ERDC-EL
Moderator: Courtney Chambers
January 29, 2014
12:57am CT

Courtney Chambers: At this time, I'll give you today's speaker on Assessing Environmental Windows using Effects Data. Dr. Burton Suedel is a research biologist at the U.S. Army Engineer Research and Development Center (ERDC), Environmental Laboratory in Vicksburg, Mississippi. Since 2005, Dr. Suedel has served as the Team Leader of the Risk Integration Team where he focuses on risk assessment and management of dredged material and invasive species, multi-criteria decision analysis, incorporating uncertainty into ecosystem restoration projects, and investigating ways in which environmental enhancements can be incorporated into navigation and port infrastructure planning. Prior to joining ERDC Dr. Suedel worked as a consultant in the ecological risk assessment, environmental toxicology and sediment hazard assessment fields. Burton has also authored numerous publications and reports on the topics of aquatic and sediment toxicology, fate and effects of contaminants in sediments, and risk and decision analysis. He is an active member of the Western Dredging Association (WEDA), the Society of Environmental Toxicology and Chemistry (SETAC), the Society for Risk Analysis (SRA), and the International Navigation Association (PIANC) where he is the chair of the Environmental Commission Working Group 143, which recently completed a report developing a standard of practice for conducting initial assessments of environmental effects of navigation and infrastructure projects.

Burton, we're very happy to have you with us today. If you need more information about Burton, you can find it in his bio posted on the DOTS page along with a copy of the power point he's going to be sharing. Okay, at this time I will give the presenter rights, Burton, and we will enter listen only mode and then we can begin.

Woman: All participants are now in listen-only mode.

Dr. Burton Suedel: Okay, Courtney, can you see my slides?

Courtney Chambers: Yes, sir, we are seeing it.

Dr. Burton Suedel: Okay, great. Courtney, thanks for the introduction. Good afternoon, everyone. It's a pleasure to talk with you today as part of the DOTS Webinar series. My Webinar today represents four years of research investigating sediment effects on various aquatic species. This research is supporting Corps districts by addressing their most pressing environmental windows issues.

This research was funded by the Dredging Operations Environmental Research program, addressing non-chemical stressors, in particular suspended sediments from dredging operations. My talk today will be structured in three parts. The first part will be a brief introduction to environmental windows issues affecting the Corps' dredging operations. Secondly, I'll provide you an overview of the fish, larvae, and egg exposure system, also called the FLEES. And finally, I'll provide three case studies where the FLEES was used to tackle a complex dredging window issue at one of our Corps districts.

For environmental windows, in spite of the fact that they're prevalent throughout the Army Corps of Engineers, they do impose restrictions on our dredging schedules, and it is considered the most frequently cited concern related to restrictions on our dredging operations across the United States. Of course there are a number of good reasons why dredging restrictions are in place, and those concerns are related to the exposure of a variety of aquatic life to suspended sediments emanating from dredging operations. This may affect or disrupt a wide variety of activities associated with life cycles of various aquatic species, including those we see here, for example, fish migrations from anadromous fish. In spite of the fact of their prevalence, the setting of environmental windows is quite controversial in many situations. There's no consistent or widely accepted methodology for objectively setting environmental windows. And one particular reason for that, is that they're oftentimes set without any scientific basis. We simply don't have the data or the science to understand the effects of suspended sediments on the species that are being used to set the window. So without those data in many situations the windows are being established by negotiations, oftentimes emphasizing conservative depressional judgments.

So what we have here basically is a really big data gap. We simply don't have the effective data for suspended sediments on species that are used to set the environmental windows for many of our dredging projects. To specifically address that need, the fish, larvae and egg exposure system or FLEES was designed, built, and then implemented to help address and generate those effects data needed to help better inform environmental windows.

The FLEES system is a think a unique system. Two pictures here on the left hand side have given you an indication of what it looks like. It consists of three modules. Each module contains a 500-liter water valve that you see in the lower left hand picture. These water valves consist of five aquaria for a total of 15 total aquaria in the system. Each aquarium consists of a 20-liter polyethylene aquarium.

Each water bath as you see in the lower left hand corner is insulated. You can see the black insulation on the sides, but also it's insulated on the top. Those balls that you see there on the top of the water bath water actually are plastic one inch diameter balls that help reduce and maintain the temperature of the water bath, especially if we try to maintain colder temperatures required by some of our more northern species.

