ReMetrix

# Seagrass Quantification Plan for Progress Energy Florida, Inc.

*Hydroacoustic Sampling with*
*Species Point Sampling*

**Revised Proposal**

Submitted to Michael Shrader, Progress Energy Florida, Inc.
July 5, 2007

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11550 N. Meridian, Suite 600
Carmel, IN 46032
317-580-8035

ReMetrix

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*Hydroacoustic Sampling with Species Point Sampling*

### General Summary for Updated Proposal

This document is a revision of a previous proposal for this project (dated 1-18-06). The revision addresses comments, questions, and requests received from Nia Wellendorf, Biology Section, FL DEP in May, 2007.

The most obvious changes are amendments to the proposed sampling plan. The table below summarizes the changes between the previous sampling plan and the current one.

*Table 1. Summary of changes to the sampling program.*

| Sampling Method | 1-18-06 Proposal | Current Proposal | Change |
|---|---|---|---|
| **Hydroacoustic** | | | |
| *transect coverage* | *210 linear km* | *210 linear km* | *same* |
| **Physical sampling** | | | |
| *double-sided thatch rake* | *50 sites, along transects* | *100 sites, along transects* | *+50* |
| **Diver quadrats** | | | |
| *primary sites* | *none* | *10 at veg sties, along transects, in pre-determined depth ranges* | *+10* |
| *ad hoc sites based on field obs.* | *as needed* | *as needed* | *same* |
| *additional QA/QC points* | *a couple* | *none* | *-2* |
| **Underwater video** | | | |
| *primary sites* | *none* | *10 co-located with diver sites, along transects* | *+10* |
| *ad hoc sites based on field obs.* | *as needed* | *as needed* | *same* |
| *additional QA/QC points* | *a few* | *min. of 10 at veg sites, along transects* | *+7* |
| **Water quality** | | | |
| *primary sites* | *none* | *5 sites the first day;<br>2 sites repeated every 48-60 hours;<br>10 co-located with diver sites.* | *+5<br>+8<br>+10* |
| **Miscellaneous QA/QC** | | | |
| *ad hoc sites* | *20 sites, off transects, any method* | *20 sites, off transects, any method* | *same* |

Other changes are incorporated in the revised proposal below. Any changes from the previous version are highlighted in gray. Non-highlighted portions of the proposal remain unchanged.

**The revised budget for the project, based on the changes, is $52,374.**

**Seagrass Quantification Plan for Progress Energy Florida, Inc.**
*Hydroacoustic Sampling with Species Point Sampling*

## General Summary *(from original 01-18-06 proposal)*

This proposal outlines a seagrass quantification plan for approximately 3,000 acres of coastal ecosystem in the Gulf of Mexico adjacent to the Progress Energy Florida facilities in Citrus County, FL. The plan is designed to be as efficient as possible regarding data collection and data delivery schedules.

**ReMetrix proposes a field sampling program primarily using a high-resolution hydroacoustic grid and physical species point sampling.** The combination of these two methodologies represents a marriage of the most practical, rapid, and thorough approaches available for assessing seagrass and algal communities in the study area. Secondary methodologies of diver points and DGPS-linked color underwater video will also be used as site conditions permit.

**On November 30, 2005, ReMetrix successfully tested all of the proposed sampling methodologies at the study site.** The company found that the best approach will be to adaptively use all of the sampling tools for the project. Hydroacoustics will be used to rapidly and completely map the large geographic area of the project, while more localized point sampling using thatch rakes, underwater video, and diving will provide detailed information on species characteristics. Sections C and E have information, maps, and figures from the Nov. 30 evaluations.

The results of the sampling program will be provided in various map and statistical formats within eight weeks the completion of data collection. A quality assurance/quality control program is included as part of the work plan (Section K).

Project timelines will begin as close as possible to the dates desired by the Progress Energy project manager.

Sincerely,

Doug Henderson
Commercial Manager
(317) 580-8035

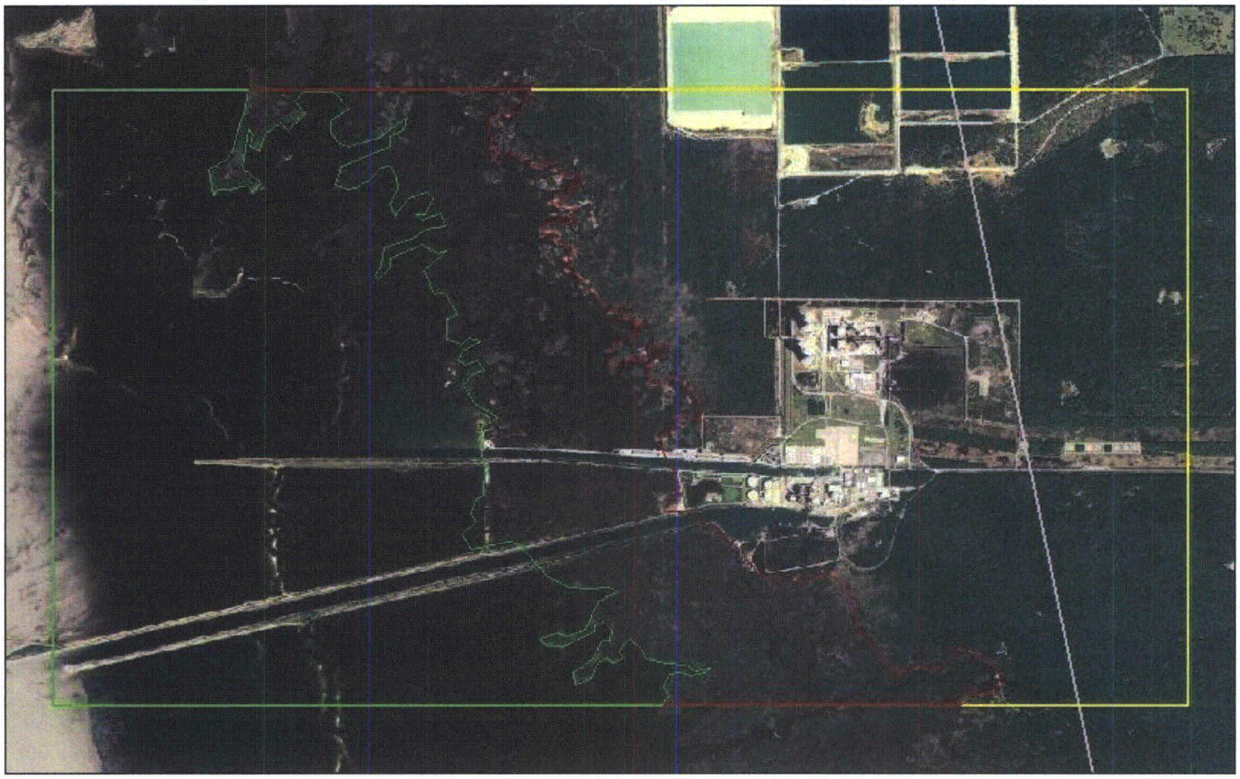


*Figure 1. The area within the green outline is the study area for this proposal (approximately 3,000-acres).*

## A. Project Goals

The hydroacoustic seagrass sampling plan is designed to meet the following specific goals:

- **(1)** Quantitatively measure the cover and biovolume of seagrass at high resolution within the study area
- **(2)** Provide distinctions between seagrass and algae presence/dominance
- **(3)** Provide multiple types of data (raw and processed hydroacoustic, physical, and photographic) to support the study conclusions
- **(4)** Provide comparison of results with those from previous sampling programs

Each one of these goals is met in the plan below.

## B. Study Area Description

The study area is the submerged region outlined in green in Figure 1 above. It is an approximately 3,000-acre coastal region in the Gulf of Mexico, adjacent to Citrus County, FL.

The study area varies from approximately three- to sixteen-feet deep and is affected by a semidiurnal tidal cycle that alters water levels from two- to four-feet within each tidal cycle. Unless otherwise noted in this proposal, water depths listed refer to the water depth at or very near high tide.

The study area supports the growth of rooted submerged aquatic vegetation (in particular, seagrass species), as well as floating, rooted, and epiphytic algae species. Seagrass species previously observed in the study area are: *Halodule wrightii*, *Syringodium filiforme*, and *Thalassia testudinum*. Algae species previously observed in the study area are rhizophytic and floating algae.

The study area is affected by very low water clarity. Navigation obstacles also exist in the study area.

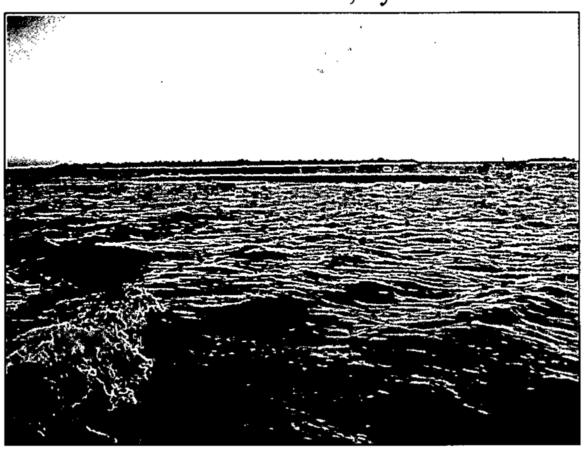
## C. Rationale for Selected Approaches

Six options exist for surveying submerged vegetation: physical sampling from the surface, hydroacoustic sampling, diver sampling, aerial/satellite imagery, underwater photography/videography, and empirical surface observations.

Each option varies in applicability based on local site conditions. Hydroacoustic and physical sampling are not affected by poor water clarity. The other four sampling techniques are affected by poor water clarity to varying degrees.

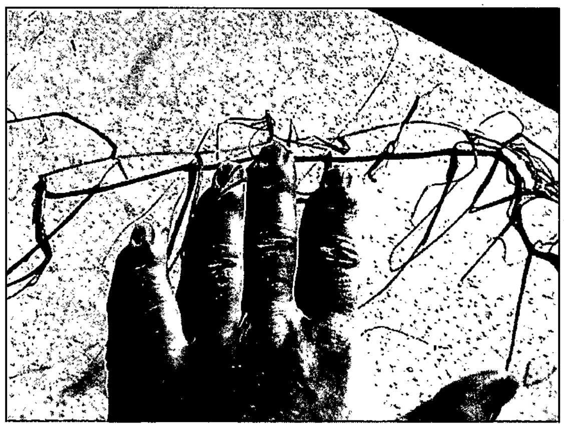
***November 30, 2005 sampling evaluations***

ReMetrix evaluated four sampling options at the project study area on November 30, 2005. Based on these evaluations, hydroacoustic and physical point sampling (rake sampling) are proposed as the primary techniques for this assessment. Color underwater video and diver sampling are also proposed as supporting sampling techniques. The degree to which the supporting techniques can be used depends on the water clarity during the project sampling window.



Two different species of seagrass were found during the survey: *Halodule wrightii* (Shoal grass) and *Thalassia testudinum* (Turtle Grass). The *Halodule wrightii* coverage occurred primarily in the shallower (~3-4 feet at +3.3 feet high tide) waters of the study area. November's survey found only sparse amounts of *Thalassia* with blade lengths measuring no more than 20 cm. Low-light color underwater video aimed at the seabed attached to a telescoping pole at a 45-degree angle was able to identify and record both species.

It is important to note that the sampling evaluations were carried out near the annual low-point of seagrass growth cycles. Water temperatures on November 30 were 19.3°C. Most seagrass species decline in areal density and blade length below 20°C. **Despite sampling at a time when local seagrasses are at their annual minimum size and densities, all of the proposed sampling methodologies—including hydroacoustics—proved to be successful.** This result strongly suggests that ReMetrix's proposed sampling plan will be fruitful. Even if water clarity is very poor during sampling period, the hydroacoustic and physical sampling approaches will still be able to complete the project successfully.


*Halodule wrightii sample collected Nov. 30, 2005*

**Results and additional photos from the November 30 hydroacoustic and physical sampling evaluations are included below in Section E.**

Hydroacoustic sampling is able to rapidly quantify large spatial areas for overall vegetation cover and biovolume (height in the water column). The large size of the project study area (~3,000 acres) lends itself well to hydroacoustic sampling. Hydroacoustic sampling does not currently distinguish between species, though it can improve the efficiency of species point sampling by targeting ideal places to sample based on variations in plant characteristics observed in the acoustic signal.

Physical sampling will be used to determine the species composition within the areas shown by hydroacoustic sampling to have submerged vegetation communities. Physical sampling is also efficient in large study areas.

Color underwater video and diver sampling will also be used for this project (unless water clarity is particularly poor). Both techniques allow up-close visual observations regarding species composition and other relevant habitat characteristics.

ReMetrix digitally records underwater video clips and encodes a DGPS coordinate on the video track at the moment of collection. This enables video clips to be located and reviewed at a later time if necessary to verify physical or hydroacoustic sampling results during analysis. Despite moderate success using this technique on the evaluation day, the frequent poor water clarity issues reported in the study area render underwater video an uncertain tool to rely on as a primary methodology. It is also slower to use than hydroacoustic and physical sampling.

Diver sampling will be used periodically to support the other sampling types with high-resolution, high-detail species composition and habitat information. While diver sampling is the most detailed sampling technique, it is also the slowest and most labor-intensive sampling option. The large size of the study area makes widespread use of diver sampling relatively impractical when compared to other available techniques. Also the frequent poor water clarity issues reported in the study area render diver sampling an uncertain tool to rely on as a primary methodology. For these reasons ReMetrix plans to use diver sampling as a support methodology.

In summary, a combination of hydroacoustic and physical species sampling, supported by color underwater video and diver sampling, will provide the most comprehensive accounting of submerged vegetation within the study area.

## D. Hydroacoustic Background Information

Hydroacoustic data are collected using a digital 420kH BioSonics transducer mounted on a boat and actively linked to DGPS. The boat operator drives transects across the study area while the transducer pings the water column approximately five-to-ten times per second. The data from each ping are linked to a geographic coordinate via the DGPS beacon. Figure 2 depicts this process.

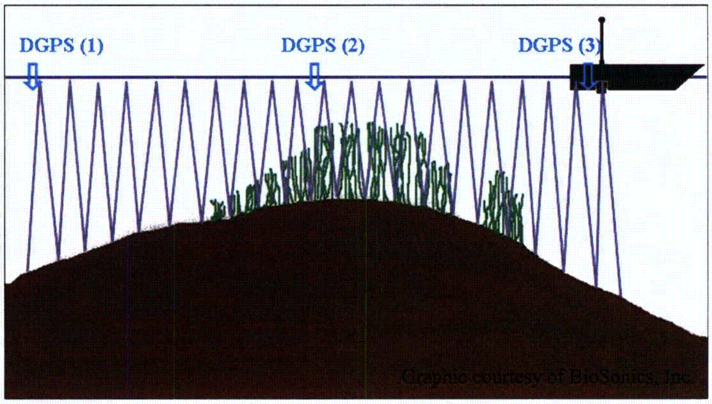



*Figure 2. Schematic drawing of hydroacoustic data collection linked with DGPS.*

BioSonics testing indicates that the hydroacoustic system returns digital samples with greater than 0.013% accuracy every 1.8 centimeters. Calibrations can be made daily in the field to address specific conditions, such as varying water temperature and salinity.

The data from each ping contain submerged plant cover and height information as well as the depth to the sediment layer. Figure 3 shows an example of the raw acoustic data collected along a transect.

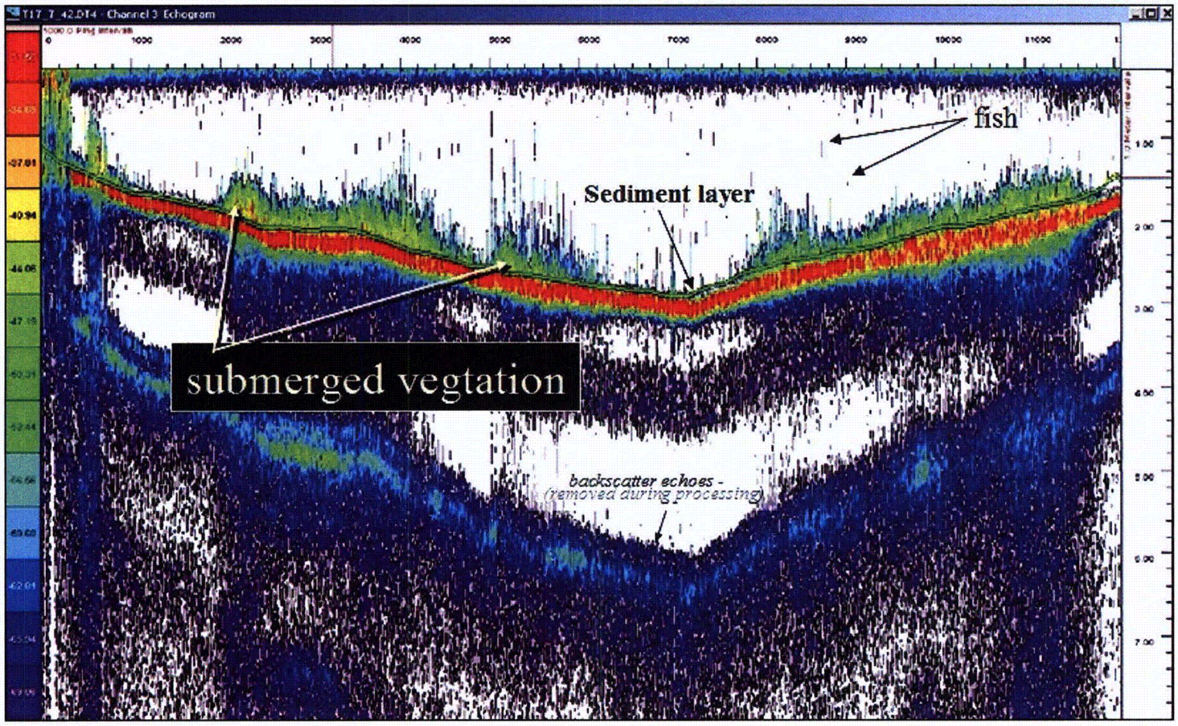



*Figure 3. Raw hydroacoustic transect data showing submerged vegetation detection.*

The raw acoustic data are processed to filter out noise, calculate statistics, and export the data for viewing in a Geographic Information System. Figure 4 shows an example of a fully processed transect, including vegetation cover and biovolume statistics for that transect.

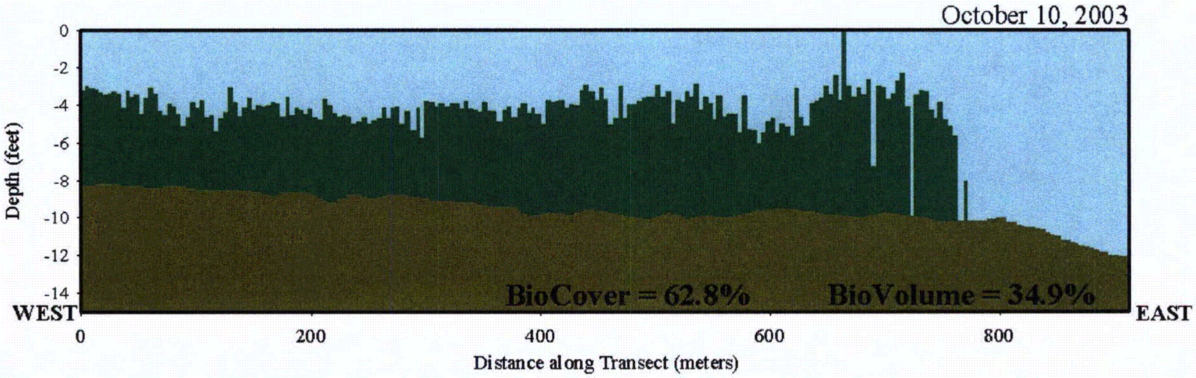



*Figure 4. Example of a final processed hydroacoustic transect showing submerged vegetation cover and biovolume statistics.*

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Data from all of the transects in the sampling program are combined and modeled using geostatistical software to produce vegetation coverage and biovolume maps for the entire study area. Statistics indicating total vegetation coverage and biovolume for the entire study area are also calculated. Figure 5 shows an example of a submerged vegetation cover map.

