

Seagrass Workshop
Everglades National Park

James Fourqurean

March 29, 2010

Hosted by the
South Florida Natural Resources Center

Video Transcript

00 minutes :17 seconds

James Fourqurean: I just ask Mike Robblee, who is the greatest guy in the room, when he started working because I remember when Mike got an interview I picked him up at the airport. I started working in the bay in 1982. There's been a lot of changes since then. It stayed the same in a lot of ways as well. When I threw my slides together this morning before taking my kids to camp I did not really have a theme. So I'm sitting here trying to think of a theme and relate them to what we are trying to do in the region we are having the workshop in. But I want you to remember, nutrient loading changes the structure and function of the seagrass beds and benthic marine habitat in Florida Bay. But, no matter how much nutrients we dump on the system we haven't been able to cause die-offs. I also want you to remember that nitrogen, not all nutrients are the same, and nitrogen may come and nitrogen may go but P is forever. So those are the take home messages. And, also I never go in the field anymore so I'm going to talk about Darryll Hubert's work, Arnold Armitage's work, Tom Frankovich's work, and a bunch of graduate student's work.

I thought I would start out just by saying that we have been collecting some things for a very long time in Florida Bay. These sites in the red are permanent monitoring sites associated Florida Keys Marine Sanctuary Monitoring Program. We repeat these transects at least four times a year. Part of the LTER we occupy these five stations every two months. At some of these stations like Spriggers Bank we have data that goes back to Mike [indecipherable]'s work picked up by Tom Frankovich, then by Jay Zehman, and at some of the sites the data are relatively new. But, the data, as soon as we can get them processed we can shove up to this whole entire network to this webpage.

I'm not going to talk much about trends in the data, because Penny's work is much better at showing trends, but these are just two of those sites that show what's going on at Duck Key and what's going on at Spriggers Bank. These are just Braun-Blanquet density values. These come from the means of ten observations randomly

located along the fifty meter transect demarcated by pins stuck in the bottom. And, mainly I just wanted to say that yeah we've been collecting data since the beginning of the LTER network at these sites using the Braun-Blanquet k-values and there is a significant decrease but not a very big one over the long term at Duck Key. Things get more interesting, as Penny also suggested, as you go further to the west. We have *Syringodium* coming and going; we have *Thalassia* coming and going. And, when you go out further into the sanctuary the biggest trend becomes calcareous algae become much much more important, orders of magnitude more important over this time series.

We've also been measuring production for a long time. That's one of the things we've been doing as part of the LTER, it's part of the LTER contract. We measure the leaves and watch how fast they grow. These are some of the data sets. Unfortunately, we took the wrong ones so I did not add 2004 to 2009. These are just some data showing how fast the *Thalassia* is growing, how fast the grass growing is a function of how much grass is there and so this was like the tail end of my dissertation. And, [indecipherable] starting in 2000 these are the bi-monthly values from the LTER monitoring network. The data sat there for a long time until Darryll showed up in the lab, and Darryll starting doing analyses, so not only do we have measures of how fast the grass was growing, we also look at how fast the populations are being replaced by generating age-frequency distributions. And, the reason we did this because we needed to know how often we were producing new shoots in the population. We needed to figure out what the below ground production is that go along with the above ground production over this time series.

The data are highly seasonal that's what's in these data. These data, the leaf emergence rate, even though we are tropical, these plants go through a relative cessation period and grow in the summer time.

Things change as you go across the system. From the nutrient replete regions in the west, Spriggers Bank, which we will talk about more, from the nutrient replete regions in the center of the bay, the northeastern corner of the bay. Then, you actually get more plants as you get close to the shoreline. Most of these things are driven by phosphorus availability and close to the shoreline, there is actually higher phosphorus available as you move out further into the bay. Probably because of the outflow of brackish groundwater that's mixed the bay seawater and the freshwater, but that's another story.

