Quarterly Report 1

(Deliverable 3)

Bioavailability and Sources of Nutrients and the Linkages to Nuisance Drift Algae

Prepared for

The City of Sanibel in Partnership with Lee County

800 Dunlop Road
Sanibel, Florida 33957

[1]Ai Ning Loh, [2]Larry Brand, [1]David Ceilley, [1]Edwin Everham, [1]David Fugate, [3]Eric Milbrandt, [1]Michael Parsons

[1]College of Arts and Sciences, Florida Gulf Coast University, Fort Myers, Florida
[2]Miami, Florida
[3]Sanibel-Captiva Conservation Foundation, Sanibel, Florida

October 2008

Contents

Contents……..1
Introduction……..……..2
Objectives……...……2
Project Initiation…….3
Work Plan Implementation…….4
Objective 1……..4
Objective 2……..……....5
Objective 3……..……....6
Objective 4……..……6
Objective 5……..……7
Objective 6……10
Objective 7……11
Objective 8……11
Planned Activities……12
Tables, Figures and Attachments

Introduction

Eutrophication of estuaries with nutrients from urban and agricultural sources is both a local problem for the Caloosahatchee estuary and for most estuaries worldwide. Beginning in the winter of 2003-2004, unusually large masses of drift red macroalgae accumulated on Sanibel Island, and then later in Bonita Springs and Fort Myers Beach. In addition, enriched nutrient concentrations (~10 fold) were found in 2005 associated with large freshwater discharge events. Concentrations at offshore reefs, however, were only 2-3 times enriched, suggesting that there was substantial absorption and cycling of nutrients en route to offshore locations. The sources of available nutrients and their role in producing large-scale macroalgae blooms on Sanibel Island and the waters of Lee County, Florida are the focus of this study, which integrates hydroacoustic surveys with bioassays, *in situ* and macroalgae surveys, stable isotope analyses, and a hydrologic model. Sampling is being conducted from the C-43 canal downstream of Lake Okeechobee, the upper, middle and lower tidal Caloosahatchee River, and the coastal waters (25 km) from Redfish pass to Wiggins pass. This broad geographic area represents a hypothesized gradient of nutrients and algal biomass downstream and away from the mouth of the Caloosahatchee Estuary.

Objectives

The sources of bioavailable nutrients and their role in producing large scale macroalgae blooms on Sanibel Island and the waters of Lee County, FL is the focus of this study. The following are the objectives of this study.

1. To determine whether Lake Okeechobee or basin sources are more important to algal biomass and productivity with an emphasis on those associated with organic and benthic nutrient sources.

2. To determine if benthic nutrient flux derived from degradation of organic matter is a significant contributor to harmful algal blooms.

3. To determine the submarine groundwater flux of nutrients to coastal waters.

4. To determine the distribution of macroalgal biomass using underwater video and hydroacoustic survey.

5. To determine the distribution and productivity of attached macroalgal biomass and the conditions that are favorable for uncontrolled growth, including the examination of substrate attachment.

6. To determine the ecological consequences of the accumulation of nuisance algal biomass by measuring the decomposition rates and nutrient recycling on area beaches.

7. To verify and calibrate the CH3D-IMS hydrodynamic model for the system to address the potential fate of nutrients that are generated and exported from the Caloosahatchee River and the fate of detached macroalgae as they enter the near shore waters around Sanibel Island and to the develop a sediment transport model and implement the coupled sediment and hydrodynamic model for the same time periods as the hydrodynamic model.

8. To develop a water quality computer model of the West Florida Shelf (WFS) in the Ft Myers region that can be used in future work to help guide nutrient reduction strategies for the management of harmful algal blooms.

9. To provide critical management tools to more accurately predict the fate and transport of nuisance algal blooms on area beaches.

Project Initiation *(completed)*

Logistical preparations and planning as well as the execution of subcontracts were completed during the project initiation. Logistical preparations included the hiring of personnel (full time technicians and part-time undergraduate student interns and graduate students), ordering of materials and fabrication and setting up of sampling and experimental gear. Planning activities include logistic meetings, training sessions and the coordination of all field efforts. Detailed reports on these were included in Deliverables 1 and 2.

Work Plan Implementation

Work Plan implementation began soon after the execution of the contract and is currently ongoing. Activities covered in this reporting period (May-September 2008) for each objective are detailed below.

Objective 1: To determine whether Lake Okeechobee or basin sources are more important to macroalgal biomass and productivity with an emphasis on those associated with organic and benthic nutrient sources. (Loh and Brand)

Caloosahatchee River Synoptic Surveys

Monthly sampling for this objective began in May 2008. Samples are being collected from three (3) stations upstream (Figure 1) and four (4) stations downstream of the S79 structure (Figure 2). Samples upstream of S79 are being collected from upstream of the S77 structure, upstream of the S78 structure and upstream of the S79 structure. These stations will provide information on cumulative inputs of nutrients from Lake Okeechobee and the East Caloosahatchee Basin and nutrients ultimately entering the Caloosahatchee Estuary. Downstream of S79, samples are being collected along the main channel of the Caloosahatchee Estuary at Markers 27, 54, 83 and 5. These stations correspond with stations CES04, CES05, CES07 and CES11 of the SFWMD CESWQ stations.

Collection of samples is being coordinated between Ai Ning Loh and Larry Brand and is done over two consecutive days. Upstream samples are being collected by Brand at the control structures (S77, S78 and S79) while downstream samples are being collected by Loh, her staff (Leslie Tomasello, the full-time technician hired on this grant, as well as other FGCU Marine Lab staff) and students (both undergraduate and graduate).

Sampling protocols did not deviate from those detailed in the Detailed Work Plan. Samples were collected at the upstream stations for surface dissolved and particulate organic matter and dissolved and particulate nutrients. Samples were also collected for surface water algal abundance and nutrient bioassays. At the downstream stations, samples were collected for surface and bottom dissolved and particulate organic matter, dissolved and particulate nutrients and sedimentary organic matter. Samples were also collected for surface and bottom water algal abundance and nutrient bioassays, and sediment surface algal abundance. All water samples collected are filtered on the day of collection at FGCU.

Analysis and processing of samples are ongoing and in various stages. Upstream samples from May-September 2008 have been analyzed for dissolved organic carbon (DOC). Preliminary results indicate that DOC concentrations from these stations are high (~9-16 mg C/L). Although it is too early to add much interpretation of the data, preliminary results of water column algae, cyanobacteria and benthic microalgae indicate an overall pattern is of higher abundances upstream and lower abundances downstream.

Gulf of Mexico Synoptic Surveys

Bi-monthly sampling of offshore stations began in June 2008 and is being coordinated with Objective 5 (see below). Samples were collected from eleven stations (Figure 2) in June 2008. Due to the uncertainties related to bottom-types (see Objective 5 below), sampling was delayed a month and the next sampling occurred in September 2008. Some stations were moved and a total of 12 stations (Figure 3) were sampled in September 2008. Gulf of Mexico surveys are conducted aboard the FGCU twin-engine Seahawk research vessel, R.V. Eagle. Water samples are also being collected by Loh, her staff and students while sediment samples are being collected by SCCF divers (see Objective 5 below).

Sampling protocols also did not deviate from those detailed in the Detailed Work Plan. Samples were collected for surface and bottom dissolved and particulate organic matter, dissolved and particulate nutrients and sedimentary organic matter. Samples were also collected for surface and bottom water algal abundance and nutrient bioassays, and sediment surface algal abundance for analyses by Brand. All water samples collected are filtered on the day of collection at FGCU.

Surface sediment samples from June 2008 were analyzed for percent organic matter using the ashing method. This gave us a rough estimate of percent organics to refine the selection of stations for the microcosm experiments (Objective 2 below). Results are presented in Figure 2.

Objective 2: To determine if benthic nutrient flux derived from degradation of organic matter is a significant contributor to drift algal blooms. (Loh and Brand)

Bi-monthly sampling of three stations offshore (see Objective 1 above) for microcosm experiments to determine benthic nutrient fluxes began in June 2008 and is being coordinated with Objective 5 (see below). Sediment cores were collected by divers from Stations GOM04, GOM06 and GOM11 for the June 2008 experiment (Figure 2). There were difficulties in collecting a deep enough core at GOM11 in June 2008 due to the thin layer of soft sediment above the bedrock. Consequently, for the September 2008 experiment, this station was moved to the GOM12 station sampled in June 2008, within San Carlos Bay (Figure 2). Note that this GOM12 station for the macroalgae work (Objective 5 below) was moved from San Carlos Bay to off Redfish Pass (Figure 3) for the September 2008 sampling. Stations GOM04 and GOM06 remained unchanged for the September 2008 sampling.

Ideally, we would like to sample Station GOM09 (Figure 3) because this station is the furthest offshore, has a soft-bottom and percent organics that is greater than 5%. In addition, macroalgae were also found growing here (Milbrandt, personal communication). This station would serve as a good control station for Objectives 1, 2 and 5. However, due to the distance of this station from shore (~20 nm), the logistics associated with sampling this station is greatly complicated by weather and the limitations posed by the size of the research vessel being used. Loh, Brand,

Parsons and Milbrandt met after the September 2008 sampling and decided that we will keep GOM09 despite the challenges associated with sampling this station due to its value as a control station for the overall study.

To adequately test the hypothesis that there are significant inputs of nutrients from sediments, microcosm cores need to be comprised of soft-sediment with moderate to high percentage of organics (>3% organics). Cores collected from Stations GOM04 and GOM06 are adequate. For the cores collected from GOM11 during the June 2008 experiment which were inadequate for the microcosms, we had to conduct the experiment using a slurry method. A slurry of the sediment is made by mixing the sediment collected with the bottom water from the same station in a clean 2L beaker. This was done in triplicate. Water blanks were also done in triplicates in clean 2L beakers. The experiment was then conducted the same way as the microcosms. Experimental and sampling protocols for the GOM04 and GOM06 cores did not deviate from those detailed in the Detailed Work Plan. All cores collected for the September 2008 experiment were adequate and experimental and sampling protocols did not deviate from those detailed in the Detailed Work Plan.

Objective 3: To determine the submarine groundwater flux of nutrients to coastal waters.

Greg Rawl has declined the subcontract offered for the completion of this objective. We would like to re-negotiate this part of the contract with the City of Sanibel and Lee County.

Objective 4: To determine the distribution of macroalgal biomass using underwater video and hydroacoustic survey. (Coen, Milbrandt, Riegl and Grizzle)

Greg Rawl and John Cassani have also declined the subcontract offered for the completion of this objective. With the permission of the City of Sanibel and Lee County, FGCU entered into discussion with SCCF and their collaborators from Nova Southeastern University and University of New Hampshire for a new subcontract to achieve the goals of this objective. A subcontract was completed with Bernhard Riegl of Nova Southeastern University and Ray Grizzle of UNH for work through SCCF on macroalgae acoustics and video assessments. Loren Coen and Eric Milbrandt from SCCF will be lead on this subcontract and will coordinate all efforts. A final version of the subcontract has been executed with SCCF. The overall SCCF total subcontract is for $94,000 for two years of work with these collaborators. The new Detailed Work Plan for this objective is attached.

