NURC/UNCW
Management Information System

Project Summary Report

PI Surname: _Szmant_____ **Project #:**___2004-16A; [2004-18B]___ **Region:**__*Key Largo*_____

Title of Project: Recruitment of *Montastraea faveolata* (species complex): Larval dispersal, settlement and post-settlement survivorship

Start Date: __*May 25, 2004*_____ **End Date**:__*Sept , 2004*_____**Year** _1[2]__ **of** __1_[2]__

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Number of Participants: *total number of science participants* _____*10*_____

OPERATIONAL INFORMATION

System	for extended ops only		Weather Days	Other (e.g. mech. prob.)	OPS Days	Total Dives [1]	Total Bottom Time [2]
	Port Days	Transit Days					
SCUBA (air)			**10**			**filled in by NURC**	
SCUBA (nitrox)							
Aquarius							
ROV							
SUB							
Center Facilities: lodging dockage X shore lab X small boats X							
Center Equipment: CTD Video camera(s) still camera(s) Other:							
Support Vessel(s) used: Wild Card; rental boat from Atlantis Dive Center							

1. *For SCUBA, SCUBN or Aquarius = man dives or excursions; for ROV/SUB = system dives*
2. *Bottom Time = surface to surface interval (hours)*

Operating Depth Range*(Meters)*: __*10*___

Project Location(s): *geographic name = area of research, e.g., Hatteras slope or Conch Reef; latitude and longitude = center of area; no more than four areas*

Site	Geographic Name	Latitude (dd-mm.m N)	Longitude (ddd-mm.m W)
1	**Key Largo Dry Rocks, FL**	25 07.37998 N	080 17.92240 W
2	**Molasses Reef**		
3			
4			

COST INFORMATION

NURC/UNCW Support (*input by Center*):

Variable Costs = *direct costs, including supplies, equipment, services, subcontracts provided by the Center for this project* **$ NURC input**

Fixed Costs = *value of Center system support based on estimated day rate for the system times number of operations days* **$**_____

Total = **$**_____

Co-funding Support (*input by PI*):

Agency	Status (Approved, Submitted)	Period (dates)	$ Amount
NSF	approved	7/1/04 – 6/30/05	$23,147
EPA	approved	6/1/03 – 6/30/05	$99,780
NOAA/NURP	approved	10/1/04-6/30/05	$94,015
			$
			$
			$
		Total Co-Funding =	$216,942

PROJECT DESCRIPTION

I. **SUMMARY OF PROJECT:** *objectives, methods, and the significance of the proposed activity to the advancement of research field, environmental management, or education. Please avoid use of first person.*

This project investigated aspects of the larval behavior, dispersal abilities, settlement and post-settlement survivorship that are significant aspects of the recruitment process of the Caribbean reef-building coral, *Montastraea faveolata*. This coral is one of the top-reef builders in the Florida Keys and throughout the Caribbean. It is abundant as large adults, less abundant in smaller size classes and rare as new recruits. *M. faveolata* has been seriously affected by bleaching and disease out-breaks over the past two decades, resulting in a significant reduction in live-tissue cover. Thus, there is heightened concern that low recruitment rates coupled with recent high mortality rates will result in a major decline of this species. Given the critical role in reef-building and community structure that this species has, it is urgent to gain a better knowledge and predictive skill in all aspects of the recruitment process. The predictive skill relates directly to the major management concern: how to assess and anticipate the ability of the diminishing number of reefs with remaining aggregations of adults to serve as sources of larvae and their ability to rebuild degraded reefs in both the near- and far-field regions.

The research plan had the dual specific objectives of:

1. Developing and testing a suite of new approaches to monitor and follow the dispersal patterns of coral spawn. These included:
(a) an antibody assay to detect coral larvae in water samples collected directly in the field
(b) "novel" neutrally buoyant particles (model coral eggs/larvae) to monitor and follow particle dispersion,
(c) moored collectors that collect the "novel" particles
(d) fluorescent neutrally buoyant particles (model coral eggs/larvae) to monitor and follow particle dispersion via an underway net-tow survey.
The survey is designed to simultaneously measure both types of particles as well as coral spawn, allowing comparisons between all three observations. Items (a) and (b) represent a new technology that could revolutionize the observation of the physical factors affecting coral reef connectivity.