Importantly each aquarium utilizes a pump. The pump attached to each aquarium allows us to effectively keep the sediment in suspension as appropriate for each of the 15 aquaria. Another unique aspect of the system is that it is transportable. These three water baths can be disassembled and pulled apart. The entire system can be put on a trailer and moved to the coast, especially in marine situations where species of fish will be really hard to transport to an inland location such as where we are in Vicksburg, Mississippi.

FLEES is a state of the art system. It utilizes the pump that you see in the lower left hand corner of the picture on the left, and this allows us to suspend the sediment in the aquaria. This is done by utilizing a 335-liter tank that you see in the picture, combined with that double-diaphragm pump. That pump then routes the slurry as appropriate through the FLEES system and into each of the 15 aquaria.

The separate concentrations then in each of the aquaria are monitored using optical back scatter sensor probes, and what I'd like to do now is show you a brief video. Hopefully it's not too far delayed on your end, but this shows the inside of the slurry tank. On the left hand side, hopefully you will see that we're adding sediment. This is project sediment collected from the dredging project that we're using then to expose the appropriate species to.

And so you can see the water here is continually being in suspension, and then this slurry tank concentration's higher than the aquaria then are then pumped into each of the 15 aquaria in the FLEES system. The FLEES is also computer-controlled. It utilizes a customized software program that interfaces to your data acquisition and control system.

This allows us a tremendous degree of flexibility in that each aquarium can be controlled for sediment concentration as needed by the dredging project and depending upon the needs of the species that we're working with, also can provide us flexibility for maintaining and changing the water inflow rate. Input parameters appropriate for the project are then entered into the software. Whatever concentration that is required for evaluation we can do that.

In the lower picture you see that our program monitors sediment concentration in each of the 15 aquaria, and what it allows us to do is when we preset those concentrations, if the concentration is reduced below that preset concentration, that will trigger the computer program to then open the valve and then add some additional suspended sediment slurry into the aquaria. This allows us tremendous flexibility to maintain our varied sediment concentration in each of the 15 aquariums.

This is probably the biggest picture of a group of five gallon buckets you've ever seen, but the point here that I'd like to make simply is that it takes - it doesn't take a whole lot of sediment to actually perform an experiment using the FLEES system, usually just a few five-gallon buckets of sediment collected from the dredging project site is all that we need to conduct an experiment.

On the right hand side you see a picture here. We established the turbidity to total suspended solids relationship. This of course is unique to each sediment, and we do this to make sure we understand this total suspended solids concentration, and that is what we use to then regulate and inform the setting of environmental windows, rather than the turbidity concentration itself.

Now with that backdrop I'd like to present to you then the first of the three case studies I'm presenting today. This involves an environmental window that's being set for walleye in Mawmee Bay, Ohio. Geographically, this is the westernmost in embayment in Lake Erie, relatively straight line - blue line that you see there is the deep draft of Toledo Harbor, a ship channel that's dredged on an annual basis. We have concerns here because walleye are spawning essentially almost immediately adjacent to the ship channel. Unfortunately, in decades past there've been some sandy and gravely substrate in the channel that was simply sidecast after dredging events, and the walleye picked up on that over time and they're now using that as a spawning area, indicated by the red areas. Walleye larvae are also using the area as a nursery, as indicated by the black arrows slightly beneath that, so we have concerns here in Mawmee Bay both in terms of effects on eggs and also early life stages for larvae as well.

One of the first things that we like to do when approaching a site like this is try to understand what the exposure parameters are for each project, so an exposure study was funded just a few years ago during an annual dredging event of the harbor channel to understand what the concentrations of suspended sediments might be in the area of the ship channel during dredging operations. And these two figures here give you an idea of the turbidity concentrations during that particular dredging event. You can see in the top figure for example indicated in the cross-section of the ship channel here that the sediment - suspended sediment is immediately dropping out of the water column right underneath the dredge, and these areas adjacent to the channel where the walleye may be spawning, you can see the concentrations are much lower, so very useful data to understand what exposure might be.

In the lower graph we see the turbidity measurements based on time for a given location adjacent to the ship channel. Here you can see obviously the suspended sediment concentrations are higher when you're closer to the dredge, for example 15 meters versus when you're about 46 meters away. So this exposure information then provides us very useful information in terms of designing and understanding what concentrations we need to set our effects experiment.