Objective 5: To determine the distribution and productivity of attached macroalgal biomass and the conditions that are favorable for uncontrolled growth, including the examination of substrate attachment. (Milbrandt, Parsons, Ceilley)

Macroalgae Distribution and Abundance

The first month of 4 samplings were undertaken on 9, 11, 16, 18 June 2008. A total of 11 stations were established where macroalgae were collected for identification and quantification of biomass (Figure 2). In addition, densities of large benthic invertebrates (e.g. urchins, pen shells) were recorded. Algae were collected in mesh bags and brought back to the lab to be analyzed. This method worked well for robust, fleshy algae. However, the mesh size was too coarse for one station where a fine *Caulerpa* spp. tended to fall through the ¼" mesh. As a result, plastic bags were used for this collection. Thirty quadrats were collected at randomly chosen positions along the 100 m transect line at each station. Given the number of quadrats necessary for a statistically representative sample and the trade off with the amount of diving time afforded by the quantity of air in dive tanks, refinement of the number of quadrats was discussed. The number of quadrats may be reduced during future samplings to accommodate the limitations of bottom time.

A follow up meeting was held on 2 July 2008 at FGCU to discuss preliminary results and a decision tree for where to sample. It was agreed that stratification based on depth/distance from shore (inshore, offshore) and bottom type (hard, soft) would be ideal. Due to the lack of hard bottom in the southern part of the study area (Fort Myers Beach) and the unknown location of much of the natural hard bottom, this may not be possible without hydroacoustics. However, after several discussions, some stations were moved for the September 2008 sampling (Figure 3) although it is likely that further changes in stations will not occur until hydroacoustic/video yields more information.

Benthic Community Surveys

The identification of macroalgae at the laboratory yielded 19 total species. Of these, 2 species were brown, 14 species were red, and 3 were green algae. The key identification characteristics and identification source were recorded along with wet and dry weights. Vouchers were dried in a herbarium press and/or fixed in formalin and alcohol as described in the Detailed Work Plan. Digital images of a number of species were also captured to be kept for our records. Video transects were transferred and backed up from master Mini DV tapes to digital hard copies on SCCF computer video. These hard copies were then burned to DVD's to be kept on file and used for analyses.

Preliminary Observations and Results

Macroalgae were found sparsely inshore associated with soft bottom types. *Dictyota cervicornis* was the most common species inshore associated with soft bottom types (Figure 4). This brown alga was also seen in abundance at our San Carlos Bay station which was characterized by a sandy bottom littered with sponges (Figure 5). Abundant macroalgae were observed at hard

bottom substrates associated with small hard and soft corals (Figure 6). The macroalgal assemblage was made up of 19 species of mostly rhodophyta. The species composition of stranded algae on Fort Myers Beach in July 2008 (see Objective 6 below) was very similar to that found at hard bottom stations in June. It seems likely that hard bottom areas offshore are one possible source for algae stranded on area beaches during non-bloom conditions. Macroalgae blooms, such as those observed in 2006-2007, may have different sources. A master list of species identified to date is included in Table 1.

Water Pam Protocols

Background and methods. Four concerns regarding the methods used to measure the quantum yields of the algal samples had to be addressed; 1) time span between collection and measurement, 2) submerged versus exposed blades, 3) number of blades/filaments to be measured per thallus, and 4) storage of samples at ambient (22 °C) or refrigerated (4 °C) temperatures. There were two concerns regarding time span; 1) the algae needed enough time to acclimate to the dark (needed to best estimate quantum yield) versus 2) too much time could result in degradation, leading to underestimates of quantum yield. a series of experiments over the course of several days were conducted to determine how quantum yield measurements changed over time (see below). During the course of these experiments, various numbers of blades (submerged within sample vessel versus exposed to the air) were also subsampled, making multiple measurements on each blade, to determine if variability was higher between blades or within-blade measurements. The analysis of these data then provided information to determine if many measurements should be made on fewer blades, versus fewer measurements on many blades.

The following hypotheses were tested:

1) There is no difference in quantum yield over time;
2) There is no difference in quantum yield between blades;
3) There is no difference in quantum yield among different blade orientations;
4) There is no difference in quantum yield at different storage temperature;
5) There is no difference in quantum yield between exposed versus submerged blades.

Multiple measurements were made on multiple blades of *Dictyota divaricata* over time (2 – 46 hours) on samples that were either refrigerated or stored at ambient temperatures in a cooler. Blades were selected for analysis if they were exposed to the air in the top of the ziploc bags, or if they were at the bottom of the bag and clearly submerged in the water. *Dictyota divaricata* was selected simply because it was the most abundant algae collected on the first day of sampling (June 9, 2008). All quantum yield measurements were made on a Walz Water PAM fluorometer. ANOVA was used to test the various hypotheses, with class differences determined using Tukey's multiple range tests. All results were tested at the $\alpha = 0.05$ level.

Results. All of the treatments gave different estimates of quantum yield, demonstrating treatment effects (Figure 7). Blades exposed to the air (class a) for two hours had lower quantum

yield values than blades that were submerged the whole time (class b). Blades examined the next day (t = 20 hours; class c) exhibited lower quantum yield values than either of the two hour measurements (a & b). Samples stored for 46 hours at ambient temperatures (class e) had lower quantum yield values than those refrigerated (class d).

A comparison of the quantum yield standard deviations between blades versus within blade indicated that between-blade variability was much greater than within-blade variability (4.76 ± 0.04 versus 1.59 ± 1.31, respectively). These results indicate that is better to examine more blades, rather than making more measurements on fewer blades.

Discussion. The above experiment demonstrated that 1) it is best to measure the quantum yield of algae two hours versus 20 hours after collection, and 2) between-blade variability is greater than within-blade variability. Applying this knowledge into practical use, it was decided that samples should be examined the night they are collected, not the next day. Additionally, three blades will be examined from each thallus, with two measurements being made at orthogonal orientations. This protocol was implemented immediately for the remainder of the June 2008 collections, and will be utilized in future analyses.

Water PAM Measurements from June 2008

Table 2 presents the data of the quantum yield measurements made on the algae collected June 9, 11, and 16, 2008. Quantum yield values should not be compared between different species, as the values are not directly comparable due to differences in morphology, cell wall characteristics, and pigment composition. We can note, however, that *Dictyota divaricata* displayed similar yields at CES11, GOM01, and GOM11, and had yields <0.005 at GOM05. The results at GOM05 indicate that this specimen of *Dictyota divaricata* was likely dying or in senescence. Otherwise, yield values ranged from a high of 0.68 for the sea grass *Halophila decipiens*, and as low as 0.17 for the diatom, *Fragilaria* sp. The true meaning of these yield values, however, will not be known until multiple samples of the same species at different stations and/or seasons is undertaken. As the next sampling event is scheduled for September, we should begin the collection of such comparable data at that time.

Purchase algae identification keys, identify algae samples, corroborate identifications with Eric Milbrandt and Win Everham.

Taxonomic characteristics were summarized and a master species list was generated from the collected material and material collected from beach stranding (see Objective 6 below). Periodic meetings among Eric Milbrandt, Mike Parsons, Win Everham and Brad Klement (a full time research assistant hired by SCCF to implement the work plan) will ensure consistency for identification of unknowns, as will the use of identical and current reference materials.

Parsons relied on Taylor (1972) and Dawes (1974) for initial algal identifications, as he was already in possession of these texts. Milbrandt recently purchased Littler and Littler (2000) and Dawes and Mathieson (2008), and utilized these texts for his identification efforts. A

comparison of identifications indicated that several of the species names have been updated since Taylor (1972) and Dawes (1974) had been published (e.g., *Dictyota divaricata* is now referred to by its basionym, *Dictyota pulchella*). Subsequent discussions with Everham resulted in the agreement that we should all be using the same identification texts. Parsons has proceeded to purchase Littler and Littler (2000) and Dawes and Mathieson (2008), and will update the algal species names during the September algal identification activities. Everham will also utilize these texts in his identification of the algae stranded on the shore (Objective 6 below), thereby providing consistent reference materials for all algal identifications. Parsons and Milbrandt have also begun compiling a set of samples to be examined by Clinton Dawes (the author of one of the older and one of the newer texts mentioned above).

Macroalgae Sampling on Artificial Reefs

A coordination meeting with VSR team and SCCF Marine Lab to go over protocols for macroalgae surveys and collection/processing of samples was conducted by Ceilley. SCCF has changed position and will not be accompanying the VSR divers nor providing equipment as originally agreed to in August. FGCU has purchased lead core line (100 meters) and other supplies needed to construct transects and meter square plots.

Reconnaissance dives at Lee County Artificial reefs and natural ledges off Sanibel and Captiva were also completed to evaluate general coverage and visibility conditions. However, no sampling dives have been conducted in September or October due to very poor visibility reported by VSR team from recon dives. Tropical Storm Fay and subsequent heavy rains, freshwater discharges and Hurricanes Gustav and Ike have decreased visibility dramatically.

Objective 6: To determine the ecological consequences of the accumulation of nuisance algal biomass by measuring the decomposition rates and nutrient recycling on area beaches. (Everham, Ceilley)

The beach sampling protocol and stations were finalized and established. Everham participated in an algae identification training session presented by SCCF. He also worked with SCCF to coordinate sampling on Sanibel and to incorporate some macroinvertebrate sampling. SCCF has set up daily beach observations on Sanibel with sea turtle volunteers and Mote Marine Lab which includes a check box for red macroalgae and amount. A toll-free number has been established at FGCU for the general public to report any beach strandings of macroalgae (see attached flyers). A presentation to the Ft Myers Beach Marine Task Force on the project was given and the toll-free number for contact shared.

Two bi-monthly samples were completed with little or no background levels of macroalgae found. One deposition event occurred in July 2008 on Ft Myers Beach and was responded to. Identification of the stranded macroalgae revealed six previously unseen species including 2

species of rhodophyta and 4 species of chlorophyta. These new algae were then added to the master species list (Table 1).

Objective 7: To verify and calibrate the CH3D-IMS hydrodynamic model for the system to address the potential fate of nutrients that are generated and exported from the Caloosahatchee River and the fate of detached macroalgae as they enter the near shore waters around Sanibel Island and to the develop a sediment transport model and implement the coupled sediment and hydrodynamic model for the same time periods as the hydrodynamic model. (Fugate)

A dual processor, 3.3 GHz computer has been purchased and configured to interact with the FGCU network. Various software packages such as Cygwin, Netcdf, and Fortran 95 have been installed on the computer. Computer code for the Regional Ocean Model System (ROMS) has been downloaded, and a test case has been successfully compiled and executed. ROMS is a free-surface, hydrostatic, primitive equation ocean model that uses stretched, terrain-following coordinates in the vertical and orthogonal curvilinear coordinates in the horizontal. The bathymetry to run the model in the Southwest region of Florida has been acquired and consists of 100 ft resolution LIDAR data and generalized 300 ft bathymetry from NOAA.

Objective 8: To develop a water quality computer model of the West Florida Shelf (WFS) in the Ft Myers region that can be used in future work to help guide nutrient reduction strategies for the management of drift algal blooms. (Everham)

Peter Bell and Brian Lapointe have declined the subcontract offered for the completion of this objective. Win Everham will be picking up this objective in addition to his work on Objective 6. This change in the investigators for this objective has been discussed with Roland Ottolini at Lee County. There are no changes in the final goals associated with this objective as detailed in the Detailed Work Plan. However, this objective is being reworked to incorporate the modeling system developed by DEP and the use of nutrient and chlorophyll data collected by Loh and Brand from Objective 1.

Planned Activities

The following activities have been planned for the next reporting period (October-December 2008):

1. Dates for the Caloosahatchee River synoptic survey (Objective 1) have been set for October, November and December, 2008.

