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FORMAT for Annual Progress Report

Project Title: SFERPM 2000: Role of Phytoplankton in benthic pelagic coupling

Grantee: Gabriel A. Vargo (coPI with Gary L. Hitchcock and Daniel DiResta, UMiami/RSMAS

Award Period: From 8/1/00 To 7/31/02

Period Covered by this Report: From 8/1/01 To 5/1/02

Summary of Progress:

l. Work Accomplishments: (as related to project objectives and schedule for completion)

a. Provide a brief summary of progress, including results obtained to date, and their relationship to the general goals of the grant; and

The primary objectives of this program are to:

1. Quantify the primary production by pelagic phytoplankton and benthic microalgae in central and western Florida Bay.
2. Assess the role of pelagic phytoplankton and benthic microalgal communities in nutrient cycling during wet and dry seasons, and
3. Quantify biomass and grazing rates of benthic filter and suspension feeders on the pelagic phytoplankton community and, where feasible, on the microphytobenthos

To achieve these objectives a bimonthly sampling program was set up which started in September, 2000. Flux rates for total dissolved and inorganic phosphorus are combined with oxygen measurements within light and dark benthic chambers to assess nutrient flux and primary production/respiration of the microphytobenthos and water column phytoplankton. The biomass of the microphytobenthos is also determined during each of the sampling runs. We will combine the range of microphytobenthic biomass levels measured over the course of a season with the flux data to satisfy objectives 1 and 2. In addition, we have initiated microcosm and mesocosm experiments to determine the impact of nutrient additions to the water column and sediment, respectively, on the microphytobenthos, water column phytoplankton and their impact on sediment nutrient flux.

Flux measurements, production determinations, microphytobenthos biomass measurements and PAM fluorometer measurements (an additional data set that will allow interpretation of the physiological state and photic state of the microphytobenthos) have been carried bimonthly at Sandy Key and, over the past year, at Whipray Basin since September, 2000. We were unable to do the first scheduled mesocosm experiment in March, 2001 due to seven days of bad weather. However, the scheduled mesocosms experiment for the wet season in July, 2001 was successfully completed at a site in the Arsnicker Key area. We have learned that the in situ mesocosms must be protected from wind and wind generated waves otherwise they do not remain in place despite using tie-downs inserted over 0.75m into the sediment. Therefore we will perform our next two mesocosm studies in totally protected basins; at Arsnicker Key again

in May, 2002 and in Whipray Basin in July-August, 2002. A no-cost extension was requested and granted in order to do the Whipray experiment because of scheduling problems at the Keys Marine Laboratory.

Results to date: Sediment flux studies

To date benthic biomass and flux measurements have been carried out at Sandy Key and Whipray Basin. At Sandy Key, benthic biomass values ranged from 1.13 - 42.9 mg/m^2 (0.9 - ~34 mg Chl a m-2). Benthic chlorophyll a values were 10-20 times greater than water column concentrations during non-bloom conditions. and equal to water column concentrations during blooms (8.3-27.4 mg chl a m-2). My values were similar to those from the WFS near the middle ground (Vargo, unpublished data). Highest chlorophyll concentrations at Sandy Key (Fig. 1) were found during May; lower concentrations were found throughout the rest of the year. At Arsnicker Keys and Whipray Basin, sediment chlorophyll concentration was also high and variable with a maximum in June (Fig. 2). Results were variable among chambers owing to the patchy nature of the benthic microalgal assemblage, but were consistent within chambers. Benthic samples contained about 55 – 93% phaeopigment (Figs. 1 and 2) compared to about 40% in the water column, which is likely due to dead pelagic phytoplankton cells, dead seagrass, epiphytes and fecal pellets. 18.05 - 152.84 mg/m^2

Hourly phosphorus flux rate ranged from -3.7 to 13.8 uM/m^2/h and was variable both within and among treatments. From spring to early fall P flux was generally out of the sediment into the water column with greater flux from the sediments in dark chambers compared to light chambers (Figs 3 and 4) although there was a difference in the sign of P flux between morning and afternoon experiments. Flux from the sediment during the morning hours occurred in ~50% of the runs regardless of whether the chamber was light or dark (Figure 3). Positive P flux was found in all the but three afternoon runs in the dark chambers, while only two afternoon experiments showed negative P flux (Fig. 4). Rates of P flux in Whipray basin and Arsnicker Key were similar to values at Sandy Key during he same time period (Figs. 5 & 6). Flux rates reported here are similar to those of Yarbro and Carlson (1999).

Curiously there are times when the sediments took up total dissolved phosphorus (TDP) while the soluble reactive phosphorus was released from the sediments. The ratio of SRP:TDP during the afternoon on one sampling date at Sandy Key decreased by about 10% indicating differential uptake of TDP relative to SRP in the dark chambers. This differential uptake was not noted in the light chambers.

Tidal pumping of P from the sediments may be important in western Florida Bay due to the variability in the sediment grain size, although peak P concentrations did not seem to correspond to any consistent tidal level. Tidal influences are diminished at Arsnicker Keys and there is nearly no tidal range evident in Whipray Basin. Spatial differences were apparent in March 2001 when two sets of chambers were placed about 100 ft. apart. This bias probably did not affect other sampling because chambers were located within a few feet of each other.

Greater hourly P flux noted in the dark chambers may be due to uptake by benthic a water column phytoplankton in the light chambers. Dark Uptake of P cannot be resolved by this

sampling method within in situ chambers. The greater P flux during the afternoon in both chambers might be due to the mediation of P flux by benthic microalgae. Highest DO measurements were found in the late afternoon corresponding to the greatest net photosynthesis in the benthic community.

