FWC Recommended Survey Protocols for Marine Habitats related to Permitting Applications (1/15/09 DRAFT)

Survey Protocols for Emergent Tidal Wetlands

SCHEME[1] Emergent Tidal Wetlands definitions:

4. Tidal Marsh (i.e. salt marsh, coastal marsh)
Communities of emerged halophytic vegetation along low-wave energy intertidal areas and river mouths. These areas are dominated by grasses, rushes and sedges (i.e cordgrass, needlerush, and sawgrass).

41. Salt pan
Exposed or water-filled depressions in a tidal marsh area. Often covered by layers of blue-green algae but possibly bare sediment only. Glassworts or saltworts may be present. Sand barrens most often exist in high marsh areas; conversely mud barrens may occur in the intertidal zone as water retention pools during low tide.

42. Salt marsh algae
Mud flats dominated by a mixture of benthic microalgae, phytoplankton, and macroalgae.

5. Tidal Swamp (i.e. mangrove, mangrove forest)
Dense, low forests primarily located along coastal areas. Various tidal marsh grasses and shrubs may be associated but these communities are dominated by a mix of red, black and white mangroves.

Alternate?????
Tidal Marsh; Saltmarsh:

Tidal Marsh; Mangrove marsh:

Tidal Swamp; Floodplain swamp:

Tidal Swamp; Floodplain forest:

Species included (but not limited to):

Tidal Marsh Plants:
black needlerush *Juncus roemerianus*
smooth cordgrass *Spartina alterniflora*
saltmeadow cordgrass *Spartina paten*
saltwort *Batis maritima*
glassworts *Salicornia spp*
sawgrass *Cladium mariscoides*
saltgrass *Distichlis spicata*

Tidal Swamp Plants:
red mangrove *Rhizophora mangle*
black mangrove *Avicennia germinans*
white mangrove *Laguncularia racemosa*
buttonwood *Conocarpus erectus*

Russian thistle *Salsola kali* [1]

Floodplain Swamp/Marsh/Forest/Bottomland Forest:
hydrophytic oaks *Quercus michauxii, Q. nigra, Q. laurifolia*
red and silver maple *Acer rubrum, A. saccharinum*
cabbage palm *Sabal palmetto*
southern magnolia *Magnolia grandiflora*
loblolly and red bay *Gordonia lasianthus, Persea borbonia*
water hickory *Carya aquatica*
sawgrass *Cladium jamaicense*
maidencanes *Panicum* spp.
buttonbush *Cephalanthus occidentalis*
bulrushes *Scirpus* spp.
arrowheads *Sagittaria* spp.
cypress *Taxodium* spp.
tupelos *Nyssa* spp.
ferns *Acrostichum danaeifolium, Osmunda regalis*
cattails *Typha* spp.

The following protocols are designed to address the surveying of coastal emergent wetland communities in Florida directly connected to marine/estuarine water bodies, including but not limited to: mangroves and mangrove marshes (tidal swamp and tidal forest), saltmarsh, floodplain swamp, floodplain forest, and bottomland forest. The protocols found herein encompass traditional survey techniques at patch scales (derived mainly from terrestrial vegetation surveying) and new technologies at landscape scaling (e.g., GIS). Both approaches should be used in concert to fully describe wetland communities, but considerations should be made based on the aerial scale of the project. For purposes of permit application, note that state and federal guidelines for wetland delineation as per inundation, soil type, and vegetative types apply (as outlined by rule, respective Operations and Procedures Manuals, Gilbert et al. 1995).

Patch-Scaled Protocols

Fine-scaled assessments of coastal emergent wetlands should encompass a descriptive vegetative survey representing a minimum of 2% of the total project area. The survey should be representative of the project area and include all vegetative habitats (and vegetative types) where possible, taking into account ecotones and community structure as defined by elevation, inundation, soil type, etc. Dominant habitats should be surveyed with greatest frequency using a scalar approach. Methods for vegetative survey can include traditional techniques such as point-center-quarter, Daubenmire method, Braun-

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Madley, K.A., B. Sargent, and F.J. Sargent. Development of a System for Classification of Habitats in Estuarine and Marine Environments (SCHEME) for Florida. 2002. Unpublished report to the U.S. Environmental Protection Agency, Gulf of Mexico Program (Grant Assistance Agreement MX-97408100). Florida Marine Research Institute, Florida Fish and Wildlife Conservation Commission, St. Petersburg. 43pp.

Blanquet scaling, nearest-neighbor, line-intercept, randomized or haphazard quadrats, and quadrats along transects (Cain&DeOliveira Castro 1959, Daubenmire 1959, Eberhart 1978, Grieg-Smith 1983, Kuchler&Zonneveld 1988, Phillips 1959). Specific variates such as DBH (diameter breast height), crown diameter, canopy cover (e.g., densiometer), and shoot density should be assessed in addition to simple presence/absence data. Survey results should focus on density, dominance, dispersion, and frequency of vegetative forms using sufficient statistical power and robust testing (Hurlbert 1984, Green 1979, Leps&Hadincova 1992, Ludwig&Reynolds 1988, Rice 1967, Sokal&Rohlf 1980, Underwood 1981, Wikum&Shanholtzer 1978, Winer et al. 1991). Surveys of specific project-related animal taxa (diversity) and physico-chemical parameters should also be conducted using traditional methods where appropriate.

Landscape-Scaled Protocols

Recent advancements in remote sensing technology have produced numerous useful tools for surveying coastal emergent wetlands at coarse scaling. Aerial photography and/or satellite imagery should be included as survey techniques. Images should be geo-rectified and incorporated into GIS when appropriate. Infra-red imagery is preferable as it provides sufficient contrast for wetland delineation and habitat identification.

References cited:

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Ludwig, J.A. & J.F. Reynolds. 1988. Statistical Ecology, John Wiley and Sons, 337pp.

Phillips, E.A. 1959. Methods of Vegetation Study, Henry Holt and Co.

Rice, E.L. 1967. A statistical method for determining quadrat size and adequacy of sampling. Eco 48:1047-1049.

Sokal, R.R. & F.J. Rohlf. 1980. Biometry, 2nd ed., W.H. Freeman Co., 859pp.

