Stephanie Otts:

So good afternoon. Thank you so much for joining us for the National Sea Grant Law Center's 2022 webinar series. We're so excited to see everyone here today. This is the fifth webinar that we've done this year, and it's been so great to see all the different topics that we've covered.

So for those who don't know me, my name is Stephanie Otts. I'm the director of the National Sea Grant Law Center and today we are featuring work that the University of Mississippi has done related to oyster restoration and I'm going to let Jessica Pruett introduce herself when I turn it over to her, but we're looking forward to seeing and hearing more about the project that we've been working on together.

So just a few housekeeping items. We are recording the webinar for posting on our website after the webinar so if you have colleagues or others that were interested in attending and couldn't make it, they will be able to watch the recording later. You may put your questions or thoughts in the chat box at any time as we go through the webinar. Right now, we have everyone on mute to cut down on background noise, but we will have time for questions and answers at the end and so you can either use the chat to ask your questions or if we have a small enough group at that time, people can come off of mute and ask their questions and so I think with that, I'm going to stop my screen share and turn it over to Jessica so she can start hers.

Jessica Pruett:

All right, Steph. Is the screen up?

Stephanie Otts:

Yes, I can see it. I think you're good.

Jessica Pruett:

Cool. Thanks, Steph, for that introduction and so, yeah, I'm Jessica Pruett. So I'm a postdoc working on a project with Steph as well as other MBRACE-funded researchers here at the University of Mississippi. So MBRACE is the Mississippi-based RESTORE Act Center of Excellence and this is sort of the second iteration of this University of Mississippi team, which I've joined working on sort of both lab experiments and water quality monitoring in the Mississippi Sound to help inform all their restoration efforts going on there. And so over the next few minutes I'm going to go over with y'all a policy brief we put together titled "Accounting for the Entire Oyster Life Cycle in Restoration Efforts", which is again, based on those experiments and water quality monitoring efforts.

So to begin, historically, Mississippi oyster landings have undergone cycles of boom and bust. The Mississippi oyster industry was really at its prime in the early 1900s when Biloxi, Mississippi was known as the seafood capital of the world, so due to the large amounts of shrimp and oysters landed and processed in the city. Yet over harvesting during World War II led to a population crash that recovered under strong management in the 1960s only to suffer again due to string of natural disasters in the late 1960s and early 1970s.

In the early 21st century, Mississippi oyster harvests were actually doing really well. They were averaging about almost 400,000 sacks between 1998 and 2004, but they plummeted after Hurricane Katrina in 2005 in which catches briefly recovered until 2010 and the Deep Water Horizon spill. Also during this time period, there's been seven Bonnet Carré Spillway openings. So this is when they divert fresh water from the Mississippi River into the Lake Pontchartrain that eventually flows into the Mississippi Sound in order to alleviate flooding risks to New Orleans. And so in 2019, it was the most devastating of these openings where there was actually two openings releasing most amount of freshwater from the Mississippi River into the Mississippi Sound and there was nearly a hundred percent oyster mortality on the public Mississippi oyster reefs and there's been no public landing since 2019.

And so as a result of these declines, Mississippi has put a lot of effort into storing oyster reef populations. In 2016, Mississippi governor Phil Bryant created the Governor's Oyster Council on Restoration and Resilience because the state recognized not just the economic value of oyster reefs, which obviously provides food and jobs for the state, but the ecological values, which are they provide a habitat for other commercially important species such as fish, blue crab, and shrimp but they provide protection from shoreline erosion and storms and since oysters feed by filtering the surrounding water to remove algae and other particles that they eat. They also contribute to improved water quality, greatly, in estuaries and so the Council set an ambitious goal for Mississippi to produce one million sacks of oysters by 2025.