2. Dates for the Gulf of Mexico samplings (Objectives 1, 2 and 5) have been set for November, 2008.

3. Continued coordination with collaborators on decision tree for where to sample is ongoing (Objectives 1, 2 and 5).

4. Workshops by Clinton Dawes are being planned in the coming months to verify our algal identifications (Objective 5).

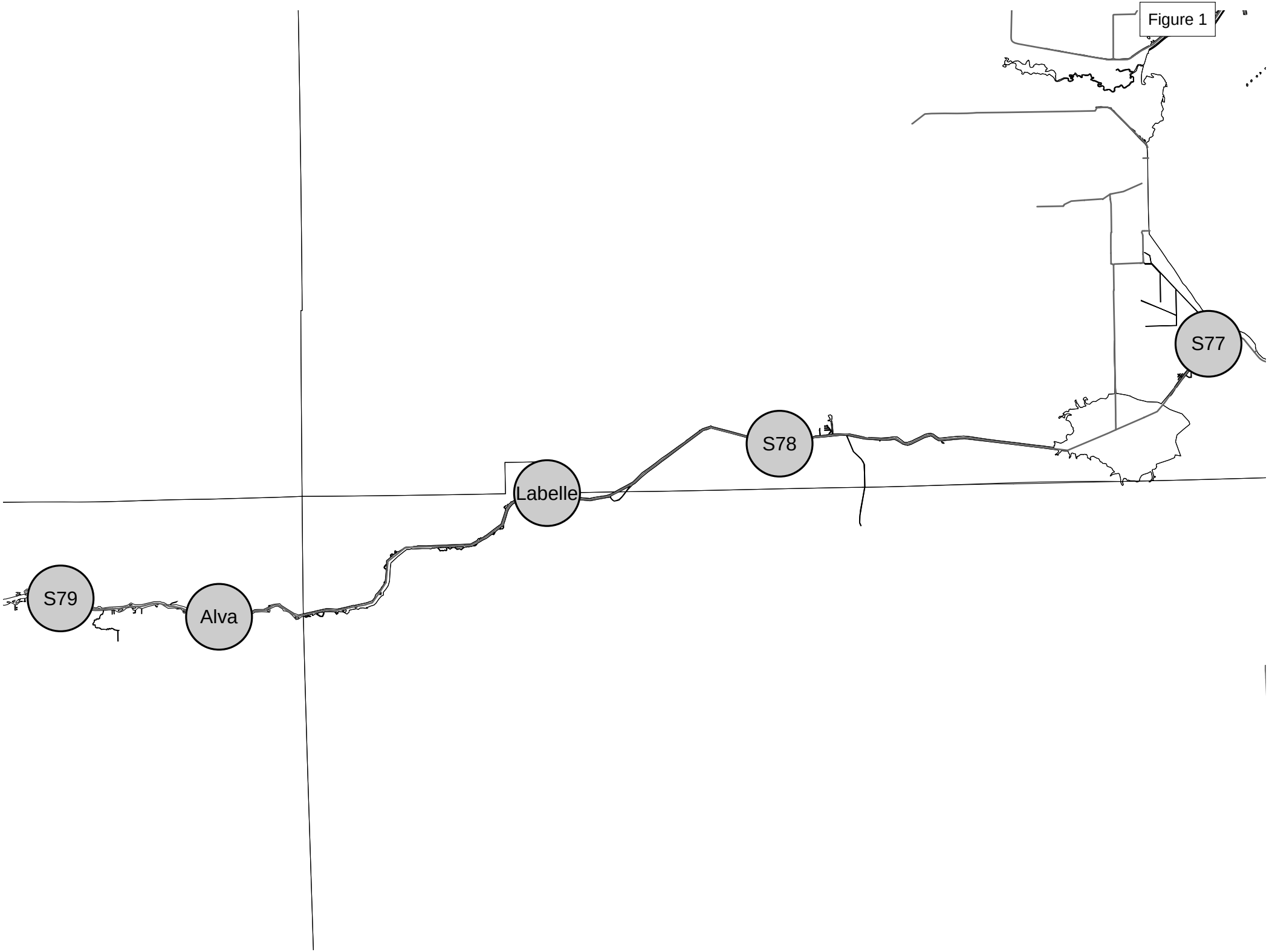
5. Next dive for sampling macroalgae on artificial reefs by the VSR team are scheduled for November 1st and 8th to begin actual surveys and collection of samples for ID and dry weight analysis (Objective 5).

6. Planning for beach stranding events has occurred detailed protocols for event response are being finalized (Objective 6).

7. We are working on potential coordinated Access and GIS database that would link and serve the data needs of all PIs'.

8. To create a grid using preexisting Matlab code called SeaGrid for Objective 7. This code has already been downloaded and grid generation will begin soon.

Figure 1



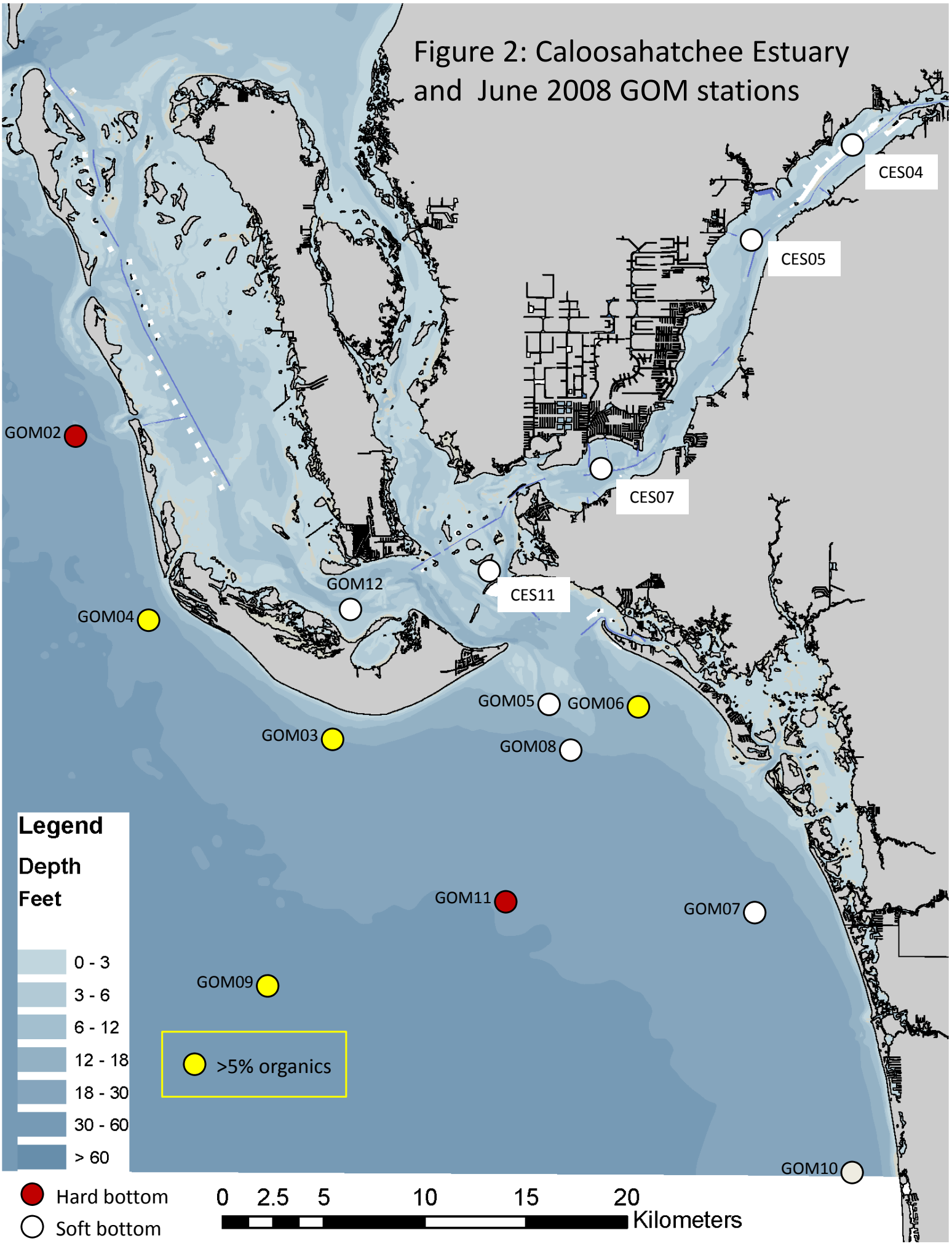


Figure 2: Caloosahatchee Estuary and June 2008 GOM stations
CES04
CES05
CES07
CES11
GOM02
GOM04
GOM12
GOM03
GOM05
GOM06
GOM08
GOM11
GOM07
GOM09
GOM10
Legend
Depth
Feet
0 - 3
3 - 6
6 - 12
12 - 18
18 - 30
30 - 60
> 60
>5% organics
Hard bottom
Soft bottom
0 2.5 5 10 15 20
Kilometers