05:00

Leaf emergence rates vary. I'm just going to go over all this stuff very quickly. Mannings and Smith paper was in Estuarine and Coast in 2009. This is the number of days between new leaves emerging. At Sprigger Bank it is a relative low 26, a relatively fast leaf emergence. At Bob Allen Key it's about 35.5. The leaf emergence

rate, which is the inverse of the plustine interval and the degree of amplitude, how big that sin wave is, are correlated with the availability of phosphorus. So as you go across the bay as Penny alluded to, we go from the phosphorus source being the Gulf of Mexico, phosphorus becomes less and less available you go up into Florida Bay until you go right up to the shore line and that seems to be controlling the growth rate of *Thalassia*. Leaf mass goes up, annual primary production goes up as it's a function of phosphorus availability and the relative growth rate of the leaves goes up. So it's a function of more fertilizer they grow quickly and it's all being driven by that regional delivery of phosphorus level of the ecosystem.

Then, we also have assessed the below ground primary production. And, we've always thought that if you just measure the below ground we know we are missing a lot of the primary production of the seagrasses. We figure we are missing about 35%. Thirty-five percent of the total production is what is happening below ground more slowly turning over tissues.

Another thing that Darryll did when he came here is that he revisited the bird stakes experiments that started by accident in 1982. They asked the question, there is a series of papers that came out that describes what happens when you fertilize sites by allowing the birds to poop before they take off. Bird stakes have now been adapted into a restoration method. Basically if you put out a pointy stick the birds don't land on them. If you put a nice perch, then they poop in the water before they take off. When we first set these up back in the early 1980's. There were some existing bird stakes and we pushed those under the mud. What I want to set up for you is in 1985-86, we pushed some stakes down into the mud that had been receiving fertilizer for three years, birds had been pooping on them for three years. Then we went ten meters, or five meters on one side and five meters on the other in and around the bird stake. And, we left them out there at that time; there were no permit requirements to take them in. Darryll came in and he got in his kayak one day and I drew him directions on a bar napkin. And, he went out and he actually found these sticks that had been pushed into the mud more than twenty years ago so these stakes are still there, these stakes are still there. So he asked the question is the structure and function of this system still markedly affected by fertilization that was discontinued 23 years ago?

So these slides, these are ones that have had birds poop in them for 20 years, ones that had been pooped on for three years and then discontinued and these are the control sites. I want you to say it, this is phosphorus in the sediments. There is forty-four percent more phosphorus in the sediments at the sites that hadn't been pooped on for 3 years, over twenty-five years ago, than there is today. Much less of course if you of course let those birds poop for twenty-five years while there is no difference is nitrogen concentration or carbon concentration.

These are time series by George Powell. George Powell is a name that everyone should know, if you don't know George Powell then he was an incredible naturalist who was the reason a lot of us came to South Florida to begin with. George sat these original stakes up in 1981. I got here this year, 1982. So we knew how much seagrass was at those bird stakes in 1981, 82, 83. This is when they were pushed into the mud. And, these are the times we've looked at them again. So what happened was when you start fertilizing an area turns out the *Thalassia* decreases. And, then when you remove that fertilization pressure, *Halodule* becomes more important. This one is easier to see so we started fertilizing with bird poop and we lost *Thalassia* and the *Thalassia* was replaced by *Halodule*. It's a faster growing species when it comes in and it can out compete *Thalassia* in this environment. So that's what happens when you change the nutrient regime permanently. This is what happens when you just fertilize it a little bit. So that's twenty-three years later, there is still a huge effect.

10:00

And, the seagrasses are telling us why the N/P ratio up around 30 would suggest the nutrient level of the seagrasses is replete with respect to their nutrient requirements. This is for *Halodule* and *Thalassia*. And, with the control sites the N/P ratios are quite high and suggesting that there is a scarcity or paucity of phosphorus and are high at these sites where fertilization was discontinued. There is still much more phosphorus available and showing up in their tissues all this time at the roots.

So we've also been are looking at structure and function at the ecosystem level, looking at metabolism rates. I forgot to put this slide in. Metabolism changes drastically. The systems, I'll show you again, tends to be net heterotrophic unless you fertilize it, then it becomes net autotrophic.