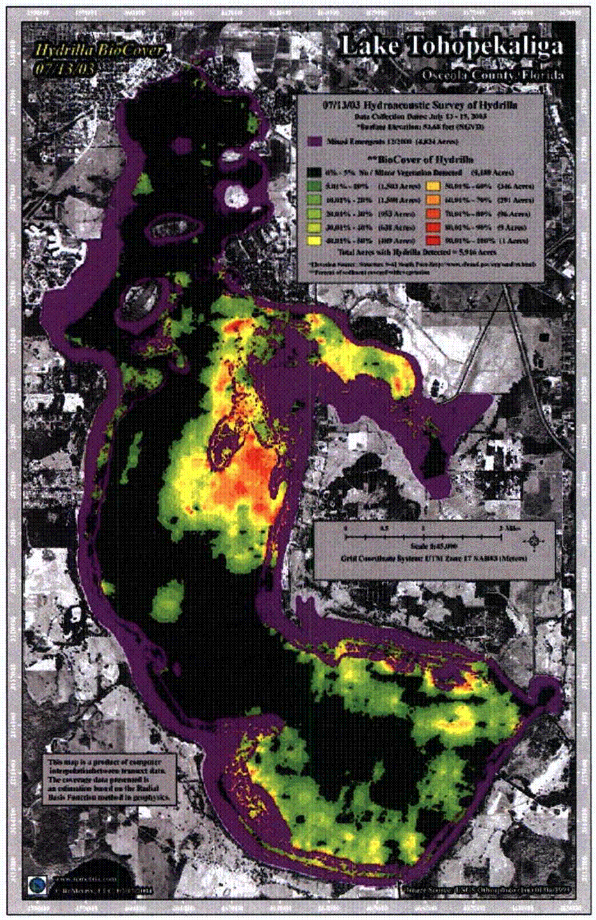


*Figure 5. Example submerged vegetation coverage map modeled from a grid of hydroacoustic transects.*

A key advantage of using hydroacoustic technology to map submerged vegetation characteristics is that the data are reproducible. Raw data can be re-analyzed for verification and/or specific transects can be re-collected if necessary.

Hydroacoustic vegetation sampling can not currently explicitly determine species by their acoustic signatures. However hydroacoustic vegetation mapping can sometimes implicitly delineate species based on their relative structural characteristics. For example, tall spindly species have a different acoustic signature than short, leafy species. These growth habit differences can sometimes be exploited to better delineate where one species or plant community transitions to another.

Situations where vegetation structural transitions can be accurately defined add further value to the hydroacoustic data collection approach. It is nearly impossible to predict in advance if the characteristics of a given water body will enable this kind of acoustic species differentiation. However if such opportunities become apparent as the project progresses, ReMetrix will attempt to extract that extra information out of the hydroacoustic data.

## E. Hydroacoustic Sampling Methodology and Plan

Methodology

Hydroacoustic data will be collected between 14-15 pings per 3-5 meters (approximately 1 ping per foot) in continuous fashion along each transect. In waters shallower than 3-meters depth, the hydroacoustic data will be collected within +/- 2.5 hours of high tide. It is important to collect shallow-water hydroacoustic data near high tide because the transducer collects cleaner data when the water column is at its deepest. In waters deeper than 3-meters depth, hydroacoustic data may be collected at any time. It is also important that hydroacoustic data for this project be collected in calm weather. *For these reasons ReMetrix recommends that at least a three week window of time be allotted to conduct sampling.* The greater control in selecting ideal collection days, the better the final data will be.

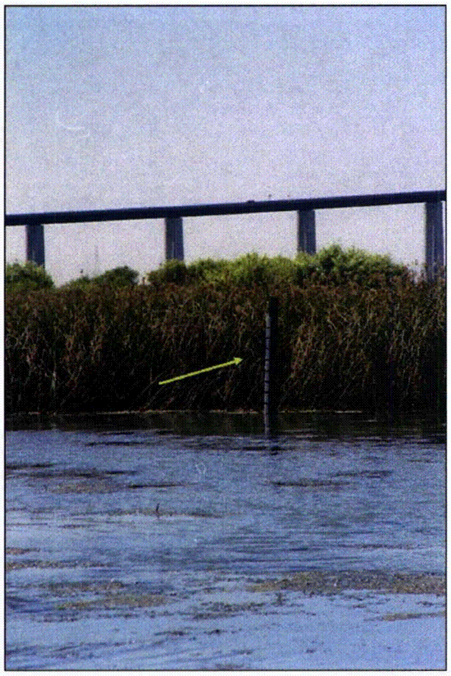

*Figure 6. Digital pressure transducer to record tidal changes during data collection. Tidal data are used to normalize water depth during hydroacoustic data processing.*

A digital pressure transducer will be deployed each day during data collection operations (Figure 6, at left). The pressure transducer accurately logs water depth once every five minutes with a vertical accuracy of 0.5-cm. The pressure transducer thereby measures the water level change due to tidal flux. The data from the pressure transducer is later integrated into the hydroacoustic data analysis to correct for the constant water level fluctuation. The use of the pressure transducer is an important step in the hydroacoustic data collection and analysis process.

Plan

ReMetrix proposes collecting digital acoustic transects totaling 210 km (~130 miles) in cumulative length. Figures 7a and 7b show proposed general transect layouts, each representing approximately 210-km of total transect length. Figure 7a shows a grid with 60-meter spacing in the north-south direction and 400-meter spacing in the east-west direction. Figure 7b shows an evenly spaced grid with 100-meter spacing.

Both layouts are considered to be high-resolution grids for an area of this size. ReMetrix prefers to collect a grid pattern similar to that shown in Figure 7a based on our experience collecting data in complex tidal areas. (It is most efficient to align the majority of transects parallel to the shoreline due to the tides.) ReMetrix will attempt to follow the proposed transect layout as much as possible, though field obstacles will periodically necessitate re-routing. Even with re-routing, a minimum of 210-km of hydroacoustic transects will be collected within the study area.

ReMetrix is open to suggestions for alternate grid layouts. We will endeavor to collect the grid layout that best meets the goals of the project. Alternate grid layouts may require project pricing adjustments.

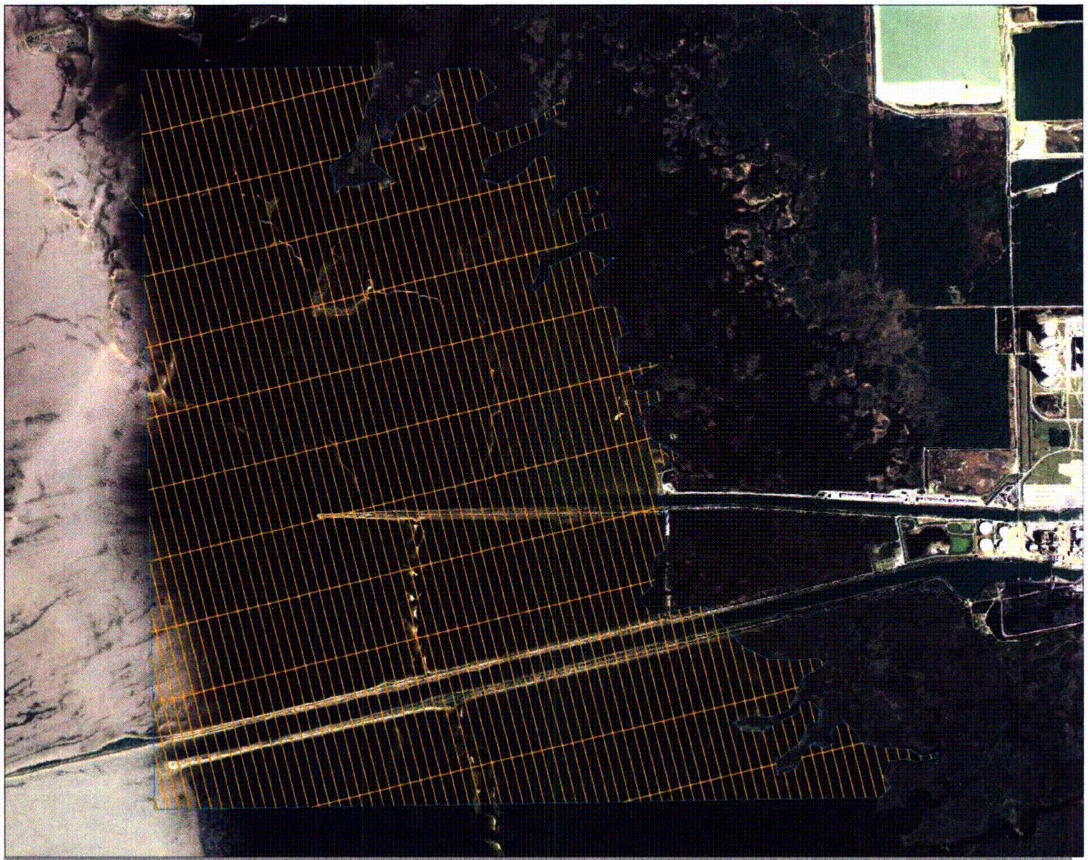

*Figure 7a. Proposed general hydroacoustic sampling grid in orange. Closely spaced transects (roughly north-south) are spaced at 60-meters; cross transects are spaced at 400-meters.*

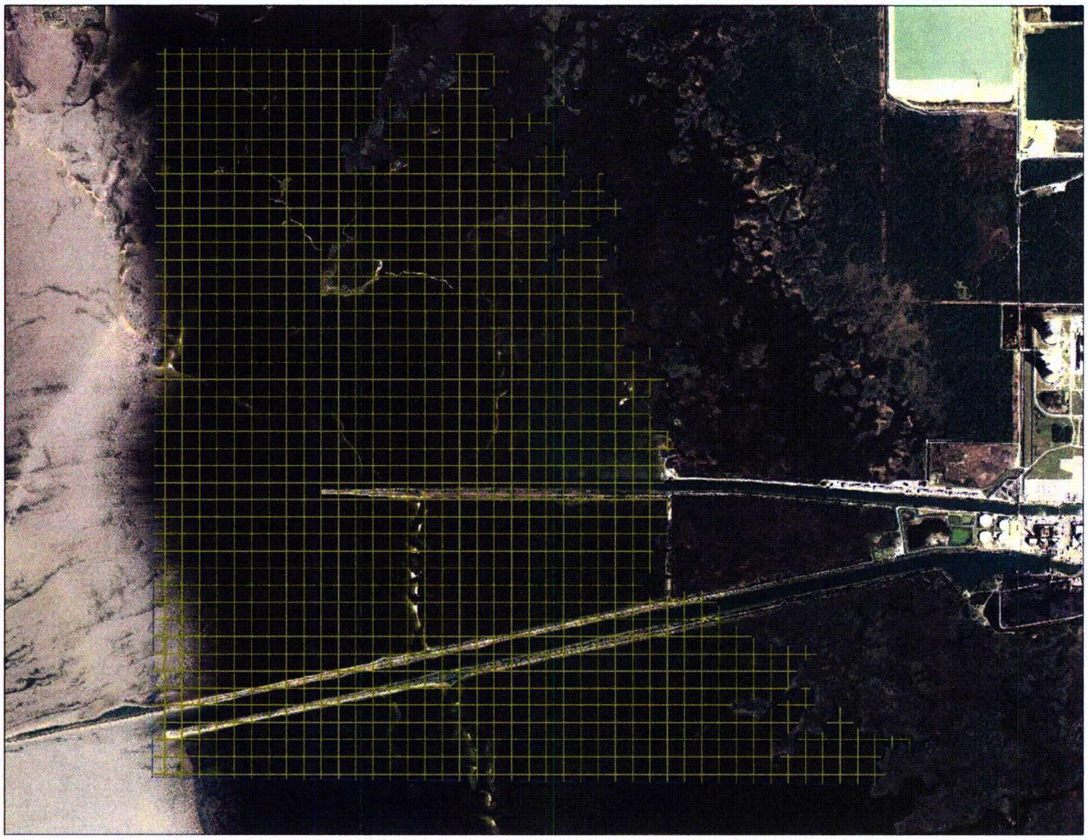

*Figure 7b. Alternate general hydroacoustic sampling grid in green. Transects are spaced at 100-meters in each direction.*

Hydroacoustic vegetation data from all of the transects combined will be modeled to produce seagrass cover and biovolume maps for the entire study area (as shown in Figure 5 above). Associated statistics for modeled cover and biovolume will be included. A subset of transects in each detailed area will also be displayed as plant bottom coverage and biovolume cross-sections, along with the cross-section statistics (as shown in Figure 4 above).

***Figures from the November 30, 2005 evaluations***

Figure 8 shows the hydroacoustic transects, physical samples, and vegetation detected during the November 30 sampling day. Figures 9-14 show the details of data from two hydroacoustic segments.

As can be seen in the figures—especially Figure 10—seagrass is definitely visible in the hydroacoustic signal.

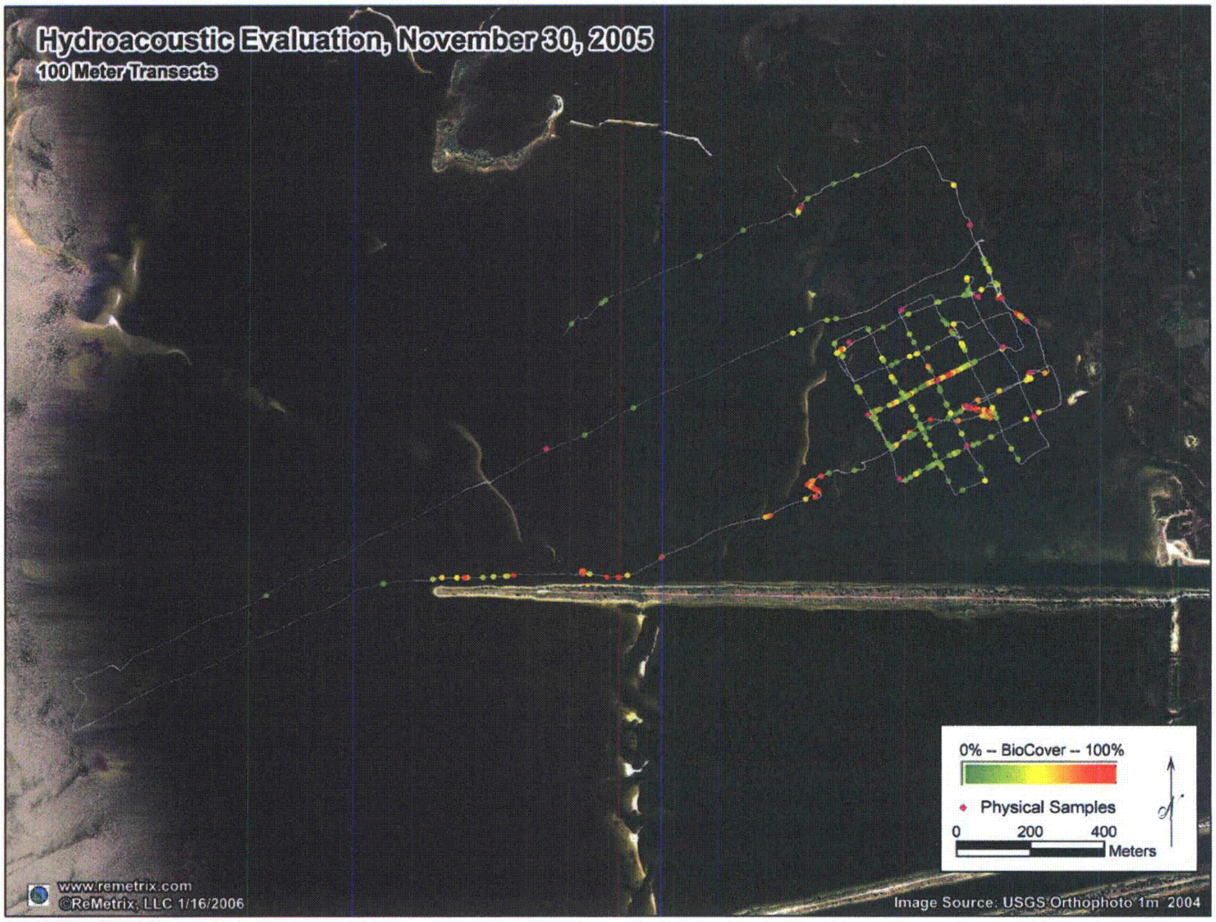


*Figure 8. November 30, 2005 hydroacoustic transects and physical sample locations. Colored dots show the areas where submerged vegetation was detected...green dots represent sparse cover, gradationally changing to red dots that represent dense cover (see legend on map). Magenta diamonds indicate physical sample sites.*

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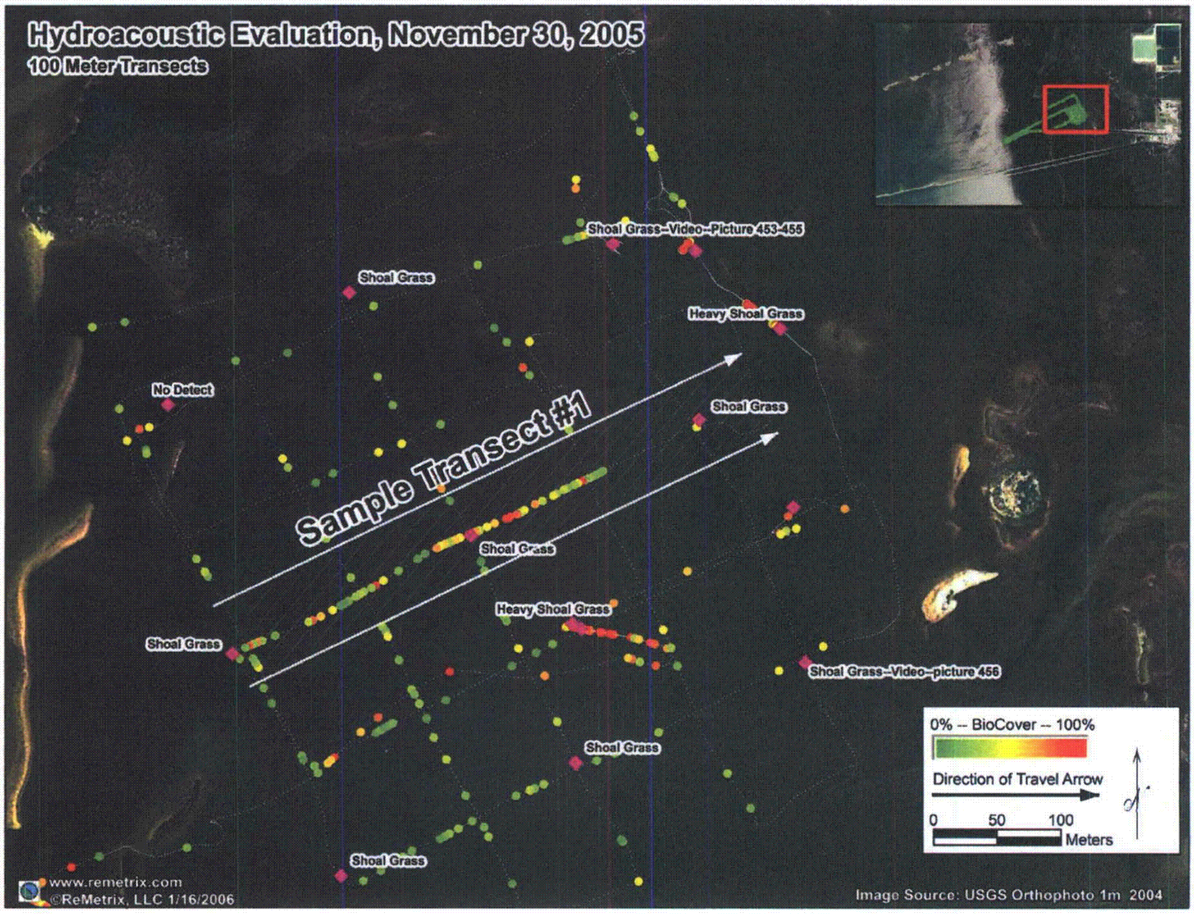


*Figure 9. Detail of sampling grid in evaluation area. A cross-section of Sample Transect #1 is shown in the figures below.*

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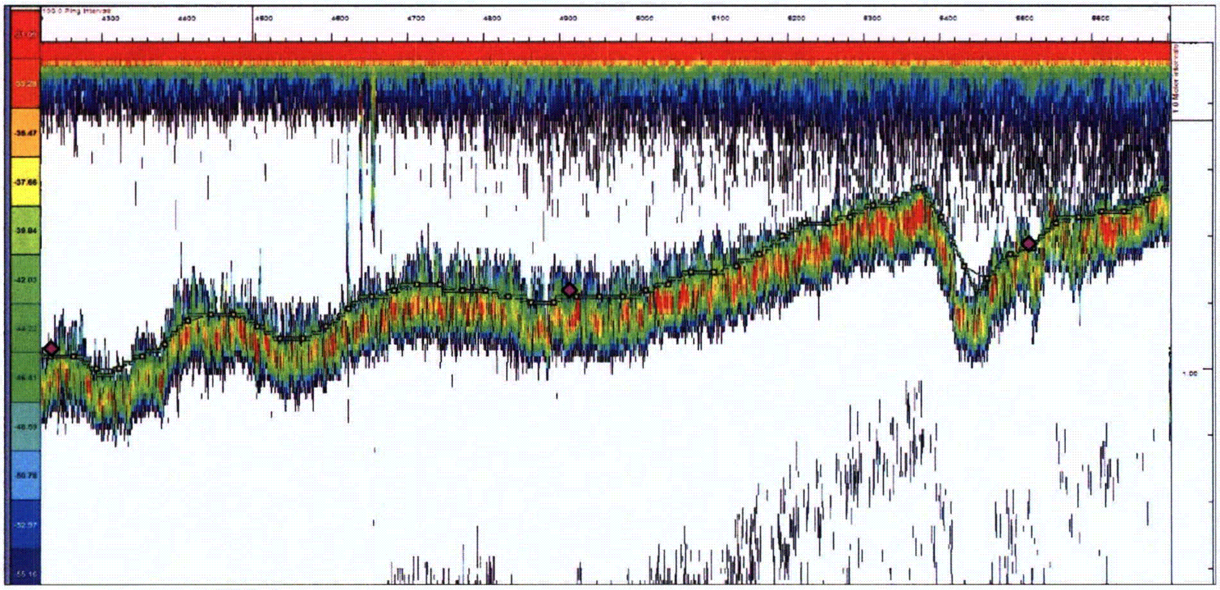