And so to make this goal a reality, there's been substantial oyster reef restorations ongoing in Mississippi with millions of dollars already spent or dedicated for future projects and these activities have largely involved deploying culture material to areas that historically contained oysters in hopes that wild populations of oyster larva will settle and over time form a functional reef. And so the rationale behind this is that you'll have adult oysters that are reproducing in the area. So as this oyster life cycle diagram shows, you've got adults releasing gametes that fertilize to form swimming larva that spend about two weeks in the water column and so they're ready to settle, or in other words attach to the bottom and their favorite surface to attach to is either other adult oysters or oyster shell. And so at that point they undergo metamorphis, kind of like a caterpillar turning into a butterfly, instead you've got an oyster larva turning into a permanently attached oyster, which we refer to as spat, and the hope is that they will grow into a reproducing adult and contribute to the population.

And so the restoration success is really dependent on the survival of these early life stages, but they're generally found to be less tolerant to environmental stressors than adults, but it's really unknown which stressors might be the most impactful and which stages might be the most vulnerable and you can also have multiple stressors occurring at the same time creating interactive effects that make it difficult to predict how oysters will respond. And so things like freshwater flooding events can cause multiple stressors, so either a Bonnet Carré opening or prolonged periods of rainfall. These cause large amounts of fresh water to flow into estuaries that are normally ... They're not quite as salty as the ocean, but they're still salty so this large amount of freshwater is going to reduce salinity levels suddenly and often for extended periods of time.

It's also going to bring in increased nutrients, which can lead to formation of algal blooms, which is known as eutrophication and associated negative water quality issues of hypoxia and acidification when these algal blooms begin to die and decay, because the bacteria that eats the dying algae also needs oxygen to breathe and it's often taking a lot more oxygen and taking that away from other animals to use, as well as bacteria or virus, too, putting off CO_2 which is going to reduce your pH and cause acidification.

And so restoration practitioners really require information about how these sensitive early life stages may be threatened by these flooding events that are becoming more common, but which flood associated stressors cause the most severe outcome and whether they can interact to modify larval and juvenile responses is not well understood. And so that's where our research really focused on, sort of examining the effects of flood-associated stressors on both larval and juvenile Eastern oysters to better understand the combined impacts of acidification, hypoxia, and low salinity on early life stages and so then we translated these findings into the policy brief that I'm discussing with you all today to really highlight the importance of these results for oyster restoration management in Mississippi, as well as other systems subjected to these frequent freshwater flooding events.

And so for the science, what we did in the lab was we exposed these four different early oyster life stages to either low dissolved oxygen, low pH, or low salinity, and isolation or combination, and then assessed the oyster response via growth and/or survival to these stressors. And so the stressors concentrations were a level we chose were actually based on quality conditions we recorded in the Mississippi sound during the 2019 spillway opening in the first iteration of the MBRACE project. And so the next few slides are going to have graph that look like this one, which ... Get my laser pointer out here. So on the Y axis you'll have some sort of oyster response, so in this case larval growth, and each of the treatments, so our control treatments are oyster response without exposure to any of the stressors, the blue one is going to be low dissolved oxygen or hypoxia treatment. Green is low pH or acidification. Red is that low salinity treatment and then gray is the presence of all three of those stressors combined.

And so we found that when we exposed 48 hour veliger larvae, so that initial swimming stage, to these stressors for 96 hours, we saw a reduced growth in response to hypoxia and low salinity and there's essentially no growth of the larva when exposed to all three of the stressors.

Next, when we exposed larvae that ... The pediveliger larvae, so these are the ones that are ready to settle, for 48 hours we found their settlement, which is the amount of larva that attached to the substrate that we gave them, was lower both in response to all the stressors independently or in combination.

And then next we exposed spat. So this is larvae that had just settled 24 hours prior, for seven days to these same stressors and we found that there was increased mortality in the presence of low salinity, which about 75% of the spat died in the low salinity or all three stressor combination. Additionally, these recently settled oysters were smaller in these treatments as well.

And then finally we exposed four-week old juveniles that were reared at the hatchery prior to exposure. So these are sort of juvenile oysters that just were the size of my finger as shown in that photo. We exposed these ones for 24 days in the lab and found that these juvenile oysters only when they were exposed to all three stressors did you see increased mortality relative to the control, but a lot lower levels. Only about 15% of them died compared to 75% of those day-old spat that died in the all three stressor treatment.