Now I want to talk about the long term experiments where we've adding nutrients more or less every two months depending on funding and the weather. Since the last eight years we've had these six sites. These are classified as highly nutrient limited and the N/P ratios are 100 to 1 more or less when it should be 30 to 1.

These sites, Duck Key and Nine Mile Bank have ratios of about 60 to 1 when it should be 30 to 1. So we would suggest then that there should be very little phosphorus response here in response to fertilization here. A maximum response to fertilization here and an intermediate response there. We fertilized these sites at a loading rate that we calculated got the maximum possible septic tank loading rate that would be possible for the 10 meters receiving end right next to the keys that would be receiving all the keys wastewater. It's a pretty high nutrient loading rate we've been hitting them with this for seventeen years. And, at two sites, Duck Key

and Nine Mile Bank, we also looked at the animal communities associated with those fertilizations. These experiments are still ongoing.

What we've done is we've set up a factorial design where we have control plots and for one we have only phosphorus and for one we had nitrogen and phosphorus. We replicated this block design six times across Florida Bay for more than five years. And, these are just the first two years of the experiment. And, what we see here is remarkably similar to what we see in the bird stake experiment. We fertilized seagrasses, this is at Duck and Nine Mile, this is Halodule that eventually after three or four years showed up at Duck Key and started growing at these fertilized sites. Also, there is no effect, we are just going to ignore nitrogen because the responses to nitrogen fertilization no matter that we have been adding nitrogen for a very long time. There is a time lag between the beginning of fertilization and when stochastically the Halodule began showing up. There is probably also a nutrient threshold also for Halodule to be competitive dominant.

So what we have started out looking like that and when we fertilize it looks like that. At Nine Mile and further out to the west what happens is as Marguerite showed in really low level high density canopies Halodule actually grows up out of the water column, up into the water column probably to harvest light to get over their big brothers, the Thalassia. So after Thalassia shows up, I mean after Halodule shows up the Thalassia starts to decline.

In this case the initial response of fertilization with an increase in Thalassia abundance, this is where the Halodule peak. And, after Halodule came in and Thalassia started to decline. There has been no competitive trade-off [indecipherable] of repeat areas in the western part of Florida Bay.

And, very interestingly, despite the fact we have been fertilizing and beat the crap out of these things we haven't seen an increase in the epiphyte loads. Kinda of a long term, global model the way you get seagrass loss is that nutrient availability increases, opportunistic growth and fast growing things increases that shades the seagrasses. Can't compete so they disappear. Despite that in Florida Bay we are fertilizing them really really heavily. We're not seeing a quantitative increase, or a big increase anyway in the epiphyte load but we're seeing a huge change in the the structure of the epiphyte community both in the diatoms as Tom Francovich's paper shows, among groups of algae. The question then that remains is what then is

15:00

controlling the [indecipherable]? Is it top down control? There are a lot of experiments out there that can still be done that can answer this question.

We know that when we enriched the seagrass the epiphyte biomass goes way up. It's not just in the eastern part of Florida Bay where there is biomass response to fertilization, but we see it even more in the western part of Florida Bay where there is no biomass response to fertilization in the primary producers. Out there you fertilize and you get a bunch more grazers. That is suggesting there is a top down control, or I mean a bottom up control in grazers as with more P you don't get a biomass response of the plants because they are being grazed down by all those grazers in the water column. The most recent paper to be published from this work late in 2009, it's a paper on the changes in the food web structure associated with this fertilization and largely we try to boil that paper down into two slides.

If this is our carbon and nitrogen *Thalassia* signature of algae and our *Thalassia* is here. The grazers are kinda here in the middle. We have predators and things that were eating them at about 3 per mil heavier. As you would suspect, their diet was some of this stuff and some of this stuff. But, when we added those nutrients what happened was we got a new primary producer in the mix. *Halodule* has a much lighter phosphorus nitrogen signature. Probably because it is responding to that nitrogen, which was about 0 g/mil which is different than what we were fertilizing them with and a different carbon signature as well. The benthic grazers are being pulled away from the other grazers suggesting that there has been a new food in town. The grazers are changing not only when they are eating but what they are eating which they are taking mainly from the primary producers.