*Figure 10. Cross-section of raw hydroacoustic data for Sample Transect #1. The seabed is shown by the segmented line. Submerged vegetation is clearly visible above the bottom along much of the transect. This is identified as seagrass based on the three physical samples collected along the transect (magenta diamonds).*

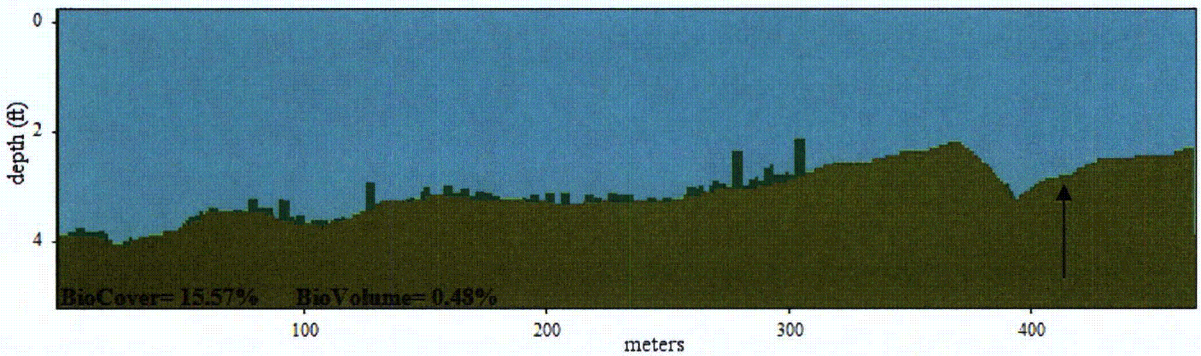


*Figure 11. Final post-processed cross-section of Sample Transect #1. Green bars depict seagrass coverage along the bottom. The transect has approximately 15% total BioCover, mostly of moderate density (approx 25%-55% density).*

*Note that the processing algorithm did miss a bit of vegetation (black arrow) that is visible in the corresponding raw data in Figure 10. ReMetrix can make adjustments to the algorithm processing parameters during the project to improve detection, but even as the algorithm currently exists it successfully mapped about 90% of the existing vegetation.*

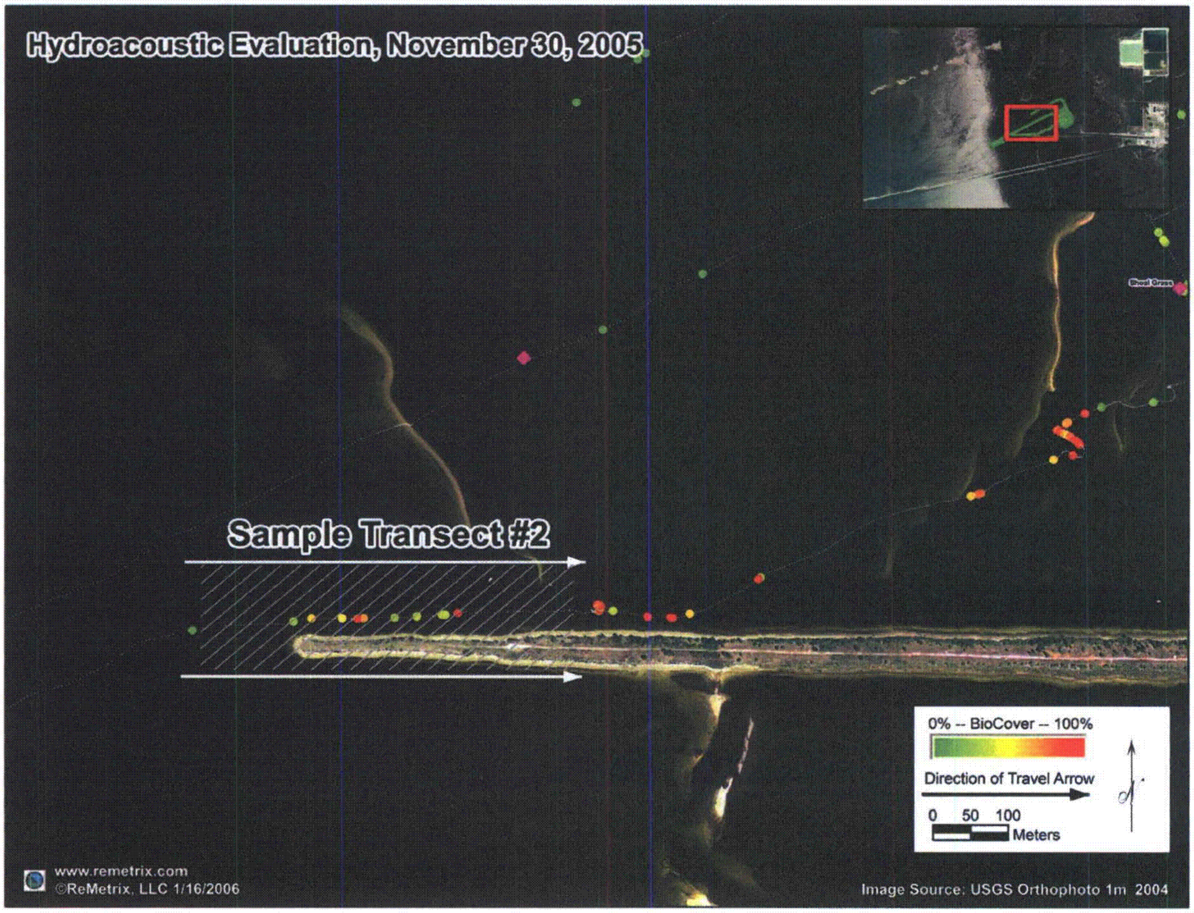


*Figure 12. Detail of sampling grid in evaluation area. The hatched region is shown as Sample Transect #2 in figures below.*

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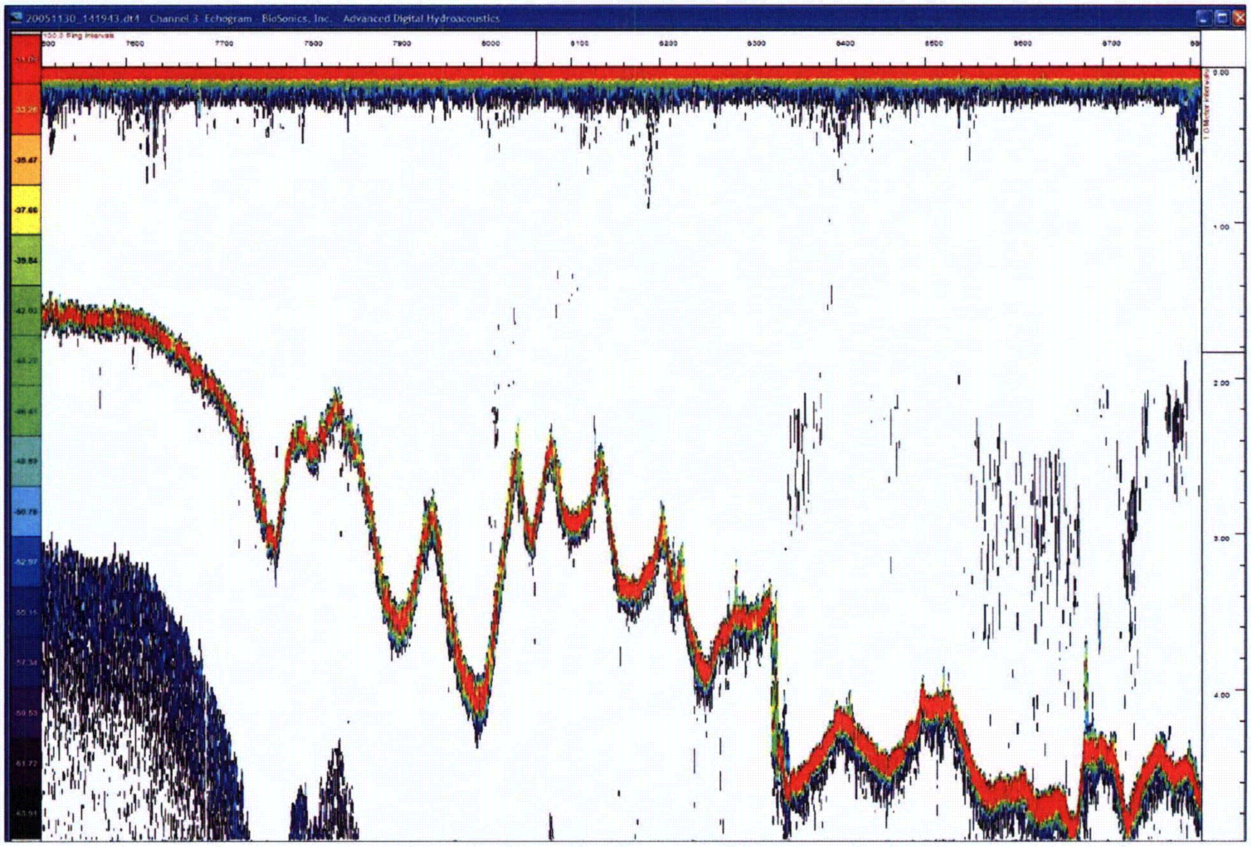

*Figure 13. Raw hydroacoustic data for Sample Transect #2, as marked in Figure 12. Only very sparse submerged vegetation was detected in this transect.*

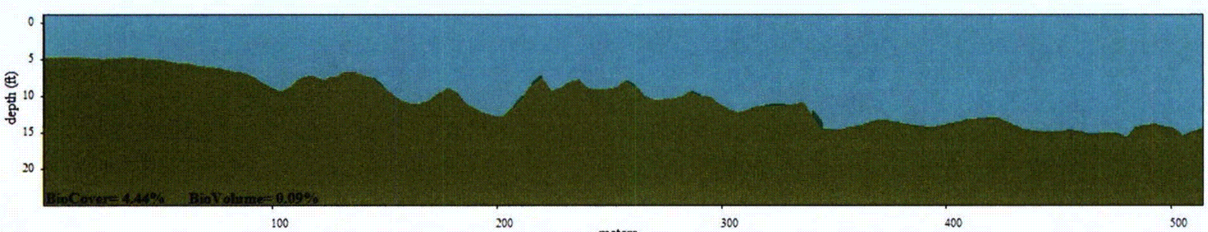


*Figure 14. Final post-processed cross-section of Sample Transect #2. Green bars depict seagrass coverage along the bottom. The transect has approximately 4% total BioCover, mostly sparse.*

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## F. Historical Species Sampling Within the Study Area

Two types of surveys were conducted in Estevez and Marshall (1995). A transect survey of 'barren areas' was conducted to find new colonies of seagrass and/or macroalgae. A site survey of 'intensive SAV beds' was conducted to measure changes in a representative sample of pre-existing seagrass/macroalgae beds.

*Table 2. Species recorded in Estevez and Marshall (1995).*

| Seagrass species: | Macroalgae species: |
|---|---|
| *Halodule wrightii* (Shoal grass) | *Caulerpa* sp. (*C. prolifera* and *C. mexicana*) |
| *Syringodium filiforme* (Manatee grass) | *Udotea conglutinata* |
| *Thalassia testudinum* (Turtle grass) | *Halimeda incrassata* |
| *Halophila engelmannii* (Star grass) | *Penicillus* sp. |

'Barren areas' were surveyed by towing a diver along fixed-transects. Total length of the 14 transects surveyed was approximately 13 km. The diver would mark the locations of new SAV beds (seagrass and/or macroalgae) and record species composition and percent cover.

Percent cover was measured using a 1-$m^2$ quadrat marker divided into a grid of 100-$cm^2$ cells. Percent cover was calculated by counting the number of cells containing at least one rooted seagrass and/or macroalgae species.

Fifteen 'intensive SAV beds' were surveyed for bed size, water depth, sediment thickness, percent bottom cover, shoot count, above-ground biomass, and productivity. Twenty quadrats (1-$m^2$) were collected per bed for percent bottom cover (10 quadrats along bed perimeter and 10 quadrats in bed interior).

Shoot count, above-ground biomass, and productivity were collected to determine SAV condition, based upon the methodology of Mattson, et al. (1986). Six quadrats (625-$cm^2$) were collected per bed for above-ground biomass of seagrass and macroalgae. Six quadrats (100-$cm^2$ for *Halodule*; 219-$cm^2$ for other seagrasses) were collected per bed for productivity and shoot counts.

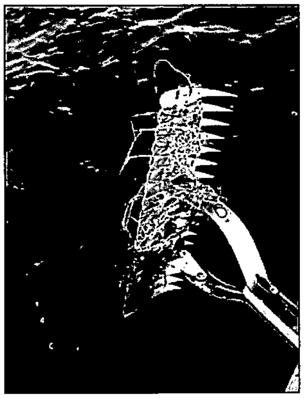
## G. Species Sampling Methodologies and Plans

ReMetrix will record the same taxa as were recorded in previous studies. The following methods and strategies will be used to survey and distinguish between species. Section G(iii) discusses distinguishing between seagrasses and algae.

## i. Physical Species Sampling Methodology and Plan

*Methodology*

A double-sided, weighted, sharp-tined thatch rake-head attached to a rope will be used to collect physical species samples of vegetation. Two samples will be collected per sample site. At each sample site the boat will stop, a DGPS point will be recorded, and the sampling rake will be "pressure-raked" across the seabed lifting the seagrass by its rhizomes embedded in the top sediment layer (Figure 15, photo at left).



This methodology was successfully tested during the November 30, 2005 evaluation day.

*Figure 15. Thatch-rake physical sample collected November 30, 2005 in study area.*

Vegetation and algae collected by the rake will be assessed and recorded for species presence/absence, relative abundance, and density. Relative abundance of each species will be determined according to Table 3 below.

*Table 3. Scale for relative abundance measurements per species.*

| Scale | Description |
|---|---|
| 100% | Present as ~100% of sample† |
| 75% | Present as ~75% of sample† |
| 50% | Present as ~50% of sample† |
| 25% | Present as ~25% of sample† |
| 5% | Present as ~5% of sample† or less |

†sample in this context refers to an aggregate of both samples per physical sample site

Density will be determined by gently compressing the aggregate vegetation sampled at each site across demarcated tines on the sample rake, analogous to that shown in Figure 16 below. Tines are marked at 20% and 60% of the distance along their length. Density will be recorded according to Table 4 below. Vegetation will not be separated by species for density measurements.

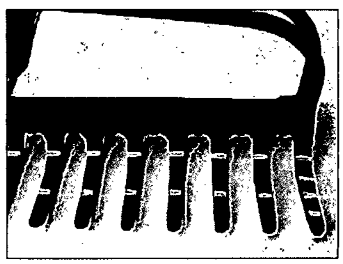


*Figure 16. Thatch-rake physical sample collected November 30, 2005 in study area.*

*Table 4. Scale for vegetation density measurements per sample†.*

| Scale | Name | Description |
|---|---|---|
| D | Dense | >60% of rake tines |
| C | Moderate | 20%-60% of rake tines |
| B | Minor | Up to 20% of rake tines |
| A | Sparse | 1-5 stems |

†sample in this context refers to an aggregate of both samples per physical sample site

While species presence/absence is a quantitative measure, relative abundance and density—as described above—are not. Instead they serve as a rapid surrogate for more quantitative methods to determine bottom cover and community composition. Using this rapid method allows for a greater total number of hydroacoustic ground-truth points and overall coverage of the study area. Ten of the physical sampling sites will also undergo diver sampling (described in Section G(ii)) to help quantify differences in estimates from the rake method and actual vegetation bed characteristics.

*Plan*

Physical species samples will be collected at a minimum of 100 points throughout the study area. Additional physical species samples above 100 may be collected at the discretion of the field biologist. Physical sampling is expected to require 1.5-to-2 days.

The physical species samples will be collected in a grid of pre-determined points. The proposed physical sampling locations will be submitted to the project manager at Progress Energy Florida for approval prior to the start of fieldwork.

To promote continuity between historical data sets and the current data set, ReMetrix is willing to sample at the same locations that were used for previous seagrass assessments within the study area. In general, ReMetrix is flexible about the locations of the physical sampling sites and will work with project managers to make sure that the needs of the project are met by the sampling design.

Species tables and maps will be produced from the physical sampling data.

## ii. Diver Sampling Methodology and Plan

*Methodology*

A minimum of 10 diver sampling sites will be collected in the study area. The diver's sampling location will be recorded using a DGPS receiver on the survey vessel. (ReMetrix has a SCUBA-certified aquatic biologist on staff.)

The sampling area for diver sites will be a 1-meter by 1-meter quadrat. At each site, the diver will measure actual water depth, bed size, actual plant heights, percent bottom-cover, and species composition. Percent bottom-cover and species composition will be measured in the interior of vegetation beds using the quadrat-cell methodology of Estevez and Marshall (1995). ReMetrix will not record shoot counts, above-ground biomass, productivity, and sediment thickness because these metrics are outside the scope of this project.

*Plan*

The diver sampling sites will be located along transect lines to help quantify potential acoustic measurement errors during the survey, which relate to final biocover and biovolume estimations. The diver sampling sites will also be co-located with physical vegetation sampling sites (Section G(i)), video sampling sites (Section G(iii)), and water quality sites (Section H) so that the plant quantification results of the various methodologies can be compared and differences can be quantified.

Based on the preliminary 2005 survey, water depths in the study area range from 0.25-meter to approximately 5-meters, with the majority of depths <3-meters. Vegetation was found at all water depths, though was much more common at <2.5-meters of depth. Vegetation in areas deeper than 3-meters were not able to be verified on the day of the preliminary survey.

Assuming acceptable site conditions (esp. water clarity), the 10 diver samples will be collected in various water depths according to the table below:

*Table 5. Depth range table for diver sampling sites*

| Water depth range (meters) | Diver sites sampled |
|---|---|
| 0.5-1 | 2 |
| 1-1.5 | 2 |
| 1.5-2 | 2 |
| 2-3 | 2 |
| 3-4 | 1 |
| 4-5 | 1 |
| **Total** | **10** |

Six of the 10 sites are in waters <2-meters deep. This reflects the suggestion in the FL DEP comments that an emphasis be placed on quantifying hydroacoustic errors in waters <2-meters deep. If conditions during the field sampling period prevent diver sampling at a specific depth interval (e.g., between 4-5 meters), the sample point from that interval will be bumped to the next shallower depth interval.

Additional diver sampling sites may be added as the survey progresses in the field, depending on field observations, sampling conditions, and time. Changes in acoustic signal response, physical sampling, and/or underwater video help target sites warranting a closer look via diving.

Species tables and maps will be produced from the diver sampling data.

## iii. Underwater Video Sampling Methodology and Plan

*Methodology*

The ReMetrix color underwater camera system digitally records video clips and tags them on the video track with a DGPS signal during collection. The camera system illuminates the water column in front of the lens with a series of lights to improve visibility and image quality. The effect of the illumination is sometimes greatly diminished by poor water quality and thus the camera is not always able to collect a high quality image even with the lighting. *For this reason, all proposed video sampling is dependent on sufficient water clarity to accurately discern targets.*

*Plan*

Color underwater video sampling will be conducted at the 10 diver sampling sites (Section G(ii)). This emphasizes areas <2-meters deep and provides corroboration between video results and diver results.

ReMetrix will also collect a minimum of 10 additional underwater video samples at vegetated sites along transects. The location of additional underwater video collection sites will be determined as the survey progresses in the field. As hydroacoustic data are being collected, changes in acoustic signal response identify locations where the ReMetrix field team considers taking a closer look beneath the water column.

## iv. Distinguishing Between Seagrass and Algae

*Distinguishing Between Seagrass and Rhizophytic Algae*

Distinctions between seagrass species and rhizophytic algae species will be made during physical, diver, and underwater video sampling. This maintains consistency with previous studies.

Distinguishing between individual seagrass and rhizophytic algae species in the hydroacoustic data is not possible. The purpose of the hydroacoustic data is to better characterize the total number and acreage of submerged vegetation beds throughout the study area, as well as the individual sizes, locations, percent cover, and biovolume of the beds.