2. Conducting field and laboratory experiments that investigate factors that affect the settlement patterns and post-settlement survivorship of *M. faveolata*.

Together, the preliminary results have already advanced our insights regarding major factors that directly (proximate) affect the recruitment success of this critical coral species on Key Largo coral reefs. Results from pending analyses should provide: 1) increased skill in anticipating (predicting) strong or weak recruitment and recruitment locations; and 2) insights to measures (active management) that can be taken to increase recruitment success.

The first objective (1) above provides new, efficient, effective and economic methods for monitoring and tracking small particle dispersion of many/most early-stage invertebrate (e.g. coral) and vertebrate (e.g. fish larvae) species and suspended or resuspended sediments or other like particles of interest. There is clear potential for a broad range of applications.

II. **SUMMARY OF RESULTS:** *Accomplishments, benefits, and new research topics: 1) preliminary results and significance; 2) success of the mission in terms of project goals; 3) plans for use of the data, for example, management needs, publications, or other products; 4) new research ideas or directions generated.*

The May mission dates (May 25 and 26, 2004) to deploy a second set of settlements at three stations was successful.

Our ability to execute the work needed to address the above objectives for the dedicated 28 August to 10 September period of 2004 was severely compromised by two major hurricanes (*Frances* and *Ivan*) that approached our field and lab sites during the above period. The consequences were not trivial. Our research group came under mandatory evacuation no less than twice during the two-week mission. We were unable to be on-site during the extremely contracted *Montastraea* spawning period as the NURC facility was closed due to Hurricane *Frances*. Post-recovery from the *Frances* evacuation forced us to charter a dive boat in an attempt to collect spawn on the night of 06 September, but this too was compromised by poor visibility and rough whether. Subsequent opportunities were impossible due to the spawning period being over and the impending arrival of Hurricane *Ivan*. However, we did manage to collect spawn from the few coral colonies we (smartly) maintained at our other field lab and these provided sufficient larvae for an abbreviated/reduced scope determination/validation of buoyancy/behaviour and settlement. Despite the weather limitations, we were highly successful in obtaining sufficient data to demonstrate the viability of the new methods.

Antibody Assay

One of the goals of the project was to develop an antibody-based assay that could be used to specifically detect *M. faveolata* eggs and larvae in samples of seawater collected at locations around the spawning site that could be used to track the larval dispersal. We had already developed polyclonal antisera to *M. faveolata* prior to arrival in Key Largo, but had not fully tested potential cross reactivity with other species of coral due to a lack of tissue samples. Since the weather delayed collection of samples of larvae during spawning, we focused on testing the cross reactivity of our antiserum using fresh coral samples. We demonstrated that our antiserum could detect larvae, adults and eggs of *M. faveolata* very well. The antiserum showed no cross reactivity with *Acropora* larvae, slight cross reactivity with *M. cavernosa* adults and larvae (20% of the level at which *M. faveolata* is detected) and detected larvae of *M. annularis* larvae about 75% as well as the *M. faveolata.* The cross reactivity with *M. annularis* may not be a problem because this species is much less common than *M. faveolata,* it is also of interest to study, and not all investigators agree that it is a different species from *M. faveolata.* The cross reactivity with *M. cavernosa* is low and can be removed from the antiserum by either using the serum at a greater dilution (which we tested during the field trip) or pre-absorbing the antiserum with some *M. cavernosa* adult material, which may reduce the detection of *M. faveolata* slightly, but not enough to perturb the assay. This optimization is currently being worked on (see below). We did manage to get out and collect four plankton tows on Sept 6th, each of which sampled approximately 30 cubic meters of seawater. We could not detect any larvae in those samples, but given that the volume of seawater collected could be concentrated down to 10ml, we used these samples in some spiking experiments using larvae that were produced by the lab corals. It was possible to detect 5 and 10 larvae in those 10ml samples quite easily and we could also see a small reaction with samples containing 1 larva in 10ml of seawater. This was using the antiserum at 1 in 15,000 dilution to ensure that no cross reactivity with *M. cavernosa* would be detected (if this were a real sample), so again this could be optimized by removing the *M. cavernosa* reactivity by absorption and using the antiserum at a lower dilution (say 1 in 10,000 or 1 in 5,000). This should allow us to detect one larva in a plankton tow sample covering approximately 30 cubic meters of seawater. On the night of Sept 6th we were able to collect a limited number of *M. faveolata* eggs and show that the antiserum detected those eggs as well as the lab samples