So with that information, we went ahead and designed our experiment. We used both walleye eggs and fingerlings. The eggs were obtained from two hatcheries. They were newly spawned and delivered to us immediately in Vicksburg. The fingerlings were 45 to 60 days old. The sediment to make as appropriate to site conditions as possible was collected directly from the ship channel in Maumee Bay. The concentrations that we used based on the exposure study I just mentioned ranged from zero, which is no sediment, to 100, 250 to 500 milligrams per liter. This was total suspended solids. The duration was decided to be three days continuous exposure or 72 hours. That was indicative on the fact that the question we wanted to try to answer there is that in any given location adjacent to the ship channel, what is the maximum amount of time that that location may be impacted by resuspended sediment? So that was determined to be no more than three days in duration.

The temperature for the eggs and fingerlings were based on the hatchery temperatures to reduce the stress to those early life stages on transport and arrival in Vicksburg. The pictures show some egg cups. They're suspended in the middle of a particular aquarium. These are really important for us to have in terms of exposing early life stages. In the upper photo, for example, we had 100 walleye eggs in that egg cup. It has mesh, obviously, that's small enough that it needs to contain the eggs, but big enough so that this suspended sediment can get inside of the egg cup and be exposed to the eggs.

Experiments and end points - the point I want to make here is we are working with live animals, and in spite of our best efforts as biologists and researchers, we're not always successful the first time out, so sometimes it takes more than one time to get the data useful that we need for a particular project.

The end points here is not so much important exactly what they are, but to point out that we need to work very closely with the regulatory agencies that are imposing windows along with the stakeholders and other interested parties to make sure we all understand which life stages of species and what endpoints are most appropriate and will be acceptable for the project going forward.

Now I'd like to provide you with an example of the results that we have for the walleye study. This case is looking at fingerlings, gill to belly endpoint. Gill and belly are susceptible to injury when a fish is exposed to high concentrations of suspended sediments, so we thought this was a very relevant endpoint. Here in the graphic we looked at and plot proportion, normal gill to belly, against total suspended sediment concentration.

And you can see here for the control we have the three sediment concentrations that we evaluated, that there was no significant effects across CSS treatments for this life stage and this endpoint. Another example result here, this is for eggs, here we're looking at and plotting percent successful hatch against total suspended sediment concentration. Again like all of the other endpoints that we evaluated, no significant impacts were observed for this particular endpoint based on these conditions. So then where is this project in terms of its space, status? We've done a really good job over a course of a couple years of generating effects data. Those data are in the process of being published in peer review journal articles, and these results are having a positive impact, you know, from - I think from everyone's perspective really, because we're reducing uncertainty associated with the effects of suspended sediment on this species.

And so as a result the Ohio department of natural resources is now considering a one-year waiver to the environmental window in Maumee Bay based on the exposure and effects data that we've generated for walleye, and we expect this to go into effect starting in 2015.

The second case study that I'd like to present to you today involves an environmental window associated with the eastern foresters that is being imposed on dredging operations in the Kings River, Virginia. This particular graphic here shows you dredging operations conducted on an annual basis in the tribal shoals area of the river, and potential concerns related to dredging impacts on the oyster fishery in this particular part of the James River.

To better understand the exposure parameters that we're dealing with in the river relative to the oyster beds, we have turned to our engineering friends in the coastal hydraulics laboratory, and they are using a particle tracking model to simulate free suspended dredging sediment transport from the dredging activity, and they're considering three placement locations as you see here in the photograph to the right hand side.

A variety of parameters were being input into the particle tracking model that you see here in this slide that are relevant to the dredging operations in the river, and this particular image just gives you an example of the output of the particle tracking model where the different colors here represent different concentrations of suspended sediment as they're being transported from a simulated dredging activity downstream and towards some of the oyster beds.

Now that we are armed with that information, we can really understand what our exposure concentration should be for our effects study. Because we had not worked with oysters before in the FLEES we did break out the experiments into two parts. First is what I call a range finding experiment. We wanted to make sure that we could transport and receive and work with the oysters so we don't harm them in the laboratory here in Vicksburg.

