Seagrass Ecosytem Metrics

(Metrics that may be sampled)

Tier 1:

Component	Metric
Seagrass	Acreage
	Bed Patchiness
	Species Composition
Macroalgae	Presence/Absence
Condition	Prop Scarring
	Bioturbation

Tier 2:

Component	Metric
Seagrass	Canopy Height
	Condition (Observed)
	Deep Edge
	Percent Cover
	Percent Cover by Species
	Biomass
	Species Composition
Environment	Depth
Macroalgae	Presence/Absence (Drift vs. Attached Algae)
Water Quality	Dissolved Oxygen
	Light Attenuation (PAR profile/Secchi)
	pH
	Salinity
	Temperature
	Turbidity/TSS
	Color/CDOM
	Chlorophyll A
Community	Composition (e.g. sponges)
Condition	Prop Scarring
	Bioturbation
	Elemental Composition of Leaf Tissue

Tier 3:

Component	Metric
Seagrass	Biomass
	Canopy Height
	Condition (observed)
	Stable Isotope Analysis of C&N
	Percent Cover
	Shoot Count/Density
	Species Composition
	Tissue Element Composition (CNP)
	Flowering
	Presence/Absence of Keynote species
	Growth/Productivity
	Stable Isotopes (C, N, P, S)
	Herbivory
	Genetic Diversity
	Stressor Proteins
	Leaf Allometry
Environment	Sediment/Substrate (grain size, organic content)
	Pore Water Chemistry
	Wave Energy
	Tidal Exposure
	Freshwater Inflow
Macroalgae	Dissolved Oxygen
	Canopy Height
	Drift vs Attached Algae
Water Quality	Dissolved Oxygen
	Light Attenuation (LICOR/Secchi)
	TSS
	CDOM/NTU
	Chlorophyll A
	Salinity
	Temperature
	Turbidity
	Nutrients
	Polycyclic Aromatic Hydrocarbon (PAH)
	pH
	Stable Isotopes (C, N, P, S)
Community	Composition (e.g. sponges)
	Epiphytic Grazers
	Invertebrates
	Epiphytic Load
	Faunal Usages/Abundance
	Herbivory
	Presence/Absence of Keynote Species
	Secondary Productivity
	Prop Scarring
	Bioturbation
	Disease

Acknowledgements:

Handley, LR, CM Lockwood, K Spear, M Finkbeiner, and J Kenworthy. 2018. *Gulf-wide seagrass monitoring and needs assessment workshop report for the Gulf of Mexico Alliance. 2018*. Gulf of Mexico Alliance Star Award, Contract No. 121701-00. 89 p.

Mobile Bay Seagrass/Alabama SAV Pilot Workshop April 2019, Mobile, AL. Mississippi-Alabama Sea Grant Consortium, USM/Gulf Coast Research Lab

Tier Application

A seagrass inventory and monitoring guideline will produce an invaluable resource to guide future efforts for conservation and restoration. The first step in producing a guideline is the development of a comprehensive approach for seagrass monitoring. The Approach is best viewed through a matrix concept by tier hierarchy based on spatial area, frequency of monitoring, and scope of project/study.

Tier 1 characterizes the overall distribution and extent of seagrasses in a defined ecosystem. The metrics used in Tier 1 are typically acquired by well-established and widely used and available remote sensing methods (aerial or satellite imagery) and analysis techniques. Tier 1 in the hierarchy is designed to characterize a few numbers of specific properties, ideally to inventory seagrasses over the entire system of interest, (e.g., GOM), while simultaneously characterizing relatively large regional areas. Tier 1 monitoring has been one of the most commonly used approaches for assessing the status and trends of seagrasses over long time periods and broad scales.