we had been using for the experiments above. We collected a further 8 plankton tows on Sept 8th and 9th, but were not able to assay them due to the 2nd evacuation order. We have attempted to assay these samples and further optimize the assay upon our return to Canada, but due to the hurricane our samples sat in customs for 6 days during shipping and many of them have lost their reactivity. We will continue to work with these samples to see if we can get any of them to react and try to absorb the *M. cavernosa* reactivity from the sample so we can optimize the detection of only *M. faveolata* and *M. annularis.*

Particle tracer study

Most time and effort expended prior to the known coral-spawning dates was spent to outfitting the NURC vessel (*WildCard*) for underway survey monitoring and sampling of both particle types, in-situ larvae, and radio-drifter tracking and assembling the equipment needed deploy the novel-particle collectors and to deploy the novel and fluorescent particles as point sources. As above, Hurricane *Frances* compromised our ability to complete no more than one brief field trial of the novel-particle collector moorings and the vessel-mounted sampling equipment that was curtailed by mandatory evacuation and field cleanup. As a result, fewer than anticipated moorings were deployed during the period 01-03 September. One "safe" mooring (as advised by NURC personnel) remained on-site during the passage of *Frances* and it survived completely intact and functioned well during the dispersal trial. Subsequent to the logistics of recovery from *Frances*, and prior to evacuation for Hurricane *Ivan*, we took advantage of the earliest possible, though very narrow, weather-window of opportunity and managed to deploy 26 on-site novel-particle collectors (21 near-surface and 5 near-bottom) on 07 September. This deployment represented ~50% of our planned collector deployment effort and was concentrated on the near-field aspect of the study, with virtually no far-field deployments. Point-source novel- and conventional fluorescent-particle deployment (weather related logistics and NURC personnel limitations forced us to charter yet another dive-boat) and release of the radio-tracked drifters took place early (~07:00) on 08 September; some two days beyond the predicted spawning date for the *Montastraea* corals. Key personnel were subsequently transferred from the particle-release dive-boat to the *WildCard* to assist with the underway monitoring and sampling of the particle dispersion field.

- Net-tow sampling system performance:

The underway and vessel-mounted sampling system was designed to be comprehensive and because redundancy was built-in, it was complex. It consisted of a 1 m^2 opening side-towed neuston-net, a 12 volt pump system drawing water and particles from the net cod-end, a particle concentrator, an inline flow meter and an integrated logging system for recording time, location, flow and fluorescence signal etc.). The concentrated particle stream passed from the concentrator, though a fluorometer (for underway fluorescent particle concentration logging), a Flo-cam particle detector/counter, a novel-particle collector (analogous to the moored *in-situ* collectors) and finally through a system of filters designed to retrieve all particles for later identification (fluorescent and novel) and enumeration. These final collections were integrated over a 2-minute period (approx. 120 m spatial resolution). However, the flow system suffered severely from the unanticipated and substantial amount of floating sea-grass that had been stirred up by Hurricane *Frances* (somebody should do a biomass input study of this phenomenon). First, the Flo-cam, then the fluorometer, then the inline flow meter and finally the particle concentrator had to be removed from the system due to the sea-grass clogging the system. Fortunately, the redundancy in the system design allowed us to revert to using conventional neuston net collections, though the spatial resolution was reduced to between 600 to 1000 m (5 to 10 minute integration per collection) and not in the desired continuous manner. The method allowed us to continue the survey/monitoring and radio-drifter tracking though the day and continued the next morning until we were forced to abandon our survey due to mandatory evacuation and field-site clean up pending Hurricane Ivan.