We also ran into issues where oysters were received in spawning condition, and any of you that have worked with oysters before know that if they're in spawning condition, they're not going to be really happy with being handled like we did. But the point here is we were then attaching the oysters as you see in the lower left hand photograph into an apparatus that allowed us electronically to ask the oyster whether its shell was open or closed.

This helped us specifically address the hypothesis basically saying that the oyster is not reducing its feeding or in other words not having its shell closed more often when exposed to higher concentrations of suspended sediment. So once armed with that useful information from the range finding study we did then design and conduct our definitive experiments in December 2012.

Because the James River oyster fishery was not yet open at that time and the oysters were still in reproductive condition, we did turn to our collaborator the Virginia Institute of Marine Science to confirm that we in fact could use oysters obtained from the Rappahannock River for this particular experiment. The oysters used were legal size three inch. We had high survival because they were not in reproductive condition. The test conditions were reflective of the conditions in the Rappahannock at the time of the selection to reduce the amount of stress associated with transporting the oysters, and James River sediment is collected from the dredging project area to mimic as much as possible and be as realistic as possible to their dredging operations in the James.

So the oysters then in the apparatus that you see in the picture were then exposed continuously for seven days to James River sediment. Here's some pictures here to give you an idea and reflect the actual concentrations that we're actually working with. In fact, this - on the left hand side you see we have the control aquarium. It's not completely clear because we have a little bit of turbidity that's induced by the food that we're introducing every day to the oysters.

And then on the three pictures on the right hand side going from low, medium, high, up to 500 milligrams per liter, one might could suggest that we're doing this electronically to ask ourselves whether the oysters are open or closed or not, because I don't think I could find anyone to help look into a very muddy container like that and ask them to tell me if the oyster is open or closed for 24 hours a day 7 days a week.

So it is essential that we do this electronically to help us understand whether the oysters are open or closed or not, so that was one of the most important endpoints that we used for the study. In addition to that another critical one is working and collaborating with VIMS. After the seven days' exposure, all 75 oysters were sent to VIMS for a 30-day grow out period after which time condition index was measured on each oyster to help determine any potential long term effects as a result of the seven days' exposure to suspended sediments in the FLEES system.

Here's an example of the results from that particular study. Here we have box and whisker plots looking at percent open for each oyster for each treatment, and you can see here that there's no significant differences across the three treatments for this particular endpoint, and this was indicative and representative of all the endpoints that were measured for this particular study.

A couple key points here relates really to collaboration, and keeping the open lines of communication open between the Army Corps of Engineers and stakeholders, especially researchers and VIMS. I can say that these relationships aren't always cordial, but we need to continue to be persistent and keep those lines of communication open and make sure that what we're doing on the effects side experimentally is very transparent to our stakeholders and collaborators on the project.

We also collaborate with universities to help support graduate student research. Also very important is the publications of the results. We expect the publication of this particular study to happen later on in 2014. Going forward we expect them to integrate the effects data that we've generated for this study combined with the exposure modeling being generated by our coastal hydraulics laboratory going forward.

Lastly but not least is the third case study. This involves an environmental window turbidity that's being imposed on Atlantic sturgeon in Savannah River and Harbor, Georgia. The problem here is indicative of what we saw with the other two species, walleye and eastern oyster. There's simply virtually no information in the published literature to help us understand any kind of effects of suspended sediment on not only Atlantic sturgeon but really any sturgeon species native to the US.

Another issue here for us is the many - that all of the sturgeon species have been recently federally listed, so it makes it even more difficult for us to obtain these species for experimental purposes. Nevertheless, we were successful with obtaining Atlantic sturgeon, and so we then went about - go ahead and really closing that data gap to help us understand the effects of suspended sediment on this particular species.

So I'd like to click on and show you a second video. This particular video is showing a single aquarium in the FLEES system. This is 100 milligram per liter concentration, so it's a little bit more transparent than the higher concentrations, and you can see two of the sturgeon that are fairly active in this particular aquarium during the three days of exposure to suspended sediments.

For scale purposes, these particular fish were roughly five inches in length, so they were fairly good sized for this particular size aquarium that we're working with. Multiple endpoints were investigated for this particular project, that was survival and growth, but we also looked at swimming performance and a variety of swimming performance metrics were evaluated for this particular study.