Underwood, A.J. 1981. Techniques of ANOVA in experimental biology and ecology. Ocean and Mar Bio Ann Rev 19:513-605.

Wikum, D.A. & G.F. Shanholtzer. 1978. Application of Braun-Blanquet cover-abundance scale for vegetation analysis in land development studies. Envir Mgt 2(4): 323-329.

Winer, B.J., D.R. Brown, and K.M. Michels. 1991. Statistical Principles in Experimental Design, McGraw-Hill Inc., 1057pp.

Survey Protocols for Estuarine/Marine Submerged Aquatic Vegetation (SAV)

Seagrass Habitat Definition:

"Seagrass habitat is defined in this document as a physical space containing seagrasses in sufficient quantity and pattern to produce the appropriate structural and physiological characteristics to support organism typical of seagrass communities. These characteristics include food webs based on organic-matter production, nutrient cycling, detritus production, shelter, and sediment formation" (Dawes C.J, R.C. Phillips, G. Morrison, 2004).

Seagrass Species included:

Ruppia maritima	Widgeon Grass
Syringodium filiforme	Manatee Grass
Thalassia testudinum	Turtle Grass
Halodule wrightii	Shoal Grass
Halophila decipiens	Paddle Grass
Halophila engelmannii	Star Grass
Halophila johnsonii	Johnson's Seagrass (T)

SCHEME (modified) Distribution criteria:

2. Submersed Aquatic Vegetation (SAV)

Any combination of SAV (i.e. seagrasses, oligohaline grasses, attached macroalgae and drift macroalgae) that covers a substrate.

21. Submersed Rooted Vascular Plants (SRV) (i.e. seagrasses and oligohaline grasses)

Habitat with cover of SRV.

211. Continuous SRV

This includes continuous beds of any shoot density (i.e. sparse continuous, dense continuous or any combination). These areas appear as continuous seagrass signatures; however, small (less than 0.5 acres) bare sediment areas may be observed as infrequent features within the area.

2111. Dense patches of SRV in a matrix of continuous, sparse SRV

Continuous coverage of sparse SRV in which dense patches of SRV are clearly observed interspersed within the area. This pattern is often the result of effects from the sediment or underlying bedrock characteristics.

212. Discontinuous SRV

Areas of SRV with breaks in coverage that result in isolated patches of SRV, usually in unconsolidated bottom, but also exist in hard bottom areas. If the hardbottom is more abundant than the SRV the polygon should be recorded as Reef/Hardbottom Class and SRV can be noted with Modifiers. Generally, these grass features appear as semi-round patches or elongated strands separated by bare sediment.

Macroalgae Habitat Definition:

Rocky shores and solid substrates down to the lower limit of the photic zone provide the main habitat for macroalgae, however, soft sediments and sands can also provide habitat for temperate to tropical estuarine and marine algae that use holdfast networks to anchor them below such sediments. The biotic and abiotic characteristics of macroalgae habitat are similar in definition to those of seagrass above.

Macroalgae species included (but not limited to):

Argardhiella spp.	*Dictyota spp.*
Avrainvellea spp.	*Digenia spp.*
Batophora spp.	*Gracilaria spp.*
Bryopsis spp.	*Halimeda spp.*
Calothrix spp.	*Laurencia spp.*
Caulerpa spp.	*Oscillatoria spp.*
Chondria spp.	*Penicillus spp.*
Cladophora spp.	*Rhipocephalus spp.*
	Sargassum spp.

SCHEME Distribution criteria:
22. Macroalgae

221. Attached Macroalgae
Habitat with 10 percent or more cover of mixed or monospecific macroalgae attached to the substrate with holdfasts, rhizomes, or other morphological feature.

2211. Continuous attached macroalgae
This includes continuous beds of any density (i.e. sparse continuous, dense continuous or any combination). These areas appear as continuous attached macroalgae or SRV signatures. Often macroalgae can't be interpreted from the imagery without field verification to detect the difference from SRV. Small (less than 0.5 acres) bare sediment areas may be observed as infrequent features within the area.

22111. **Dense patches of attached macroalgae in a matrix of continuous, sparse macroalgae**
Continuous coverage of sparse attached macroalgae in which dense patches of attached macroalgae are clearly observed interspersed within the area. This pattern is often the result of effects from the sediment or underlying bedrock characteristics.

2212. Discontinuous attached macroalgae
Areas of attached macroalgae with breaks in coverage that result in isolated patches, usually in unconsolidated bottom but also exist in hard bottom areas.

Survey Timing:

Seagrass surveys should be conducted during the main growing season in most locations in the state. This provides the agencies with the best information (maximum aerial extent of seagrass, peak above ground biomass and greatest diversity of species) for permitting decisions. Seagrass surveys conducted outside the main seagrass growing season are inadequate to address the avoidance of seagrass habitat by project construction, or to determine the amount of seagrass resources affected, which is needed to correctly determine the required mitigation.

Seagrass surveys must be conducted between April 1st to October 31st with the following exceptions:

Seagrass surveys may be conducted year-round in southern Dade County (Virginia Keysouth) and Monroe County where seagrass growth is not significantly different during the winter as they are in most other areas of the state.

Florida East Coast between Indian River County (Sebastian Inlet) and Dade County (Virginia Key) seagrass surveys should be conducted April 1st through August 31st to accommodate the Johnson's Seagrass growing season and period of maximum abundance pursuant to the Johnson's Seagrass (*Halophila johnsonii*) Recovery Plan (JSRP).

Seagrass survey products:

The following information is needed to assess the seagrass resources at the project site, what resources will be impacted directly or indirectly by the project and if necessary.

- A map showing seagrass distributions by species within the project boundaries.
- A site map showing the footprint of the construction project in relation to all seagrass resources.
- A map indicating the location of the seagrass transects or sampling locations.
- The percent coverage of seagrass or seagrass shoot density for each species present.
- Total amount (acres or sq.ft.) of seagrass habitat impacted as a result of the proposed construction.

