

Siena Fouse (00:03):

Okay. Good afternoon everyone. Thank you so much for joining us for our sixth and final webinar of our 2025 webinar series. My name is Siena Fouse. I'm an ocean and coastal law fellow at the National Sea Grant Law Center. In today's presentation, Florida Sea Grant's NOAA HAB liaison, Betty Staugler and I will discuss harmful algal blooms science impact and legal challenges. Just a little bit about our office, the National Sea Grant Law Center was founded in 2002. We are housed at the University of Mississippi School of Law. Our mission is to conduct legal research, education, and outreach for the wider Sea Grant network of 34 Sea Grant programs and their stakeholders. If you're interested in learning more about our work, I encourage you to visit our website and follow us on social media.

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Before we begin, just a few quick housekeeping notes. Right now we have everyone on mute to cut down on background noise. This webinar is being recorded and we will post it to our website as soon as we can after the webinar. It usually takes a couple of days to get the transcripts and captions finalized, but we'll share it over email and post it on our website. If you have technical issues, you can private chat Lauren Fremin, National Sea Grant Law Center's project coordinator and webinar host. And finally, if you have questions during our presentations, you can put them in the chat, but I want to let you know that we will have time for a q and a at the end of the webinar when we'll respond to questions. So with that, I want to get to what we're all here for today and pass it to Betty Staugler to get us started with the science impacts mitigation and control of harmful algal blooms.

Betty Staugler (01:49):

Great. Thanks, Sienna. Okay. So thank you very much. Today I am going to be giving a very broad overview of harmful algal blooms, their impacts and management strategies, including mitigation and control, and hopefully setting the stage for Siena who will follow. So harmful algal blooms are an increasing societal problem. They're caused by a very small subset of algae that produce toxins or otherwise cause harm and some of the ways in which they cause harm. Many cyanobacteria produce a suite of potent toxins that pose diverse risks to humans and animals. The Dinoflagellate, Alexandrium Catenella, and many species of the diatom, pseudo-nitzschia generate neurotoxins. These can accumulate in shellfish and result, result in shellfish poisoning syndromes and aerosolized toxins produced by the Dinoflagellate Karenia brevis can cause respiratory irritation when toxins blow on shore. Additionally, the golden alga Prymnesium parvum has barbed structures that damage fish gills, and also while the Dinoflagellate Karlodinium Veneticum produces fish killing ihiotoxins.

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And finally, the Picoplankton, produce dense brown tides that can shade vegetation, disrupt feeding, and lead to odors and oxygen depletion. And this photo that you're looking at is of a brown tide in the Indian River Lagoon. This is an undated photo from the St. John's Water Management District. So harmful algal blooms progressed through four interconnected stages. These are initiation, growth, maintenance, and termination. And while these stages vary among species in general, initiation begins with sea populations such as resting cysts or low density cells. When they encounter favorable conditions like nutrient enrichment, stratified waters or sufficient light. During the growth stage, cells divide rapidly and as they take advantage of available nutrients, upwelling or runoff or internal recycling, while physical and biological factors such as light, temperature, water, residence, time grazing and competition affect the pace of expansion. And then the maintenance phase follows as the bloom persists through nutrient recycling, grazing resistance and transport by winds and currents, allowing a bloom to remain in place or expand and spread across larger areas as long as conditions are suitable. And then finally, termination occurs when environmental factors become unfavorable, such as nutrient depletion, cooler temperatures, salinity changes, and some species may transition back to resting stages to survive until conditions become favorable again.

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So what you're looking at is a bird's eye view of HABs Across the United States, the colors represent different bloom types, each having different effects on people, animals, ecosystems and economies. And what you can see from the image is harmful algal blooms have been reported in every US state, in addition to Puerto Rico and US Virgin Islands. Harmful algal blooms have a wide range impacts on communities. For instance, when HABs contain toxins, they can affect human health through exposure, sometimes necessitating medical intervention. Fisheries and shell fisheries experience closures or losses which affect commercial, recreational, and subsistence harvesters and recreation and tourism may also be impacted, for instance, as a result of fish kills or closures to beaches and shorelines. And these effects ripple through economies influencing restaurants, shops, hotels, marinas and other businesses. Persistent blooms can also contribute to property value declines, reducing waterfront real estate values, as well as local tax revenues.

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And at the same time, governments and agencies incur significant expenses, monitoring and managing harmful algal blooms. Additionally, freshwater HABs can drive up drinking water costs as utilities have to invest in advanced filtration and removal technologies to ensure safe water supplies. And finally, HABs can also affect agriculture where contaminated irrigation water can harm crops and livestock leading to economic losses and increased management expenses. In addition to socioeconomic impacts, harmful algal blooms can have widespread impacts across entire ecosystems. These often start at the base of the food web where HABs have effects on healthy populations of phytoplankton and zooplankton. Toxic species can have an accumulate and shellfish and harm crustacean small fish and larger predators leading to fish kills and bioaccumulation up the food chain and eventually reaching top predators such as seabirds, marine mammals, and sea turtles. And in extreme cases lead to mass strandings or large die offs, such as what we saw in California earlier this year.