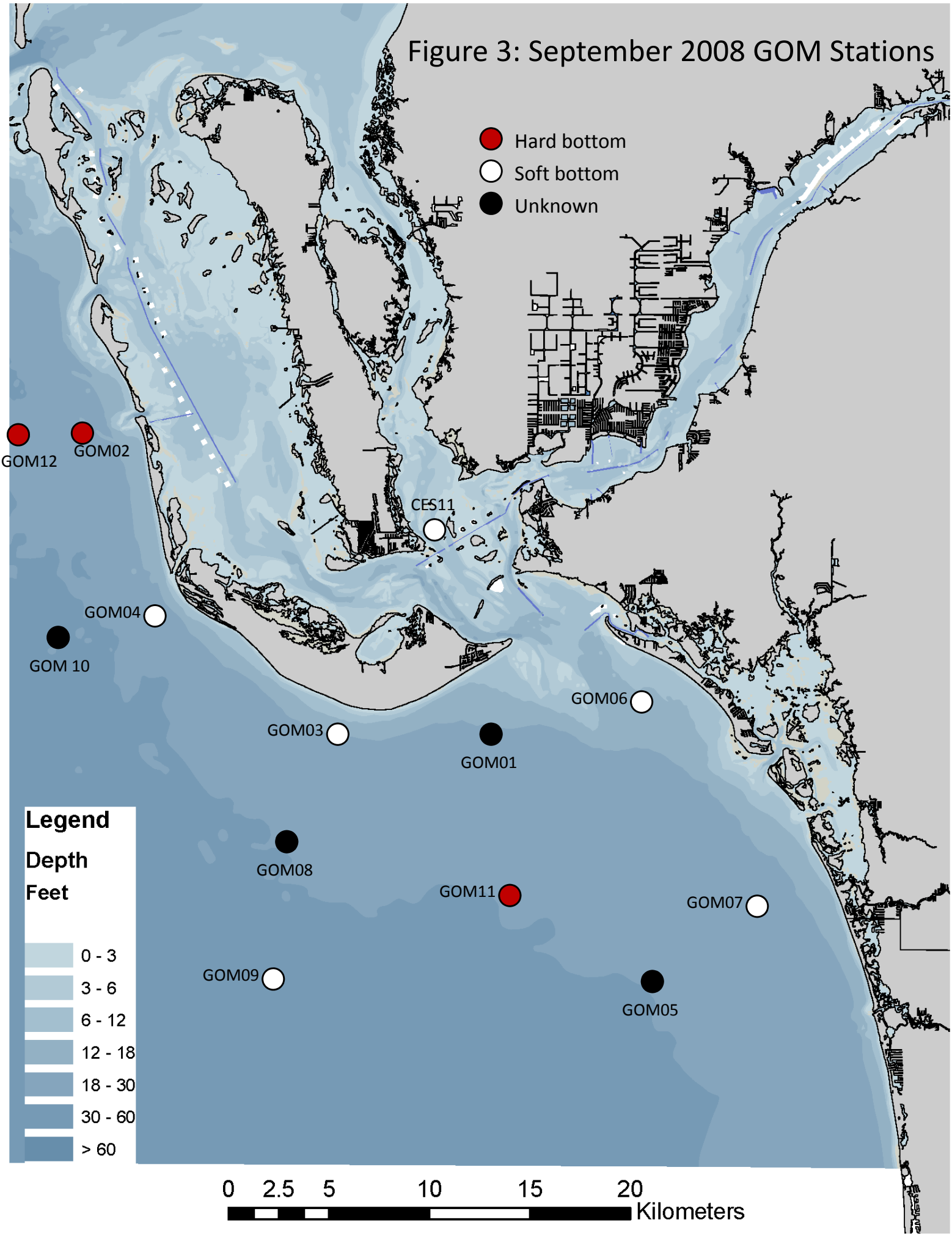


Figure 3: September 2008 GOM Stations
Hard bottom
Soft bottom
Unknown
GOM12
GOM02
CES11
GOM04
GOM 10
GOM06
GOM03
GOM01
GOM08
GOM11
GOM07
GOM09
GOM05
Legend
Depth
Feet
0 - 3
3 - 6
6 - 12
12 - 18
18 - 30
30 - 60
> 60
0 2.5 5 10 15 20
Kilometers

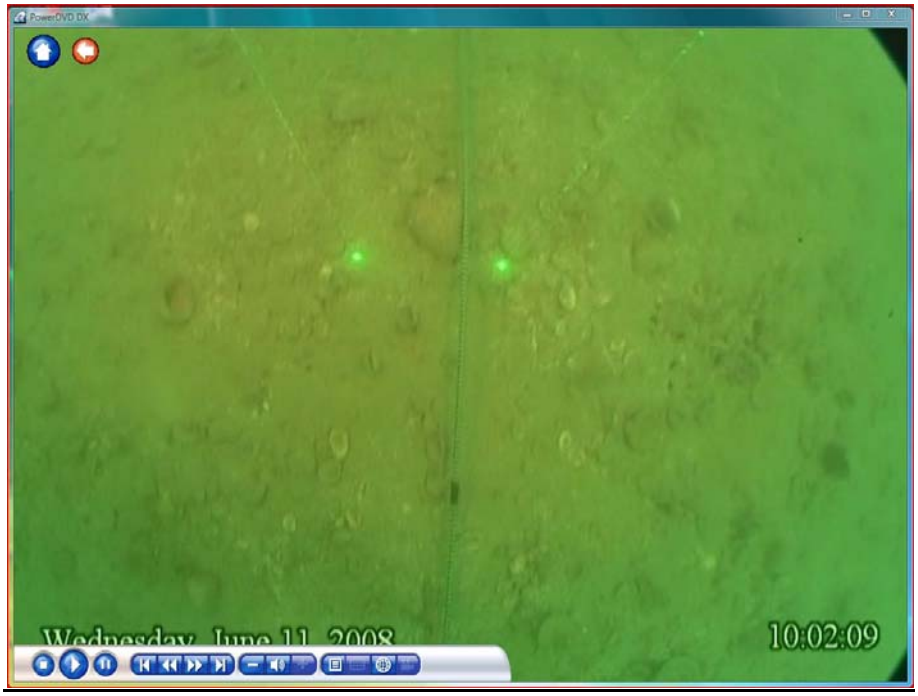


Figure 4. Screen capture of video transect showing inshore soft bottom type with shells, urchins and penshells.

Figure 5. Screen capture of video showing inshore sandy bottom type with sponges, macroalgae, and colonial hydrozoans.

Figure 6. Screen capture of video transect showing benthic community associated with hard substrates. Macroalgae, sponges, hard and soft corals are attached to limestone.

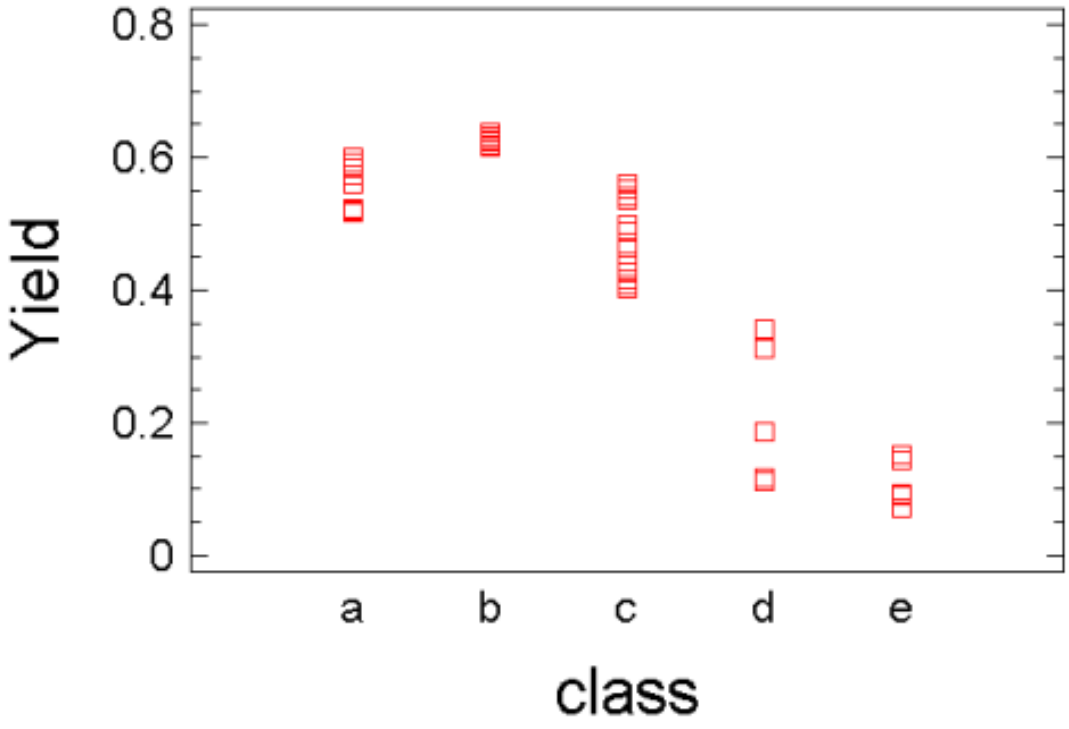


Figure 7: Quantum yield versus treatment class as outlined in the text.

Table 1. Tentative species collected and identified to date based on diver sampling.

Rhodophyta

Gracilaria mammilaris
Gracilaria blodgettii
Gracilaria bursa-pastoris
Gracilaria caudata
Gracilaria tikvahiae
Solieria filiformis
Botryocladia occidentalis
Halymenia floresia
Halymenia pseudofloresia
Hypnea spinella
Agardhiella subulata
Agardhiella ramosissima
Eucheuma isiforme var. denudatum
Acanthophora spicifera
Hypnea musciformis
Dasya ramossisima

Phaeophyta

Dictyota cervicornis
Dictyota pulchella

Chlorophyta

Udotea abbottiorum
Caulerpa mexicana
Caulerpa prolifera
Caulerpa sertularioides
Ulva flexuosa
Ulva sp. *(*Sheet-like form, fragment too small to id to species)
Codium isthmocladum

Table 2. Average (± standard deviation) quantum yield values for the algal (and sea grass) samples collected for the June, 2008 sampling period. Station locations and sampling dates are provided. Note that *Fragilaria* sp. is a colonial diatom and that *Halophila decipiens* is a sea grass species.

Date	Station	Algal Species	Quantum Yield
June 9, 2008	CES 11	*Dictyota divaricata*	0.65 ± 0.05
June 9, 2008	CES 11	*Polysiphonia* sp.	0.48 ± 0.00
June 9, 2008	GOM 1	*Dictyota divaricata*	0.59 ± 0.04
June 9, 2008	GOM 5	*Dictyota divaricata*	0.00 ± 0.00
June 9, 2008	GOM 6	*Fragilaria* sp.	0.17 ± 0.04
June 11, 2008	GOM 11	*Botryocladia occidentalis*	0.41 ± 0.03
June 11, 2008	GOM 11	*Dictyota divaricata*	0.65 ± 0.06
June 11, 2008	GOM 11	*Gracilaria cylindrica*	0.46 ± 0.03
June 11, 2008	GOM 11	*Gracilaria verrucosa*	0.36 ± 0.03
June 11, 2008	GOM 11	*Udotea conglutinate*	0.67 ± 0.03
June 16, 2008	GOM9	*Halophila decipiens*	0.68 ± 0.06
June 16, 2008	GOM 9	*Polysiphonia macrocarpa*	0.31 ± 0.03

Algae Busters

Who ya' gonna call?

Florida Gulf Coast University (FGCU) and Sanibel Captiva Conservation Foundation (SCCF), working with other partners, have initiated a two-year study of drift algae dynamics – which species grow where and why, and why does it end up washed up on the beach. This work is funded by Lee County and the City of Sanibel. If you have information about algae washing up on the beach, please call this toll free number:

1-866-724-3428

Got Algae?

Who ya' gonna call?

Florida Gulf Coast University (FGCU) and Sanibel Captiva Conservation Foundation (SCCF), working with other partners, have initiated a two-year study of drift algae dynamics – which species grow where and why, and why does it end up washed up on the beach. This work is funded by Lee County and the City of Sanibel. If you have information about algae washing up on the beach, please call this toll free number:

1-866-724-3428

Scope of Work for Sanibel Drift Algae Project

Subcontract to SCCF for Hydroacoustic/Video Surveying and Related Ground-Truthing

Submitted by: Loren Coen (SCCF) and Eric Milbrandt (SCCF)

Total Subcontract for ~~24~~ 22 mo.: $94,000 (8/26/08)

Remote surveys of bottom types and relative algal biomass offers the advantage of covering large areas in a relatively short amount of time. Acoustic seafloor discrimination provides a method that is not dependent on water clarity. The method is well established (see Riegl et al. 2005 and references therein) and numerous commercially available systems exist (e.g., RoxAnn, Biosonics, Echoplus, QTCView). These instruments and associated software have been used to differentiate sediment types, artifacts from sediments and bottom 'habitats' or biotopes by simultaneously using biological and acoustic sampling. Additional ground-truthing using video and diver collections will also be employed to verify that the discriminated 'classes' are indeed seagrasses, macroalgae at several densities, hard substrates and bare sediments.

Given prior work (see CVs) by investigators from NOVA University (Dr. Riegl and associates) and University of New Hampshire (Dr. Grizzle), we are contracting with both groups through an additional subcontract to SCCF from FGCU to utilize their expertise, vessel and equipment to conduct both hydroacoustic and video surveying in conjunction with existing work directed by Dr. Milbrandt at SCCF through an existing contract. We will also coordinate and conduct related ground-truthing during or soon after the three major field efforts with the above investigators during the next two years.