Seagrass Survey Data Collection Techniques:

Seagrasses, especially the diminutive species, can be difficult to see or identify in turbid water conditions, at depth or accurately distinguishing seagrass bed edges can be difficult to determine, as can be determining algae from seagrass without conducting an in-water survey. Because of this, seagrass surveys conducted with observations made from a boat will not be accepted and aerial survey data will not be accepted as a sole survey methodology.

Potential Survey Methods:

- Visual (in-water) reconnaissance (should be a prerequisite for all sites).
- Regularly spaced transects (if seagrass is located within the project boundaries)
- Diver-towed transects
- Video Transects (either mounted on a sled or towed by a boat)
- Aerial Surveys (considered supporting information and will not substitute for visual surveys)

Unacceptable Methodology:

Out of water seagrass surveys conducted by boat

Ponar or Eckman grabs – (destructive sampling is not condoned and these techniques do not survey a broad enough area to be adequate).

Sonar – currently this technique has not proven to be able to detect all seagrass species and densities. In addition, water depths and water quality conditions also affect the reliability of the information collected by this method. Other hydroacoustic and hyperspectral imaging techniques are also not proven to adequately detect seagrass at the necessary resolution for permitting survey needs.

Seagrass Data:

- Seagrass species identification and location.
- Identify the locations of the nearshore bed edge and seaward bed edge within the project site.
- Delineation of patch distribution if seagrass distribution is not continuous within the project site.

Quantification of seagrass resources – Any of the following techniques would be acceptable to describe the seagrass resources within the project area:

- Areal % Cover by species and totaled for all species present (meter square quadrate assessment method along transect lines)
- Species Density (Braun Blanquet method)

- Shoot Density (random or systematic shoot counts within quadrates distributed within the project area).

A minimum of 10% of the transect length should be quantitatively assess (10 meter squares/100 meter long transect).

Halophila johnsonii Recovery Plan Methodology:

Recommended Methods:

The most appropriate approach depends on scale, and the amount of expected error depends on the approach. Unless a complete survey of the entire area is done, the estimated distribution and abundance of this species may be significantly in error. With the exception of very small project areas, efficient field sampling may require sampling in two stages. A preliminary visual reconnaissance of the site should be conducted to locate any occurrences of *H. johnsonii*. "The importance of preliminary sampling is probably the most under emphasized principal related to field studies. There is no substitute for it." (Green 1979). Following the preliminary reconnaissance, a more comprehensive sampling, using one of the techniques outlined below, should be initiated.

In situ monitoring for *H. johnsonii* is absolutely necessary. Aerial photography may be used to map distributions of larger canopy-forming species; however, mapping of *H. johnsonii* cannot be done reliably from aerial photos. Because of significant seasonal and annual variation in distribution and abundance of *H. johnsonii*, surveys must be conducted during spring/summer (April-August) period of maximum abundance, and sampling in more than one summer is recommended. Length of time between survey date and actual start of project should consider the potentially rapid turnover and migration of *H. johnsonii*. Personnel conducting the survey should clearly demonstrate that they can distinguish between *H. johnsonii* and *H. decipiens*. Surveys labeled simply as *"Halophila"* are not sufficient.

Recommended Survey Techniques by Property Size

Small size projects - applicants that have < 100 feet of shoreline (JSRP <0.1 ha, 10m x 10m)

- Between Sebastian Inlet and Virginia Key a visual reconnaissance of the site must be conducted for *Halophila johnsonii*. A visual reconnaissance should be conducted at all sites to assist in identifying the seagrass bed locations and edges.
- Space seagrass transects 25 feet apart along the linear extent of the shoreline, and extend them 20 feet passed proposed activity.
- Nearshore and seaward bed edges and the water depth (MLLW) should be identified for each transect.
- Seagrass patches should be identified by species composition and located on a map.

- Random sampling for seagrass density or percent cover. Random samples can be conducted on transect lines or random throws of quads. Number of quads should provide a representative sample of the site (e.g. 10% of area).

Intermediate size projects – applicants that have >100 feet but < 300 feet of shoreline (JSRP 0.1 to 1ha – 100m x 100m)

- Between Sebastian Inlet and Virginia Key a visual reconnaissance of the site must be conducted for *Halophila johnsonii*. A visual reconnaissance should be conducted at all sites to assist in identifying the seagrass bed locations and edges.
- Space seagrass transects 25 feet apart along the linear extent of the shoreline, and extend them 20 feet passed proposed activity.
- Nearshore and seaward bed edges and the water depth (MLLW) should be identified for each transect.
- Seagrass patches should be identified by species composition and located on a map.
- Random sampling for seagrass density or percent cover. Random samples should be conducted on transect lines and be equivalent to 10 to 30 % of transect.

Large size projects – applicants that have >300 feet of shoreline (JSRP >1ha)

- Between Sebastian Inlet and Virginia Key a visual reconnaissance of the site must be conducted for *Halophila johnsonii*. A visual reconnaissance should be conducted at all sites to assist in identifying the seagrass bed locations and edges.
- Space seagrass transects 50 feet apart along the linear extent of the shoreline, and extend them 20 feet passed proposed activity.
- Nearshore and seaward bed edges and the water depth (MLLW) should be identified for each transect.
- Seagrass patches should be identified by species composition and located on a map.
- Random sampling for seagrass density or percent cover. Random samples should be conducted on transect lines and be equivalent to 10 to 30 % of transect.

<u>LARGE-AREA PROJECT SITES (>1 ha). Three choices are possible after preliminary visual reconnaissance.</u>

- Random sampling of points or quadrats within the area.

Sampling at least 1-30% of the total area.

- 2 stages: (1) visual reconnaissance, then stratify, (2) second intensive sampling, with intensity relative to abundance of *H. johnsonii* within the strata.

· single step of 100 -1,000 points/quadrats (min. # = ?).

2. Intensive survey of transects.

Transects across the entire area, sampling at least 1-30% of the total area.
· point-intersects sampling along transects (with the size of a "point" defined, e.g., 5 x 5 or 10 x10 cm).
· belt transect, of 0.1-2 m width.
· transects randomly located (min. # transects = 10-50 or min. spacing = 50 m).
· regularly-spaced transects (min. #transects = 10-50 or min. spacing = 50 m).
· quadrants at regular intervals along line (min. # = 10-50 or min. spacing = 50 m).