Data from the other methodologies will ground-truth the hydroacoustic results, in addition to providing the detailed species-level data that is desired. It is possible—though not guaranteed—that reasonable inferences may be able to be made between the hydroacoustic data and the species-level data. For example, certain combinations of bed depth, location, size, percent cover, and/or biovolume, may correlate well with a given species or mix of species. This will only be able to be determined during the latter stages of data analysis.

*Distinguishing Between Rooted Species and Drift Algae*
Comments from FL DEP reference the possible presence of drift algae up to 1-meter thick over the seagrass beds.

Large quantities of drift algae could present hydroacoustic challenges if present at or very near the sediment layer. Drift algae mats at or near the surface will be a navigational inconvenience but should not hamper the survey in any significant way. ReMetrix will simply navigate around the algae if necessary. Drift algae in mid water-column will not be confused with bottom growing vegetation and thus should not be a hindrance.

Thick layers of drift algae (such as >1.5-feet thick) near the bottom will strongly attenuate and/or absorb the hydroacoustic signal, but in doing so will create a different signal response than the sediment layer. This should make it possible to correct-for or eliminate most such areas within the data set (though doing so will create a data-gap when eliminated).

Thin layers and/or dispersed drift algae near the sediment layer may be more difficult to recognize in the hydroacoustic signal, depending on the specific characteristics of the drift algae (e.g., the amount of trapped air bubbles). Ground-truthing activities occurring throughout the survey should help determine if drift algae is present in this manner. If present in abundance, it is expected to affect the percent cover and biovolume calculations within beds, but not the location and size of the beds. Also, as stated earlier, unusual changes in the hydroacoustic signal response as the survey progresses will alert the field team to investigate closer and determine the nature of the signal response.

It should be noted that no problems with drift algae were encountered during the November 2005 evaluations. Nevertheless, the scheduling of field data collection should attempt to take advantage of seasonally low periods of drift algae, if at all possible.

## H. Water Quality Data Collection

*Methodology*
Water temperature, salinity, turbidity, and light transmittance will be recorded using various tools. Temperature and salinity will be measured using a YSI 556 multiprobe. Turbidity will be measured using a Lamotte 2020 turbidity meter (range 0-1100 NTU). Light transmittance will be measured using a Secchi disk.

Sampling will be conducted before any physical sampling occurs at each site in order to avoid disturbance of the sediment layer. Water depth will be physically recorded at each sample site.

Water temperature, salinity, and turbidity measurements will be collected at least a foot below the water surface.

*Plan*
Water temperature, salinity, turbidity, and light transmittance will be recorded at a minimum of 15 sites. Ten of the sites will be the same as the diver sampling sites (Section G(ii)). Five of the sites will be independently selected and are referred to below as 'non-diver' sites.

The ten water quality sampling sites that are co-located with the diver sites will help compare water quality metrics with species-level seagrass/rooted algae/drift algae metrics.

Five non-diver sites will be sampled at or near high tide on the first day of the overall sampling program. These five sites will be located in various water depths according to the table below:

*Table 6. Depth range table for initial water quality sampling sites that are independent of the diver sites (a.k.a. non-diver sites)*

| Water depth range (meters) | WQ sites sampled |
|---|---|
| 0.5-1.5 | 1 |
| 1.5-2 | 1 |
| 2-3 | 1 |
| 3-4 | 1 |
| 4-5 | 1 |
| **Total** | **5** |

After the initial five sites are sampled, two of the five sites will be selected for ongoing water quality monitoring throughout the overall sampling period. The two sites will be sampled for the same parameters approximately every 48-60 hours (based in part on the progression of high tide). One of the two ongoing sites will be located in the 1.5-2 meter depth range, and one will be located in the 3-4 meter depth range.

## I. Other Sampling Factors

***Potential Field Hurdles***
The unique characteristics of the study area present a few challenges to field data collection. Navigation obstacles exist within the study area, and sampling around these obstacles does result in additional field time.

Weather conditions can greatly hinder field data collection. Strong wind and/or rain render field data collection impossible. An extra day has been built into the sampling plan as a contingency for unfavorable sampling weather.

Water clarity and tides are discussed above in Sections C, E, G, H, and I.

ReMetrix has significant experience working in challenging aquatic environments. The company has collected data in stump-filled Florida lakes and swampy lakes in Louisiana. ReMetrix also has experience collecting data in large study areas (up to 40,000-acres) and in tidal systems. For the past four years the company has successfully completed multi-site submerged aquatic vegetation assessments across a tidal estuary of approximately 300 $km^2$. Such projects demonstrate that our company is capable of handling any field data collection challenges that may occur during this project. ReMetrix has all of the equipment necessary for conducting the proposed project.

***Timing of Field Data Collection***
ReMetrix will make every effort to collect the field data at the best time for Progress Energy Florida, Inc. We calculate that the proposed field data collection will take approximately 10-12 days to complete in total. ReMetrix works on a first-commitment schedule for planning field missions, so the sooner a project is confirmed the more likely field data collection can proceed at the desired time.

***Sampling Adjustments for Patchy Vegetation***
Occasionally near-surface vegetation species can occur in very spotty, non-contiguous patches within a sampling area. Should this occur, ReMetrix will add a few extra sample points in each patchy area in order to guarantee that the surface vegetation patches are indeed sampled. This is a situation that is nearly impossible to predict in advance, but can be easily accounted for once the sampling crew is in the field. The same scenario exists for floating vegetation/algal species.

***Repeatability***
All of the data collected will be georeferenced using DGPS. All raw data are digital, allowing for independent confirmation of results even years later. Furthermore, ReMetrix will work with the program manager to provide the final data and statistics in a format that enhances the ability to make comparisons between this project and previous/future efforts within the study area.

## J. Data Processing and Delivery

ReMetrix will deliver sampling results in the forms of maps, tables, and statistics within the timeline proposed in Table 7 below. Faster delivery timeframes for portions of the data can sometimes be arranged. Please discuss with us if this is desired.

To date ReMetrix has processed hydroacoustic transect data greater than the distance from Seattle to San Diego. Hydroacoustic data will be processed and mapped by trained, experienced data analysts in a very efficient manner. To date ReMetrix has also processed and mapped physical vegetation sample data from over 11,000 points.

Maps, tables, and statistics from this project will be compared to any results provided from previous assessments. ReMetrix will work with the Progress Energy Project Manager to determine desired method(s) of comparison and resulting deliverables. Comparisons to data from other years are also possible if previous data is provided in ESRI, MS Excel, or other common digital format.

Maps are available in multiple printed and digital formats, including large-format plots. A summary report will also be provided that outlines methodologies used to complete the project. Drafts of the final deliverables can be provided for review and comment if desired, though extra time for draft reviews may need to be added.

## K. QA/QC Plan

The ReMetrix QA/QC plan involves three components:

1. Copies of all raw data will be preserved. These can be accessed for verification of results if necessary.

2. Up to four different data types will be collected. The above sampling plans ensure that redundant data collection will occur at numerous sites throughout the study area:

    - At least 100 sites will have an overlap between hydroacoustic and physical sampling;
    - At least 10 sites will have an overlap between hydroacoustic and diver sampling;
    - At least 20 sites will have an overlap between hydroacoustic and underwater video;
    - Ten sites will have an overlap between diver and underwater video.

    Some sites may end up having all four data types, permitting multiple methods of cross-referencing and ground-truthing.

3. At least 20 additional random physical samples, video samples, and/or diver samples will be collected off-transects throughout the study area. These will be used to help verify and improve the results of vegetation data modeled between the hydroacoustic transect lines. This approach reproduces the practice of field verification of final draft maps without incurring the extra costs of a second field visit. Once errors of omission and commission (Type I and II errors) are calculated, the additional sample points can then be incorporated into the final analyses to refine the final maps and calculations, if necessary.

## L. Budget

**The proposed price for this comprehensive seagrass and algae assessment plan is $52,374.**

The proposed price accounts for all aspects of fieldwork and data processing as described above. Based on the proposed scope above, the project budget will not exceed the total amount proposed. If the project scope is changed prior-to or during the project, budget adjustments may need to be made. Such scope changes must be mutually agreed upon between ReMetrix and the client's Project Manager prior to implementation.

The price above is valid for six months from the date of this proposal.

ReMetrix requests 20% of the project budget be paid in advance of the project initiation in order to help cover field deployment costs. The remaining project budget will be invoiced monthly based upon percent completion of the project (a.k.a., progress billing).

## M. Estimated Project Timeline

The schedule below is proposed and can be amended as necessary.

*Table 7. Proposed project schedule.*

| Step | Task | Proposed Timeframe | Description |
|---|---|---|---|
| 1 | Field data collection | Sampling window to be determined by Progress Energy project manager | Hydroacoustic and physical point sampling (also video and diver sampling if conditions permit) |
| 2 | Data analysis | 8 weeks after fieldwork completion | Hydroacoustic, GIS, and geostatistical processing |
| 3 | Comparison to historical data | 4 weeks after Step 2 completion | Change-comparisons |
| 4 | Delivery of preliminary results | 1 week after Step 3 completion | Draft results submitted for feedback |
| 5 | Delivery of final results and summary report | 4 weeks after draft feedback received | Completion of project. |

## N. Previous, Similar Work Experience for the Florida DEP

ReMetrix has conducted many submerged vegetation assessments using hydroacoustic technology for the Florida DEP since 2000. More than a dozen Florida public lakes have been assessed for hydrilla cover and biovolume for the DEP's Bureau of Invasive Plant Management. The point-of-contact for this work is Jeff Schardt, Director, Aquatic Plant Management Section, (850) 245-2809, jeff.schardt@dep.state.fl.us.

A second example of a submerged vegetation assessment conducted using hydroacoustic technology for the Florida DEP is included in the Appendix.

## O. Company Qualifications

***Company***

ReMetrix is a registered Florida Surveying & Mapping Business (LB7528).

ReMetrix has pioneered and continues to refine new and unique approaches for quantifying aquatic vegetation. For this reason, ReMetrix is ideally skilled and experienced to conduct this project.

ReMetrix was the first company to develop practical techniques for using the BioSonics and U.S. Army Corps of Engineers hydroacoustic vegetation quantification tools. ReMetrix has successfully completed hydroacoustic vegetation monitoring assessments for over 250,000 surface acres of water in seven states. This is by far the most comprehensive use of this system by any organization worldwide.

The company specializes in conducting projects in large study areas. The innovation and accuracy of ReMetrix's assessments have played a key role in many aquatic vegetation management initiatives.

ReMetrix has documented experience of successfully completing projects similar to the one proposed in this RFP. Examples supporting this statement are:

- *Submerged Vegetation Change Analysis for Lake Tohopekaliga, 2001-2005*, conducted for the Florida Department of Environmental Protection, Bureau of Invasive Plant Management
- *Monitoring Aquatic Herbicide Treatment Efficacy, Sacramento-San Joaquin Delta, California,* conducted for the California Department of Boating & Waterways EDCP and the USDA-Agricultural Research Service, 2003-2005.
- *Hydroacoustic Assessment of Pre- and Post-Treatment Vegetation, Houghton Lake, Michigan, 2001-2004*, conducted for the Houghton Lake Improvement Board and the U.S. Army Corps of Engineers – ERDC.
- *Submerged Aquatic Vegetation Multi-Temporal Change Analysis*, conducted for the Big Bear Municipal Water District, CA, 2002-2004.

ReMetrix strives to use trained personnel and the best technology to achieve success in each project. The company endeavors to tailor each project to the known characteristics of the water bodies being monitored. Attention to such details supports the assertion that ReMetrix brings solid expertise to each project from the beginning.

Thank you for considering ReMetrix for this project. Please contact us with any questions.

Sincerely,

Douglas Henderson
Commercial Manager
ReMetrix LLC
(317) 580-8035
doug@remetrix.com

## REFERENCES

Estevez, E. D. and M. J. Marshall, 1995. *1995 Summary Report for Crystal River 3-Year NPDES Monitoring Project.* FPC Contract S01100 (Addendum 1), Environmental Service Department Florida Power Corporation.

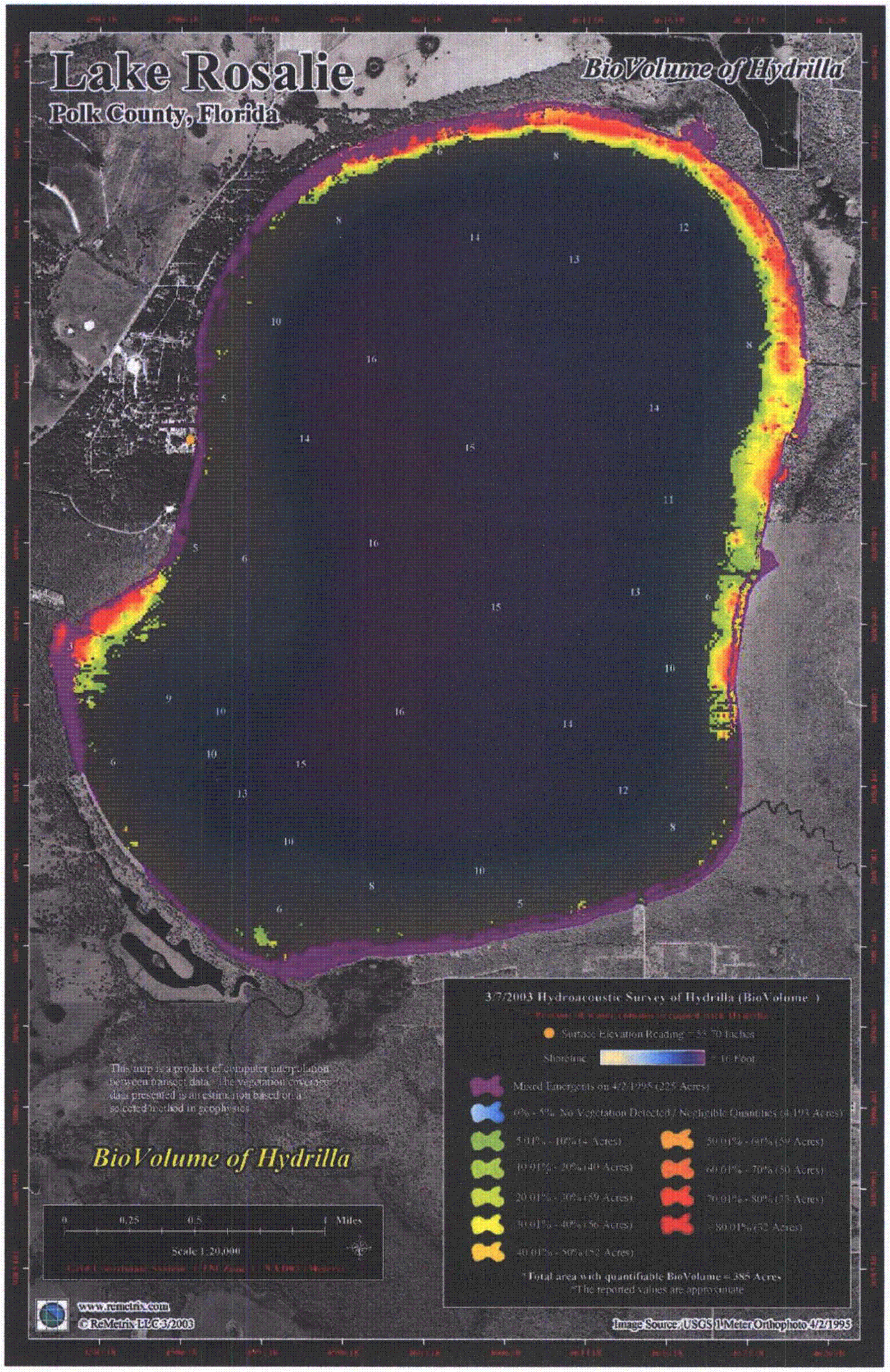
Mattson, R., J. A. Derrenbacker, Jr., and R. R. Lewis, 1986. *Effects of thermal addition from the Crystal River generating complex on the submerged macrophytic communities in Crystal Bay, Florida.* In Mahadevan, K., et al., (eds.), Proceedings: Southeastern Workshop on Aquatic Ecological Effects of Power Generation, Mote Marine Laboratory Technical Report Number 124, Sarasota, FL, p. 11-67.

# Appendix:

## *An additional example of hydroacoustic submerged vegetation quantification also used by the FL DEP*

Seagrass Quantification Plan for Progress Energy Florida, Inc.

*Hydroacoustic Sampling with Species Point Sampling*




*Biovolume map of Lake Rosalie, FL. Biovolume is a measure of plant height in the water column. Biocover maps, which are similar in appearance, indicate the density of plant coverage on the bottom of the water body.*

**Progress Energy**

VIA CERTIFIED MAIL

September 17, 2007

Mr. Bala Nori
Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Re: Progress Energy Florida, Inc. – Crystal River Units 1, 2, and 3
NPDES Permit No. FL0000159
Thermal Plume Assessment Plan of Study

Dear Mr. Nori:

Enclosed please find three (3) copies of a draft biological evaluation plan of study (POS) for the Department's review. You'll recall that we agreed to defer submittal of the Crystal River Units 1, 2, and 3 POS pending approval of the Bartow POS. The Bartow POS was subsequently approved by FDEP in late June of this year.

If you or others within FDEP have questions concerning this information, please contact me at (727) 820-5410.

Sincerely,

Dave Bruzek

David A. Bruzek
Lead Environmental Specialist
Progress Energy Florida, Inc.

bcc: Ron Johnson, CN77 (w/att)
Mike Shrader, PEF-903 (w/o att)
Dave Bruzek, PEF-903 (w/o att)
File: CR South\NPDES\Corresp.\2007 (w/att)

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St. Petersburg, FL 33733

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Mr. Bala Nori
FL Dept. of Environmental Protection
2600 Blair Stone Road
Tallahassee, FL 32399-2400

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# PLAN OF STUDY FOR A THERMAL PLUME ASSESSMENT CRYSTAL RIVER UNITS 1, 2, and 3 CITRUS COUNTY, FLORIDA

**September 2007**

Submitted by:

Progress Energy Florida, Inc.
299 First Avenue North
St. Petersburg, Florida 33701

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## LIST OF FIGURES

## 1.0 INTRODUCTION AND APPROACH

As part of the National Pollutant Discharge Elimination System (NPDES) permit for the Crystal River Units 1, 2, and 3, Progress Energy Florida, Inc. (PEF) is required to develop a Plan of Study (POS) in accordance with Rule 62-302.520(1), F.A.C. This plan shall be designed to determine any effects on biological communities from the thermal plume discharge to Crystal Bay. The POS shall address monitoring of the thermal plume, submerged seagrasses, benthic macroinvertebrates, and shall include a proposed implementation schedule and reporting requirements. The POS shall identify data provided by other existing programs as well as any additional monitoring to be conducted by PEF as necessary.

To understand how to characterize potential impacts to seagrass beds and benthic organisms exposed to the thermal release from the Crystal River Energy Complex, this plan of study is structured as a phased approach that will initially focus on determining and understanding the spatial and temporal distribution of the thermal plume under various environmental and plant operating conditions. Once the location of the plume has been established, (Phase I) it will then be possible to determine how and where to evaluate potential impacts to seagrass beds and benthic organisms exposed to the thermal plume (Phase II).

The Crystal River Energy Complex is located on an approximately 5,000 acre site near the Gulf of Mexico in Citrus County, Florida. The Complex is approximately 7.5 miles northwest of the City of Crystal River, within the coastal salt marsh of west central Florida (Figure1). The complex contains five electric generating units. Units 1 (400 MW) and 2 (500 MW) are coal-fired and Unit 3 (890 MW) is a nuclear-fueled electric generating plant located within the Complex. These three units utilize once-through condenser cooling and are authorized to discharge cooling water by NPDES permit No. FL0000159. Units 4 (640 MW) and 5 (640 MW) are coal-fired units and utilize closed cycle cooling with natural draft cooling towers. Unit 4 and 5 withdraw water for cooling tower makeup from the discharge canal of Units 1, 2, and 3. During certain times of the year (May 1 through October 31), once-through helper cooling towers are operated to reduce the thermal discharge from Units 1, 2, and 3. The helper cooling towers cool a portion of the heated water which has passed through the condensers from Units 1, 2, and 3 and then discharge the cooled water back into the discharge canal. The helper cooling towers are operated as necessary to ensure that the discharge temperature does not exceed the current permit maximum of 96.5 °F as a three-hour rolling average at the point of discharge into the Gulf of Mexico. Source water for Units 1, 2, and 3 is withdrawn from a common canal located south of the units which extends into the Gulf of Mexico, a Class III marine water.

NPDES Permit No. 0000159 authorizes the following for Crystal River Units 1, 2, and 3:

> *Operation of an industrial wastewater treatment and disposal system to serve the referenced facility: The facility consists of two fossil-fueled units (Unit #1 and Unit #2) and a nuclear fuel-fired unit (Unit #3) The units have a combined daily flow of 1898 MGD and a total nameplate rating of 1854.8 MW. The facility discharge consists of once-through condenser cooling water, treated auxiliary cooing water, treated-sluice ash water, treated coal pile rainfall runoff, canal debris wash water, and treated non-radioactive wastes/radiation waste. Treated effluent is discharged to the site discharge canal thence to the Gulf of Mexico, a Class III marine water, and a wetland area of the Gulf of Mexico.*

The most recent study to evaluate the impact of the thermal plume at Crystal River was conducted in 1983 – 1984. As part of a 316 Demonstration, physical studies were conducted in Crystal Bay to collect data for hydrodynamic and hydrothermal modeling. The models were designed to characterize hydrodynamic conditions within the study area, and using that data, simulate the thermal discharge resulting from the operation of Crystal River Units 1, 2, and 3 under various environmental conditions.