SCCF diver surveys provide species diversity and algal biomass but are confined to a very small area. A combination of these approaches will be used to provide information about benthic (primarily macroalgae and epifaunal invertebrate) communities offshore of Lee County (Ft. Myers Beach) and the adjacent Sanibel-Captiva Islands. We are estimating approximately four weeks of planned field work to complete the remote surveys (hydroacoustic, video, related ground-truthing). This includes a limited number of diver days for associated ground-truthing assessments planned in addition to the already funded bi-monthly stations. Survey tracks were designed to overlap with existing stations where hard and soft bottom types and algal communities were characterized by divers in June 2008.

Since even a coarse analysis of the hydroacoustic data cannot be performed in Real-time during the pilot visit in August-September 2008, divers will rely on results from the video. This approach allows some stratification to target areas with macroalgae present and/or bottom type. To do this, divers will be aboard a separate vessel provided by Lee County and at regular intervals will establish a 100 m transect nearby the survey track. A Garmin GPS will be used to approximately follow the survey track, although winds, current, waves, etc. will make an exact transect line deployment on the survey track difficult. Once the line is deployed, divers will follow established protocols for macroalgal biomass determination. A sufficient number of random quadrats along multiple transect lines will be sampled collecting all algae in mesh bags and returned to the laboratory for identification. Large, conspicuous infaunal and epifaunal invertebrates (e.g., urchins, pen shells, hard/soft corals) will be enumerated and sediment will also be collected and examined initially with a series of sieves.

As stated in Figure 1, the minimum distance we are envisioning the contractors will assess and classify bottom type(s) will be approximately 210 km as estimated by the FGCU-SCCF team. We will meet during the contractors initial visit at SCCF to discuss pre-mission details and then again (after their initial effort) to assess with all of the interested parties how we want to proceed from there. If the utilization of the hydroacoustic/video surveys prove to be inadequate as judged by relevant entities (group consisting of the City of Sanibel, Lee County and SCCF/FGCU scientists) for delineation of bottom types and macroalgae, its use for this purpose can be discontinued prior to the second year of the study. Additionally in the second year of the study, the number and/or length of transects maybe adjusted based upon the findings from the initial efforts.

Additionally, FGCU working with SCCF will ensure that sufficient sediment material (cores or grabs) is collected during dives related to the original SOW effort or during ground-truthing here. SCCF will be responsible for delivery to FGCU for said samples if not during original sampling effort already in place.

Major Deliverables:

Overall Final Report to contain the following items (see Subcontracts below for more detail):

1. Products showing distribution of classified major bottom types in study area in the vicinity of Sanibel-Captiva Islands and off Ft. Myers Beach (portions of Lee Co.), with

approximately five targeted major classes. These will be integrated with the existing efforts by SCCF's subcontract to E. Milbrandt.

2. Integration of NOVA's assessment of seafloor conditions in the study area, with emphasis on the distribution and abundance patterns of any existing denser macroalgal accumulations and the potential as attachment substrates; and
3. Integration and recommendations for future mapping efforts relative to the observed distribution and abundance of denser macroalgal accumulations through 2009-2010.

SCCF will work closely with Drs. Riegl and Grizzle and others (e.g., FGCU, City of Sanibel, Lee Co.) to ensure that every possible effort is made to coordinate efforts and ensure the maximum likelihood of a successful collaboration using an adaptive sampling strategy throughout this two-year effort.

Project Chronology and Work Tasks

Phase I (2008): Preliminary studies on-site; plan development (one site visit; estimated at a 1 week duration)

Task 1: Work with contractors during their assessment using hydroacoustic and video to meet the overall project objective (see below).
Task 2: Work with contractors to provide the best approach(es) for concurrent hydroacoustic and underwater video mapping.
Task 3: Provide FGCU with overall progress report working with Drs. Riegl and Grizzle and submission.

Phase II (2008-09): Seafloor mapping around Sanibel-Captiva Islands (Lee Co., one site visit; estimated at a 2 week duration)

Task 4: Seafloor mapping along multiple transects in the vicinity of Sanibel-Captiva Islands and off Ft. Myers Beach (i.e. portions of Lee Co.).
Task 5: Collaborative assessment of video imagery, hydroacoustic data with ground-truthing.
Task 6: Progress report preparation and submission.

Phase III (2009-2010): intensive mapping of additional areas (one site visit; estimated at a 1 week duration)

Task 7: Seafloor mapping at additional sites using an adaptive approach. This includes discussions with FGCU, City of Sanibel and Lee Co.
Task 8: Collaborative assessment of video imagery, hydroacoustic data with ground-truthing by video and diving.
Task 9: Final Progress report preparation.

Budget Justification – SCCF

Details of the efforts by Riegl and Grizzle are discussed below in detail. SCCF is requesting funds for assisting with ground-truthing of the hydroacoustic and video mapping. Supply costs consist mainly of fuel for the Lee Co. or FGCU vessel, disposables, and air fills. Minimal boat days for nearshore SCCF vessel use and mileage are also requested. SCCF

personnel costs include 0.25 man months for two divers and a database/GIS scientist (5% added to year 2) to assist with acoustic/video deliverable tracking and integration. A minimal amount of indirect (10% on overall total exclusive of subcontracts and equipment) is included to manage the three contracts/subcontracts and associated deliverables. Gas in supply budget will be used to assist with collections of sediment material (cores or grabs) either during dives related to the original SOW effort or during ground-truthing here. SCCF will be responsible for delivery to FGCU.

Details of Overall SCCF Subcontract Budget

	Year 1	Year 2	Total
Lead for Subcontract			
L. Coen	match	match	match
E. Milbrandt	match	match	match
Other Personnel			
A. Martignette (0.25 mm)	806	846	$1,652
J. Siwicke (0.25 mm)	783	822	$1,605
A. Rybak (0.25 mm)	1,438	1,509	$2,947
Total Salaries	**$3,027**	**$3,177**	**$6,204**
Total Fringe @ 37%	**$1,120**	**$1,175**	**$2,295**
Salary & Fringe Expense			
Total Salaries & Fringe	**$4,147**	**$4,352**	**$8,499**
Office, Lab, & Field Supplies	1,305	1,091	**$2,396**
Boats	600	600	**$1,200**
Vehicle mileage (@$0.585/mile)	176	182	**$358**
Subcontract to NOVA	**$27,549**	**$27,569**	**$55,118**
Subcontract to RG	**$12,615**	**$12,568**	**$25,183**
Indirect 10% (all but subs)	**623**	**623**	**$1,246**
Total Grant Cost	**$47,015**	**$46,986**	**$94,000**

Subcontract through SCCF

Drs. Raymond Grizzle (UNH) and Bernhard Riegl (NOVA)

Subtotal for ~~24~~ 22 mo.: $80,301

Overall Objective: Determine the distribution of bottom substrate types and potential macroalgal classes using underwater video and hydroacoustic surveys.

Major Deliverables:

A Final report to contain the following items:

1. A map showing distribution of major bottom types in study area in the vicinity of Sanibel and Captiva Islands, with five initial targeted major classes: a) soft sediment (sand/silt combinations); b) shell; c) rock and rocky outcrops; d) dense macroalgae; and e) other biogenic (e.g., pen shells, worm tubes, large buried molluscs) structure;
2. An assessment of general seafloor conditions in the study area, with emphasis on what factors determine distribution and abundance patterns of existing denser macroalgal accumulations and the potential as attachment substates; and
3. Recommendations for additional mapping studies relative to the observed distribution and abundance of denser macroalgal accumulations.

Throughout the effort, Drs. Grizzle and Riegl will work closely with SCCF Marine Lab staff (through Dr. Coen and staff) and others (e.g., FGCU, City of Sanibel, Lee Co.) to ensure that every possible effort is made to coordinate efforts and ensure the maximum likelihood of a successful collaboration using an adaptive sampling strategy throughout this two year effort.

Project Chronology and Work Tasks

Phase I (2008): Preliminary studies on-site; sampling, methodology development (one site visit; estimated at a 1 week duration)

Task 1: Assessment of hydroacoustic and video systems for the overall project objective.
Task 2: Protocol development for concurrent hydroacoustic and underwater video mapping.
Task 3: Progress report preparation.

Phase II (2008-09): Seafloor mapping around Sanibel (one site visit; estimated at a 2 weeks duration)

Task 4: Seafloor mapping along multiple transects around Sanibel Island
Task 5: Collaborative assessment of video imagery, hydroacoustic data with ground-truthing.
Task 6: Progress report preparation.

Phase III (2009-10): Intensive mapping of additional areas (one site visit; estimated at a 1 week duration)

Task 7: Seafloor mapping at additional sites using an adaptive approach.
Task 8: Collaborative assessment of video imagery, hydroacoustic data with ground-truthing.
Task 9: Progress report preparation.

METHODS

Phase I

Task 1: Assessment of Hydroacoustic and Video Systems for Study Objective

This task will consist of fieldwork and subsequent data analysis aimed at development of an effective overall protocol for using hydroacoustic and underwater videographic methods to map macroalgae distribution and abundance patterns. As needed, SCCF will assist with divers to conduct additional ground-truthing.

A catalog of geo-referenced and ground-truthed sonar samples representative of the major categories of submerged aquatic vegetation and substrate will be collected with a Biosonics DT-X echosounder and two multiplexed, single-beam digital transducers operating at frequencies of 38 and 420 kHz. A small plot within the Sanibel-Captiva study area will then be surveyed acoustically, and the post-processed survey data will be classified using the aforementioned supervised catalog to produce an along-track map of the distribution and abundance of attached and/or drift macroalgae. The efficacy of the acoustic methodology will be evaluated by comparison to video data collected in-line with the acoustic survey. Geo-referenced video samples will be collected inline with the acoustic survey for subsequent accuracy analysis of the acoustic predictions of attached and/or drift macroalgal distributions.

A SeaViewer model 550 color video camera will be deployed concurrently with the Biosonics hydroacoustic system as described above in two different modes to assess its effectiveness in providing supplementary data for the hydroacoustic data: (1) as a drop-camera to acquire imagery in a relatively small area; and (2) in 'towed' mode to acquire imagery along transects. The lens can be aimed perpendicular to the bottom or at an oblique angle in either mode, thereby providing additional flexibility in imagery acquisition that affects the amount of area that can be covered and image quality. As needed, SCCF will conduct assessments with divers either concurrently or soon after.

Acoustic bottom class detection relates the diversity of the seafloor to the returning waveforms. Submerged aquatic vegetation can be detected by scattering either at the leading edge (BioSonics-EcoSAV plant-detection software) or trailing edge (BioSonics Visual Bottom Typer software) of the first echo. For the initial studies, attempts will be made to detect three classes of algal density: no algae; sparse algae; and dense algae. This level of detection is demonstrably within the capabilities of the system. It is also anticipated that the acoustic data will be able to differentiate sandy sediments from rocky bottoms.

Task 2: Protocol Development for Concurrent Hydroacoustic and Underwater Video Mapping

Based on the results from Task 1, an effective protocol(s) for concurrently deploying hydroacoustic and video systems will be developed. It is anticipated that this task may result in more than one potential protocol, each with a different combination of pros and cons.

Task 3: Progress Report Preparation

A progress report describing the results of Tasks 1 and 2 will be prepared and submitted. A major aim of this report will be to provide sufficient information so that a decision can be made regarding continuation of the project using a combination of hydroacoustic and underwater video. This report will be submitted prior to implementing the second phase (Tasks 4–6) of the study.