And then we also saw that shell growth was slower in the presence of all three of the stressors, in particular low salinity, and shell growth was actually negative when we exposed them to all three stressors. And so this is kind of evidenced by these photos. So on the top here is a picture of one of the juvenile oysters at the end of the exposure and the controlled treatment. So this right here is sort of the new shell growth, whereas in this picture on the bottom is an oyster that was exposed to all three stressors for 24 days and you can see there's no new shell growth and it's actually sort of rounded out and it was probably dissolving. So the amount of shell they're producing is less than what's being dissolved by the environment that they're in.

And then, so we kind of put all these results together and back into the context of the Eastern oyster life cycle and the implications this may have for oyster reef restoration efforts and already existing field populations. So if you deploy cultch or have a reef in an area with suboptimal water quality or that's prone to these flooding disturbances, even if you have spawning elsewhere once larva enter these conditions, you're going to see reduced growth, which is going to cause them to spend a longer time in the water column, meaning they're going to be more vulnerable to predation as well as they're going to use up more of their energy reserves, decreasing the likelihood that they're actually reach the settlement stage, at which point you're going to see reduced settlement under these conditions which is going to reduce the amount of oysters that you're potentially getting to recruit onto your restored reef or existing reef.

And then for the oysters that do actually settle, especially in those first initial days and in the presence of low salinity, you're going to see really high mortality rates which is going to further reduce the amount of recruitment you're getting to your reef. For the ones that do survive they're going to have slower growth rates in these conditions, which is delaying the time till they reach sexual maturity or can become a reproducing adult, as well as reduce their ability to deal with future stressors because of the stress that they were exposed to as juveniles. So really just decreasing the likelihood that you'll have a successful restored reef or that you're going to be able to maintain populations in these conditions.

And so this is where the policy brief comes in. So we translated these findings, so this is the first page of the brief and then on my final slide, I'll actually have a QR code for a link to the project website that has the PDF but basically we summarized our main takeaways that overall flood associated water quality stressors had negative impact on oysters in their early life stages, which may limit or prevent the recovery of resilience of oyster reefs and in particular, low salinity had negative effects on all of the early life stages and newly settled spat were the most vulnerable. So therefore we suggest salinity as the most important water quality indicator of oyster recruitment at a potential oyster restoration site, but hypoxia and acidification stressors should also be considered because they added to the already damaging effects of low salinity and in the Mississippi Sound where this restoration work is taking place, these flood-associated stressors are a real threat.

This is evidenced by last year, which was actually the wettest year on record for all three of the Mississippi coastal counties, and reduced salinity levels were observed across the coast during the peak oyster recruitment months of May through September at both water quality stations maintained by MDMR and USGS as well as sensors we had deployed at St. Stanislaus College in Bay St. Louis. So this graph shows sort of the average salinity and the number of days below five or between five to ten parts per thousand. As you can see, three of the five sites averaged below six parts per thousand, which was the concentration we used for our low salinity treatment and all sites experienced sustained periods of low salinity conditions.

Additionally, at the Bay St. Louis site where we deployed our sensors with the help of St Stanislaus High School and the amazing marine science program they have, we were able to record pH and dissolved oxygen data during this prolonged low salinity event and so in these graphs, the horizontal dashed lines represent the conditions in our lab exposures and so for pH, you can see that the pH levels in the Sound were falling between the conditions we expose oysters to, or often they were below pH levels and as well, there was a three-day hypoxic event at the end of July at this site. So this data supports that these stressors do co-occur in present oyster reef habitats, and they may be limiting recruitment success and oyster reef restoration efforts.