For any of these transect methods, x-y-z diameters of any patches encountered should be measured. At a minimum, presence-absence should be recorded at each point of each quadrat.

3. Combinations of above methods, e.g.,

(a) Intensive mapping in area of primary impact (e.g., within footprint of proposed dock), plus random points in surrounding, potentially affected area.

(b) Stratify from random point sampling, then map intensively in areas of greatest abundance.

It is the position of the Johnson's seagrass Recovery Team, however, that the adoption of a valid survey protocol for identifying Johnson's seagrass be required by permitting agencies in the range of the species. In all seagrass surveys, emphasis should be placed on the identification of seagrass habitat as well as the distribution of currently existing patches. Identifying impacts to seagrass habitat, particularly from large projects, is more important in the long run than the "point-in-time" management approach of avoiding currently existing patches.

References:

Dawes, C.J., R.C. Phillips, and G. Morrison. 2004. Seagrass Communities of the Gulf Coast of Florida: Status and Ecology. Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute and the Tampa Bay Estuary Program. St. Petersburg, FL. iv + 74 pp.

Green, R.H. 1979. Sampling design and statistical analysis methods environmental biologists. John. W. and Sons, Inc., New York.

Fonseca, M.S., W.J. Kenworthy and G.W. Thayer 1998. Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters. NOAA Coastal

Ocean Program Decision Analysis Series No. 12, NOAA Coastal Ocean Office, Silver Spring, MD. pp. 1-222.

Morris, L.J., L. Hall and R. Virnstein. 2001. Field Guide for Fixed Seagrass Transect Monitoring in the Indian River Lagoon. St. Johns River Water Management District.

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Survey Protocols for Reef Systems (other than mollusk reefs)

(Suggested format change for coral reef section : Erin 2/15/08)

Reef Survey Guidelines

I. Habitat Definitions
- A. Nearshore Hardbottom
- B. Offshore Reefs
  1. Patch Reefs
  2. Transitional Reefs
  3. Bank Reefs
- C. Artificial Reefs

II. Species included

III. Survey Protocol
- A. Survey Timing
- B. Surveys for Acropora
- C. Nearshore Hardbottom Surveys
  1. Methods for small-scale project (X to X m^2)
  2. Methods for large-scale project (X to X m^2)
- D. Offshore Reef Surveys
  1. Methods for small-scale project (X to X m^2)
  2. Methods for large-scale project (X to X m^2)
- E. Artificial Reef Surveys
  1. Methods for seawalls, docks, and other inshore structures
  2. Methods for small-scale offshore projects (X to X m^2)
  3. Methods for large-scale offshore projects (X to X m^2)
- F. Survey Products
  1. Maps
  2. Data

IV. References

SCHEME Coral Reef definitions:

31. Coral Reef

Hardened substrate formed by reef building corals. May be live coral or relict reefs. Often bedrock is the base for these reefs but the presence of coral or remnant coral on the surface is reason to categorize the dominant habitat as coral reef.

311. Platform Reef (also bank reef)

Hardened substrate formed by reef building corals that exist in a quasi-continuous structure along a shelf edge or similar dropoff removed from any coastline. These are typically elongate structures and may be referred to as bank reefs. The following Subclass categories may be present in various combinations within a platform reef.

3111. Linear Reef

Linear, contiguous coral formations. Reef crest, fore reef, and back reef zones could be mapped as Linear Reef. Most often has associated spur and groove and reef rubble habitats.

31111. Reef Terrace (high profile)

Contiguous reef with high complexity and high relief (>2m).

31112. Remnant (low profile)

Reefs of relief less than 2m that lack distinctive spur and groove characteristics. These reefs consist of coral and hard bottom features; often support soft corals, sponges, seagrass; and are usually found growing parallel to the reef tract, though they may form transverse features that grow perpendicular to the reef tract.

3112. Spur and Groove

Distinct coral bands separated by sand or uncolonized hardbottom grooves. This habitat type usually occurs in the fore reef zone.

31121. High Relief Spur and Groove

Distinct coral bands separated by sand or uncolonized hardbottom grooves. The coral bands have 1.5- 4m relief.

31122. Low Relief Spur and Groove

Distinct coral bands oriented perpendicular to the shore or bank and separated by sand or uncolonized hardbottom grooves. The coral bands have <1.5m relief.

3113. Reef Rubble

Dead, unstable coral rubble that often occurs landward of platform reefs.

312. Patch Reefs

Irregularly shaped reef communities. They may range in size from tens to thousands of square meters. Patches are separated from each other by uncolonized hardbottom, sand, or colonized substrate with submersed aquatic vegetation (SAV), macroalgae, gorgonians or sponges. Most often the patches are surrounded by a halo of bare substrate created by foraging, obligate reef inhabitants.

3121. Individual Patch Reef

Isolated, single reef (larger than the minimum mapping unit of the project) without associated halo area. These individual reefs may have an associated halo, however if large enough (i.e. greater than the minimum mapping unit) to be delineated the halo will be mapped as its own subclass.

3124. Aggregated Patch Reefs (includes Halo areas if present)

Clustered patch reefs, usually too small (less than the minimum mapping unit) or too close together to map individually or where halos coalesce.

3125. Pinnacles

High complexity patch reefs that have high relief (up to 15m) from the sea floor. These structures may occur in clusters and are typically surrounded by large sand plains.

313. Patchy Coral and/or Rock in Unconsolidated Bottom

Areas of primarily sand, submerged aquatic vegetation (SAV), or low relief rock covered with a sand veneer. Often adjacent to spur and groove habitats, these areas contain small, individual corals or rocks that are distinctive yet a very low percentage of the total cover (and certainly smaller than the minimum mapping unit).

Species included (but not limited to):

Corals
Acropora cervicornis
Acropora palmata
Acropora spp.
Agaricia spp.
Montastrea annularis
Oculina varicosa
Porites porites
Porites spp.
Lophelia prolifera
Enallopsammia profunda
Siderastrea spp.

SCHEME other marine reef definitions:

33. Annelid Reefs (i.e. Sabellariid reefs)

Structures formed from colonies of Sabellariid worm tubes. Commonly found in the tidal zone on the east coast of Florida, these structures are mostly formed on hard substrates and may be exposed at low tide. Storm events can break the sand structures thus changing the extent of the colony at the time of mapping. The reefs also expand as worm larvae settle on the mounds and build additional tubes.