Phase II

The second phase will include the actual mapping of seafloor habitats in the vicinity of Sanibel-Captiva Islands and off Ft. Myers Beach. At this time, methods for the three proposed work tasks can only be described in general terms because some details will depend on the initial results of Phase I.

Task 4: Seafloor Mapping Along Multiple Transects In and Around Sanibel-Captiva Islands

At this time, it is anticipated that data collection will be accomplished along multiple transects in the vicinity of Sanibel-Captiva Islands and off Ft. Myers Beach as illustrated in Figure 1 below. Note that the shiptracks shown in Figure 1 are considered tentative at this time; the final grid design will depend on the findings from Phase I. However, it can be specified that these studies will involve continually logged hydroacoustic data geo-referenced using an integrated Global Positioning System (GPS) receiver. Video imagery will likely consist of some combination of continuously logged transects as well as imagery obtained in "drop camera" mode. The video imagery also will be geo-referenced using concurrently recorded GPS.

Task 5: Collaborative Assessment of Video Imagery and Hydroacoustic Data

The hydroacoustic data from Task 4 will be post-processed to provide substrate and macroalgal classifications for each acoustic record along the length of each transect. The video imagery from Task 4 will be assessed mainly to provide ground truthing of the hydroacoustic data as well as additional information such as species composition and relative abundance that will supplement the hydroacoustic data. The resulting data will be used to map the distribution and abundance of the macroalgae relative to water depths, sediment type and distribution, and possibly other variables.

Task 6: Progress Report Preparation

The Phase II results will provide a baseline of information on the distribution and relative abundance of macroalgae. This mapping, along with the actual transect data, will aid in the selection of specific sites for more in depth evaluation of benthic characteristics in Phase III. A progress report on the results of Phase II studies will be submitted prior to initiation of Phase III. Deliverables for Phase II will include: (1) map of major bottom habitat types (see more below) in study area; and (2) map of distribution and relative abundance of major macroalgal taxa (from grabs or diver collections) in study area; and (3) map showing locations of proposed intensive sites for further study during Phase III. It is anticipated that five major bottom classes will be mapped: soft sediment (sand/silt combinations); shell; rock; macroalgae; and other biogenic (e.g., pen shells, worm tubes, etc.).

Phase III

The final phase of the project is aimed at providing additional information that may be useful in understanding drift algae distribution and abundance patterns in the vicinity of Sanibel-Captiva Islands and off Ft. Myers Beach. It will yield data from sites among and between benthic stations sampled in Phase II to provide greater resolution of sediment and macroalgal distributions. At this time, it is anticipated that the following three tasks will be addressed.

Task 7: Seafloor Mapping at Additional Sites

This task will consist of collections of high density transect data from a series of transect grids (0.25 km^2) around the 11 benthic stations sampled during Phase II. This will provide higher resolution of both sediment and benthic macroalgal coverage. Additionally, a series of transects totaling up to 32 km will be run between benthic stations to provide increased resolution. This approach is subject to change based on earlier results and discussion among PIs at FGCU, SCCF and collaborators (i.e. Contractors).

Task 8: Collaborative Assessment of Video Imagery and Hydroacoustic Data

Data from Task 7 will be integrated into the maps resulting from Phase II to provide further resolution of macroalgae distribution and abundance patterns and other relevant seafloor characteristics. Although only near- and offshore transects were proposed for Phase II, inshore transects in Pine Island Sound and in the Caloosahatchee River will also be sampled in the third phase. The anticipated general locations of these additional sites are shown in Figure 2 below.

Task 9: Final Report Preparation

A final report will be prepared and will include revised maps from Phase II (see Task 6), and containing the following items:

1. A map showing distribution of major bottom types in study area in the vicinity of Sanibel and Captiva Islands, with five initial targeted major classes: a) soft sediment (sand/silt combinations); b) shell; c) rock and rocky outcrops; d) dense macroalgae; and e) other biogenic (e.g., pen shells, worm tubes, large buried molluscs) structure;
2. An assessment of general seafloor conditions in the study area, with emphasis on what factors determine distribution and abundance patterns of existing denser macroalgal accumulations and the potential as attachment substrates; and
3. Recommendations for additional mapping studies relative to the observed distribution and abundance of denser macroalgal accumulations.

Budget Justification – Riegl and Grizzle

Requested funds for the hydroacoustic and video mapping consist mainly of salary and wages, travel, food, lodging, and boat costs. Most of the salary and wages will be for Riegl and Grizzle who will participate in the fieldwork, data analysis, and report writing. Two technicians employed by Riegl will also participate in most work tasks. Salary and wages are requested in the amounts and at the daily rates outlined in the budgets below for Years 1 & 2 and total.

The daily rates for Riegl and colleagues reflect their rates at Nova Southeastern University; daily rate for Grizzle is based on his work as a collaborator. The time and dollar amounts associated with each of the nine work tasks are given in the budgets below. Travel charges reflect estimated costs for airfare for Grizzle and car travel (boat to be towed) for Riegl and colleagues for three separate trips to the study site. Food, lodging, and car rental costs are estimated based on the time of stay required for the three trips (also as detailed in the budget spreadsheet): estimated at 7, 12, and 5 days for the three field trips during the two year study.

Supplies costs mainly consist of shipping and associated costs to get equipment to the study site. Miscellaneous supplies for equipment repairs and modifications are also included.

The Riegl budget also includes costs based on established rental charges at Nova for use of their boat, and lease of hydroacoustic equipment owned by NOVA. Grizzle will deploy his video equipment from the NOVA and SCCF-directed vessels. Indirect (10%) and fringe (26.2%) benefit rates as established by NOVA are included in the Riegl budget.

Details of R. Grizzle Subcontract Budget

	Year 1	Year 2	Total
Lead Video Contractor			
R. Grizzle	$7,800	$7,800	$15,600
Total PI Payroll Tax	$0	$0	$0
Total PI Fringe @ 0%	$0	$0	$0
Other Personnel			
Total Personnel	$7,800	$7,800	$15,600
Total Fringe @ 0%	$0	$0	$0
Salary & Fringe Expense			
Total Salary	$7,800	$7,800	$15,600
Total Fringe	$0	$0	$0
Total Salary & Fringe	**$7,800**	**$7,800**	**$15,600**
Travel, etc.	$3,500	$3,500	$7,000
Office, Lab, & Field Supplies	$1,315	$1,268	$2,582
Total Grant Cost	**$12,615**	**$12,568**	**$25,183**

Details of NOVA Subcontract Budget

	Year 1	Year 2	Total
Lead Hydroacoustic Contractor			
B. Riegl	$5,672	$6,682	$12,354
Total PI Fringe @ **26.2%**	$1,486	$1,751	$3,237
Other Personnel			
G. Foster	$3,452	$3,452	$6,904
K. Foster	$3,107	$1,985	$5,092
Total Fringe @ **26.2%**	$1,718.	$1,424	$3,143
Salary & Fringe Expense			
Total Salary	$12,231	$12,119	$24,350
Total Fringe	$3,205	$3,175	$6,380
Total Salary & Fringe	**$15,436**	**$15,294**	**$30,730**
Office, Lab, & Field Supplies	$10,571	$10,746	$21,317
Indirect 10% (sal. & fringe)	$1,542	$1,529	$3,071
Total Grant Cost	**$27,549**	**$27,569**	**$55,118**

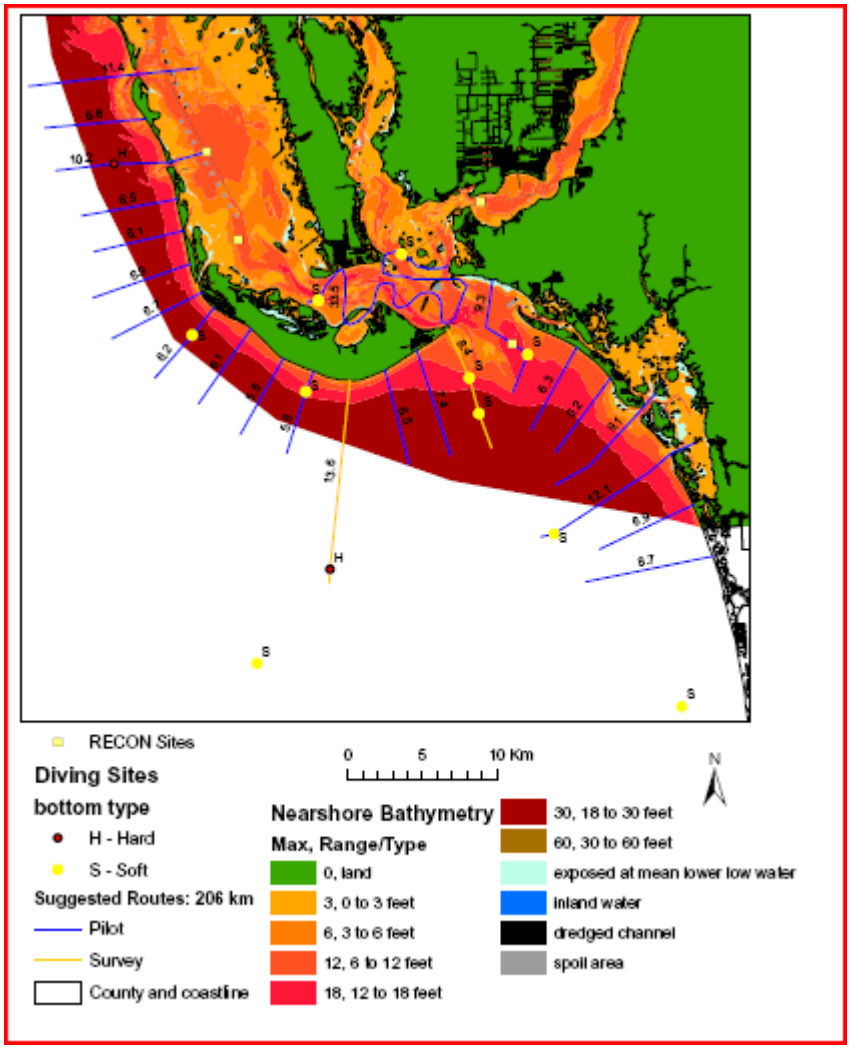
Overall deliverables from SCCF and its two subcontractors.

Hydroacoustic/Video Survey Work Schedule

Year 1	Months after Contract Execution											
Research Activities and Deliverables	1	2	3	4	5	6	7	8	9	10	11	12
Hydroacoustic/Video Survey												
Task 1: Assessment of hydroacoustic and video systems	X											
Task 2: Protocol development for hydroacoustic and video mapping		X	X									
Task 3: Progress report preparation			X			X			X			X
Task 4: Seafloor mapping along multiple transects									X			
Task 5: Assessment of hydroacoustic and video data										X	X	X
Deliverables/Associated Quarterly Reports			X			X			X			X

Year 2	Months after Contract Execution									
Research Activities and Deliverables	13	14	15	16	17	18	19	20	21	22
Hydroacoustic/Video Surveys										
Task 5: Assessment of hydroacoustic and video data	X									
Task 6: Progress report preparation.			X			X			X	
Task 7: Seafloor mapping at additional sites using an adaptive approach.			X							
Task 8: Assessment of video imagery, hydroacoustic data				X	X	X	X	X		
Task 9: Final report preparation										
Deliverables/Associated Quarterly Reports			X			X			--	
Final Report										X

Figure 1. Conceptual survey routes shown below with video and hydroacoustic methods for all tasks. **Note:** this is to be used only as a starting point for the effort. It is not meant to be used as a required binding effort requirement. Ultimately it will be modified based on initial pilot efforts in August or September 2008.