This was done in the swim tunnel that you see in the picture. What I'd like to do now is show you the third and final video. This shows an Atlantic sturgeon immediately after the three days of exposure. The Atlantic sturgeon was randomly selected from each aquarium and placed in the swim tunnel to help understand the potential effects of resuspended sediment on swimming performance. The concern here was that if a sturgeon that swims into the turbidity plume then swims back out, if this has the potential to affect its swimming performance that could increase its susceptibility to predation, so we thought that was a relevant endpoint to investigate for this particular project.

Here's a table showing you some of the primary results from the sturgeon experiment. This shows total suspended sediment concentration in the control, 100, 250, and 500 milligram per liter CSS concentrations. We looked at survivorship immediately after three days of exposure, and you can see here no significant differences were observed. We additionally held those fish for an additional 14 days after exposure looking at post-exposure survival, again proportion surviving 14 days after the monitoring period showing no significant effects, so we did see a slight drop-off at the highest concentration.

We're still evaluating and analyzing the effects on swimming performance, but the two swimming performance endpoints you see here were showing no significant effects on swimming performance after three days of exposure to suspended sediment. So there's some obvious trends I think going forward that are worth noting here. We're certainly increasing our understanding in terms of the potential effect of suspended sediments on these species.

So in light of reducing the uncertainty regarding these risks associated with these effects thresholds and certainly using the range of dredging induced turbidations that we expect for this project, we're seeing a fairly constant consistent story here and we're not really seeing any effects. So I think the environmental windows at least for these three projects warrant further investigation given the results of these effects data.

I'd also like to point out the fact that hey, I'm a research biologist, but if the job - my job's not done when the research is done. We need to continue to reach out and communicate the results of these experiments with our stakeholders and other interested parties to help them understand what these data mean in terms of life, of whether we need to revise the windows or not for these particular species in these water bodies.

It becomes abundantly clear fairly quickly to us that a variety of products and deliverables particularly related to approach is needed in terms to successfully address environmental windows or work closely with our regulators and collaborators, and so this gives you a fairly complete list of what that should probably entail. The fourth bullet here related to journal papers.

I know as research biologists we do this on a fairly regular basis, but the fact remains that if we're able to publish our results, and they pass peer review muster, then that really carries a lot of weight in terms of the results that we're obtaining for these particular studies, so it's very important to work with our stakeholders and agencies collaboratively to make sure that this research process really takes place transparently and there aren't any surprises as far as this process.

Before I open it for questions, there's a couple last things I'd like to leave with you today. There are obviously other capabilities associated with the FLEES system that we have yet to really take advantage of. I mentioned - alluded to this just a little bit ago is that we can perform pulse exposures in the FLEES system. It is flexible to allow us to do that.

The three experiments that I shared with you today obviously were continuous exposures, but if the project requires or is more appropriate that we use pulsed exposures, we can certainly do that. You know, plants should not be considered the forgotten kingdom here. We can perform experiments with submerged aquatic vegetation. Certainly there's a lot of projects around the country involving dredging where there's potential concerns related to dredging of submerged aquatic vegetation.

And then finally, also importantly, there's some concerns in some dredging projects related to potential burial of eggs in spawning grounds in the areas adjacent to dredging operations, and so we have the capability of performing those types of experiments as well. That's all I have today. I appreciate your attention. Now I'll open it up for questions. Thank you.

Courtney Chambers: Great, thank you very much, Burton. At this time I'm going to return us to interactive mode.

Woman: All participants are now in interactive talk mode.

Courtney Chambers: Great, okay, so at this time feel free to take your phone line off of mute and ask a question, or you can utilize the chat feature, and as soon as Burton returns to our meeting window. If you can do that, Burton, we'll be able to view the chat box in the lower right hand corner of your screen. Excellent, there we are. While you're thinking, I did receive one question during your presentation, Burton. We had the question of what type of sensor was used to measure the open or closed state of the oyster? He mentioned a tiltometer, a strain gauge, something like that?

Dr. (Burton Suedel): Oh, yes, you're going to have to ask my electrical engineering gurus that worked on that, (Charlie Lutz) and (Justin Wilkins). Those sensors were really important. We had to make sure that we had the right sensor type, and make sure that each sensor was you know, hot glued to the particular point of the oyster where we could detect that that sensor was moving and whether it was open or closed, but I don't know the exact sensor. But I do have that information written up and I can send that to anyone who is interested.