34. Hardbottom

Hard substrate composed of exposed bedrock or created through syndepositional cementation of sediment.

341. Bedrock

Exposed bedrock and/or rocky outcrops with low to high relief and high complexity.

342. Pavement (i.e. low relief hardbottom)

Flat, low relief, mostly solid rock substrate.

Information Requirements (some or all of these may be required for a given project**)**

- Habitat Map
- Defined sample area (NOAA 2005)
- Defined sampling objectives (NOAA 2005)
- Control or reference sites (NOAA 2005)
- Physical characteristics: air temp, water temp, tidal stage, flow, current velocity (NOAA 2005)
- Biological characteristics: chlorophyll content, species id, measurements of density, size, weight,

age class, sex (NOAA 2005)
- Chemical characteristics: salinity, dissolved oxygen (NOAA 2005)
- Information necessary to perform UMAM (USACE 2006)
  - adjacent habitat
  - invasive species (all, not just plants)
  - nearby stressors (e.g., outfalls, anchorages)
  - relief
  - substrate type
  - rugosity
  - structural complexity
  - dependency of uplands on quality/quantity of reef protection
  - protection of reefs to upland/shore habitats
  - light penetration
  - turbidity
  - sedimentation
  - nutrient load
  - habitat stability (ephemeral or ble)
  - area (m^2)to be impacted
- Information necessary to perform HEA (Kohler and Dodge 2006). Note that the information necessary for a UMAM is used to assist in assessing many of the criteria listed below.
  - area (m^2)to be impacted
  - relative value of lost services vs. gained services
  - discount rate
  - level of services provided by resources prior to impacts
  - level of services provided by the compensatory action at the onset of the compensatory action
  - time span of service loss
  - time span of service gain
- Information necessary to assess mitigation
- Habitat functions provided (esp nearshore hardbottom)
- Maturity of the reef community
- Stony coral species density (colonies/m2) and percent live coral cover (Broward monitoring)
- Shannon-Weaver Diversity Indices for coral abundance and live polyp coverage (Gilliam et al. 2006)
- Density of Porifera and Octocorallia (colonies/m^2) (SECREMP)
- Sea Turtle utilization of reefs (esp. nearshore) (FDEP)
- Rugosity

Survey Methods*

- Belt-quadrat transects
- Video transects
- Point-intersect transects
- Linear-intersect transects
- ROV and remote sensing
- Rapid Habitat Assessment (for general, qualitative survey) (NOAA 2008)
- AGRRA (Atlantic and Gulf Rapid Reef Assessment) (Kramer 2005)
- See Fonseca, et al. 2006 and NOAA 2008 for rugosity measurement method

* Note all methods should incorporate *in situ* data and take planar images of the colonies to document condition and measure growth.

Support of Section 7 Consultations.

Recommended References for Survey Methods-

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Reef/Hardbottom Habitat Types (All classifications based on Florida SCHEME) (FMRI 2004)

- Coral Reefs
  - Platform Reef
  - Patch Reef
  - Patchy Coral and/or Rock in Unconsolidated Bottom
- Mollusk Reefs
  - Bivalve Reef
  - Gastropod Reef
  - Annelid Reef
- Hardbottom
  - Bedrock
  - Pavement
- Artificial Reefs
  - Tires
  - Concrete Materials of Opportunity
  - Designed Materials
  - Vessels, Automobiles, Planes, Military Ordinance
  - Steel Structures
  - Cables
  - Pipelines

Nearshore Hardbottom-Harbottom communities are characterized by their shallow depth (1-4m), low topographic relief (less than 0.5 m), and a sessile community comprised of various species of gorgonians, sponges, algae, and eurytopic scleractinian corals. (Jaap 1984, Chiappone 1996)

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Bivalve Habitat Surveys

SCHEME Mollusk Reef definitions:

32. Mollusk Reefs

Concentrations of sessile mollusks that attach to hard substrate and with the correct conditions will proliferate allowing the reef to grow. In Florida, these areas are most common in estuarine areas and are not known to occur in water deeper than 40 feet.

321. Bivalve Reefs (i.e. oyster reefs)

Mollusk reefs dominated by oysters; at times partially exposed during low tide.

322. Gastropod Reefs (i.e. Vermetid reefs)

Mollusk reefs created by a worm-like mollusk of the genus Petaloconchus. In Florida, these reefs are only known to be found in shallow waters seaward of the outer islands in the Ten Thousand Islands area of southwest Florida.

Shellfish Habitat Definition

In general, shellfish habitat serves as a source of food; provides natural water filtration, and reef-forming shellfish, such as the eastern oyster (*Crassostrea virginica*) form a hard substrate with significant topographical relief that result in complex three-dimensional structures. Prior to the usage of mechanized harvesting techniques, oyster reefs extended as much as several meters above the bottom, that provided habitat for finfish and invertebrates. In the present day, oyster reefs rarely extend more than a few decimeters above the bottom, approximately $\frac{1}{10}$ of its former height.

Natural reefs are primarily of four types: (a) alongshore reefs oriented parallel to shore and located near or attached to the shoreline; (b)reefs extending perpendicular from the shoreline or a point nearshore out into the bay; (c) patch reefs composed of one or more relatively small more-or-less circular bodies; and (d) barrier reefs extending across or nearly across the bay. **Oyster populations** are categorized by characteristic spatial dispersions (densities) that allow an estimate of each reefs' standing stock

Environmental Requirements

Temperature[1]	20 and 30 "C
Salinity[1]	10 and 30 ppt
Substrate[1]	shallow bays, mud, offshore sandy bars bottoms
Current[1]	Moderate (volume o above an oyster ree renewed 72 times p
Tidal Flow[1]	156 to 260 cm/sec
Oxygen Consumption[1]	39 ml/kg for a whol including the shell o of wet tissue
pH[1]	6.75 to 8.75
Suspended Solids[2]	clog gills and interfe filter feeding and re
Water Depth[1]	0.3 m above to 12 m mean low tide

[1]Derived from: Stanley and Sellers, 1986; [2]Ellis, et al., 2002

Economical Value

The landings value for the Florida fishery in 2003 was over $2.8 million.