Shown here are the potential areas of interest with numerous profiles totaling approximately 210 km. Numbers next each survey profile transect line depict their estimated length in kilometers. Two pilot survey (Phase I studies) routes (yellow lines) total approximately 22 km. Depending on sea conditions and constraints from NOVA University's regulations these may be conducted using another vessel from FGCU or Lee Co. with additional video.

CURRICULUM VITAE

NAME: Bernhard Michael Riegl

CONTACT ADDRESS:

National Coral Reef Institute, Oceanographic Center, Nova Southeastern University, 8000 N Ocean Drive, Dania, FL 33004, rieglb@nova.edu, (954) 262 3671

PRESENT POSITION:

Associate Professor, Oceanographic Center, Nova Southeastern University, Ft. Lauderdale, FL

Associate Director, National Coral Reef Institute

OTHER APPOINTMENTS:

Adjunct Professor, Institut für Geologie und Paläontologie, Karl-Franzens-Universität Graz, Austria

Adjunct Professor, Rosenstiel School of Marine and Atmospheric Science, University of Miami (Division of Marine Biology and Fisheries and Division of Marine Geology and Geophysics)

PROFESSIONAL ACTIVITIES:

Council member, International Society for Reef Studies (2005-09)

President (09-10), Association of Marine Laboratories of the Caribbean

Scientific council member, Khaled bin Sultan Living Oceans Foundation

Organizing Committte, 11th International Coral Reef Symposium, Ft. Lauderdale

Former recording secretary, International Society for the Study of Fossil Cnidaria and Porifera

EDUCATION:

2000: **Habilitation** in Actuopalaeontology, "Aspects of the biogeology and environmental geology of Cenozoic coral reefs", Karl-Franzens-Universität Graz

1993: **PhD** in Zoology, University of Cape Town, "Taxonomy and Ecology of South African reef corals".

1989: **MSc** in Zoology, University of Vienna, "Community structure of stony corals on reefs in the northern Red Sea". with distinction

1975-1983: Bundesgymnasium Wien 8 Piaristen, Matura (matriculation) with distinction

ACADEMIC POSITIONS HELD:

2003: **Associate Professor** at the Oceanographic Center, Nova Southeastern University and **Associate Director** of the National Coral Reef Institute.

2001- 2003: **Adjunct professor** at the Oceanographic Center, Nova Southeastern University.

2000 - 2003:**Research Scientist** at the National Coral Reef Institute, Nova Southeastern University.

Since 1999 :**Adjunct professor** at Karl-Franzens-University Graz.

1999: **Austrian Science Foundation Research Fellow** at the Institute of Geology and Paleontology, Karl-Franzens University Graz, Austria. **Adjunct faculty** at the Division of Marine Geology and Geophysics, RSMAS, University of Miami (since July 1998).

1998-1999: **Manager** and **Senior Scientist** of the Caribbean Marine Research Center (National Undersea Research Center, NOAA) at Lee Stocking Island, Bahamas.

1995-1997: **Adjunct Lecturer** at Institut für Paläontologie, Universität Wien, Austria.

1995: **Erwin Schrödinger Post-doctoral Research Fellow** (Austrian Science Foundation) at Institut für Paläontologie der Universität Wien, Austria, and Universidad de Granada, Spain.

1994: **Post Doctoral Research Associate** at the Institut für allgemeine Biologie and Institut für Paläontologie, Universität Wien, Austria.

1990-1993: **Doctoral student** at the Oceanographic Research Institute in Durban and at the University of Cape Town, South Africa.

OTHER CAREER RECORD:

Sept. 1996-Aug. 1997: **Project Manager** of EU project "Gulf of Aqaba Protected Areas Development Project". During the project also responsible for the Ras Mohammed Marine Laboratory.

Dec. 1995-Sept. 1996: **Senior consultant** at Martin Mid East Ltd., Abu Dhabi.

1989/90: Corps of Engineers (HpiB2), Austrian Defence Force.

BIBLIOGRAPHY (Partial)

THESES:

Riegl, B. (1989) Gesellschaftsstruktur von Steinkorallen (Scleractinia) an Riffen des nördlichen Roten Meeres. MSc thesis, University of Vienna: 1-116.

Riegl, B. (1993) Taxonomy and ecology of South African reef corals. PhD thesis, University of Cape Town: I-VI, 1-494.

Riegl, B. (2000) Aspects of the biogeology and environmental geology of Cenozoic coral reefs. Habilitationsschrift, Karl-Franzens-Universität Graz, 1-192.

PEER REVIEWED PAPERS IN SCIENTIFIC JOURNALS (SELECTED)

Riegl, B. & W.E. Piller (2000) Mapping of reefs and associated biota in northern Safaga Bay (Red Sea, Egypt): a tool for proactive management. *Aquatic Conservation: Marine and Freshwater Ecosystems* 10: 127-140.

Riegl, B. & Piller, W. E. (2000). Benthos-mapping: applications in environmental geology and resource management (Red Sea, Egypt). *Journal of African Earth Sciences* 30 (4A): 74-75.

Riegl, B., J.L. Korrubel and C. Martin. 2001. Mapping and monitoring of coral communities and their spatial patterns using a surface-based video method from a vessel. *Bulletin of Marine Science* 69(2): 869-880.

Kirschner AKT, Riegl B, Velimirov B (2001) Degradation of emergent and submerged macrophytes in an oxbow lake of an embanked backwater system: implications for the terrestrialization process. *International Revue of Hydrobiology* 86(4-5): 555-571

Moyer RP, Riegl B, Banks K, Dodge RE (2003) Spatial patterns and ecology of benthic communities on a high-latitude South Florida (Broward County, USA) reef system. *Coral Reefs* 22:447-464

Andréfouët S, Kramer P, Torres-Pulliza D, Joyce KE, Hochberg EJ, Garza-Pérez R, Mumby PJ, Riegl B, Yamano H, White WH, Zubia M, Brock JC, Phinn SR, Naseer A, Hatcher BG, Muller-Karger FE (2003) Multi-site evaluation of IKONOS data for classification of tropical coral reef environments. *Remote Sensing of Environment* 88: 128-143

Andréfouët S, Riegl B (2004) Remote sensing: a key tool for interdisciplinary assessment of coral reef processes. *Coral Reefs* 23(1): 1-4

Purkis SJ, Riegl B (2005) Spatial and temporal dynamics of Arabian Gulf coral assemblages quantified from remote-sensing and in situ monitoring data (Jebel Ali, Dubai, U.A.E.*). Marine Ecology Progress Series* 287:99-113.

Riegl B, Purkis SJ (2005) Detection of shallow subtidal corals from IKONOS satellite and QTC View (50, 200 kHz) single-beam sonar data (Arabian Gulf; Dubai, UAE). *Remote Sensing of Environment* 95: 96-114

Riegl B, Moyer RP, Morris L, Virnstein R, Dodge RE (2005) Determination of the distribution of shallow-water sea grass and drift algae communities with acoustic seafloor discrimination. *Revista de Biologia Tropical* 53 (Suppl. 1): 165-174.

Moyer RP, Riegl B, Banks K, Dodge RE (2005) Assessing the accuracy of acoustic seabed classification for mapping coral reef environments in South Florida (Broward County, USA). *Revista de Biologia Tropical* (Suppl. 1): 175-184.

Riegl B, Moyer RP, Morris LJ, Virnstein R, Purkis SJ (2005) Distribution and seasonal biomass of drift macroalgae in the Indian River Lagoon (Florida, USA) estimated with acoustic seafloor classification (QTCView, *Echoplus*). *Journal of Experimental Marine Biology and Ecology* 326: 89-104.

Halfar J, Strasser M, Riegl B, Godinez-Orta L (2006) Oceanography, sedimentology and acoustic mapping of a bryomol carbonate factory in the northern Gulf of California, Mexico. in: Pedley H.M, Carrannante, G., (Eds.) Cool-Water Carbonates: Depositional Systems and Palaeoenvironmental control. *Geological Society, London, Special Publications*, 255, 199-217.

Hetzinger, J, Halfar, J., Riegl, B., Godinez-Orta, L. (2006) Sedimentology and acoustic mapping of modern rhodolith beds on a non-tropical carbonate shelf (Gulf of California, Mexico). *Journal of Sedimentary Research* 76: 670-682.

Purkis SJ, Myint S, Riegl B (2006) Enhanced detection of the coral *Acropora cervicornis* using a contextural classifier. *Remote Sensing of Environment* 101: 82-94.

Hernandez-Cruz LR, Purkis S, Riegl B (2006) Documenting decadal spatial changes in seagrass and *Acropora palmata* cover by aerial photography analysis in Vieques, Puerto Rico: 1937-2000. *Bulletin of Marine Science* 79(2): 401-414.

Banks KW, Riegl BM, Shinn EA, Piller WE, Dodge RE (2007) Geomorphology of the southeast Florida continental reef tract (Miami-Dade, Broward, and Palm Beach Counties, USA). *Coral Reefs* 26: 617-640.

Purkis SJ, Graham NAJ, Riegl B (2008) Predictability of reef fish diversity and abundance using remote sensing data in Diego Garcia (Chagos Archipelago). *Coral Reefs* 27:167-178

Riegl B, Moyer R, Dodge RE, Kohler K, Walker B, Gilliam D (2008)A tale of storms, bombs, and germs: Geomorphology and coral assemblage structure at Vieques (Puerto Rico) and St. Croix (U.S. Virgin Islands). *Journal of Coastal Research* 24(4):1008-1021

Walker B, Riegl B, Dodge RE (in press) Mapping coral reef habitats in southeast Florida using a combined-technique approach. *Journal of Coastal Research*

Rowlands G, Purkis SJ, Riegl B (in press) The 2005 coral-bleaching event Roatan (Honduras): Use of pseudo-invariant features (PIFs) in satellite assessments. *Journal of Spatial Research.*

REVIEWED PAPERS IN CONFERENCE PROCEEDINGS AND BOOK CHAPTERS (SELECTED)

Riegl B (2002) Phoenix from the ashes? Repetitive mass mortality and the biogeology of southern Arabian Gulf (United Arab Emirates) coral systems. In Bright M, Dworschak PC, Stachowitsch M (eds) *The Vienna Scool of Marine Biology. A Tribute to Joerg Ott*. Facultas, Vienna: 137-159

Walker BK, Riegl B, Dodge RE, Moyer RP (2002) Integration of remotely-sensed optical and acoustic data for the delineation of reef-lines in Broward County, Florida (USA). *Proceedings of the 7th International Conference on Remote-Sensing in Coastal and Marine Habitats, Miami* (on CD)

Moyer RP, Riegl B, Dodge RE, Walker BK, Gilliam D (2002) Acoustic remote-sensing of reef benthos in Broward County, Florida (USA). *Proceedings of the 7th International Conference on Remote-Sensing in Coastal and Marine Habitats, Miami* (on CD)

Riegl B, Moyer RP, Andrefouet S (2002) Integration of satellite remote-sensing of subtidal habitats with vessel-based video survey (Dubai, UAE, Arabian Gulf). *Proceedings of the 7th International Conference on Remote-Sensing in Coastal and Marine Habitats, Miami* (on CD)

Riegl B, Piller WE (2002) Reefs and coral carpets in the Miocene Paratethys (Badenian, Leitha Limestone, Austria). *Proceedings of the 9th International Coral Reef Symposium, Bali, Volume 1*: 211-216