Courtney Chambers: Great, thank you, Burton. Are there any other questions? Here's another one, Burton. We had the question if you could restate the oysters' survivorship rate. Did you have that in your presentation?

Dr. (Burton Suedel): I did not. In the interest of time I didn't want to bore everyone with multiple slides of results, but we saw excellent survivorship of the oysters. They were well above 90% for all the concentrations, and I should also point out that the condition index data came back very well, no effects on condition index after the 30 days grow out period after the seven days of exposure. Oh by the way, those are reed switches, R-E-E-D switches, that were used on the oysters. Thanks, (Justin).

Courtney Chambers: Excellent, thanks, Burton. I did have the question, if the power point would be available, and yes that will. It will be available on the DOTS Web site under the resources tab, with the recorded meeting from today, and that'll be as a WMV file as well as Burton's biography and such. Any other questions this afternoon? I'm going to go back to the introductory slide that we had, and it's got the DOTS Web site available. Just one second.

(Cynthia): Courtney, this is Cynthia. I've also added it to the chat feature.

Courtney Chambers: Oh, okay, great. Thanks, (Cynthia). Well with that they can copy the link that you posted. I'm going to return - whereas they couldn't on this intro slide, I'll return to Burton's presentation. Okay, here's another question. Generally how long does it take a project to be completed once the given species is identified?

Dr. (Burton Suedel): You're only looking at a few months. You know, when you think about dredging operations and how long a dredge can impact a given point along a ship channel, it's not very long, but that is the exposure time that we target to mimic in the FLEES system, so the actual performance of the experiment may be only on the order of two to three days and the seven day continuous exposure with the oysters actually so far has been the longest exposure time that we used so far.

But we - but of course after we finished that, I mean, if you have the 30 day condition period that's another month, and of course the analysis interpretation and write up the data, but still this is - this can be done within a relatively short, like say six months or so, maybe nine months.

Courtney Chambers: Okay, Burton, on a fairly similar note, what's the cost for this type of experimental work, we had the question?

Dr. (Burton Suedel): Well I can tell you, it wasn't real cheap to actually design and build the FLEES, but one of the advantages is - quite frankly is the system is already built, and it's already been proven in my eyes, and one of the advantages of it is that it's essentially a research resource that can be used, and so that cost is - you know, it's already accounted for and paid for by the DOER program, so the costs are going to be reduced substantially as a result. It doesn't take a tremendous amount of money really to perform a relatively short experiment then analyze the data. It's really difficult to provide cost estimates because they can vary widely. These types of experiments can be done relatively inexpensively.

Courtney Chambers: Great, thanks, Burton, and I would assume if they had any more detailed questions they could email you and visit with you or give you a call, is that right?

Dr. (Burton Suedel): Absolutely. You know, what was hinted - hidden in the second to last slide was the tech note that we published to describe the FLEES system, so if anyone's interested I do have a report that I can send you, and then almost all of the - there's the tech note at the bottom, and we've essentially published all of the walleye research, and so those publications are also available if anyone is interested in them.

Courtney Chambers: Great, thank you, (Burton). Okay, any other questions before we close today? All right, well I'm just going to remind you if you would like any PDH credit, be sure to send me a chat. I've received several requests already, and I'll need your full name and affiliation, and email if you're not with the Corps of Engineers. (Burton), it was a wonderful presentation. Do you have any closing comments before we end today?

Dr. (Burton Suedel): No, I don't think so. I just wanted to encourage everyone to contact me if they have any additional questions or want additional information about the FLEES system and the capability.

Courtney Chambers: All right, that sounds great. Thank you very much, (Burton). It was a great presentation.

Dr. (Burton Suedel): Thank you everyone for taking interest.

Courtney Chambers: Yes, sir. And I want to encourage all of our participants to be watching for upcoming notices on additional Webinars. We're planning to have one in March, so watch for that announcement from (Cynthia Banks) here at ERDC, and again thanks for participating. That's what makes these Webinars successful.

(Cynthia): Courtney, this is (Cynthia). I also want to let the participants know I've added the link to (Burton)'s tech note to the chat feature.

Courtney Chambers: Oh, great. Thank you very much, (Cynthia). That will be very helpful. Okay, you all have a wonderful afternoon.

Dr. (Burton Suedel): Thanks, you too.

END