Sampling proceeded from around 11:00 on 08 September until dusk, and began at first light the following day, after the radio drogues and dispersion field were re-located. The sampling consisted of net-tows approximately 10 minutes in length along tracks oriented primarily in the cross-shore direction and terminated at ~11:00 on 09 September 9 due to mandatory evacuation for Hurricane Ivan. On the afternoon of 09 September we retrieved the collector moorings, packed and secured our equipment for return shipment, cleaned the laboratory spaces and the NURC accommodations, and evacuated.

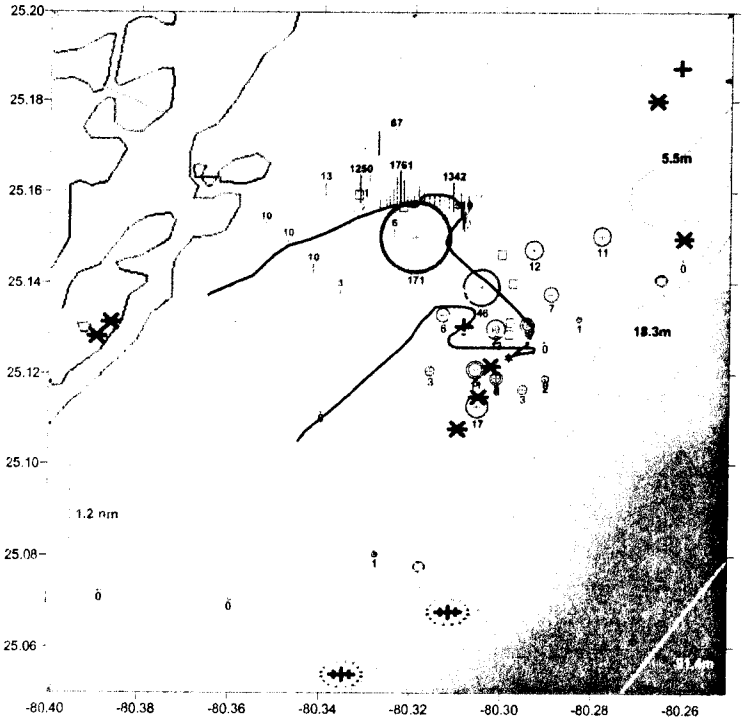
- Post-experiment assessment

The forced hurricane evacuations had a severe impact on our ability to achieve our goals. We were unable to deploy as many collectors as planned, for as long as planned, nor with the near- and far-field coverage planned. Further, we were unable to release the particles during the *Montastraea* spawning, and we were only able to monitor/track the particles using our net tow system for 24 hours rather than the 4-6 days that had been planned. Finally, the huge amount of floating grass caused the net tow system to work less effectively than planned, though we recovered all data, but at a lower resolution than desired.

Was the tracing experiment a failure? Not for a second! The original scientific plan was excellent, and most importantly: 1) we were able to track the fluorescent and the novel-particles; 2) we were able to monitor and assay for larval antibodies using the in-situ net collections; and 3) the passive novel-particle collectors moored in-situ worked exceedingly well and beyond all expectation. We clearly demonstrated that this new and demonstrably integrated coral dispersion sampling/monitoring technique shows excellent promise - so much so that new research funding applications are being prepared at the time of this report.

We could have used some more key technical personnel to assist with preparation of our underway survey system and electronics, and the design needs modifications (all feasible) to make it more robust, flexible and resistant to sea-grass clogging.