Those are the data that ended in 2007 because that was the year that Anna worked them up and sent them to me. Alright, I will just tell you that we continued the work until 2009. I think we've been out there, Tom, we've fertilized this year didn't we? So, Tom has fertilized this year.

And, the point to this is that is from the 2002 to 2009 fertilization, seven years of fertilization, there are still changes going on. We reset the nutrient supply rate of the ecosystem since 2002 and the system is still changing. Much like the things that Penny saw. We can have an invented Florida Bay and there isn't a new equilibrium what is a response to that in decades. And, even in this relatively small patches we are seeing that. We are fertilizing and they are still changing, the relative abundance of organisms is still changing almost a decade later.

So these are the flux data, so we are looking at structure and function differences, and the next manuscript hopefully to go in soon from Darryll's analyses of our work.

So here is Duck Key, South Nest, and Bob Allen Keys. These are the phosphorus limited sites. Here we have Rabbit, Nine Mile, and Sprigger Bank. This is fall, winter, and summer. And, these are nutrient flux chambers put down on the bottom. And, remember we added nitrogen and phosphorus, and there were

nitrogen affects and it is now being condensed down from sites when we didn't and when we did add phosphorus. And, in the sites where there was a large biomass response we are also seeing a huge difference in the, the dark bars are respiration rate, which you see increase when you add phosphorus, the dot is net production and the bars are gross production. The interesting thing to see in these instantaneous rates taken during the day time is that the phosphorus limited part of Florida Bay except for this in that case, is almost zero. So, the system, is full of seagrasses tends to almost be autotrophically balanced. Not really autotrophic, not really heterotrophic. It's not until we get higher biomass either through the additional phosphorus either through the phosphorus limited part of the bay are there naturally higher phosphorus levels in the western part of Florida Bay does the system become autotrophic.

Those are all the slides I threw together this morning. So remember, what I tried to

20:00

impress you with was the data records that are complementary to the data records that everyone else has shown you. We're looking at changes in structure and function. I concentrated here mainly on nutrient delivery because that's always been such a huge question not just in coastal management here in South Florida but everywhere else. You stick phosphorus in the system and it stays there forever. Whenever changes are brought by an increase in anthropogenic nutrient loading it's likely to stay there in phosphorus limited system. If it was a nitrogen limited system, it was just go away. The nitrogen would be denitrified and lost to the system. We calculated that all the phosphorus that we have dumped into those sites in the last eight years 96% of it is still in the quadrangle plot area where we dumped it. And, there is none of the nitrogen left. It's, the nitrogen levels are the same. So phosphorus isn't the same as nitrogen and nutrient loading affects structure and function.

Participant: I have a question about your top-down system that you mentioned. Are you saying that the western area that was more P rich, the plants themselves were being raised more or the epiphytes?

James Fourqurean: The epiphytes. So what happened out there is we see more grazers response to phosphorus addition. What we don't see is epiphytes response to phosphorus addition so it looks like there the greater community is organized from bottom up.

Participant: Now is that phosphorus getting to the epiphytes [indecipherable]?

James Fourqurean: Chris is trying to get me to tell you our methods. What we are actually doing is taking dense fertilizer and sewing it into the sediment. And I've

been criticized for that as it not being a realistic way to load these systems. And I say poppycock it's the best way to load these systems because there is very little dissolved inorganic nutrients in the water column. If there is anything coming in it is coming in as particulate matter, it goes through the sediments, and then it's re-released. We know that phosphorus is available all the way through the plant canopy because the nitrogen and phosphorus ratios of the epiphyte community are highly affected by phosphorus. So it's getting up in the water column.

Participant: So you think of that is coming from the plant itself?

James Fourqurean: You know a lot of people, back to Holly Paneheil, the DOC and DOP, it very well could. I think a likely, or at least as likely explanation is that it's [indecipherable] up in the water column to become available.