To provide comprehensive, synoptic thermal data, thermographs were deployed at 51 near-surface stations throughout the study area. At 21 of these stations, thermographs were also deployed at subsurface stations for detection of stratification. Meteorological, bathymetric, current, and tide data were also collected in support of the hydro-dynamic modeling effort.

Thermal plume delineation was accomplished during the study period under incoming and outgoing diurnal and semi-diurnal tide conditions. Sampling was conducted during August and January when the in situ study was in progress. Boat crews synoptically sampled four basins near the discharge point measuring conductivity and temperature searching for bottom separation of the thermal plume.

The far-field modeling effort for Crystal River Energy Complex was conducted with CAFÉ-1 and DISPER-1, a pair of two-dimensional finite-element mathematical models developed at the Massachusetts Institute of Technology. The objectives of the far-field modeling were to determine the far-field thermal plume configuration and determine the station effects on far-field meroplankton concentrations (source water body analysis).

The selection of a near-field model for the Crystal River Energy Complex was based upon an examination of the results of the thermal plume delineation surveys. No significant or consistent plume stratification could be detected due either to temperature or salinity. Thus, the near-field modeling was conducted utilizing a model which describes a plume uniformly distributed over the water depth. The results of the near-field model were used to modify the isotherm locations predicted by the far-field model. The far-field model supplied an approximate distribution to the average temperature in the region of the point of discharge and the near-field model provided the detailed distribution.

Upon examination of the thermal plumes obtained from physical data collected, the only phases of the tide which exhibited any substantial near-field behavior were ebb tide and low water slack. Near field behavior was apparent by the existence of locally elongated isotherms which follow and enclose a jet emerging from the point of discharge. Furthermore, data supported the conclusion that heated water is primarily confined to the dredged discharge canal throughout its length, especially at low tide levels. True near-field plume behavior did not begin until the discharge emerged from the channel into the bay (Figure 3).

Thermal plume simulation results agreed well with results from the biological and water quality sampling portions of the 316 study. Basin 1, nearest the point of discharge was consistently exposed to water with temperature elevated 5 – 8 ° C above ambient. On ebb or low slack tides, however, the largest volume of the thermal discharge was confined to the dredged channel adjacent to the discharge spoil. The plume at that point tends toward the southwest, but rapidly becomes well mixed in the relatively shallow water. On flood or high tides, the plume effect is lacking as the discharge spreads quickly over more of the bay. Little variation was seen in the summer or winter cases. Simulations represented worst case, full load operation. Interpretation of the results was complicated by low salinity and sedimentation experienced in Crystal Bay. Particularly with benthic communities, the effects of salinity and sedimentation are very similar to thermal effects, and this was demonstrated by faunal similarities observed between northern area stations and those in area affected by the thermal discharge.

As a result of findings from this study, Florida Power Corporation reached a tentative agreement with the U. S. Environmental Protection Agency (EPA) and Florida Department of Environmental Regulation (FDER) in March 1988 outlining a 3-phased approach towards mitigating impacts from the once-through cooling water system at Units 1, 2, and 3. FPC agreed to install helper cooling towers to reduce thermal impacts, construct and operate a multi-species fish hatchery to address impingement and entrainment impacts, and implement a 15% reduction in overall cooling water flow from November 1 through April to further reduce impingement and entrainment impacts.

Four mechanical draft helper cooling towers designed to cool approximately one-half the condenser cooling water discharged from Crystal River Units 1, 2, and 3 were installed and began operation in 1993. The cooler tower discharge water is reintroduced and mixed in the discharge canal to achieve a three hour average maximum temperature of 96.5 °F at the point of discharge.

## 2.0 PLAN OF STUDY

The objective of this POS is to assess the potential impacts of the thermal plume from current operation of Crystal River Units 1, 2, and 3 on submerged grasses, benthic macroinvertebrates, and other aquatic species, as appropriate. This POS is divided into the following phases and sections:

### 2.1 Monitoring to Determine the Spatial and Temporal Distribution of the Crystal River Energy Complex Thermal Plume

The objective of this phase is to understand the spatial persistence and temporal distribution of the thermal plume as it relates to current plant operations and ambient environmental conditions.

#### 2.1.1 Thermal Plum Delineation

Earlier physical studies provided detailed near-field and far-field thermal plume simulations correlated with extensive physical data collected in and around Crystal Bay. A fairly accurate account of thermal plume spatial and temporal performance was determined from those studies. However, those studies were completed prior to the installation and operation of the helper cooling towers and the resulting NPDES permit condition of a maximum thermal discharge temperature of 96.5 °F as a three-hour rolling average at the point of discharge into the Gulf of Mexico.

This POS is designed to assess the spatial distribution of the thermal plume resulting from the operation of Crystal River Units 1, 2, and 3 and helper cooling towers. To map the spatial distribution of the thermal plume a total of 20 sampling stations will be synoptically monitored twice monthly from April through October. Sampling station locations are shown in Figure 2 and are based in part on expected plume trajectories from model simulations run during the previous 316 study. Exact station locations will be determined during the first field effort using GPS. Station location is grid based to enhance statistical analysis and interpolation. Each synoptic survey will take place prior to slack water for both ebb and flood tidal cycles. Surface and bottom temperature, dissolved oxygen, and salinity measurements will be taken at each station. Secchi disc depth will be determined at each station as a measure of light penetration. If water depth at a sampling site is less than one meter, only surface (0.2m) measurements will be taken.

To supplement the synoptic surveys three continuous recorders (datasonde) will be placed at key locations to measure temperature, dissolved oxygen, and salinity 24 hours prior to and after each synoptic survey. A fourth datasonde will be placed as a control south of Crystal Bay outside of the area influenced by the thermal plume. Datasondes will be suspended near the bottom through bottom anchoring and surface floats. The datasondes will be programmed to record data every 15 minutes. The datasondes will provide a continuous record of temperature, salinity, and dissolved oxygen concentrations during each survey period for areas that are expected to be within the thermal plume, as well as a control.

The objective of this study will be to characterize the fate of the thermal plume under present plant operating conditions. The mapping effort will include the establishment of isotherms associated with the thermal plume. The gradient of thermal contours will provide data to establish areas within and outside of the thermal plume, allow comparison to previous modeling results, and dictate location of biological sampling stations. If conditions are encountered that indicate the proposed stations will not allow an adequate delineation of the thermal plume, select stations will be moved or additional stations will be added for adequate temperature mapping.

2.1.2 Sampling Frequency

Synoptic surveys will be conducted twice monthly from April through October during slack low and high tides in order to collect data during worst case, full power demand conditions. This will provide information on the effect of plant operating conditions including worst case on the fate of the thermal plume. Sampling will begin just prior to a slack flood or ebb tide. It is anticipated that sampling will begin in the spring of 2008 pending approval of this POS by the FDEP.

2.1.3 Environmental Measurements

Concurrent with each survey air temperature, wind speed, direction, rainfall, cloud cover and general weather conditions will be observed and recorded. Meteorological data will be obtained from the meteorological tower operated on the Crystal River Energy Complex site. Also, tide height data will be recorded, and plant operational parameters will be collected for each sampling event.

2.1.4 Water Quality Assessment

In addition to synoptic water quality sampling (temperature, dissolved oxygen, and salinity), mid-depth water samples will be collected once per tidal cycle and once per month at five stations. These samples will be analyzed for dissolved organic carbon, ortho-phosphate, nitrate/nitrite, ammonia, and turbidity. Methods and holding times will follow appropriate 40 CFR Part 136 and FDEP SOP guidelines. Stations to be sampled for water quality parameters are shown in Figure 3.

2.1.5 Data Management

Field and laboratory data sheets will be used to record raw data. All field data will be entered into an ACCESS database with identifiers of station, date, and depth to allow for full analysis of data.

2.1.6 Data Analysis and Results

To determine the fate of the thermal plume under various plant and environmental conditions, data from April through October will be collected and analyzed. Isothermal contours will be generated for 1.0 °C isotherms. Since previous studies indicated little vertical stratification, isotherms will be considered to be consistent throughout the water column.

These isotherms will be compared to near-field isotherms generated during the 1985 316 Demonstration Study. With no significant changes in hydrology or topography it may be possible to compare results from this study to prior conclusions. This will be determined as data becomes available.

The datasonde results will be used to provide information on temperature and dissolved oxygen concentrations at selected areas during periods that bracket the surveys. A comparison will be made between day and night dissolved oxygen concentrations to assess any temperature-dissolved oxygen interactions.

To supplement the thermal plume mapping and assist in determining what additional studies, if any, will be required to evaluate the impact of the existing thermal plume on seagrass beds, available GIS data and maps will be collected and layered with thermal plume data.

In addition, the isotherm mapping will provide data to identify if, and where, benthic sampling should be conducted to be representative of the various temperature contours, as well as identify background temperature areas for comparative purposes. It will also be used to assess the relevancy of the 1985 benthic studies to current isotherm distributions.

2.1.7 QA/QC Plan

It is the policy of the EHSS Department to ensure that all biological activities (field, laboratory, and reporting) are accurate, complete, and repeatable. This policy is accomplished by developing a system of activities outlined in the EHSS Biology Program QA Manual. This manual includes both administrative and technical activities. Vendors performing biological studies for EHSS must comply with the criteria and guidance outlined in the QA manual.

2.1.8 Reporting Requirements

Progress reports will be issued quarterly and will present thermal plume mapping information for temperature, salinity, and dissolved oxygen along with water quality information that is available.

A final report will be prepared within 6 months of the last sampling to discuss the fate of the thermal plume, the assessment of potential biological impacts from available information and recommendations for Phase II sampling.

2.2 Phase II – Conduct a Biological Assessment of Seagrass Beds and Benthic Macroinvertebrates Impacted from the Thermal Plume

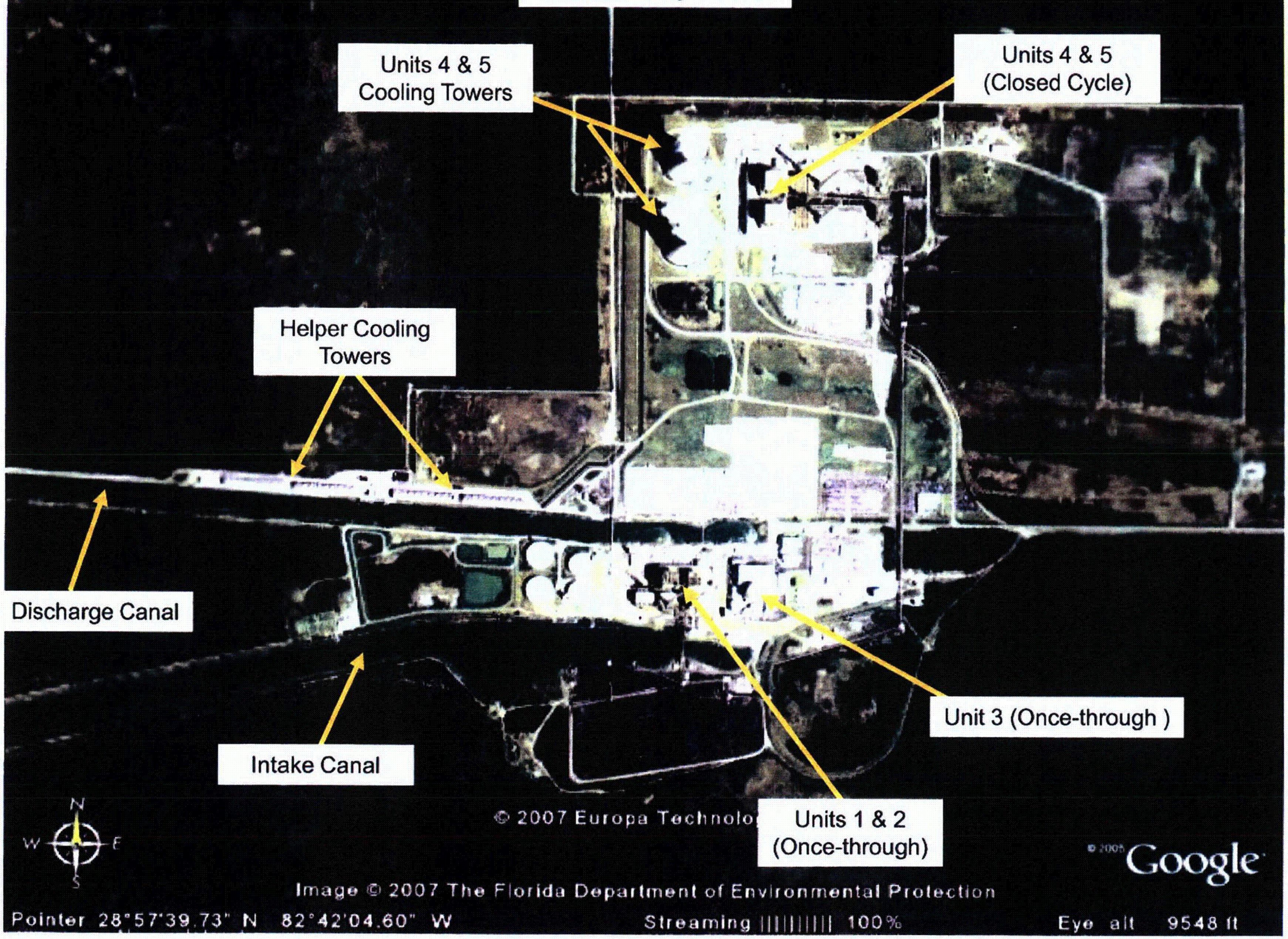
2.2.1 Characterization of the Spatial Distribution of Seagrass Beds Likely Affected by the Thermal Plume

The scope of this study will be deferred until the spatial and temporal extent of the thermal plume is defined and an appropriate Plan of Study can be prepared and submitted to FDEP for approval.

2.2.2 Characterization of the Benthic Community Potentially Affected by the Thermal Plume

The scope of this study will be deferred until the spatial and temporal extent of the thermal plume is defined and an appropriate Plan of Study can be prepared and submitted to FDEP for approval.

Figure 1. Site Layout



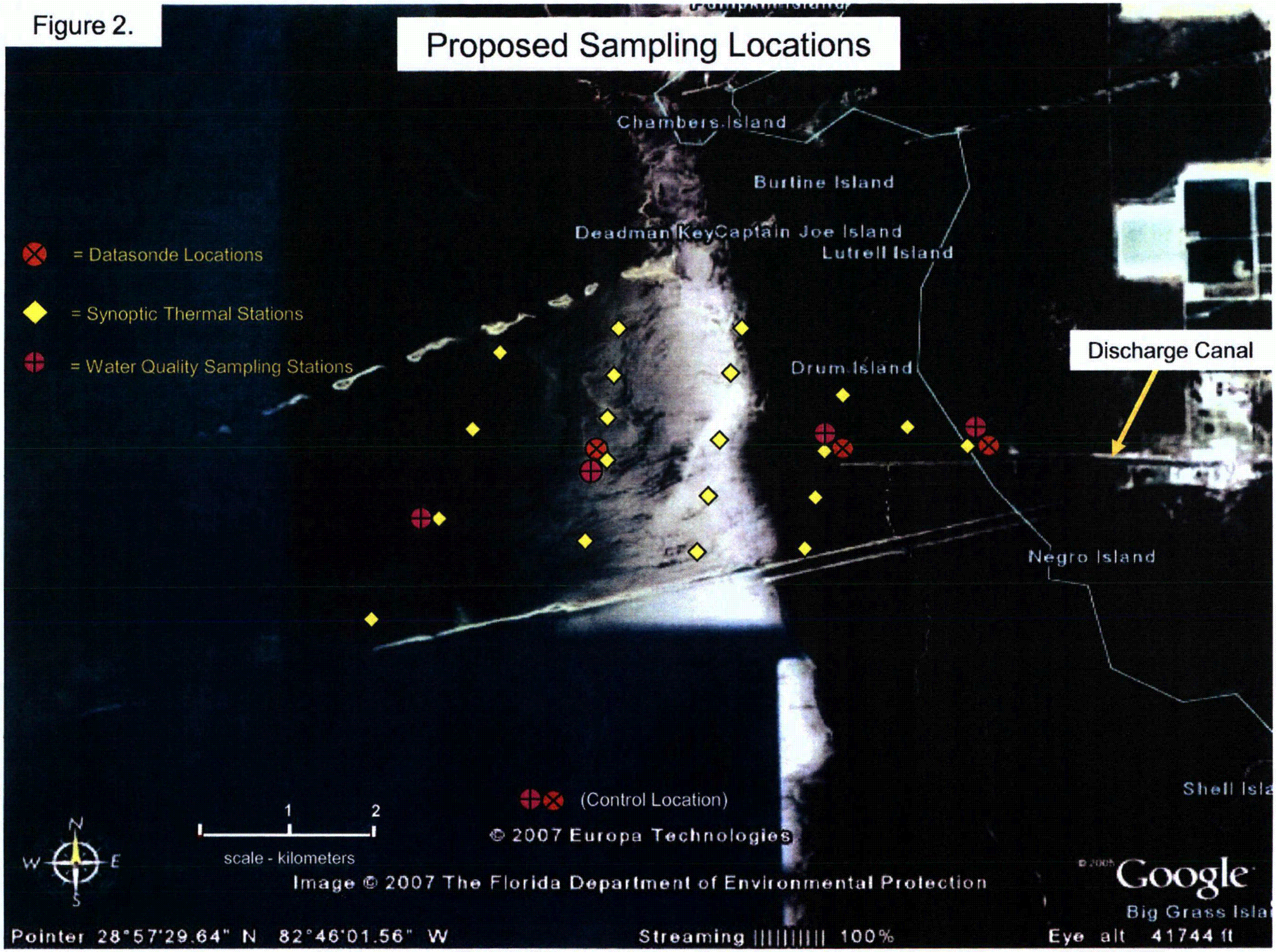
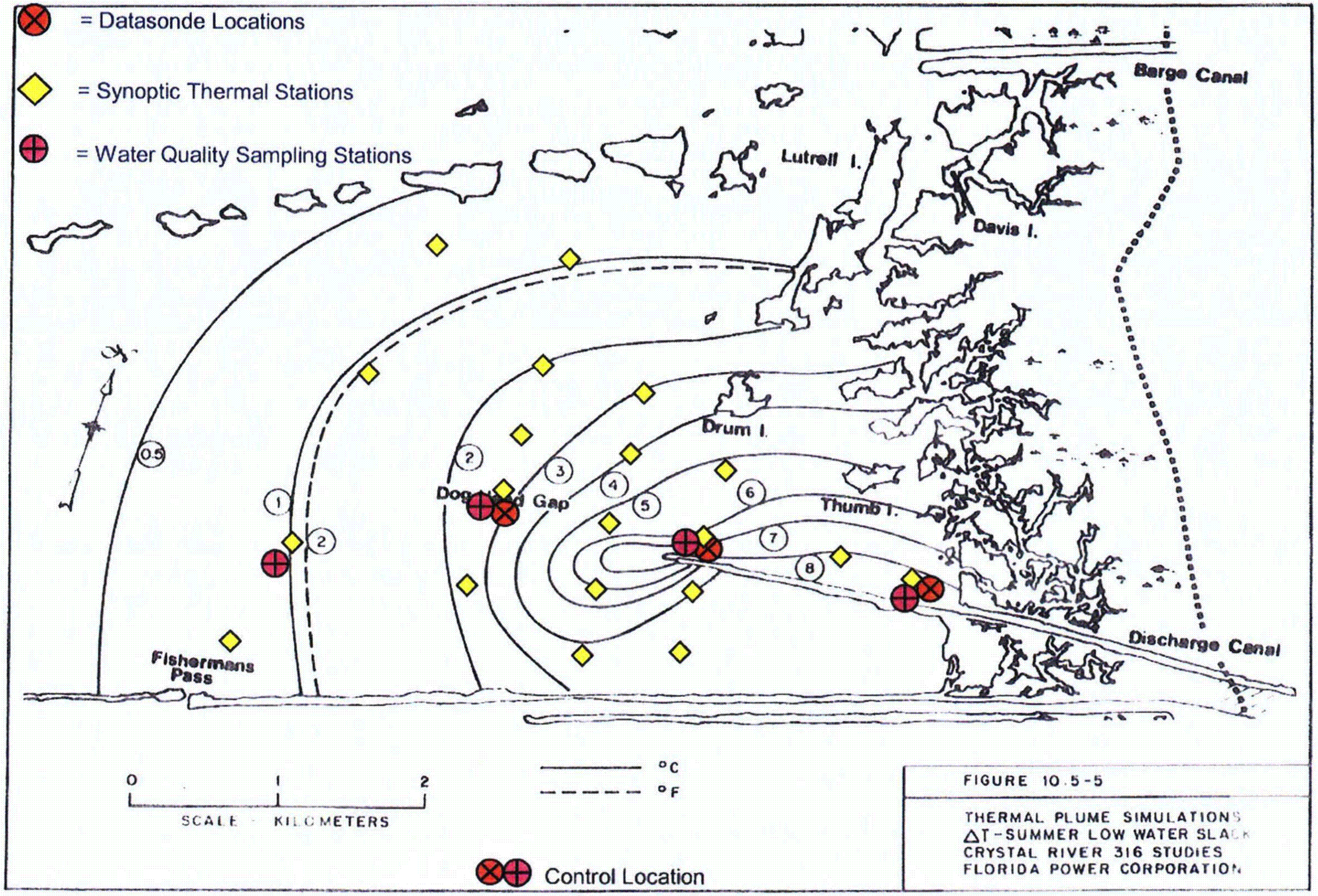


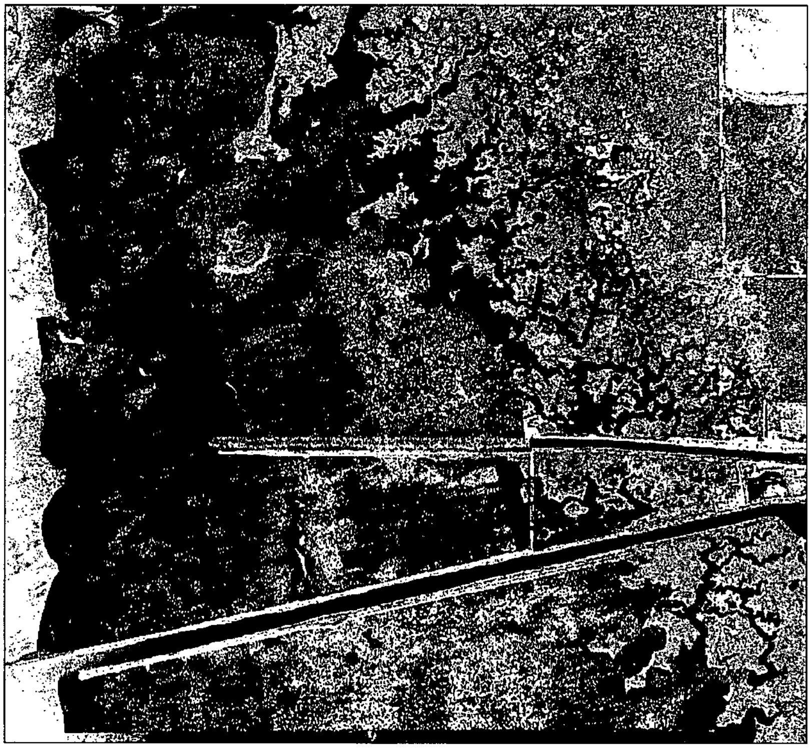

Figure 2.