- Post-experiment preliminary analysis



We have been actively collaborating with Jerome Feichter of RSMAS, who was instrumental in assisting with the fieldwork, and is currently running numerical model simulations of the 2004 Key Largo particle release. We are exchanging observational and modelling results, and plan to work together on a joint publication describing the experiment and its results. The preliminary particle results are given in detail in a data report (Logan, 2005). One figure combining several aspects of the analysis is reproduced here, showing the net tow counts of fluorescent particles (vertical lines in green and blue), counts of novel particles from moored collectors (red circles), track of a radio buoy (yellow squares), and model-predicted drift track for surface (blue line) 0.5 m (white line), and 1 m (black line) depths.

- The major conclusions are:

1. The objective of validating the novel particles against fluorescent particle behavior has been achieved. This implies that future experiments can be performed with only the novel particles and by using simpler observational techniques for larval assay (e.g. ring- or Bongo-nets).
2. The collector system gave orders of magnitude more areal complete coverage with far less time, effort and expense than "conventional" survey systems. The collector deployment, release of novel particles, and collector recovery took about the same time as was used for one ½ day of net tow observations, but it is clear from the results that the net tows give incomplete coverage (i.e., the patch spread faster than we could survey it). The moored collectors mapped the transport of novel particles over a much larger region, giving complete coverage.
3. The numbers indicate that the novel particles and collector technique should be able to observe particle motions, and hence ecological connectivity, over several 10s of km and several days, as was originally planned. We are confident, based on these results that the scale can be extended even further to 100s km and weeks.
4. Both types of particles moved in conjunction with the radio-tracked drifter buoys.
5. Feichter's model simulations predict particle drift in general accord with observations, and further show that the precise direction of the drift is very sensitive to particle buoyancy characteristics. It matters a great deal whether particles are at the surface, or 0.5, or 1 m below the surface.
6. The antibody titration is very sensitive, responding to as little as a single larvae per m^3, and should work well in conjunction with ring-net tows to measure particle concentrations in future spawn/release experiments.

II. CENTER SUPPORT: *Advantages of NURC/UNCW program, particularly in situ support, to the project and your research program. Please comment on operations and highlight both strong and weak points; suggestions for improvement are appreciated.*

Advantages: NURC is extremely well-located to serve as a base of operations for work in the Key Largo, Dry Rocks area. Vessels are spacious enough for over-the-side work. Mike, our captain was simply excellent. He was professional and carried an admirably helpful attitude and a wealth of expert knowledge and advice that helped us achieve our rather "tricky" goals. The accommodations were excellent. We found that living right above the facility allowed us to work long days (and nights) in setting up and preparing our equipment.

Disadvantages: Some work was made more difficult due to lack of lifting/towing capabilities, such as an on-board davit or winch. It was necessary to jury-rig a side-towing setup for our nets, though we do recognize the dive focus of the facility and not necessarily operational oceanography – but we did pretty well with what was available (many thanks to Mike and Otto)

The electrical and electronic equipment was designed to run on a 12 volt power supply, but it was necessary to jury-rig a high-current connection to the power supply of the *Wildcard.* A separately fused 12 volt supply for scientific needs, running from a battery separate from the ship's supply would be desirable. A built-in invertor system capable of providing 115 volt power to a few laptop computers would also be desirable.

IV. PUBLIC INFORMATION RELEASE: *please help us promote undersea science by writing a paragraph highlighting the importance of the research that may be used for public distribution and press releases.*

The "novel" particles and collector system are currently the subject of a patent application, so we cannot yet allow public release of information about the system. This situation should be rectified in 2006, when the PI's will happily respond to a request for such information.

V. FUTURE EFFORTS:

Based on the success of this project, we have obtained additional funding from a World Bank funded Targeted Coral Reef Research program to do further testing of the antibody assy during the August 2005 spawn season. Ruddick and Taggart are also expected to be funded by NSERC to further develop the bead technology. We are in the process of submitting proposals to NURC/UNCW and CRMC for funding to continue the work both in the Florida Keys (summer of 2006) and the Mesoamerican Barrier Reef System (MBRS: summer of 2007).