Seagrass Workshop
Everglades National Park

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Video Transcript

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Marguerite Koch-Rose: Thank you Tracy and Jerry for inviting us to come and talk today and for us to really come together and see if we can have some more synergistic research opportunities. It sounds great to put our heads together. For those of you that don't know the work that I have been doing is really focused on habitat sustainability. I've been looking at multiple stressor effects of both macro-alge and seagrass in Florida Bay as well as work in the Bahamas. And, we also look at sort of an ecosystem scale. We also focused on nutrient cycling, seagrass sediments and some phytoplankton work. And, more recently related to some of the things we will talk about today, looking at climate change impacts in some of these systems. How any increases in temperature although this winter we kind of backtracked. We will see what is going to happen this summer, if we are going to stay cool or if it will start warming up again. It definitely influences shallow ecosystems. Part of our work has been really trying to address the hypothesis generated questions by people who have been working in the bay for many years. Paul Carlson, Jim Fourqurean, and others. And, by taking it to the mesocosms and trying to do some experimental work. We have this experimental system that we built. It has sixteen 500 liter tanks. We have the capacity to modify temperatures. We just set it up to do ocean desalinification [indecipherable]. These have been very powerful to try to do multiple experiments and look at temperature and thresholds on salinity and thalassia sulfide effects. And, based on a number of experiments that we don't have time to go through today, you can go to my website and actually all my publications are there based on these experiments, and what we found are Thalassia, and these are from Florida Bay, there are thermal tolerance thresholds, in terms of continuous temperatures it is about 34 degree C. The hypersalinity threshold is about 60 PSU so they are actually living fairly close to their temperature-salinity thresholds.

We also looked at belowground interactions and Thalassia has a high capacity to oxidize porewater sulfides; however, if they are stressed out like at 65 ppt the effect of sulfides can actually influence the plants. We also have dissolve carbon and temperature impacts on the sulfate reduction rates so the microbial community and increasing the sulfide stress on the plants. However, they are actually able to fairly high survive sulfide levels as long as the oxygen is high in the overlying water. So based on a series of experiments over several years we come up with the conclusion that salinity, temperature and sulfide are sorta like the silver bullet that is initiating seagrass die-off. Seems like these are stressors that are actually influencing the oxygen imbalance of plants and I am going to talk a little bit about that. We did take it to the field and try to validate some of these hypotheses that were generated by the mesocosm experiments. And, we added gluclose in the field to drive up sulfides. And, what was interesting was that we saw a die-off, let's take one step back, we are lucky that during this time period we had a major drought event with extremely high salinity and extremely high temperatures. So we were actually able to look at these measures in the field, high salinity, high temperatures, and then by also injecting glucose in the sediment driving up the porewater sulfide we were able to see a field validation of that. And, what we found was that, well we were lucky that we actually also got die-off in two of our western basin sites. These are our eastern based sites and I know we are not going to have enough time to talk about these eastern based sites, but here where we found the die-off during the summer. So this is July with extremely high salinities and extremely high temperatures at these sites, but we really didn't see any die-off. We didn't see any die-off until the fall and coming into the winter when you start to get shorter day lengths. And, it seemed like it was really this down regulation that was really driving the [indecipherable] up. You can see here, this is Buchanan

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Bank. One of the things that always intrigued me was when you see a major die-off you always see a few patches that are still there. And, so when of my students was actually looking at one of the genetic aspects. Could be that there is some potential for some genetic variability and an increase in resilence and long term stability and you can see that here, too. Especially with this grove of plants we don't know where they stop and end individually. So that is one thing we really want to look into a little bit more. Half the seagrass bed here died off. And, if you look right here, this was our glucose flow. This had nothing to do with our experiment. This was more of a larger phenomon that was occurring prior to this die-off. We did look at some pore water calibrator work, some sulfides across the sediment water interface and this is attritubed to Karl Carlson and the work that they did looking at sulfides as a major stressor in Florida Bay. What we found was right where we got these die-offs in Barnes Key was high sulfide in the surface water. And, we really did not believe it. When we went back out to stop at Barnes Key, we still have high gradient here at the sediment water interface of the sulfides. Then, it stopped. The die-off started at Buchannan where we actually saw this high sulfide at the surface water.