Participant: I was thinking about that. It wouldn't take much to get the phosphorus up there to enrich the epiphytes. And, maybe an alternative explanation could be that the top down in water column is pretty efficient as well as the sediments in taking out the phosphorus. So have you been looking at the P, sort of a profile of phosphate in the water column?

James Fourqurean: I haven't done that kind of work since I worked on my bachelor's degree.

Participant: I know.

James Fourqurean: But, Darryll keeps threatening to go out and do biogenesis experiments.

Participant: Because the thing is that you don't see the same thing as you see in Tampa Bay, right? And, the explanation for that is that you are not really getting your treatment into the water column.

James Fourqurean: No, no.

Participant: I mean you are but you aren't. I think you are getting enough to get a signal. But, I don't really think.

James Fourqurean: I agree with you but not for the reason you are making the argument.

Participant: What else does happen? That's a good one.

James Fourqurean: We are absolutely effective at fertilizing these [indecipherable]. We know the [indecipherable]. Because the way we're fertilizing these small areas, there is no way we are ever going to see a phytoplankton response because we get a very slow diffusion of phosphorus up.

Participant: Right, that's what I was going to say.

James Fourqurean: Right, so we are not simulating the effect of a phosphorus rich IDFC phytoplankton response over these sites. We're really looking at, I think a more realistic time anyway, rate method of loading and I think that is particulate organic matter as well as any below ground. Yeah, but, no this, I don't think we can get the permits to do a basin scale experiments as we would need to do to get that water column response.

Participant: At the base see any response from Atophora. See any response?

James Fourqurean: Well you know, I have it on my lap top. No, not in the same

25:00

way because we are generating a really dense Halodule canopy. I don't think the Atophora does well as an understory plant. If we probably ripped out all the seagrass.

[indecipherable]

Participant: They capped everything after the die-off.

James Fourqurean: Yeah, the DDC frame, they are little green fuzz balls.

Participant: Also the plant diurnal intervals, does it change with fertilization? Does it get shorter?

James Fourqurean: Yes. Like any good plant does. It responds to an increase in nutrient availability so the average age of the population decreases

Participant: [indecipherable] substrates available [indecipherable]

James Fourqurean: Yeah, but the work that Tom did and others suggest that the rate of leaf overturn is a really small contributor. It's around 20%. In [indecipherable] Dorn did these kinds of experiments, and Tom. So the change in leaf turnover has some kind of effect but it's relatively minor compared to others.

Participant: So you are saying with your phosphorus loading you are not seeing any large accumulation or increased accumulations of epiphytes but yet you are having an increase in grazers. Are they knocking each other down or I mean, because of the grazers you are not seeing an increase in epiphyte load?

James Fourqurean: When you look at the data on a basin scale there are some structure of the epiphyte and there is some chlorophyll increase but it is very minor compared to the total range of epiphyte load you see across South Florida. I think epiphyte production is being spurred by this phosphorus addition. But, we are not

seeing an increase in biomass because the effect of top down control. So we have actually traced carbon flow through those epiphyte communities, I'm sure that it's [indecipherable] higher now under this phosphorus loading regime than it was before

Participant: So as far as epiphytes go 50% can be calcium carbonate which is also got be sequestering the [indecipherable].

James Fourqurean: Yeah, so one of the cool things about working in South Florida is everyday working in the canopy when the oxygen is low in the water and the pH goes up and [indecipherable] utilization you get the formation of these fine calcium carbonate particles that sorb all the phosphate that is in the water anyway. So those [indecipherable] as phosphate scavengers and the epiphytes as well because 30 to 40% of the dry mass is calcium carbonate.

Participant: Are [indecipherable] shrimp on your [indecipherable]?

James Fourqurean: Yes, yes.

Participant: So they increase in number with.

James Fourqurean: With the fertilizer. Even if you go out to Nine Mile Bank where I think there is enough phosphorus for everything. If you fertilize with phosphorus then you don't get this response.

28:14

[credits]