	Active or Passive Monitoring Style	Passive	Passive	----
	Specialty Computer Software Required	No	Yes	GIS required for mapping outputs (SAV subtidal)
	Availability of Online / External Resources	Some	Many	Other suggested use documents are available
Potential Limitations	Wetland Type Applicability	All	Subtidal only	----
	Images or Multi-Media Required	Images Required	GIS Required	----
	Degree of Impact / Disturbance	Moderate Disturbance	Low Disturbance	Walking through channels will disturb sediments
	Vegetation Height Limitation	Not Applicable	Not Applicable	----
	Appropriate for Tidal / Wet Habitats	Yes	Yes	----
	Tide Height	Low Tide Only	N/A	----
	Regional or Broad Implementation *	Almost Always Used	Frequently Used	----
	Potential for Hazards / Risk	Low to No Risk	Low to No Risk	----
	Restrictions	None	None	----

** based on monitoring literature review table*

APPENDIX 3.1B
(modified from Bight '08)

Submerged Aquatic Vegetation Sampling Data Sheet			
Date:		Transect #:	Page ____ of ____
Time (Start):	Time (End):	Notes:	
Field Lead:		Entered: ______________________________	Date:
Field Staff:		QAQC: _______________________________	Date:

Site Observations

Days Since Last Rainfall (approx):	Tide Gate Postion: Open / Closed
Weather: Clear / Partly Cloudy / Overcast / Rainy / Foggy	Time of Low Tide: Height of Low Tide:
Photo Oceanward: Y / N	Time of High Tide: Height of High Tide:
Photo Landward: Y / N	Direction of Tide: Ebb / Flood / Max / Min
Vertical Zonation of Marcoalgae: Y / N Describe:	
Comments:	

Macroalgal Transect

Quadrat	1	2	3	4	5	6	7	8	9	10
Distance (M)										
Matt Thick (MM)										
Estimated?	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N
Condition	Frsh / In / Des /Dd	Frsh / Int / Des / Dd	Frsh / Int / Des / Dd	Frsh / Int / Des / Dd	Frsh / Int / Des / Dd	Frsh / Int / Des / Dd	Frsh / Int / Des / Dd	Frsh / Int / Des / Dd	Frsh / Int / Des / Dd	Frsh / Int / Des / Dd
Bare										
Ulva intestinalis (string-like)										
Ulva lactuca (sheet-like)										
Ceramium										
Gracilaria										
Filamentous algae										
Ruppia (spp.)										
Macrocystis Wrack: Y/ N										
Phyllospadix Wrack: Y / N										
Decayed and Unidentifiable										
Cerathidia										
Trash: Y / N										
Other 1:										
Total:										
Biomass: Y / N										

Field Lead Signature: ___________________________________