And so what are the next step, because we do believe there is hope for oysters in the Gulf of Mexico and that the restoration and projects the state is investing in can be successful. But our first recommendation is really incorporating these early life stage tolerance thresholds into existing decision making tools, such as habitat suitability indices, which are normally based on adult tolerances or just the year-round average of a location with really salinity being the most important. Additionally, continue investing in the hatchery, larval production from a remote setting and seed aquaculture, because these are going to be really important restoration activities that will help boost oyster populations in years of poor recruitment due to flooding events and additionally sort of leveraging the environmental data sets that we already have. So our team is currently working on synthesizing other MBRACE-related data and external data sources to really aid in understanding the issues and challenges that affect oyster reef resilience and then hopefully translating this into another brief that we can share with the community to practice. And then finally, just funding to purchase and install, and most importantly, the hardest part is maintaining these monitoring stations to provide the necessary real time data from relevant oyster habitats to continue informing oyster restoration and fisheries management.

And so with that, I like to thank the whole MBRACE team that's led by Deb Gochfeld, as well as all those that helped make these experiments possible and the interns and Letha Boudreaux at St. Stanislaus High School for helping maintain our sensors and the funding from MBRACE and all the oysters supplied by Auburn Shellfish Lab.

And so with that, this is the link to the project website, I can put it in the chat as well, and then there's the QR code. We've got plenty of time for questions.

Stephanie Otts:

Yeah. Great. Thanks, Jessica. Thanks so much, and I also dropped the link to the project webpage in the chat. So yeah, Jessica, I think questions are kind of come in. Because we're recording them and folks won't be able to see that when they're watching the recording, I'll read them for you and then it'll show from there. So the first question is, "So it looks like those three stressors might be slightly decoupled based on the graphs from Bay St. Louis. Looks like as the salinity is climbing back to normal that the dissolved oxygen is dropping along with pH increasing. So I'm wondering about the timing of stressors, whether order of exposure might impact survival or if the stressor occurred sequentially instead of simultaneously."

Jessica Pruett:

Yeah, so actually a lot of times with that freshwater, it's going to be more that's coming from rivering sources, it's going to be more acidic than your oceanic water. So when you get these low salinity fluxes, you might also get the low pH then, and a lot of times we see the hypoxic events more in those warmer August summer months. So you get the additional sort of temperature stressor too but I think the fact that the low salinity really drove a lot of the responses that we saw, that even if you change some of the stressor combination, it might actually have a higher impact, but definitely through all the life stages and even just a couple of days that low salinity was sort of driving a lot of the responses. But I think it's definitely important to consider earlier in the sort of spawning season, you might see more of a pH in low salinity and then as you get, although it might not be as much low salinity sort of towards the hotter months, but then you're going to get into your hypoxic and the higher temperature, which is more stressful as well.

Stephanie Otts:

Great. Thanks. Are there others that have questions? I think with this small group, you're welcome to come off of mute and ask your question as well.

I know it's a little hard with webinars to get questions and so I would just add, as we're waiting for folks to type their questions in, that Jessica mentioned the policy brief. So the policy brief was intended to highlight the key research takeaways of this research for policy makers in Mississippi and so we think that is a really useful one if you are just kind of interested in a more general overview, not just of these particular research findings, but in the context of what's been happening in Mississippi related to oysters over this extended period of time, where we are currently and certain things, next steps that might be considered, which like Jessica mentioned include thinking about early life stages in existing decision making tools is one of the recommendations in there.

Great. All right. Well, we'll give folks just one more minute to see if anybody has questions or thoughts. As well, I also want to thank MBRACE for the funding supporting this project and for giving of this opportunity to look at it. This is the kind of second pot of funding the research team has had with respect to MBRACE funding, and yes, we're grateful to be able to have that and to share that with everyone. Okay. Oh yes. We have a question.

Webinar Participant:

I was wondering oysters are more exposed because there aren't very many of them and what impact having a healthy population to start off, if any, would make on these results.

Stephanie Otts:

Yeah. Jessica, just in case, that was a little hard to hear, we had an echo, but I think Christina was saying are the oysters more exposed because they're at ... There's fewer of them on the reef and that if there was a healthier population to start with, would you maybe see different outcomes?