Tier 2 characterizes the ecological condition of seagrasses over relatively large areas by carefully selecting statistically valid sample sites and monitoring frequency. Tier 2 surveys are generally restricted to subsections of the larger ecosystem, collected in or on the water at a greater number of sites and a higher temporal frequency than Tier 1. Tier 2 data provides more detailed properties describing the spatial-temporal variation in seagrass structure (e.g., species composition, size) and abundance (e.g., percent cover, shoot density) to quantify stressor/response relationships and produce estimates of the ecological condition of resources over broad areas.

Tier 3 monitoring includes more intensive monitoring than Tier 2, sometimes using a larger number of metrics sampled simultaneously and more frequently, and usually at a smaller number of sites that are smaller in size. Tier 3 monitoring is driven by specific scientific hypotheses (e.g., measuring levels of uncertainty, evaluating multiple process-related responses) and local and regional programs that directly address questions regarding the specific mechanisms responsible for the changes detected in Tiers 1 and 2. Tier 3 can be effectively used to monitor the suspected drivers of change simultaneously with multiple seagrass stress response metrics to gain much better resolution and decrease ambiguity. Tier 3 monitoring is designed to test hypotheses and confirm or refute suspected mechanisms for stressor/response relationships.

Matrix and Hierarchy Integrations

The benefits of integrating Tiers 1 and 2 in the hierarchical framework are major improvements for understanding the status and trends of seagrasses with regard to the factors responsible for change. Tier 2 metrics also are used to groundtruth and verify the interpretation and accuracy of remotely sensed data acquired in Tier 1. Also, Tier 1 and Tier 2 metrics can be combined with other environmental monitoring to assess broad-scale relationships. When integrated with Tiers 1 and 2, the high-resolution information generated from Tier 3 metrics can be used to provide resource managers with scientifically defensible support and the necessary guidance for making critical conservation and management decisions. A fully integrated hierarchical approach to monitoring also provides the comprehensive multi-scale information needed to develop more reliable predictions with ecosystem-based models that are designed to incorporate seagrasses.

Metrics and Indicators

Seagrass beds are dynamic, complex systems, and many of the metrics used to characterize habitat condition exhibit considerable temporal and spatial variability. Indicators derived from metrics are used to quantify changes in metrics with respect to spatial or temporal reference measurements (relative status), change over space and time (trend), and responses to specific stressors (stressor response). To accurately assess seagrass ecosystem condition, monitoring should include frequent sampling at selected permanent stations. The Tier 1, 2, and 3 indicators would yield consistent and comparative information on Gulf-wide and regional seagrass habitat status and trends.

The selection of metrics takes into account several generic attributes:

1) is measurable with standardized and repeated non-destructive or minimally destructive techniques,
2) is sensitive and responsive to change with low measurement error,
3) does distinguish natural variation from background, and
4) is predictable in a threshold response to factors known or hypothesized to affect seagrasses.

The integrated characteristics of the Tier Approach are designed so that metrics and indicators collected at different spatial-temporal scales can be shared and integrated across the Tiers to comprehensively inform scientists and managers about the complex interactions that occur between components across the large seagrass ecosystems of the Gulf of Mexico.

Each Tier measures different metrics determined by:

- a consensus of the scientific understanding of ecological processes,
- the policy needs of environmental managers, and
- the stakeholders expected to benefit from using the information gathered in the monitoring program. .

For application of the Tier 1 and 2 information to explicit management problems, the metrics should be: 1) cost effective; 2) readily transformed into indicators of status and trends; and, 3) when needed, integrated with Tier 3 data to infer cause and effect.

Seagrass conservation and management program goals span different temporal and spatial scales and some of the attributes may be more or less applicable to a program, depending on its scale.