Proposed Sampling Locations

Figure 3.

# Historical Thermal Plume Profiles





# *Seagrass Quantification Report for the Area Adjacent to the Crystal River Power Generation Facility, Florida*

*Data collected: Nov-Dec, 2007*
*Report: Apr 24, 2008*

**Prepared for:**
**Progress Energy Florida, Inc.**
**515 Independence Highway**
**Inverness, FL 34453**


Prepared by:

ReMetrix

11550 N. Meridian, Suite 600
Carmel, IN 46032
317-428-4591

## Table of Contents

## A. Introduction/Project Goals

Progress Energy is a power generating facility that discharges coolant water into a marine costal area containing submerged aquatic vegetation (SAV). The purpose of this study was to estimate the area covered by various species of seagrass, various species of macro algae, and areas with no plant cover, and to compare these results, if possible, to the conclusions of previous studies done in the same area from previous years.

To address these goals, ReMetrix employed several methods of data collection including hydroacoustic transect sampling, point-intercept rake sampling, SCUBA diver random point surveys, and several underwater video random samples. Each method had unique advantages and limitations, but each contributed to an accurate overall estimation of SAV.

## B. Study Area Description

The study area encompassed 3,522 acres although 688 acres were inaccessible due to oyster beds, shoals, or very shallow water. A total of 2,842 acres was analyzed for SAV cover. The area had many challenging navigational obstacles such as, sensitive vegetation and corals, shoals, oyster beds, shallow water areas, and manatee. Other challenges of this study area included tide fluctuations greater than three feet, areas with high winds, and water with low visibility.

During data collection, there were several manatee, dolphin and stingray sightings. The majority of these sightings occurred in the area labeled  on the map.

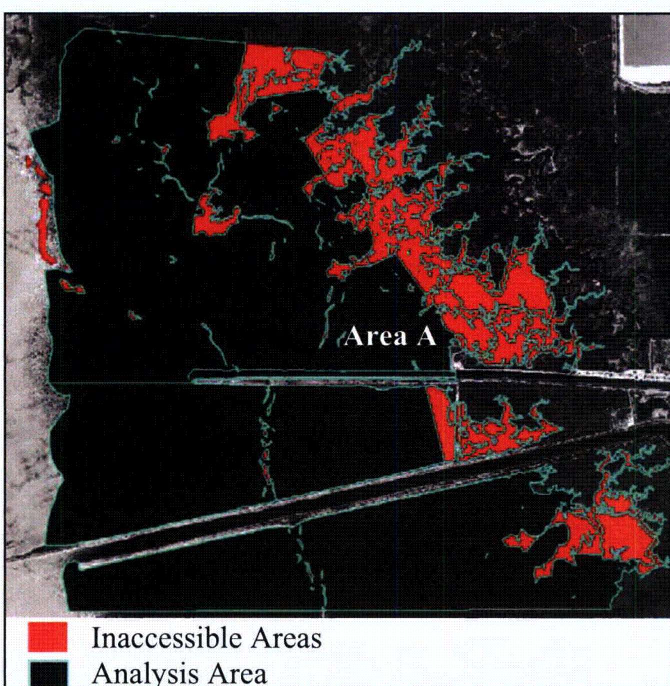



Figure 1. The area surrounded by the teal line represents the study area for this project.

## C. Water Quality Sampling

Water quality information was collected at five of the ten diver sites at the same time the diver was in the water. Two sites representative of the average depths found throughout the study area were monitored every other day for the remainder of the study period. Five parameters were collected : water temperature, salinity, turbidity, light transmittance, and water depth.

Water temperature and salinity were measured using a YSI 556 multi-probe system (www.ysilifesciences.com, Figure 2a), turbidity was measured using a LaMotte 2020e portable turbidity meter (www.lamotte.com, Figure 2b); all three measurements were taken 1 foot below the water surface. Light transmittance was measured using a Secchi disk (Figure 2c) and water depth was measured by using a graduated lead line (Figure 2d). Table 1 below shows the breakout of water quality monitoring sites by depth. The full dataset of water quality information can be found in the Appendix.

Table 1. Water Quality Monitoring Sites

| Water depth range (meters) | WQ sites sampled |
|---|---|
| 0.5-1.5 | 1* |
| 1.5-2 | 1* |
| 2-3 | 1* |
| 3-4 | 1* |
| 4-5 | 1* |
| **Total** | **5*** |

*Sites were sampled every other day throughout the data collection period.

Figure 2a. YSI 556 multi-probe system.


Figure 2b. LaMotte 2020c turbidity meter.

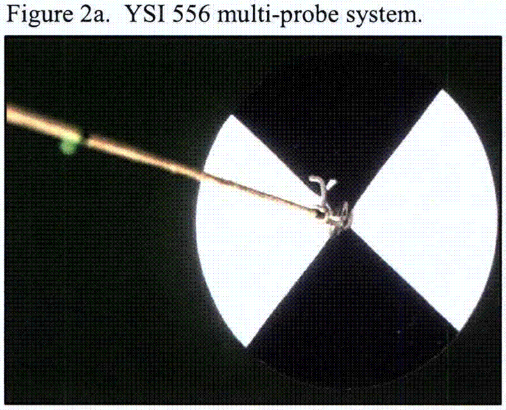


Figure 2c. Secchi disk

Figure 2d. Graduated lead line

## D. Hydroacoustic Methodology (Background)

Hydroacoustic data is collected using a digital 420kH BioSonics (www.biosonicsinc.com) transducer mounted on a boat actively linked to DGPS. Transects are driven across the study area while the transducer pings the water column approximately five-to-ten times per second. The data from each ping are linked to a geographic coordinate via the DGPS beacon. Figure 3a depicts this process.

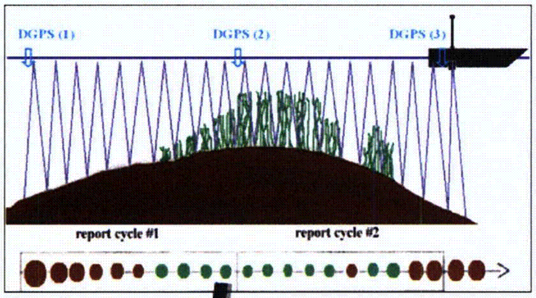



Figure 3a.

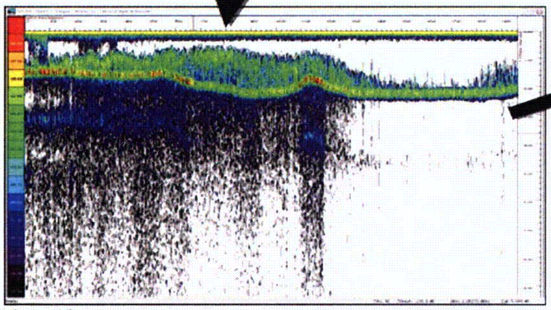


Figure 3b.

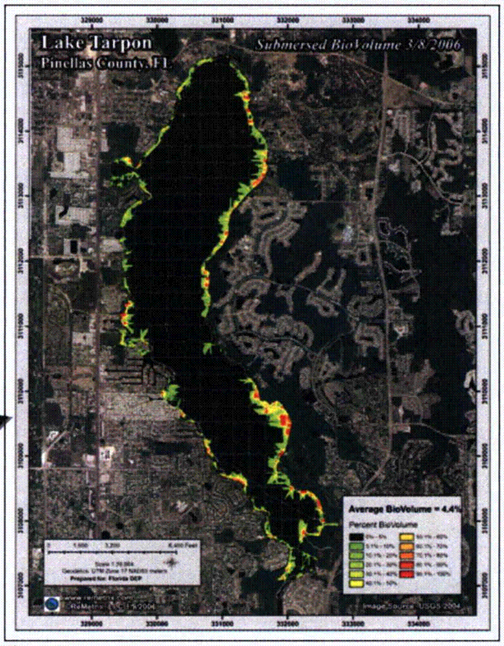



Figure 3c.

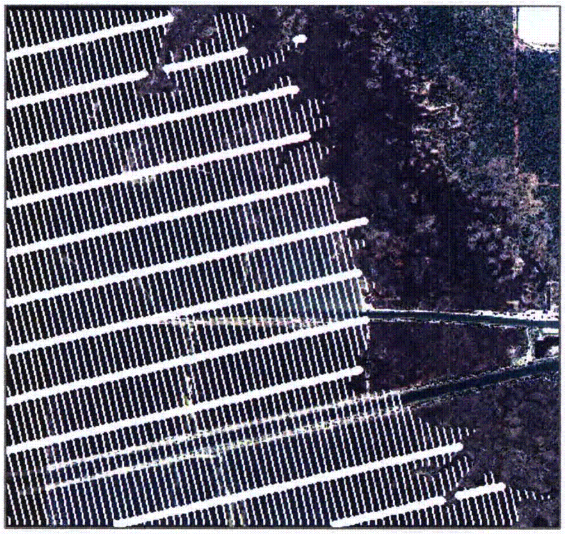
Figures 3a-c. General depiction of the hydroacoustic mapping process. See text for explanations.

The data from each ping contains submerged plant cover and height information as well as the depth to the sediment layer. BioSonics Inc, testing indicates that the hydroacoustic system returns digital samples with greater than 0.013% accuracy every 1.8 centimeters. Figure 3b (above) shows an example of raw acoustic data collected along a sample transect.

Raw acoustic data are processed to filter out noise and calculate statistics, and then exported for viewing in a geographic information system (GIS). Data from all transects is combined in GIS and modeled using a geostatistical GIS extension to produce a vegetative cover estimate, (biocover) maps for the entire study area. Biocover is an estimate of the percentage of the bottom covered with plants. Figure 3c above shows a whole-site biocover model.

ReMetrix collected data from crossing transects oriented WSW to ENE spaced 400-meters apart and SSE to NNW spaced 60-meters apart. This totaled approximately 140 miles of transects collected over the 2,842-acre site. Figure 4 represents the proposed crossing transects used for hydroacoustic sampling of this site.

Figure 4. Crossing transects planned for hydroacoustic data collection totaled approximately 140-miles within the 2,842-acre study area. Closely spaced transects (oriented roughly north-south) were 60-meters apart, and widely spaced transects (oriented roughly east-west) were 400-meters apart.



## E. Species Sampling Methodology

Hydroacoustic vegetation sampling alone cannot currently explicitly determine species by their acoustic signatures. For this reason, supplemental physical sampling must be used in order to determine species. ReMetrix used three methods for collecting physical samples: rake samples, underwater video and SCUBA diver surveys.

*Rake Sampling Methodology*
In areas deeper than three feet, a physical plant sample was collected by throwing a double-sided thatch rake toward the shoreline at each sampling site. A rake tethered to a 25-foot rope was tossed into the water and allowed to sink until it made contact with the bottom. The rake was then slowly dragged along the bottom back toward the boat, (Figure 5a).

In areas shallower than three feet, a rake with a handle was dipped into the water until it made contact with the bottom. Steady pressure was put on the rake handle as it was scraped along the bottom (Figure 5b,c).

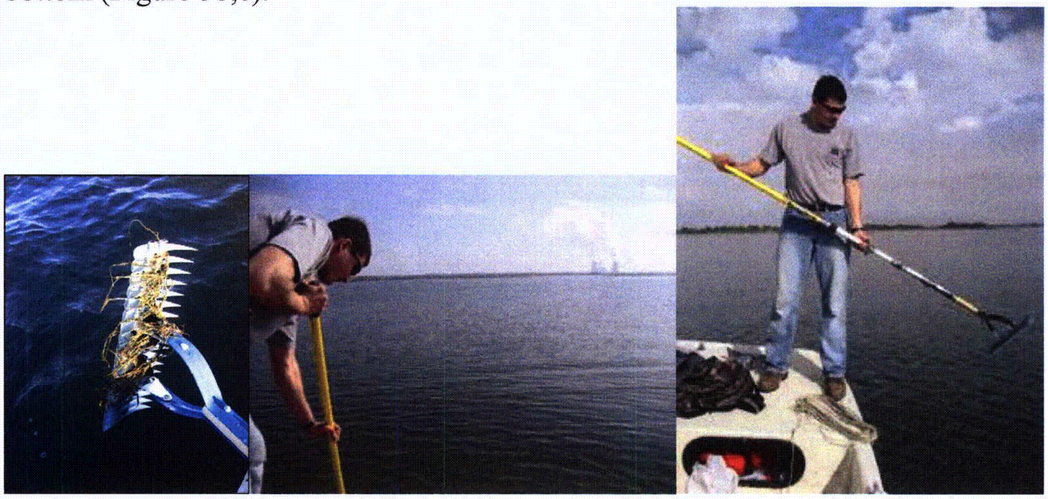


Figure 5a. Figure 5b. Figure 5c.
Figures 5a-c. A double-sided thatch rake was used to sample submerged vegetation at 109 sample points.

At least two rake samples were taken at each of 109 sample points (Figure 6). Ninety-one point-intercept sites were located at hydroacoustic transect crossings and 18 off-transect sites were selected randomly to facilitate biocover model accuracy assessment. The data recorded about each sample included species name, relative abundance, density, and latitude and longitude (Table 2). If no plant was found, then "no plant" was recorded as the species name. Photos were taken at most sampling sites where vegetation was found.

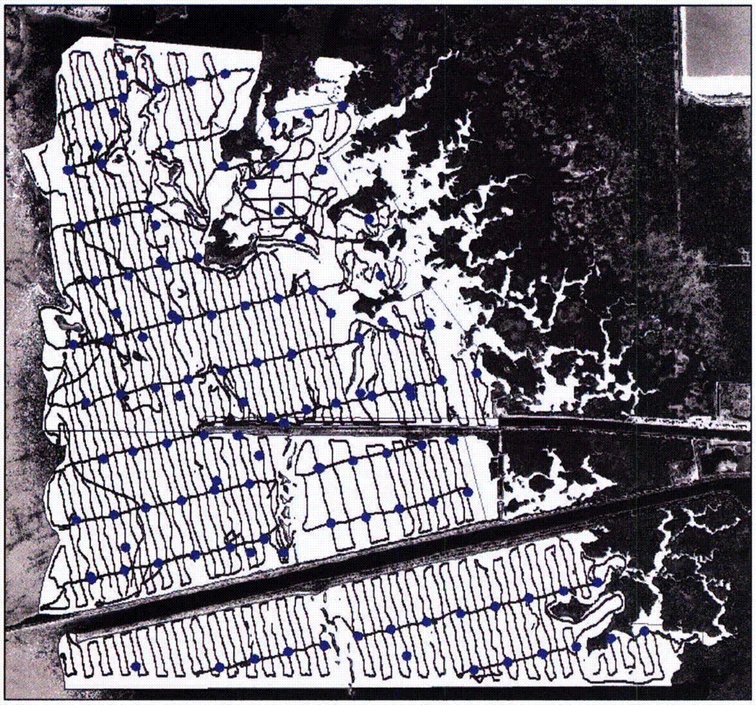


Figure 6. Rake samples were taken at 109 locations (blue points); 91 points were collected at hydroacoustic transect crossings and 18 points were collected off-transects. Point numbers can be found on the Monitoring Sites map in the Appendix.

Relative abundance

Relative abundance is a visual estimation of the proportion of the two rake samples combined for a site that each species represents. For example, if two species were found during a rake sample, one may have represented 75% of the sample and the other may have only represented 25% of the sample. In order to make this estimation quickly in the field, each species' relative abundance was assigned a score placing them in one of five easily discernable ranges. The ranges used in this study are listed in Table 2.

Table 2. Relative abundance scores from two rake samples at each of 109 sample sites were placed into five visually discernable ranges for cover.

| Score | % Cover | Description |
|---|---|---|
| 1 | 100% | Present as ~100% of sample† |
| 2 | 75% | Present as ~75% of sample† |
| 3 | 50% | Present as ~50% of sample† |
| 4 | 25% | Present as ~25% of sample† |
| 5 | 5% | Present as ~5% of sample† or less |

†sample in this context refers to an aggregate of both samples per physical sample site

Density

Density is the percent of the immediate sample area represented by each species. For example, if only a few stems of a plant were pulled up by the rake, the density would be considered sparse. This estimation was made by gently compressing the combined vegetation sample and placing each species onto a one sided garden rake with graduated tines (Figure 7). The relative density of each species was estimated using four categories representative of the percent of the tines each species covered. Table 3 lists the categories and scale used for this estimation.

Figure 7. Species density was estimated by gently compressing the sample onto a one-sided garden rake with graduated tines. The white stripes on the tines mark 20% and 60% of the total tine length.

Table 3. Density scale for species found during rake sampling at each of the 109 sample sites estimated from the percent of the rake tines each species covered.

| Scale | Name | Description |
|---|---|---|
| D | Dense | >60% of rake tines |
| C | Moderate | 20%-60% of rake tines |
| B | Minor | Up to 20% of rake tines |
| A | Sparse | 1-5 stems |

*Video Sampling Methodology*

A video camera specifically designed for underwater use was affixed to a 12-foot long pole and carefully lowered into the water until it was just above the sediment layer. It was then panned around to find vegetation. When vegetation was observed, the camera was maneuvered to a range where the plants could be identified and held stationary for several seconds (Figure 8a). Thirty-one videos where taken at seventeen different random sampling locations (Figure 8b). ReMetrix encountered adverse environmental conditions that yielded mixed results when attempting to use video sampling as a reliable physical sampling method at some sample site locations.


Figure 8a. When vegetation was found, the video camera was maneuvered to a range where plant identification was possible.