And, if we continue to look at all the sites. What you see is this April and spring, this is June. It looks like in the spring the plants are able to lower this gradient across the sediment water interface [indecipherable] but in the summer, there is perhaps some oxygen demand that influences the high sulfate reduction rates. And, we also know that sufate reduction rates and pore water sulfide increases is a function of glucose this inorganic, excuse me, this dissolved inorganic carbon that the plants are releasing, and that's why some of those can be secondary effects. So once you start seeing die-off and the plants are releasing more DOC feeding the microbes reducing the sulfide driving up those sulfate reduction rates and we've seen this experimentally as well as out in the field. Temperature is also influenced by that. Actually the optimum of sulfide reduced is like 40-50 cc so they do well at really high temperatures. So we came up with this sort of model and it's really built to help other people working in the bay. At these western bay sites with high nutrients coming in on the Gulf of Mexico pretty much driving up the biomass in these areas. And, what happens is in July and August you get this high plant biomass, high plant productivity rates, high respiratory rates, too. Those plants have hugh oxygen demands. The sediment, decomposition rates, DOC being produced, sediment oxygen demand increase sulfate reduction rates. This high salinity high temperature events towards the end of the summer accelerate the oxygen respiratory rate as well. They also accelerate the sediment oxygen demand and accelerate sulfate reduction rates. Then come, the fall, September, October, shorter day lengths, lower temperatures, shift in the P to R ratios, potential increase in epiphyte load because the plants are not growing as fast, sulfide oxydation is consuming the oxygen, more release of DOC as the shoot density start to decline, and that also accelerates sulfate reduction rates having a ratcheting affect. And, you get reduced oxygen in the rhizosphere and this causes nighttime potentially water column plant apoxia as well as potential asphyxiation and potentially leads to die-off. Whether or not this is a direct effect of this apoxia or whether it is generating the sulfide coming into the plant, we are still working on that. So what are the impacts of this? Large scale seagrass mortality events – most of the nutrients out there in seagrass are in the leaves. So when you have a die-off event you can have about five micromoles of phosphorus per square meter being released. In the western bay it is more like 1.1. And, if you say it is about 1 meter water column that comes out to be about 45 micromoles per liter of phosphorus. That is a couple of orders of magnitude that usually is in the concentration that’s there. It's a pulse event before

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the big die-off than say that big die-off that occured back in the 90's of about 4,000 acres when a bout 6,000 kilograms of phosphorus was released. So that's a huge amount of nutrients added to the system. So that was a couple years ago and we got all the papers out as we've been wanting to get back to really address what really caused it. Can we understand this die-off better. And so I've been working with the water management district and setting up some hypothesis to the test whether this die off during the fall is a result of plants down regulating to two shorter day lengths, Which is pretty much what I was talking about before . Is this hypoxia in the overlying water exasperated by hypersaline and high temperature conditions. Is water column hypoxia a factor in controlling Thalassia dominance with some perhaps competitive effects in that? And looking at resilience of seagrass species as a function of genetic diversity, morphology and or biochemical production. We're looking at heat shock proteins and catalyses as an indicator of production of [indecipherable] oxygen species and metabolites. So we started this project in July of 2,009. And it was right when Tracy called up and asked what about this die off? Well we are on our way out there to set up these sites. So we decided to set up one of the sites where they had die off problems in the Buoy Key region. We are trying to do is not sample whole bay but sample a few sites and do a lot of work from the plant physiology and biogeochemistry monitoring as well. And so we also wanted to get the salinity gradient because that is the one thing the district is interested in too. So up here we have a site up here in Garfield key, Bouy Key, and Johnson key and perhaps we can link some of the surface water monitoring to some of these sediment and plant level monitoring.