Summary

1. Benthic chlorophyll a ranged from 9 - ~34 mg chl a m-2 and was 10 – 20 times that measured in the water column (non-bloom conditions). Benthic microalgal biomass contained proportionally more phaeopigment than water column measurements.

2. Benthic microalgal chlorophyll a values were similar to those from the west Florida shelf. Central and western Florida Bay exhibited similar chlorophyll a values.

3. Hourly flux rates of inorganic P from the sediments were variable, but generally greater in dark chambers vs. light chambers. This is probably the result of P uptake by benthic microalgae. Less P flux was noted during sampling in 2001 vs. 2000.

4. Inorganic P flux was greater in the afternoon during peak photosynthesis, probably as a result of mediation by benthic microalgae.

5. Similar P flux measurements were found in both central and western Florida Bay during the summer of 2001.

6. Hourly P flux rates presented here agree with other measurements in Florida Bay.

Results: Mesocosms

Two types of containers were used for our mesocosm experiments during the past trial: our in situ Plexiglas cylinders which contain approximately 100 liters of water and are inserted 10cm into the sediment (approx. a 90 cm water column in final position), and a series of plastic "shoeboxes" which contain a sediment community and are incubated in water tables at the laboratory. The "shoeboxes" are filled by taking multiple cores from a desired location and inserting them into the container in the proper orientation until it its filled with sediment.

Nine in situ mesocosms and eight microcosms were used which received the following nutrient additions:

Mesocosm number	Nutrient addition
1,6,8	controls
2,4	P + Si
5,9	N + Si
3,7	N + P

Microcosm (shoebox) number	Location of nutrient additions
1,6	controls
2,5,7	nutrients added to water column
3,4,8	nutrients added directly to sediment

Nitrogen was added as ammonium to a final concentration of 10 uM, phosphorus as ortho-phosphate to a final concentration of 2 uM, and silicate to a final concentration of 10 uM. The same final nutrient levels were used in the microcosm experiments as well except that the N, P, and Si were all added together to either the water column above the sediments or injected to a depth of 1 cm into the sediments. All experiments were sampled daily for a variety of parameters specified in the original proposal. We will only present the chlorophyll data here. We were also pleased to have Mr. Ian Hewson, a student of Dr. Jeb Furhman at the University of Southern California join us for a short while during the experiment. We collected final samples for him for the determination of virus and bacteria abundance in the water column and sediments of the in situ mesocosms. His results are included in this summary.

Results to date: Mesocosm and microcosm experiments

Six of the nine in situ mesocosms replicated reasonably well with respect to water column chlorophyll concentrations (Fig. 7). However, the two mesocosms receiving P + Si additions and one of the N + P addition cylinders exhibited dramatic phytoplankton growth after 5 days of nutrient additions. Pennate diatoms, chlorophytes and cyanobacteria were typically responsible for the enhanced growth which mainly occurred on the cylinder walls and sloughed off during sampling. Sediment chlorophyll concentrations did not respond in a systematic way to nutrient additions (Fig. 8) The two maxima on July 12 and 15 occurred in the controls. A similar lack of relationship to nutrient additions to either the water column or directly into the sediments also occurred in the microcosms. The peaks in sediment chlorophyll values on the 18^{th} occurred in a water column add (Chl 4), a control (Chl 6), and a sediment addition (Chl 7). One feature that is not quantified but was common to both the in situ and shoebox experiments was a rise in the anoxic layer from 2 to 3 cm in depth to the sediment surface at the end of the experiments. Although sediment bacteria populations appeared to be slight reduced during the course of the experiment (Fig. 10), water column populations did increase significantly possibly leading to enhanced heterotrophy in the near bottom layer which was in the direction of reducing oxygen levels in the surface sediments. It is of interest to note that viral particles increased in the water column irrespective of nutrient additions whereas only P + Si additions appeared to stimulate viral growth in sediments (Fig. 10).

PAM fluorometer measurements were taken in all in situ mesocosms throughout the experiment. However, as with the sediment chlorophyll values, there were no general trends in any of the PAM measurements.

b. Provide a brief summary of work to be performed during the next year of support, if changed from the original proposal; and indication of any current problems or favorable or unusual developments; and any other significant information pertinent to the type of project support by COP, or as specified by the

terms and conditions of the grant.

We do not plan to alter our experimental design over the next year of the project. We will continue to use the PAM fluorometer but measure a different set of parameters that may be better indicators of the benthic microalgal physiological state. We will also measure the depth of the reducing layer in the sediments using a millivolt electrode and record diurnal changes in oxygen in as many mesocosms as possible. Because Dr. Hitchcock only has one in situ recording oxygen sensor available we will use it sequentially in each of the mesocosms during the course of the experiment.

2. Applications:

a. Publications, presentations, workshops;

Our preliminary results of benthic phosphorus flux and microphytobenthos biomass were presented at the April 23-26, 2001 Florida Bay Science Conference as a poster presentation and Ms. Merrie Beth Neely presented her benthic flux data at the Estuarine Research Federation Meeting in October, 2001. She will also present them as an oral presentation at the Ocean Sciences Meeting in Victoria, BC, Canada, in June, 2002.

b. Applications to management or research;

Not at this time.

c. Data and/or information products;

Data is archived in G. Vargo's laboratory in the College of Marine Science, Univ. of South Florida.

d. Partnerships established with other federal, state, or local agencies, or other research institutions (other than those already described in the original proposal).

At the recent Florida Bay Science Conference we discussed the possibility of combining our information on benthic suspension filtering and ingestion rates with data from Dr. Brad Peterson of Florida International University on the abundance and distribution of these organisms to determine the potential overall impact of this group of organisms on water column phytoplankton blooms in Florida Bay. I (G. Vargo) agreed to send him our filtering rate data and he will set-up another model run for comparison with results based on literature values for filtering rates.