Jessica Pruett:

Yeah. So I think sort of in years past we've had sort of these extreme flooding events, but just in the past, this 21st century, there's just not a hearty or a large adult population out there so it's these early life stages and their survivals really having a bigger effect, whereas before you would maybe see ... It would actually sort create a clean substrate then you would get boost in sort of settlement but now that sort of some of the existing stock isn't quite as high as it was before, it's definitely the earlier life stages and if they're surviving is even more important.

Stephanie Otts:

Okay. Great. Thanks. I'm starting to see hands come up. I have Ben Passadas next and then Kevin Felcher. So Ben, do you want to ask your question?

Webinar Participant:

All right, Jessica, this might be a forward question, but based on the findings that you have and your policy recommendations towards the end, how would you relate that to looking at the effectiveness of the restoration efforts of the oyster reef past, let's say, 10 years and those efforts that will be done the next 10 years in terms of the type of the materials that have to be planted into the oyster reefs, the timing of the planting or restoration efforts, the density of the restoration materials that have to be put per acre of the reef and so on and so forth. Generally what I'm trying to look at, because I'm also looking at this for a different angle, this results of yours would surely guide some decisions that will be made with regards to restoring the state's public oyster reefs. So what will this mean in terms of type of materials, timing of the planting and the density of the amount of the cultch material to be planting.

Jessica Pruett:

Yeah. I think some of that sort of substrate question doesn't ... Sort of our work doesn't really get to that, but I think the idea of if you've got cultch material or with spat already on it, I think definitely we've seen that just between a couple of days to they're being a month old, they're definitely a lot more resilient to some of these stressors. So if you're deploying that kind of sort spat on shell out onto a reef, definitely as it ... I mean, it's costly to keep them in a hatchery setting, but as long as you can wait and if the conditions out there aren't good, it's not even worth the time to put them out there because they're just going to die. But in trying to time sort of deploying your shell as close to the spawning season, because another ... We didn't really ... We don't have sort of the science to back this up, but they like clean shell material as well.

I know just from putting our sensors out there, things just foul up in a matter of weeks out there. So if you can deploy materials in April, they might ... or towards the May, getting those peak spawns that are occurring in June and July, but we're also just still getting the data of when these larger spawns are happening is still sort of data that a lot of reefs sort of everywhere ... We don't really know when these larva are in the water and so to continue to doing our best will require that kind of information as well.

Stephanie Otts:

Great. Thanks. Okay, Kevin is up next.

Now I'm on mute. I think you may be on mute. Let me see if I can help you. There you go.

Kevin:

Good afternoon.

Stephanie Otts:

There you go.

Kevin:

Can you hear me?

Jessica Pruett:

Yeah.

Kevin:

Hello?

Stephanie Otts:

Yes. You're good. Thank you. Yes, you're good.

Kevin:

Okay. Perfect. Thank you. Hey, my question was are y'all currently work ... Your group currently working on or have you endorsed any restoration projects along the Gulf Coast in Mississippi yet?

Jessica Pruett:

So yeah, we're sort of ... We're not directly connected with any restoration projects, but we're sort of part of the RESTORE funding to do science that informs them and then to work sort of closely with the agencies that are doing those.

Stephanie Otts:

Great. Yeah. So our research has been shared with DMR and DEQ, so other folks that are involved in the restoration funding and selection of restoration projects, and so yeah, we haven't worked directly for particular individual projects, but hopefully it's informing their decisions moving forward.

Great. Okay. Thanks.

Well I don't see any other questions, so we'll go ahead and start to wrap up but if you have one last thought you're free to put it in the chat but as I mentioned, we will be sharing this recording of the webinar on the National Sea Grant Law Center's website following today. It may take us a couple days to get it uploaded because we do get captions and transcripts and get that all in order before we post it online, but I will share that information with all of the individuals who registered for the webinar so that you'll have access to that and can share with others in your networks. And so I just want to thank everyone again for joining us today. If you check in the chat box, you can get a link to the policy paper, and also other research papers that our team has done.

So thank you for joining us and we look forward to you coming back to another webinar in the future and thanks, Jessica, for presenting your research and doing the webinar today. So, thank you.

Webinar Participant:

Thank you.