So just kinda go through when we went out there that day in July of 2,008 when this big die-off was occurring you can kind of get a feel for what it it is actually like all there and what you actually see one of these die off events. These are actually Halodule blades floating on the surface, that is where a lot of this rack is coming from [indecipherable]. You can see the brown tips of Thalassia. Whether this as something to do with this diet off is not exactly clear. One of the things you also see are these opportunistic spores and algae coming into the system very rapidly taking advantage of these nutrients pulses. And you can see your these leaves are actually green and they are definitely coming off like we were saying in a big clump. Let you can also see nutrients are coming off being associated with that. Jim Fourquean was showing that the nutrient loss from the green light from the water column are extremely high. And, so there are a lot of opportunistic algae being supported under this type of situation. You can see filimental algae at the sediment surface. You can also see some macroalgal abundance here, see one here. And, so the take home is that it is not just about Thalassia it is about all species. At this site there was Thalassia, Halodule, and Syringodium. All were negatively affected. One of the things that was very clear too was the [indecipherable] was really effecting the belowground tissues so we can't just look at the water column, you really have to get the sediment part of the chemistry and the roots. This is Syringodium and you can see here and the roots as well coming up. And, you can see here the plants are completely detached, this is Halodule. And, you can see this in some of the other conditions [indecipherable] of the experiment. But this was like really amazing. They were just all detaching from the sediment.

There was definitely something in the sediment that was influencing the ability to maintain. So what we're trying to do is see what the plants are seeing instead of just putting the light sensor in the water column although it would be nice to have that comparison. But if these things weren't so expensive we'd love to do that. By the time you put the oxygen probes and the Ph probes on there it gets, it can get extremely expensive but perhaps there are some opportunities for our Center while we are looking above ground processes in the water column we can actually also look at some biogeochemical dynamics. We also have these light sensors in there, they are Hobos but they are actually giving us some pretty good data, but it is better and then the light data. Too bad the light sensor was adding another ten to $15,000.00 . But still worth doing at a couple of sites and something we should consider doing. I'm going to step through some data from Bouy Key from that period of time when that major die-off

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was occurring. What we are looking at here is daily average max and min dissolved oxygen, this is from the optical probes within the seagrass beds. What you can see is from this July-August period. The minimums were always below 2 milligrams per liter continuously. The salinity was about 40 ppt; the temperatures up about 35 degrees C so pretty high conditions. That minimum is really driven by this diurnal nighttime oxygen below 2 milligrams per liter you can see right here the 2 miligram per liter line. You can see every night we are going under. What was interesting, if you follow, what were are really using this monitoring data for is to understand the mechanisms so what you see is when you come into the year, so you see that's August, we are no longer going down into nighttime apoxia levels. And, it might be related to this decline in temperature so maybe there is an interaction with temperature. And, the one time you see it jump up here it's when we also had a lot of rainfall. It can be one of two things, rainfall can stratify and make it so you don't get oxygen to the other levels, but it can also perhaps decrease the temperature a little bit [indecipherable]. But, anyway, you can see here this kind of stratification event and this might have been where you have gray water effectially stirring things up , maybe there was a storm of sorts. There's a lot of things we really don't know. And, if we compare, this is Buoy Key, this is where we get some data from, this is March, this is this month. And, we compare that to the die-offs back in here we see different things. We get below 2 milligrams per liter of course this is a lot cooler, salinity is lower, cooler temperatures to the other one. And, if we take those 21 days from July and those 21 days from January, or Feburary, and we look at the slopes of respiration and the slopes of the oxygen and we can then calculate sorta of an ecosystem respiration rate. And, what we see here are the respirations rates in that 21 day period during July it's about 20 milligrams per liter [indecipherable].