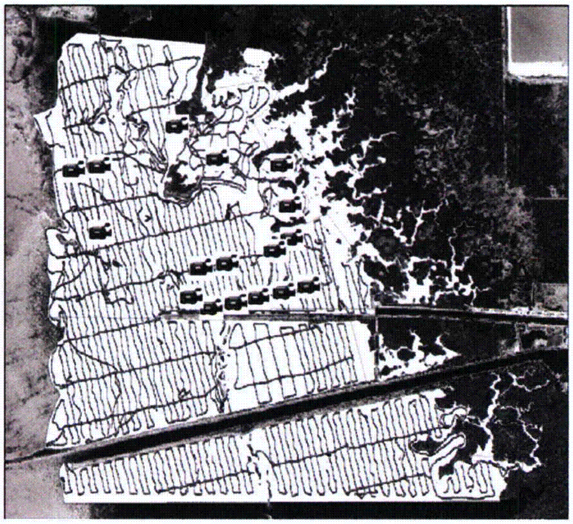


Figure 8b. Thirty-one video clips were made from seventeen random sampling locations (black videocamera symbols), all located north of the discharge canal. Site numbers can be found on the Monitoring Sites map in the Appendix.

*SCUBA Diver Survey Methodology*

To verify the plant type and growing conditions, a SCUBA diver survey was used. Prior to the diver entering the water, a hydroacoustic pass was made over the site, a DGPS point was taken over the specific diver entry site and a water quality sample was taken. Divers then entered the water to locate submerged plant beds, identify vegetative species present, measure plant heights, estimate percent bottom cover, and characterize overall bed density. Ten diver sites were surveyed (Figure 9).

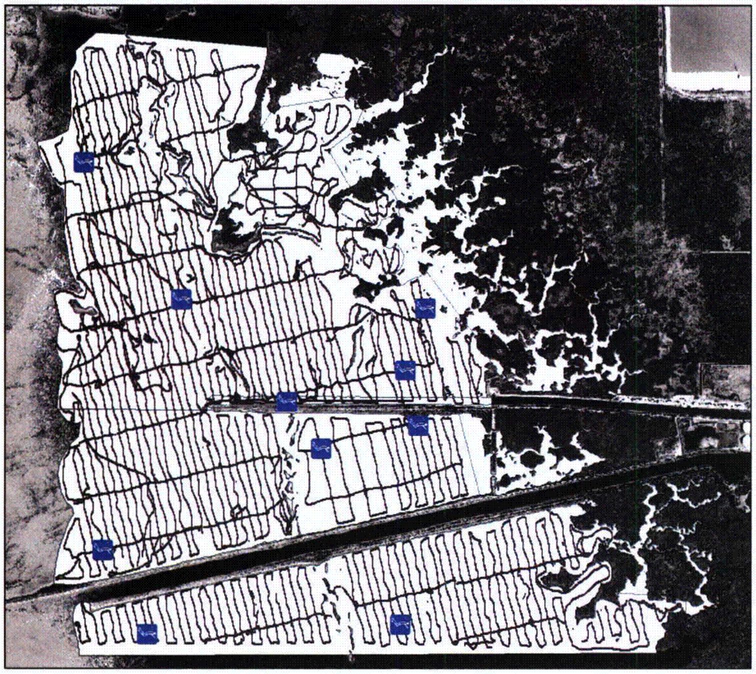


Figure 9. Ten randomly selected SCUBA diver survey points (blue symbols) were sampled between 11/15/2007 and 11/16/2007. Site numbers can be found on the Monitoring Sites map in the Appendix.

Density
Bed density was visually estimated as sparse, low, medium, or high density.

Cover
Percent bottom cover and species composition was measured using the quadrat-cell methodology described by Estevez and Marshal (1995). Once a plant bed was found, a 1-$m^2$ quadrat subdivided into one hundred 100-$cm^2$ cells was positioned two to three meters inside the bed's edge (Figure 10). Species name and number of 100 $cm^2$ cells each species occupied was recorded. A cell was considered populated by a species if at least one rooted stem was found within a cell. The number of populated cells out of 100 is the percent bottom cover for the species. An example of a diver site cover table can be found in Table 4.

Table 4. Genus and number of populated 100 $cm^2$ cells data from a sample diver site.

| | *Halodule* | *Thalassia* | *Caulerpa* spp. | total seagrass | total rooted SAV |
|---|---|---|---|---|---|
| Total count | 30 | 42 | 27 | 51 | 72 |

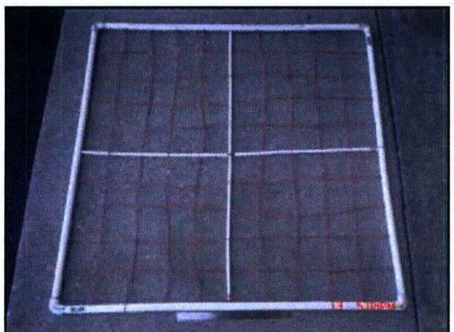


Figure 10. A sub-divided 1-$m^2$ quadrat assisted divers in estimating species cover.

**F. Methodology Discussion**

The goal for each of these methods was to help determine species type and cover. Although each successfully accomplished the goal of determining species presence/absence, they each had unique strengths and challenges.

The most time effective method to determine vegetation presence/absence was hydroacoustics. The challenge to using hydroacoustics is that it does not provide species information.

Diver sites were an excellent way to obtain accurate cover and species type without disturbing the vegetation. The drawback to diver sites was time. Diver surveys were too time consuming to sample the entire study area.

Video sample methods were an excellent way to determine if vegetation was growing on the bottom. It had the advantage of providing species identification and the exact latitude and longitude on screen. It was not as time consuming as a diver site, yet seagrass presence/absence could still be confirmed. The primary challenge with this method was determining the exact species due to cloudy or obscured water conditions. Furthermore, since the area the camera could view was small, there were times when the bottom was scanned for several minutes before any plants were detected.

The rake sample method could successfully capture the species type, relative density, and estimate relative abundance. Additionally, this method could be employed while collecting the hydroacoustics making this the least time consuming of all the methods. Another advantage was photos could be taken to document the species and abundance, which could be linked back to a precise spatial location. The primary challenge involved while sampling with the rake method was retrieving a plant sample from the sediment. The only way to verify if the rake sample was missing vegetation was to check the hydroacoustics. If the hydroacoustics indicated plant while rake samples showed no plant, additional rake samples were attempted. Certain seagrass species were missed by rake sampling simply due to plant physiology. Long narrow leaf blades, dense root mats and un-branched structure allowed the rake to "comb" through sparsely populated seagrass stands rather than hooking or snagging the vegetation. For sites where this was true, vegetation was typically pulled up by the anchor, which dug into the soil like a shovel (Figure 11). Anchor samples were recorded as rake samples when these situations arose.

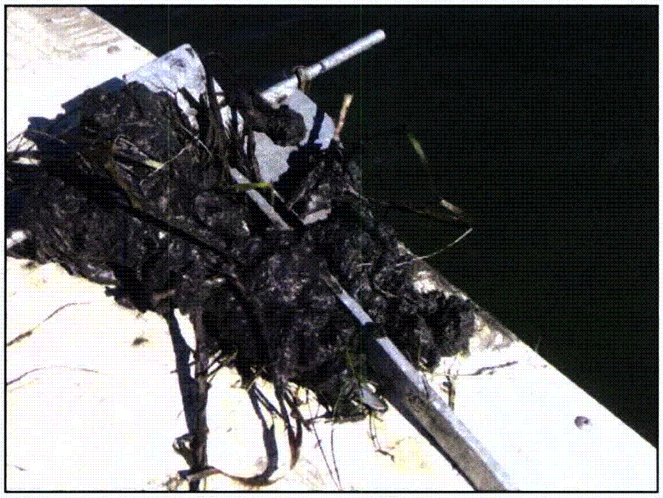


Figure 11. The anchor would occasionally capture vegetation samples in seagrass beds when rake sampling did not.

## G. Data Analysis

In order to calculate the area of the project and define an extent for all the data, a study area polygon was created by tracing the water-land interface. This interface was based on digital ortho-rectified quarter-quadrangle (DOQQ) imagery dated 2004 and obtained from the USGS seamless data website (http://seamless.usgs.gov). Islands and obstructions were also isolated from the analysis area in a similar manor. The hydroacoustic data were processed though software that analyzes the return signature to determine the percent biocover.

*Continuous and Dot-Density Representations*
After processing the hydroacoustic data, spatial data models were made to estimate biocover by interpolating between measured hydroacoustic samples and unsampled areas (Figures 12a and 12b). Both figures communicate slightly different informational contexts about estimated biocover, so both figures are included for discussion. Figure 12a shows the biocover model as a continuous surface, with color gradations indicating the percent biocover at each given location. A continuous biocover surface is the typical map output because the model estimates biocover

values for all geographic space between data transects. However, the seagrass and macroalgae beds within this study area typically occur as patchy cover, not large contiguous beds. For that reason, Figure 12b was created to more intuitively communicate the patchy nature of the beds. Figure 12b shows the exact same biocover model as seen in Figure 12a, but shows it as a gradational dot-density surface instead. Areas of high percentage biocover (reds and oranges on the map) have dots (a.k.a., "beds") spaced very closely together, as one might expect to naturally observe in a high biocover area. Areas of lower percentage biocover (yellows and greens) have dots (beds) spaced further apart, as one might expect to naturally observe in a low biocover area. It is important to note that the coverage statistics for both types of maps are the same; only the display techniques are different. Other figures using the dot-density technique are included in the Appendix.

After the model was completed, assessments for model accuracy were conducted by checking the model against rake samples, diver surveys, and video samples to calculate errors of omission and commission (see Section H).

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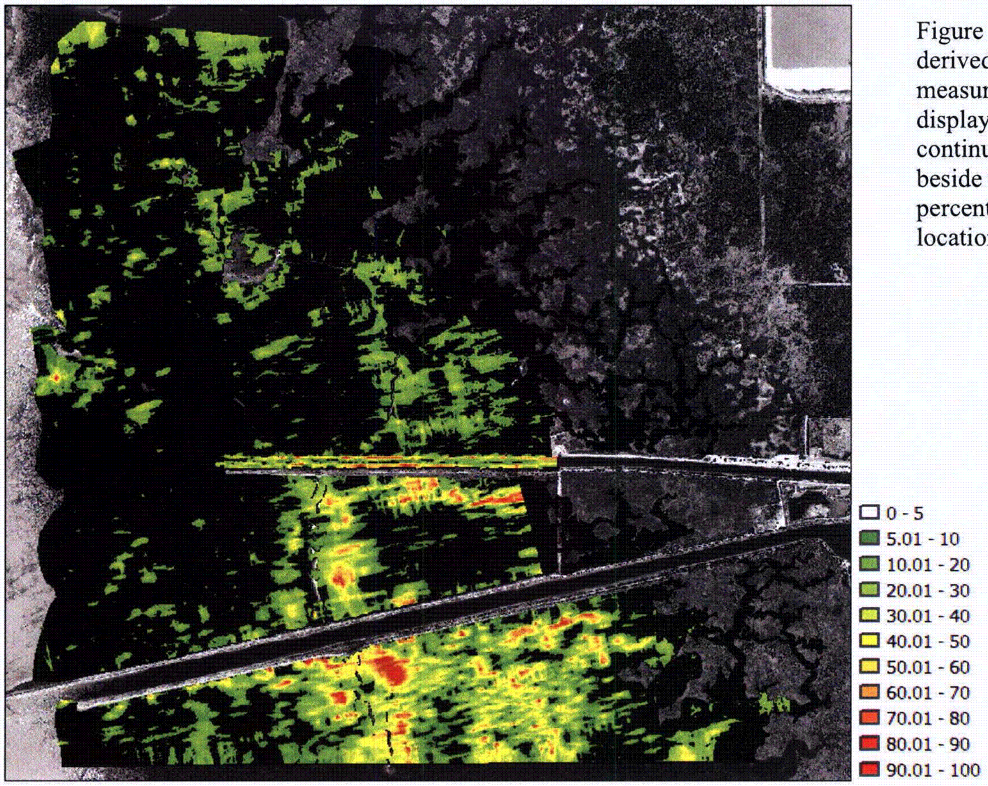


Figure 12a. BioCover model derived from hydroacoustic measures of vegetative cover, displayed as a gradational continuous surface (the legend beside the figure indicates percent biocover at a given location).

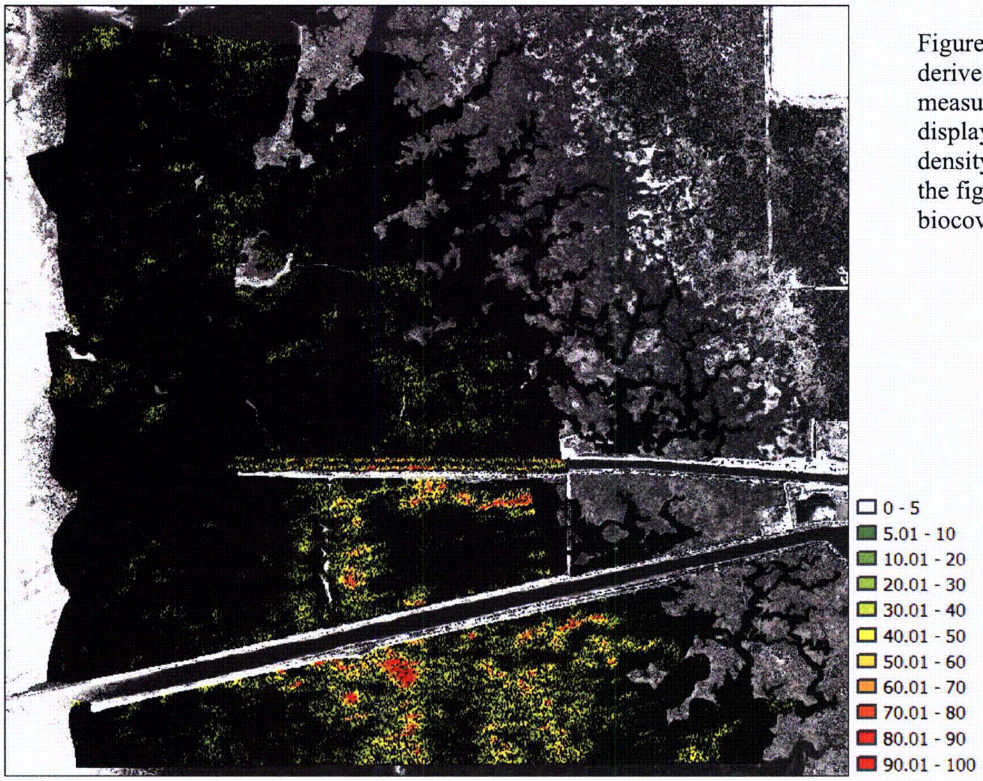


Figure 12b. BioCover model derived from hydroacoustic measures of vegetative cover, displayed as a gradational dot-density surface (the legend beside the figure indicates percent biocover at a given location).

*Endpoints of Noise Threshold Settings*
A patented software algorithm is used to interpret the amount of submerged vegetation along each hydroacoustic transect. Examples of this process can be seen in the figures labeled "Transect Line 2007*x*" found in Appendix (these show the raw transect data with corresponding interpretations). Noise threshold settings influence how conservatively the algorithm filters noise within the hydroacoustic signal responses. The noise threshold settings are based on established ranges and can be adjusted by the data analyst during data processing. As processing proceeds, the data analyst compares the amount of submerged vegetation interpreted by the algorithm with visual inspection of raw transect data and other field data types. Noise threshold settings are considered acceptable when the data types are in agreement.

For any project, noise threshold settings can fall within an acceptable range based on a variety of environmental and physical factors related to the data collection (e.g., surface noise during data collection, water depth, physical structure and density of the target vegetation, etc.). The acceptable noise threshold settings in this project fell within a small range primarily due to the short, spindly nature of the seagrass blades. The endpoints of the acceptable range are termed 'conservative' settings and 'less conservative' settings. The data models obtained using results within the acceptable range are considered by ReMetrix to be realistic models of the actual submerged vegetation cover in the project area. For that reason, cover models produced from each endpoint of the acceptable range are provided for comparison in Figures 13a ('conservative' thresholds) and 13b ('less conservative' thresholds).

The total biocover for the conservative noise threshold settings is 7.6%. The total biocover for the less conservative noise threshold settings is 10.4%. Table 7 in Section I provides greater detail of specific biocover types for the threshold endpoints.

The total biocover results obtained by the conservative noise threshold settings are used in the statistical calculations discussed in Section H and elsewhere in this report, unless noted otherwise.

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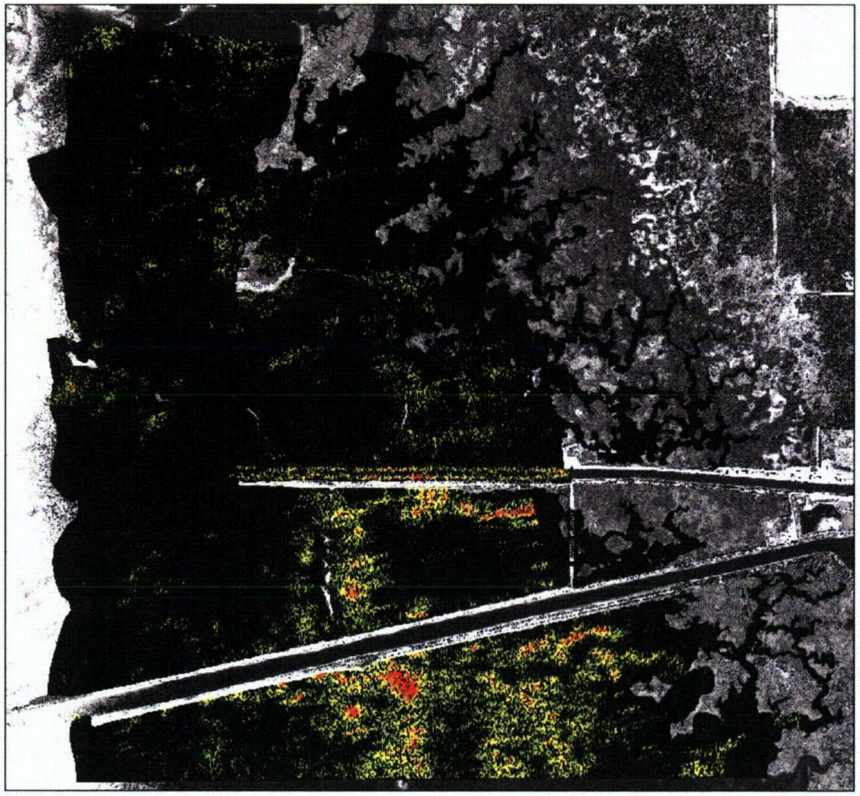


Figure 13a. Map showing the ‘conservative’ interpretation of total biocover (7.6%) within the project area. (See above section for explanation.)

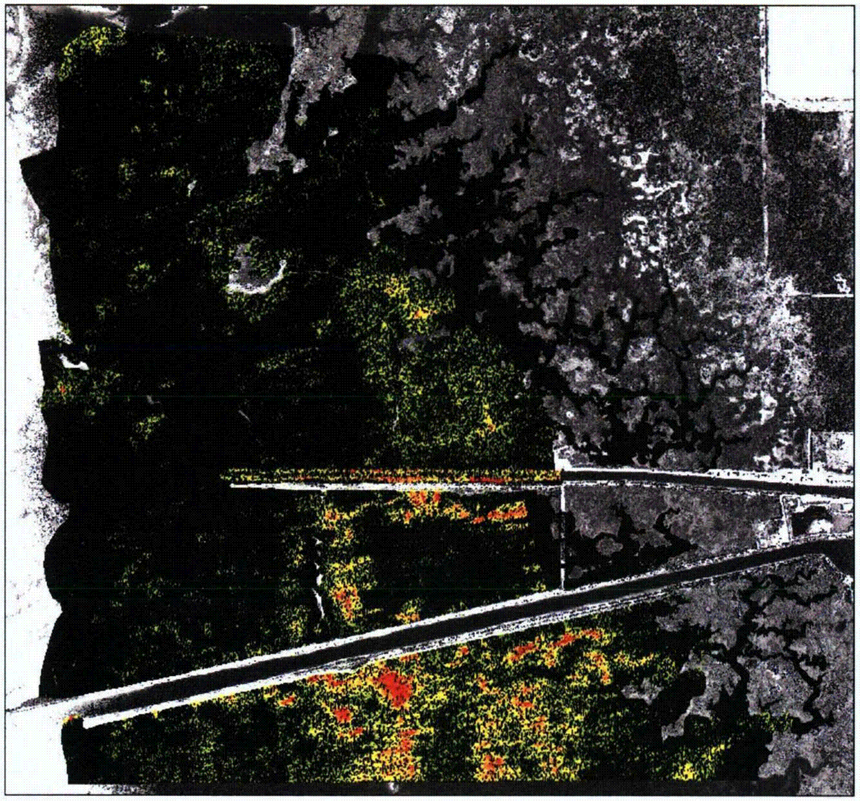


Figure 13b. Map showing the ‘less conservative’ interpretation of total biocover (10.4%) within the project area. (See above section for explanation.)

## H. Accuracy Assessment of the Model

Typical measures for error in models are *omission* and *commission* error. These measures estimate how well a model correlates with actual sample data at the same location. For this analysis, ReMetrix compared all three types of physical sampling results (both as a whole and individually) to the biocover model derived from hydroacoustic transect data as a means for determining model correlation.