A Seagrass Monitoring Approach for the Gulf of Mexico

Revised 2020

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Seagrass Monitoring Community of Practice (GOMSMCoP)

And

Gulf of Mexico Monitoring Community of Practice (MCoP)

A Seagrass Monitoring Approach for the Gulf of Mexico

Tier	Definition	Implementation (When and How)	Data Acquisition Technology	Data Analysis	Metrics † (Minimum to be Sampled)	Indicators	What is informed by Tier
1	**Characterizes a few ecosystem properties simultaneously at very large spatial scale, typically using high resolution remote sensing methods.**	• Should be conducted on: Optimal 2-5 years Minimum 10 years. • No hexagon grid used for groundtruthing or sampling. • Imagery acquisition optimal late April through mid-June. *Groundtruthing* • Must have a groundtruthing element (lower intensity sampling than Tier 2). Observations are not applied at a per unit area basis. • As possible, near simultaneous to imagery acquisition.	Remote observation • High resolution (≤1m pixel) satellite imagery • Airborne (≤1m pixel) imagery • Side-scan sonar • Single-beam sonar • LIDAR* • High resolution airborne hyperspectral imagery* *Groundtruthing* • On-water observation • Underwater video/still photography	• OBIA (Object-based Image Analysis) • Visual interpretation • Spectral clustering • Acoustic signal processing • Accuracy assessment statistics *Groundtruthing* • Visual determination	Seagrass Component • Area coverage • Acreage by cover • Distribution (geographic)	• Increase • Decrease • No Change • From/ To Conversions	• Adaptive Management • Presence or absence • Synoptic extent and distribution (ex. Patchy vs continuous beds) *Groundtruthing* • Species composition • Presence or absence
2	**Broad-scale surveys in bays, sounds, and lagoons used to address specific environmental issues or biotic & abiotic ecosystem properties at a finer resolution of samples; provide more detailed information using field in-water sampling.**	• Time scale should be more frequent than Tier 1. • Hexagon grid used to determine sampling locations. Hexagons at a minimum of 500m on each side for small bays, up to a maximum of 750m on each side for large bays. • Tier 2 and 3 monitoring should inform each other in terms of when to remap. • More samples quantified at a smaller scale, sufficient to characterize system-wide statistical estimators (e.g. mean, medium, coefficient of variation, etc.).	• Tier 1 technologies can be used with Tier 2 analysis and monitoring. • PAR profile/Secchi disc • Quadrats • Underwater video/still photography • UAS (drones)	• Beer's Law • In-situ visual interpretation (non-destructive) • Braun Blanquet scores • Visual interpretation (lab)	Seagrass Component • Percent cover • Percent cover by species • Species composition Environmental Component • Water depth Water Quality Component • Light attenuation (PAR profile/Secchi) • Salinity	• Increase • Decrease • No Change	• Adaptive Management • Stressor/response relationships • Estimates of the ecological condition of resources over broad areas • Quality of the system as a function of physical, chemical, and biological parameters • Cover categories
3	**Relatively smaller area surveys than Tiers 1 and 2 addressing a greater number of biophysical and chemical properties at a much smaller number of locations or index sites. These locations can be processed-based investigations or hypothesis testing conducted at a site or multiple sites within the larger system.**	• Tier 3 locations may be monitored at greater frequency than Tier 2. • Tier 2 and 3 studies should inform each other. • Potentially, more samples quantified at a smaller scale. • Fixed stations / transects are preferred. • Some form of random sampling. • Monitoring on at least an annual basis. • Location of Tier 3 sites and sampling intensity/frequency is driven by the hypothesis being tested.	• Tier 1 and 2 technologies can be used with Tier 3 analysis and monitoring • Destructive sampling • Multiple sampling sensors/data loggers • Elemental/gas analyzers • Additional data acquisition technologies	• In-situ (non-destructive) • Laboratory (destructive) • Visual interpretation (lab)	Seagrass Component • Percent cover • Percent cover by species • Species composition Environmental Component • Water depth Water Quality Component • Light attenuation (PAR profile/Secchi) • Salinity	• Increase • Decrease • No Change	• Adaptive Management • Monitoring • Causal relationships • Specific research hypotheses • System-wide predictive capabilities or understanding past changes

† See reverse side for metrics.

* These technologies have been applied at small scales but have not been operationally applied at the Tier 1 level. Still in the R&D phase.