Now in the winter time we have about 6 milligrams per liter, so you can see. Well, it's got to be low respiration rates. This is the kind of thing we need to do to start understanding what is causing these apoxia events. And, that's the biological, and that's part of what we talked about earlier today there is this physical chemical aspect meaning that when looking at the salinity in the summer, which was 40 psu, temperature of 35, we have a theoretically oxygen, percent oxygen saturation point of about 5.62. Compared to in the winter we had a temperature of about 20 and salinity of 30 and a saturation point of 6.2 compared to the summer we're like one whole milligrams per liter over that. If we look at our sort of worst case scenarios [indecipherable] at 55 parts at psu is sort of our worst case scenario, you can see what we get in terms of liters per gram saturation. When we do get oversaturation and that occurs pretty much every day, but in my view these gases are losing some of this oxygen more quickly at night. Notice here there is some, one thing that I've noticed if you notice the range of temperatures that we find in the bay, the ranges are sort of a salinity we are looking at, the temperature changes may be more important in terms of driving this oxygen saturation. Another thing that we've been doing lately is working with Mark Foreman, he did some microbe oxygen work with Jay Zieman in Wisconsin.

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We've been really trying in my lab the last two months been looking at the oxygen capacity to reduce oxygen at a rate and some of the morphological aspects. You can see that Thalassia has the capacity to be full of oxygen whereas Halodule will very quickly lose oxygen in the plant [indecipherable]. This is some of the work we are trying to do with the plants. We are doing this here because we are not the only ones with seagrass die-off problems, it is a world wide problem. There are a lot of places where the seagrasses are not ever going to come back. We want to figure out why not. We've also done some PAM, we've also done some experiments to test if its apoxia because then let's look at apoxia. This some work that [indecipherable] had done just before, which we are actually repeating because it seems so incredulous even though we think apoxia might be the sliver bullet here, this was 48 hours after apoxia pretty much in the water column and the plants were still surviving. So obviously there is a lot we still don't understand. So what I'm thinking about in terms of what we need for seagrass research in Florida Bay we need a better mechanistic understanding of the die-off. [indecipherable] and now all die-offs are the same. We need to have a better feel for what is driving it. And, in terms of oxygen dynamics and drivers at the canopy level as well as the underlying water we're looking at the mechanism of resilience at different scales and species scale. And, the linkages between water column and benthic dynamics, nutrient transformations and fate. Where's all the oxygen going? The biogeochemical processes across this nutrient gradient. And, recruitment potential for seagrass in the bay and we are doing some work on the freshwater transition zones. We need to think about restoration, we hardly ever talk about this. This is a park, right? Something we might not need to think about now, something in the future. And, then maybe some rates of seagrass bank accretions in terms of sea level rise. So that's where we are right now.

Science Coordinator: We have time for just one or two questions and then we have to move on.

Participant: Marguerite Koch-Rose, I'm glad you brought this up at the end and I am glad you are putting emphasis on this water column apoxia. The forum 2005 paper was for me was the nailing down of the mechanism for seagrass die-off. Because it's not until do you get that water column apoxia you get the sulfide increase [indecipherable].

Marguerite Koch-Rose: Yes, the thing is, the problem I have with that, we've all come the day after.

Participant: It was experimental work.

Marguerite Koch-Rose: It was experimental work. It was at a site that had already died off. But the plants that he measured didn't die.

Participant: But, we didn't get sulfide increase

Marguerite Koch-Rose: Right.

Participant: unless there was the water column apoxia.

Marguerite Koch-Rose: But there are ways that plants contain sulfide, elemental sulfur, or some other ways,you know the plants, I used to work on salt marsh plants and some plants can actually turn into cistine sulfur.

Participant: It looks like that confusion that happens down in the cellulose and that is where a lot of the oxygen is coming from to detoxify that sulfide. And, once you get that water column apoxia it doesn't happen anymore.

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[credits]