Survey Techniques

- **Ancillary data**: temperature, salinity, shell matrix depth, reef elevation, adjacent water depth, and numbers of dead vs. live oysters.

- **Ground Truth Surveys**: GPS data is collected as linear representations (transects) of intertidal oyster populations (distribution and abundance). Oyster density, reef size (or footprint), and location data, in addition to time sampling, are collected in the field, along with video (Coen and Bolten-Warberg, 1995).

  Example: Beach boundaries are delineated by determining the upper (+5' MLLW) and lower clam boundaries (-2' MLLW). Transects are set perpendicular to the water's edge and spaced 50 feet apart between these boundaries. One square-foot dig sites are established every 50 feet along each transect using a Global Positioning Satellite Unit to navigate to the sites. Shellfish are collected and measured for length from the dig sites each year. Length data is converted to weight using past data and length/weight trend lines. Weight density maps for each beach are produced using GIS post-process.

- **Laser or split image rangefinders** measures each oyster population to determine the reef's dimensions (Powell and Soniat, 1991).

- **Global Positioning System** (GPS) coordinates are taken in the center of each reef, the area is digitized, and later coordinates are entered into the Geographic Information System (GIS). Furthermore RTK-GPS equipment is used to map in both the horizontal and the vertical. This procedure is very labor intensive, but important for mapping the vertical dimensions (Jefferson, *et. al.,* 1991).

- **Acoustic Signal Processors (e.g. Dual Frequency Acoustic)**: An oyster reef appears as a dark, dense series of spikes projecting well above the background signature from a mud or sand bottom. Primary identification of oyster reefs relied on the record from the 300 kHz channel (Powell, *et .al.,* 1997).

- **Airborne multi-spectral digital imagery**: derives results including location, extent, and condition of intertidal oyster populations along coastal areas (Coen and Grizzle, 2007).

- **Videography**: reduces the need for direct diver observation; produces a permanent record of observations that are objective and not vulnerable to interpretation; allows detailed observation and characterization of the habitat; allows to distinguish between living and dead; used to confirm habitat presence or clarify causes of uncertain signatures in the imagery (U.S. NOAA Coastal Services Center. 2001).

Calculations

[1]**Larval Component Index** (LCI) = Spat Settlement^w x Salinity^w x Temperature^w x Substrate Availability^w x Flow^w.

[1]**Adult Component Index** (ACI) = Spat Settelement^w x Density of Living Oysters^w x Salinity^w x Temperature^w x Frequency of Killing Floods^w.

[1]Component indices are the weighted geometric mean of the variables, with no variable recording a zero. The default weight is w = 1 / number of variables. The weight can take on different values for the variables; however, the sum of the weights must be equal to one, with no individual variables recording a zero (Volety et al. 2004).

Bivalve Species of Florida

Family Nuculidae
Nucula proxima
Family Nuculanidae
Nuculana acuta
Nuculana concentrica
Family Mytilidae
Amygdalum papyrium
Brachidontes exustus
Brachidontes modiolus
Geukensia granosissima
Ischadium recurvum
Lioberus castaneus
Modiolus americanus
Modiolus squamosus
Perna viridis
Family Arcidae
Acar domingensis
Anadara floridana
Anadara notabilis
Anadara transversa
Arca imbricata
Arca zebra
Barbatia cancellaria
Cucullaearca candida
Fugleria tenera
Lunarca ovalis
Scapharca brasiliana
Family Noetiidae
Arcopsis adamsi
Noetia ponderosa
Family Glycymerididae
Glycymeris americana
Glycymeris decussata
Glycymeris undata
Tucetona pectinata
Family Pteriidae
Pinctada imbricata
Pteria colymbus
Family Isognomonidae
Isognomon alatus
Isognomon bicolor
Family Pinnidae
Atrina rigida
Atrina seminuda
Atrina serrata
Pinna carnea
Family Limidae
Ctenoides mitis
Ctenoides scaber
Lima caribaea
Family Pectinidae
Aequipecten glyptus
Aequipecten lineolaris
Aequipecten muscosus
Argopecten gibbus
Argopecten irradians
Argopecten nucleus
Brachtechlamys antillarum
Caribachlamys imbricata
Caribachlamys ornata
Caribachlamys sentis
Euvola papyracea
Euvola raveneli
Euvola ziczac
Nodipecten fragosus
Spathochlamys benedicti
Family Plicatulidae
Plicatula gibbosa
Family Anomiidae
Anomia simplex
Pododesmus rudis
Family Spondylidae
Spondylus americanus
Spondylus ictericus
Family Ostreidae
Crassostrea virginica
Cryptostrea permollis
Dendostrea frons
Ostreola equestris
Family Lucinidae
Anodontia alba
Callucina keenae
Codakia orbicularis
Ctena orbiculata
Divalinga quadrisulcata
Divaricella dentata
Lucina pensylvanica
Lucinisca nassula