Riegl B, Piller WE (2002) Upwelling areas as possible refugia in times of rising SST? Further evidence from the Caribbean and Indian Oceans. *Proceedings of the 9th International Coral Reef Symposium, Bali, Volume 1*: 315-320

Riegl B, Dodge RE (2008) Introduction: A diversity of oceans, reefs, people, and ideas: a perspective of US coral research. In: Riegl B, Dodge RE (eds) Coral Reefs of the USA. Springer-Verlag, Dordrecht, 1-9

Riegl B, Purkis SJ, Houk P, Cabrera G, Dodge RE (2008) Geologic setting and geomorphology of coral reefs in the Mariana Islands (Guam and Commonwealth of the Northern Mariana Islands). In: Riegl B, Dodge RE (eds) Coral Reefs of the USA. Springer-Verlag, Dordrecht, 687-714

Banks KE, Riegl BM, Richards VP, Walker BE, Helmle KP, Jordan LKB, Phipps J, Shivji M, Spieler RE, Dodge RE (2008) The reef tract of continental Southeast Florida (Miami-Dade, Broward, and Palm Beach Countoes, USA). In: Riegl B, Dodge RE (eds) Coral Reefs of the USA. Springer-Verlag, Dordrecht, 125-172

Birkeland C, Craig P, Fenner D, Smith L, Kiene WE, Riegl BM (2008) Geologic setting and ecologic functioning of coral reefs in American Samoa. In: Riegl B, Dodge RE (eds) Coral Reefs of the USA. Springer-Verlag, Dordrecht, 737-762

Riegl B, Purkis SJ (in press) Markov models for linking facies in space and time (Arabian Gulf, Miocene Paratethys) in: Swart P, McKenzie J (eds) Perspectives in Sedimentary Geology: A Tribute to the Career of Robert Nathan Ginsburg, IAS Special Publication

BOOKS, SPECIAL ISSUES:

Editor of Special Issue: “Remote-sensing coral reefs” (together with S. Andrefouet). *Coral Reefs 23(1)*, 2004, 168 pp.

Editor of Special Section: “Marine Habitats in Vieques, PR” (together with R. E. Dodge). *Bulletin of Marine Science 79(2)* (2006.)

Editor of Book: “Coral Reefs of the USA” (together with R.E. Dodge). *Springer Verlag, Dordrecht*, 2008, 801pp.

CURRICULUM VITAE

(August 2008)

Raymond E. Grizzle, Ph.D.

Jackson Estuarine Laboratory and Department of Biological Sciences
University of New Hampshire
Durham, NH 03824 USA
Phone: 603-862-5130 Fax: 603-862-1101 email: ray.grizzle@unh.edu

EDUCATION

Ph.D. 1988, Department of Biological Sciences, Ecology Program, Rutgers University, New Brunswick, NJ
M.S. 1981, Biology Program, University of Central Florida, Orlando, FL
B.S. 1972, Major: Biology, Florida State University, Tallahassee, FL

PROFESSIONAL POSITIONS (since 1990)

2007-pres.	Research Professor: Department of Zoology, University of New Hampshire, Durham, NH
2000-07	Research Associate Professor: Department of Zoology, University of New Hampshire
2000-02	Director: Jackson Estuarine Laboratory, University of New Hampshire
1999-00	Research Scientist III: Jackson Estuarine Laboratory, University of New Hampshire
1996-99	Associate Professor of Environmental Science: Taylor University, Upland, IN 46989; tenure granted, August 1998.
1994-96	Assistant Professor of Environmental Science: Taylor University
1992-94	Assistant Professor of Biology: Campbell University, Buies Creek, NC 27506
1989-92	Assistant Professor of Biology: Livingston University, Livingston, AL 35470

PUBLICATIONS (relevant here)

Grizzle, R.E., M. Brodeur, H. Abeels, and J.K. Greene. 2008. Bottom habitat mapping using towed underwater videography: subtidal oyster reefs as an example application. *Journal of Coastal Research* 24:103-109.

Cutter, G.R., Jr., Y. Rzhanov, L.A. Mayer, and R.E. 2005. Ground-truthing benthic habitat characteristics using video mosaic images. pp. 171-177 In: *Benthic Habitats and the Effects of Fishing.* P.W. Barnes and J.P. Thomas (eds.) American Fisheries Society Symposium 41.

Grizzle, R.E., L.G. Ward, J.R. Adams, S.J. Dijkstra, and B. Smith. 2005. Mapping and characterizing oyster reefs using acoustic techniques, underwater videography, and quadrat counts. pp. 153-160 In: *Benthic Habitats and the Effects of Fishing.* P.W. Barnes and J.P. Thomas (eds.) American Fisheries Society Symposium 41.

Grizzle, R.E., L.G. Ward, R. Langan, G.M. Schnaittacher, J.A. Dijkstra, and J.R. Adams. 2003. Environmental monitoring at an open ocean aquaculture site in the Gulf of Maine: results for 1997-2000. In: *Open Ocean Aquaculture: from Research to Reality*. Eds: C.J. Bridger and B.A. Costa-Pierce. The World Aquaculture Society, Baton Rouge, LA, USA. JEL Contribution Series, No. 388.

Grizzle, R.E. Grizzle, R.E., L.G. Ward, J.R. Adams, S.J. Dijkstra, and B. Smith. 2003. Research note: mapping and characterizing subtidal oyster reefs using acoustic techniques, underwater videography, and quadrat counts. Proceedings of Symposium on the Effects of Fishing Activities on Benthic Habitats: Linking Geology, Biology, Socioeconomics, and Management. American Fisheries Society.

Grizzle, R.E., J.R. Adams, L.J. Walters. 2002. Historical changes in intertidal oyster (*Crassostrea virginica*) reefs in a Florida lagoon potentially related to boating activities. *Journal of Shellfish Research* 21:749-756

ABSTRACTS, PRESENTATIONS & WORKSHOPS (selected since 2000)

Grizzle, R.E. Recovery of seafloor habitats in the Western Gulf of Maine fishing closure area. New England Estuarine Research Society, Spring 2008 Meeting, Sandy Point, New Hampshire. April 2008

Grizzle, R.E., H.A. Abeels and J.K. Greene. Mapping and characterizing oyster (*Crassostrea virginica*) reefs with towed, underwater videographpy. National Shellfisheries Association, San Antonio, TX, March 2007

Grizzle, R.E., L.G. Ward, L.A. Mayer, A.B. Cooper, A.A. Rosenberg, M. Brodeur, J.K. Greene, H. Abeels, and M. Malik. Effects of the Western Gulf of Maine closure area on seafloor habitats: GIS-based assessments. Geographic information systems and ocean mapping in support of fisheries research and management. MIT Sea Grant symposium, Cambridge, MA, April 2006.

Grizzle, R.E. Effects of the Western Gulf of Maine closure area on benthic habitats. Maine Fishermen's Forum, Rockport, ME, March 2006.

Grizzle, R.E. Seabed mapping using acoustics and underwater videography. UNH Zoology Department Seminar Series, November 2003, Durham, NH.

Greene, J.K., R.E. Grizzle and J. Adams. Mapping and characterizing eastern oyster (*Crassostrea virginica*) reefs using underwater videography and quadrat sampling. National Shellfisheries Association annual meeting, April 2003, New Orleans, LA.

Grizzle, R.E., L.G. Ward and J.R. Adams. Mapping and quantitatively characterizing seabed habitats with underwater videography. Emerging Technologies, Tools, and Techniques to Manage Our Coasts in the 21st Century, 27-30 January 2003, USEPA, Cocoa Beach, FL.

Grizzle, R.E., L.G. Ward and J.R. Adams. Mapping and characterizing subtidal oyster reefs using GIS and underwater videography. Fishing and Benthic Habitats, USGS/NOAA/AFS/ESA, 12-14 November 2002, Tampa, FL.

Grizzle, Raymond, Jamie Adams and Linda Walters. Long-term changes in intertidal oyster reefs and the potential effects of boating activities. Marine Benthic Ecology Meeting 2002, 21-24 March, Orlando, FL.

Adams, Jamie, Raymond Grizzle, Larry Ward, Semme Dijkstra and John Nelson. A comparison of acoustic techniques, videography, and quadrat sampling for mapping and characterizing subtidal oyster reefs. Marine Benthic Ecology Meeting, 21-24 March 2002, Orlando, FL.

Grizzle, Raymond, Jamie Adams and Linda Walters. Long-term changes in intertidal oyster reefs in a Florida lagoon potentially caused by boating activities: an analysis of aerial imagery from 1943-2000. National Shellfisheries Association Meeting, 14-18 April 2002, Mystic, CT.

Adams, Jamie, Raymond Grizzle, Larry Ward, Semme Dijkstra and John Nelson. A comparison of

acoustic techniques, videography, and quadrat sampling for mapping subtidal oyster reefs. National Shellfisheries Association Meeting, 14-18 April 2002, Mystic, CT. *Journal of Shellfish Research* 21: 413 (abstract)

GRANTS, CONTRACTS & AWARDS (selected since 2005)

Effects of the Western Gulf of Maine closure area on groundfish populations in rocky habitats. 10/06-9/08. Funded by the Northeast Consortium. $339,103 (total for 2 yrs) (principal investigator with Hunt Howell, Mike Leary)

Environmental monitoring at UNH's Open Ocean Aquaculture Demonstration site. 9/06-8/07. Funded by NOAA/Sea Grant. $50,000 (Grizzle portion only) (principal investigator with L. Ward, UNH, Jim Irish, WHOI)

Monitoring marine protected areas: intensive study of the Western Gulf of Maine Closure Area - Bottom habitat mapping. Funded by NOAA/UNH Cooperative Institute for New England Mariculture and Fisheries (CINEMar). $130,873. 9/05-8/07. (principal investigator with Andy Rosenberg)

Development of a general protocol for characterizing subtidal oyster reefs using remote sensing techniques. 3/04-12/05. Funded by NH Sea Grant. $119,121 (total for 2 yrs) (principal investigator with Semme Dijkstra and Brian Smith)

Monitoring marine protected areas: intensive study of the Western Gulf of Maine closure area - Bottom habitat mapping. Funded by NOAA/UNH Cooperative Institute for New England Mariculture and Fisheries (CINEMar). $70,883. 9/04-8/05. (principal investigator with Andy Rosenberg)

Oyster reef mapping and softshell clam population assessments. 3/03-12/03. Funded by USEPA/NH Estuaries Project. $19,000.

An Environmental Impact Assessment of the Spaulding Turnpike widening project: Seafloor Mapping. 03/03-10/06. Funded by VHB, Inc./NH Department of Transportation. $50,135.

New remote sensing technologies for mapping subtidal oyster reefs. 12/01-8/02. Funded by NOAA/NH Sea Grant and the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), University of New Hampshire. $11,514 (principal investigator with L. Ward, S. Dijkstra, UNH; J. Nelson, NH Fish & Game Department)

A new video system for bottom habitat mapping. 3/01-2/02. Funded by UNH Hubbard Endowment Fund. $14,900. (principal investigator with Larry Ward and Lloyd Huff, UNH)

A comparison of low altitude aerial imagery and satellite imagery for monitoring changes in intertidal oyster reefs in the Canaveral National Seashore. 9/97-8/98. Funded by the Eastern National Park & Monument Association and the US National Park Service. $7,500.