We used two 'classes' to develop the error estimate: '*plant*', for where a rake sample or biocover model indicated plant was present, or '*no plant*', where a rake sample or biocover model indicated no plants were present. As a means for explaining a particularly difficult concept we will follow just one comparison through the description, however error was calculated for both 'classes' and both types of error. In the following example, we will use 'plant' rake samples and 'no plant' areas in the model.

Calculating omission error: Of all the physical sampling points indicating plant was found, what proportion of these points lie within a 'no plant' area in the model? In this scenario, a high omission error suggests that the model could be underestimating the amount of plant that is truly present at that location.

Calculating commission error: Of all physical sampling points ('plant' or 'no plant') that lie within a 'no plant' area in the model, what proportion are 'plant' physical sample points? In this scenario, a high commission error suggests that the model could be overestimating the amount of 'no plant' that is truly present at that location.

Table 5 shows omission and commission errors of the model compared to all physical sampling methods combined. The higher 'no plant' omission error would suggest the model may not account for all the non-plant areas that were actually present, however some factors should be taken into consideration. Rake samples were taken from the bow of the boat while the hydroacoustic equipment and GPS antenna were located near the stern of the boat (approximately 18-feet of separation). The typical rake sample was made approximately 20-feet away from the boat. Combining these two distances results in a margin of error up to 38-feet between the nearest hydroacoustic point and the site of rake collection (depending upon the orientation of the boat and the actual rake sample distance at each site). Additionally, the boat may have drifted with currents while video of the bottom was taken so the actual position of the GPS antenna may have not coincided precisely with the location of the video sample or the hydroacoustic sample. Similarly, divers did not necessarily remain directly under the boat (or GPS antenna) while counting plants and therefore diver reference points may not directly relate to hydroacoustic estimates. These positional errors can account for a majority of the error when evaluating the omission and commission statistics (Table 6).

Table 5. Study area-wide BioCover model accuracy estimate without consideration of positional error (38-feet) due to GPS antenna location on the boat relative to the physical sampling location.

| | | | Raster Classification | |
|---|---|---|---|---|
| | | omission error ↓ | plant | no plant |
| All physical samples | plant | 17% | 62 | 13 |
| | no plant | 62% | 36 | 22 |
| | | commission error → | 37% | 37% |

Table 6. Study area-wide BioCover model accuracy estimate after consideration of positional error (38 feet) due to GPS antenna location on the boat relative to the physical sampling location.

| | | | Raster Classification | |
|---|---|---|---|---|
| | | omission error ↓ | plant | no plant |
| All physical samples | plant | 0% | 75 | 0 |
| | no plant | 62% | 36 | 22 |
| | | commission error → | 32% | 0% |

The patchiness or randomness of aquatic vegetation beds, and the characteristics of very low-density vegetation might explain the remaining error. A majority of the areas where the model indicated there was "plant" but physical sampling indicated "no plant" occurred in areas of very low-density vegetation (69% in < 5% cover, 86% in < 10% cover), where the probability of a physical sampling method contacting vegetation was low. No adjustments were made to the model for these areas since the number of hydroacoustic samples (1,116,900) vastly out-numbers the number of physical samples (139 total). After reviewing the hydroacoustic data for many of these areas, ReMetrix confirmed that these zones have low-density plant populations where a limited number of physical samples may have easily missed patchy or sparsely populated plant beds.

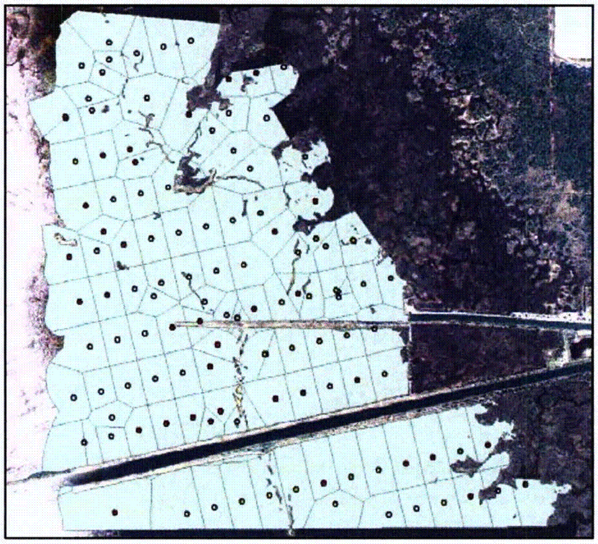
Results of additional error estimates comparing each physical sampling method individually can be found in the Appendix.

## I. Vegetation Area Determination

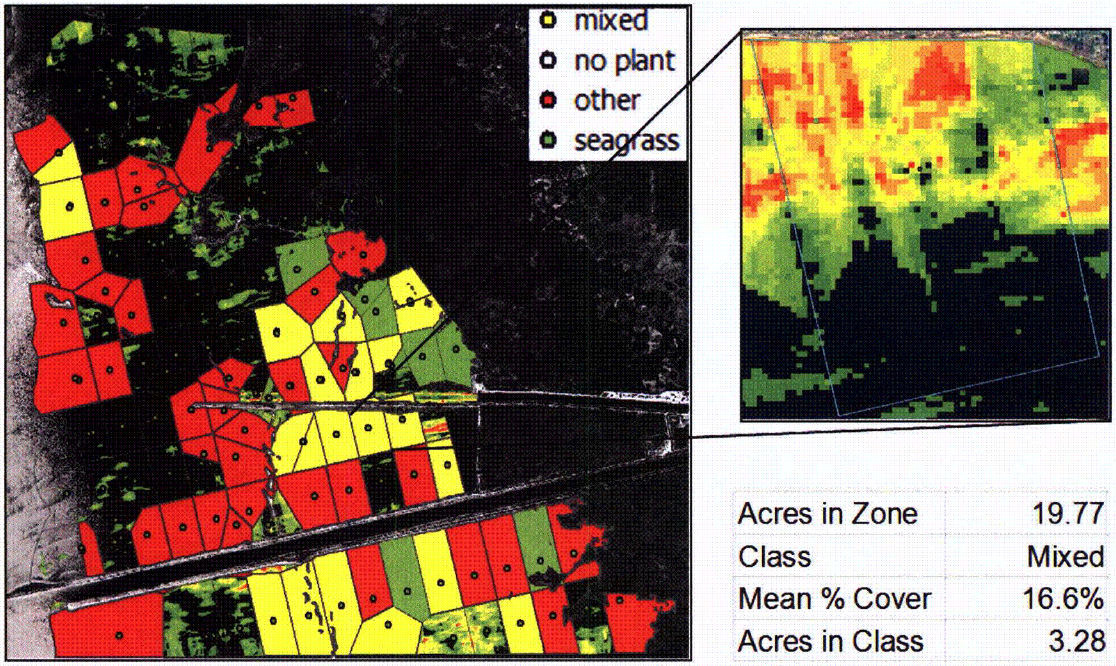
The overarching goal of this project was to determine the number of acres of seagrass. Using the physical samples as a guide, ReMetrix separated vegetated areas in the study area into four classes: seagrass, other, mixed and no plant. Sample sites where *Halodule spp., Syringodium filiforme, Thalassia testudinum,* or *Halophila engelmannii* were found exclusively were placed in the 'seagrass' class. Sample sites where vegetation other than seagrass, e.g. *Caulerpa* or *Udotea*, was found exclusively were classed as 'other'. Sites where both seagrass and other species were found together were classified as 'mixed', and sites where no plants were collected during the rake sample, diver survey, or video sample, were placed into the 'no plant' class.

The second step in this process was to divide the study area into zones which could be labeled one of the four predefined classes. Zone boundaries were made using a method called Thiessen polygons. Thiessen polygons are mathematically defined by the intersections of perpendicular bisectors of the lines between all the sampling sites (Figure 14). Each zone was assigned the class of its corresponding sample site's classification, and the area of vegetation within that zone was calculated.

Figure 14. The study area was divided into Thiessen-polygon-defined zones based upon the spatial location of the sampling sites.



The percent cover within each zone was calculated from the biocover map derived from the hydroacoustic sampling method. The product of the zone area and the mean percent cover within that zone returns the number of acres of vegetation in that zone. Figure 15 shows an example of one zone with tabulated results.




| | |
|---|---|
| Acres in Zone | 19.77 |
| Class | Mixed |
| Mean % Cover | 16.6% |
| Acres in Class | 3.28 |

Figure 15. Acres of vegetation in a class were calculated from the area of the zone and the mean percent biocover from the hydroacoustic model.

Acres of each vegetation class by zone were summed to determine the number of acres of seagrass, other, mixed, and no plant classes (Table 7).

Table 7. Vegetation class areas were summed from the acres in class calculated in each zone and percent of the total project acreage was calculated.

Conservative Noise Threshold

| Category | Acres | Percent Total Area |
|---|---|---|
| **seagrass** | **16** | **0.56%** |
| **mixed** | **81** | **2.85%** |
| *seagrass* | *46* | *1.62%* |
| *other* | *35* | *1.23%* |
| **other** | **65** | **2.29%** |
| **unclassified** | **58** | **2.04%** |
| **No plant** | **2622** | **92.26%** |
| **Total Area** | **2842** | |

Less Conservative Noise Threshold

| Category | Acres | Percent Total Area |
|---|---|---|
| **seagrass** | **27** | **0.95%** |
| **mixed** | **101** | **3.55%** |
| *seagrass* | *58* | *2.04%* |
| *other* | *43* | *1.51%* |
| **other** | **85** | **2.99%** |
| **unclassified** | **80** | **2.81%** |
| **no plant** | **2549** | **89.70%** |
| **Total Area** | **2842** | |

It was possible to subdivide the 'mixed' class acres into percent 'seagrass' and 'other' since relative abundance of individual species was recorded. The product of the area of a mixed zone and the corresponding relative abundance for each species yielded the acres of each class (seagrass and other). The model indicated plants were present in a number of 'no plant' zones. Acres of vegetation found within a no plant zone were assigned to a new class named 'unclassified'. The unclassified acreage represented 29% of the total vegetated area so it is important to understand where these unclassified zones occurred. Fifty percent of the unclassified vegetation occurred in just 10% of the no plant classified zones. This means the bulk of the unclassified data occurred in a relatively small number of zones. All six of these zones were surrounded by zones of a defined vegetation type. Based on the classification of adjoining zones, many were likely mixed stands of seagrass (Figure 16). Most likely, the rake sampling was not representative of the whole zone.

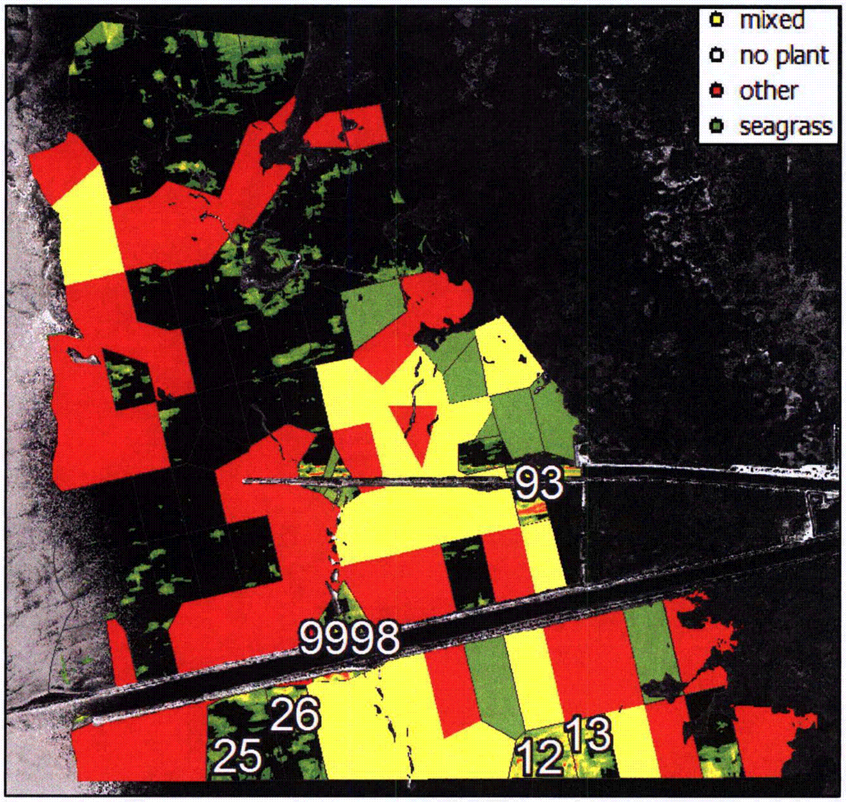


Figure 16. The six 'no plant' zones showing high vegetative cover were most likely 'mixed' zones where a physical sampling method was unable to locate vegetation.

## J. Comparison to Previous Work

Broad comparisons were made between 2007 data and the transect data reported in Marshall (2001). The data from 2001 was loaded into a GIS and transects were drawn between the sampling points. Average biocover was calculated from the current model along the 2001 transects in an attempt to compare the same areas. Average cover was tabulated for both 2001 and 2007 (Table 8). There could be several reasons the 2007 results were lower than the 2001 results. First, 2007 data were not sampled along the exact same transects, rather they were based on a segment laid over a model of hydroacoustic data. Both transects 2a and 3w each had two data points that were more than 50 meters from any 2007 sampling locations.

Table 8. Comparisons were made for average cover between 2001 and 2007 along similar transect lines.

| Name | 2001 Mean | 2007 Mean |
|---|---|---|
| 1N | 32.09 | 6.01 |
| 1W | 46 | 1.70 |
| 2a | 20.25 | 0.15 |
| 2W | 39.19 | 4.90 |
| 3W | 34.52 | 4.83 |
| 4W | 5.28 | 3.04 |
| 5W | 0.25 | 1.66 |

Another concern when comparing these two sample methods is simply the difference in the sampling methodology used to calculate cover. Comparing quadrats sampled along a transect to a model derived from hydroacoustic transect sampling should be done with careful consideration of how each method calculates percent cover. The 2001 quadrat method estimated plant cover as 1% per 100 $cm^2$, even if it was very sparsely distributed and repeated every 100 meters along the transect. A transect's average biocover was then calculated by averaging over all cover estimates for that transect. Hydroacoustic sampling records 10 pings per second of plant or no plant and computes an average across 10 pings to make one sample estimate of biocover. This equals one sample per second or roughly one sample per 2.5 meters. These samples are then used to create a model, thereby interpolating a 5-meter grid between samples in all directions. As a example, we investigated video point 9992 located less than 300 ft from a 2001 reported sampling location along transect 4w (Figure 17). The 2001 sample listed *Halodule* at 86% cover, while the 2007 model estimated it at 11% cover.

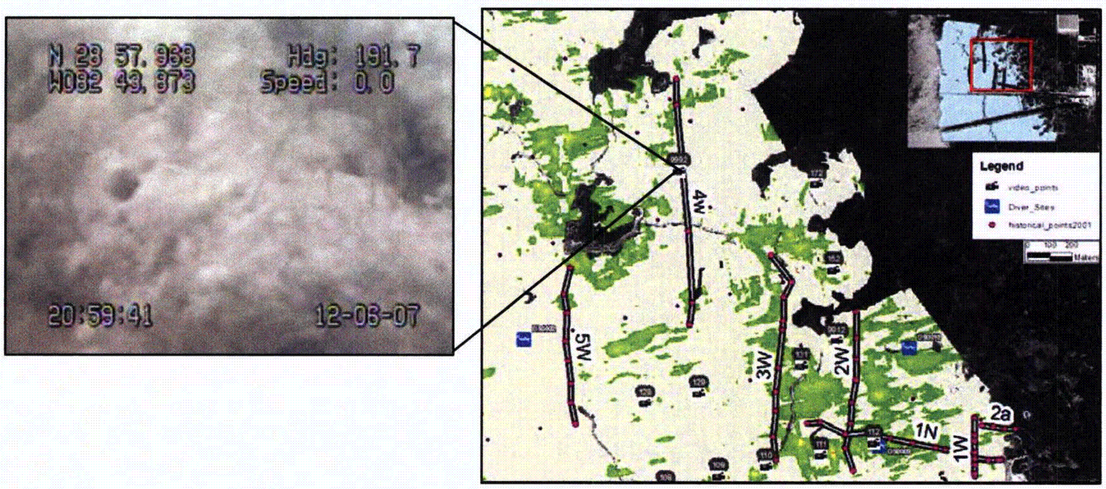



Figure 17. Screen capture of digital underwater video sample (left) showing sparse vegetative cover, with corresponding sample location (right).

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The following illustration (Figure 18) may describe why the average cover comparison from 2001 to 2007 differs so greatly. In the following diagram, a green cell represents a 'plant' cell.

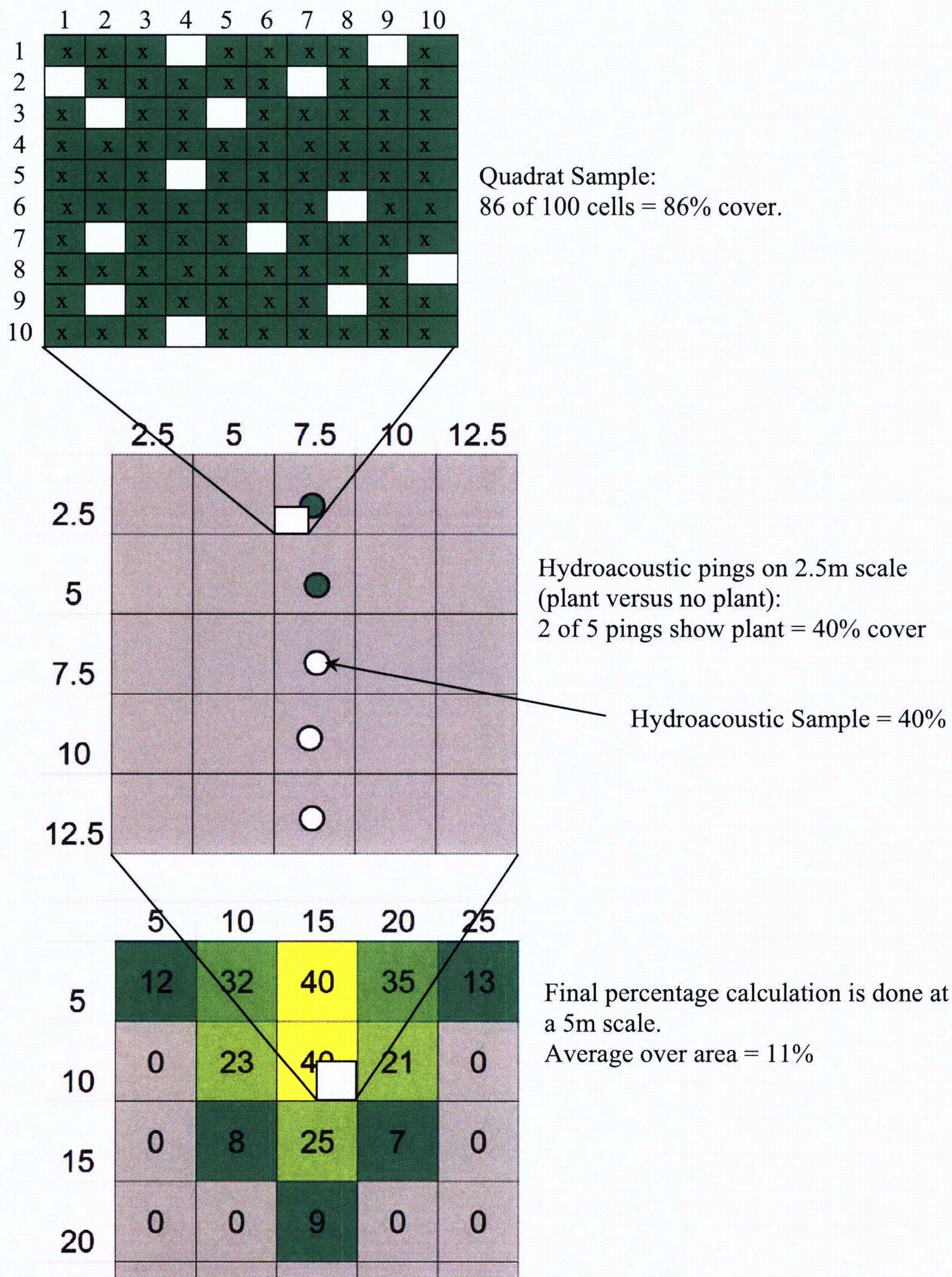


Figure 18 (whole page). Comparison of scales for different data collection methods.

Furthermore, transects 1W, 1N, 3W, and 4W don't appear to be sampled on 100-meter intervals. This indicates there may have been some post-directed sampling used for the 2001 data, which may have greatly influenced the average cover for the transect.

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Marshall, M.J., 2001. *Seagrass Survey: November 2001 Resurvey at the Florida Power Crystal River Generating Facility*, Coastal Seas Consortium, Inc., Bradenton, FL, 19 p.