Parvilucina crenella
Pleurolucina leucocyma
Phacoides pectinata
Radiolucina amianta
Stewartia floridana
Family Ungulinidae
Diplodonta punctata
Family Sportellidae
Basterotia quadrata
Family Chamidae
Arcinella cornuta
Chama congregata
Chama florida
Chama inezae
Chama macerophylla
Chama radians
Chama sinuosa
Family Carditidae
Carditamera floridana
Pleuromeris tridentata
Pteromeris perplana
Family Crassatellidae
Crassinella lunulata
Eucrassatella speciosa
Family Cardiidae
Acrosterigma magnum
Americardia media
Dinocardium robustum
Laevicardium laevigatum
Laevicardium mortoni
Laevicardium pictum
Papyridea soleniformis
Trachycardium egmontianum
Trachycardium muricatum
Family Mactridae
Anatina anatina
Mactrotoma fragilis
Mulinia lateralis
Raeta plicatella
Rangia cuneata
Spisula raveneli
Family Pharidae
Ensis minor
Family Tellinidae
Angulus merus
Angulus tampaensis
Angulus texanus
Arcopagia fausta
Eurytellina alternata
Eurytellina lineata
Laciolina magna
Leporimetis intastriata
Macoma brevifrons
Merisca aequistriata
Scissula similis
Scissula carnaria
Strigilla mirabilis
Tellidora cristata
Tellina radiata
Tellinella listeri
Family Donacidae
Donax variabilis
Iphigenia brasiliana
Family Psammobiidae
Asaphis deflorata
Heterodonax bimaculatus
Sanguinolaria sanguinolenta
Family Semelidae
Abra aequalis
Cumingia coarctata
Cumingia vanhyningi
Semele bellastriata
Semele proficua
Semele purpurascens
Family Solecurtidae
Tagelus divisus
Tagelus plebeius
Family Corbiculidae
Polymesoda maritima
Family Veneridae
Agriopoma texasianum
Anomalocardia auberiana
Callista eucymata
Chione elevate
Cyclinella tenuis
Dosinia discus
Dosinia elegans
Globivenus rigida
Gouldia cerina
Lirophora latilirata
Lirophora paphia
Macrocallista maculata
Macrocallista nimbosa
Mercenaria campechiensis
Mercenaria mercenaria
Periglypta listeri
Pitar fulminatus
Pitar simpsoni
Puberella intapurpurea
Timoclea grus
Transennella conradina
Family Petricolidae
Choristodon robustum
Petricolaria pholadiformis
Family Pholadidae
Barnea truncata
Cyrtopleura costata
Martesia striata
Pholas campechiensis
Family Lyonsiidae
Entodesma beana
Lyonsia floridana
Family Pandoridae
Pandora trilineata

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Appendix I

TAXONOMY OF DIRECT THREATS TO COASTAL & MARINE ECOSYSTEMS[1]

v6.4

1. **Infrastructure Development–** Threats from human settlements or other non-agricultural land uses with a substantial footprint.
   - 1.1. Housing & urban areas – Human cities, towns, and settlements including non-housing development typically integrated with housing. *(urban areas, suburbs, villages, vacation homes, shopping areas, offices, schools, hospitals)*
     - 1.1.1. Commercial waterfront development (*e.g.* container ship loading, shipyards, restaurants, other commercial/industrial waterfront facilities)
     - 1.1.2. Marinas
     - 1.1.3. Mooring fields
   - 1.2. **Commercial & industrial areas –** Factories and other commercial centers *(factories, stand-alone shopping centers, office parks, train yards, docks, ship yards, airports, landfills)*
   - 1.3. **Tourism & recreation areas –** Tourism and recreation sites with a substantial footprint.

2. **Agriculture and Aquaculture** – Threats from farming and ranching as a result of agricultural expansion and intensification, including silviculture, mariculture and aquaculture
   - 2.1. Annual crops
   - 2.2. Perennial non-timber crop(s) or farming system
   - 2.3. Wood & pulp plantations
   - 2.4. Livestock farming & ranching
   - *2.5.* Marine & freshwater aquaculture – Aquatic animals raised in one location, also hatchery fish allowed to roam in the wild. *Indicate species and/or method, or choose from specific types below.*
     - 2.5.1. Fin fish net pens (indicate whether coastal or offshore)
     - 2.5.2. Shellfish (indicate whether on or off-bottom culture, coastal or offshore)
     - 2.5.3. Algae culture (for food)

3. **Energy Production & Mining** – Threats from production of non-biological resources.
   - 3.1. Oil & Gas Drilling – Exploring, developing, and producing petroleum and other liquid hydrocarbons *(oil wells, gas wells)*
     - 3.1.1. Oil
     - 3.1.2. Gas

3.1.3. Hydrates

3.2. Mining & quarrying– Exploring, developing, and producing minerals and rocks *(coal strip mines, alluvial gold panning, diamond mines, rock quarries, sand and salt mines, coral, deep sea nodules)*

3.2.1. Upland mining operations

3.2.2. Coastal sand mining

3.2.3. Coastal / offshore mining (minerals, metals, etc.)

3.3. Renewable Energy – Exploring, developing, and producing renewable energy *(geothermal, solar farms, wind farms, tidal farms)*

3.3.1. Wind farms

3.3.2. Hydrokinetic (currents and tides)

3.3.3. Marine biomass (e.g. Laminaria)

4. Transportation Infrastructure – Threats from long narrow transport corridors and the vehicles that use them, including associated wildlife mortality.

4.1. Roads & Railroads – Surface transport on roadways *(highways, primary roads, secondary roads, primitive roads, logging roads, trails, roadkill)*

4.1.1. Bridges

4.1.2. Causeways

4.2. Utility Lines – Transport of energy & resources *(electrical and phone wires, aqueducts, oil & gas pipelines)*

4.2.1. Oil & gas pipelines

4.2.2. Submarine cables

4.3. Shipping Lanes – Transport on and in freshwater and ocean waterways *(dredging, canals, shipping lanes, ships running into whales, anchor damage, introduction of invasives)*

4.4. Flight Paths – Air and space transport (*flight paths, jets impacting birds)*

5. Biological Resource Harvesting – Consumptive use of biological resources.[2]

5.1. Hunting & trapping terrestrial animals

5.2. Gathering terrestrial plants

5.3. Logging & wood harvesting

5.4. Fishing and harvesting aquatic resources

5.4.1. Bottom contact net & dredge fisheries

5.4.1.1. Stationary nets (*e.g.* gill, fyke, pound nets)

5.4.1.2. Otter trawls (*e.g.* several types & variations)

5.4.1.3. Mid-water trawls (*e.g squid, mackerel, whiting*)

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[2] Threats in this category include both the direct impacts on focal species or habitats (*e.g.* harvest of focal fish species) as well as incidental harvest (bycatch).

5.4.1.4. Dredges (*e.g.* scallops, mussel drags)
5.4.1.5. Purse seines (*e.g.* salmon, menhaden)
5.4.1.6. Dip-net (*e.g.* recreational and commercial smelt, elvers, etc)

5.4.2. Trap fisheries
5.4.2.1. Lobster, crab & shrimp pots
5.4.2.2. Eel
5.4.2.3. Snails (*e.g.* whelks, aka "conch" in NW Atlantic)
5.4.2.4. Other (indicate species)
5.4.3. Hook and line fisheries
5.4.3.1. Long line (*e.g.* tuna, sharks, halibut)
5.4.3.2. Harpoon (*e.g.* bluefin tuna, whales)
5.4.3.3. Hook and line (*e.g.* recreational and commercial cod, flounder, salmon)
5.4.4. Mechanical Gear
5.4.4.1. Intertidal hand, rake & shovel (*e.g.* recreational & commercial clams, marine worms)
5.4.4.2. Subtidal hand operated gear (*e.g.* clam rakes, oyster tongs)
5.4.4.3. Motorized harvesters (*e.g.* hydraulic clam harvester, geoduck harvest gear)
5.4.5. Blast fishing
5.4.6. Fishing with poisons
5.4.7. Algae harvests (*e.g.* kelp, rockweed)

6. **Human Intrusions –** People spending time in nature or traveling in vehicles outside of established transportation corridors, usually for recreational reasons.
6.1. Recreational activities – Vehicles and boats traveling outside of established transport corridors *(motorboats, jet-skis, dive boats)*
6.1.1. Jet-skis
6.1.2. Whale watching
6.1.3. Power boating (includes water skiing)
6.1.4. Beach use (driving on beaches with motorized vehicles)
6.1.5. Sailing, rowing, paddling
6.2. War, civil unrest, & military exercises
6.3. Research

7. **Natural System Modifications**
7.1. Fire and fire suppression
7.2. Dams & water management/use
7.2.1. Dams
7.2.2. Surface water withdrawals
7.2.3. Groundwater withdrawals
7.2.4. Inadequate culverts
7.2.5. Tide gates

7.2.6. Dikes, berms & ditches

7.3. Topographic/Geologic modifications

7.3.1. Buffer conversion and alteration

7.3.2. Shoreline hardening

7.3.3. Piers, jetties, docks & groins

7.3.4. Filling (intertidal)

7.3.5. Channel dredging

8. Invasive and Other Problematic Species and Genes – Threats from non-native and native plants, animals, pathogens/microbes, or genetic materials that have or are predicted to have harmful effects on biodiversity.

8.1. Invasive species

8.1.1. Plants (indicate species)

8.1.2. Invertebrates (indicate species)

8.1.3. Vertebrates (indicate species)

8.2. Problematic native species (plants and animals released from predation or competition directly or indirectly due to human activities)

8.3. Introduced genetic material (*e.g.* genetically modified aquaculture species)

8.4. Parasites and Pathogens (where problematic in combination with human impacts)

9. Pollution – Introduction of exotic and/or excess materials from point and non-point sources.

9.1. Chemicals & Toxins – Industrial chemicals and toxins in the air, land, and water *(mercury from goldmines, heavy metals, PCBs, acid rain, smog, ozone depleters, oil from cars, chemical dumping, oil spills, agricultural pesticides, lead bullets, endocrine disrupters, caffeine in sewage)*

9.1.1. Legacy metals and toxins in submerged/intertidal sediments (*e.g.* industrial, dredge spoils, lead shot

9.1.2. Legacy metals and toxins in uplands (*e.g.* Superfund sites, landfills)

9.1.3. Current industrial discharges (point sources)

9.1.4. Biocides – agriculture

9.1.5. Biocides – lawn chemicals

9.1.6. Atmospheric deposition – metals, NOX, SOX

9.1.7. PCPPs (personal care products and pharmaceuticals)

9.2. Nutrient Loads – Excess nutrients *(nitrogen from farms or municipal sewage phosphates from detergents)*

9.2.1. Wastewater treatment plants

9.2.2. Septic systems

9.2.3. Atmospheric deposition - nitrogen

9.2.4. Agricultural runoff

9.2.5. Urban/suburban non-point runoff (includes lawn fertilizer, pet wastes, etc)

- 9.3. Garbage – Garbage and other materials *(garbage, litter, flotsam & jetsam)*
  - 9.3.1. Marine debris
  - 9.3.2. Derelict ("ghost") fishing gear
- 9.4. Sedimentation & residual materials – Excess or scarcity of sediment in the system and large-scale byproducts of development or resource use activities
  - 9.4.1. Dredge spoil dumping
  - 9.4.2. Offshore garbage dumping
  - 9.4.3. Munitions (*submerged mustard gas, nerve gas, etc.*)
- 9.5. Radioactive Materials – Radioactive materials *(bomb test fallout, nuclear power waste, medical waste)*
- 9.6. Salt – Excess salt *(snow removal chemicals, residue from irrigation, replacement of freshwater with seawater)*
- 9.7. Sound – Excess noise *(noise from highways, airplanes, sonar)*
  - 9.7.1. Oil and gas exploration tests
  - 9.7.2. Other research *(e.g. mid-frequency sonar)*
- 9.8. Heat – Excess heat or extraction of heat from the environment *(e.g. power plants, LNG conversion)*
- 9.9. Light – Excess artificial light that disturbs animals or ecosystems and disrupts migration patterns, or lack of light caused by turbidity *(urban areas, lamps attracting insects)*

10. Geologic Events – Threats from catastrophic geological events

(Geological events may be part of natural disturbance regimes in many ecosystems. Such events may need to be considered a threat if a species or habitat is damaged from other threats and has lost its resilience to disturbance)

- 10.1. Volcanoes
- 10.2. Earthquakes/tsunamis
- 10.3. Avalanches/landslides

11. Climate Change & Severe Weather – Threats from long-term climatic changes which may be linked to global warming and other severe climatic/weather events.

- 11.1. Habitat Shifting & Alteration – Major changes in habitat composition and location *(sea-level rise, desertification, tundra thawing, coral bleaching)*
  - 11.1.1. Sea-level rise
  - 11.1.2. Altered water temperature
  - 11.1.3. Altered salinity
  - 11.1.4. Altered currents
  - 11.1.5. Ocean acidification
- 11.2. Climate Variability – Intensification and/or alteration of normal weather patterns *(droughts, hurricanes/cyclones/typhoons, monsoons)*

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[1] Slight modification of IUCN–CMP Unified Classification of Direct Threats, Marine Version 20 March 2006.