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But of course, harmful algal blooms can also have significant impacts on ecosystems even when toxins aren't involved. Dense blooms often lead to hypoxia, which can result in fish kills and dense algal blooms can also involve shading of submerged aquatic vegetation, which alters fish habitat. And then HABs can also alter nutrient cycling, promoting internal loading of nitrogen and phosphorus that sustains eutrofication. And all of these can lead to long-term habitat degradation and reduction in biodiversity. So that leads me to HAB management. What are we doing about it involves prevention, mitigation, and control. And each of these have different goals and strategies. Prevention includes watershed and ecosystem strategies that reduce boon drivers such as nutrients, and it includes things like habitat restoration, hydrologic restoration, agriculture, best management practices, and advanced sewer treatment just to name a few. And prevention is vital because once blooms occur, management becomes costly, complex, and often less effective than addressing the root cause before blooms start.

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But even when blooms are present, reducing nutrient sources and restoring hydrology can limit bloom's severity, duration, and prevent secondary impacts, and also support long-term recovery. Efforts to mitigate the socioeconomic and ecosystem impacts of harmful algal blooms depends heavily on monitoring. State coordinated monitoring programs are typically the first line of defense when it comes to HAB management and often includes many partners such as academic partners, federal agencies, local governments, tribes and NGOs. And state monitoring programs relies heavily on microscopy, which is the gold standard for confirming HAB species. Results are used for regulatory decisions such as shellfish closures and public health advisories. Though this process takes time, especially during heavy bloom conditions when additional monitoring is needed. To supplement these monitoring efforts, additional types of monitoring is often conducted, some of which provides faster results and can be used for real-time assessment.

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And in many areas in situ monitoring is supported with satellite monitoring. So on the left ocean color imagery is used to track bloom extent duration and movement over time in North Carolina's Elmar sound and Pamlico sound regions. And because satellites provide a broad continuous view of the coast, they also offer valuable input along with in situ data for forecasting where blooms may develop and move next. And so on the right we see sea harm, which is a three day forecast that predicts pseudo-nitzschia and particulate domoic acid along California and southern Oregon's coast. And all of these monitoring efforts are focused on mitigating risk through avoidance and response. And this includes things like increased monitoring, reporting, communication, posting signages to alert the public that HAB is present, as well as efforts to respond to impacts when they occur, such as closing shellfish beds or recovering stranded....[inaudible]. All these steps are vital to HAB management process. They aren't actually doing anything to control or stop a bloom.

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And so that's where HAB control comes in. So have control involves the active interventions aimed at reducing, suppressing or eliminating algal biomass or toxins. And it's arguably one of the most challenging and controversial aspects of HAB management and it remains the least developed of all HAB science in the United States, particularly in marine systems. And there are reasons that freshwater have control is much more advanced than marine control, starting with regulatory ownership and ownership differences. Freshwater systems such as lakes, reservoirs and ponds are often managed by a single entity such as a municipality, water utility, a lake association, and this makes permitting and applying control measures a little bit easier, whereas marine waters are public trust waters with overlapping jurisdictions creating complex permitting and liability hurdles.

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Additionally, there's differences in physical scale where freshwater systems are typically smaller and controlled, allowing for localized treatment to be effective and measured, whereas marine systems are open, dynamic and much larger with stronger currents, tides and mixing that dilutes treatments and makes containment virtually impossible. There's differences in bloom characteristics. For instance, many freshwater habs are dominated by cyanobacteria, which often forms surface scums accumulates in nearshore areas, which makes it easier to target physically and chemically, whereas marine habs involve diverse taxa with different life cycles, cyst stages and vertical migration patterns that complicate control. And then finally, there's differences in research and funding history. Freshwater habs often threaten drinking water supplies, and this has prompted immediate utility investment and innovation in treatment technologies. Whereas in marine systems, habs are more diffuse leading to less centralized funding. However, in the last few years, marine HAB control has expanded significantly as federal and state programs have invested in investment and coordination.

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So to look at a few examples of HAB control, HAB control is categorized into three different types, although there's overlap between them. Physical control methods are those that physically harvest, settle, and bury cells or block the spatial extent of a bloom. And this includes clay flocculation and sedimentation mixing, aeration or circulation enhancement, ultrasonic disruption and barriers or physical removal. And the example graphic that's on the slide here is of clay dispersal, which creates clay cell flocks that rapidly sink to the sediments. Along the way, they trap additional cells and they also destroy or sequester toxins from the water column.

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Chemical controls rely on the release of dissolved organic or inorganic elides that kill, inhibit or remove algal species and their toxins. These include in freshwater systems elides such as copper sulfate as problematic in marine waters, but also hydrogen peroxide, which is being evaluated from marine waters

and has been successfully applied in a single case example in the Netherlands. Other marine controls being developed include activated carbon, curcumin, polyphenols, and flavonoids. And then finally, biological controls use microorganisms to kill, inhibit, or remove algal cells. And these include natural bacteria, viruses, grazers such as zooplankton and ves and competitive or apathic species. And the example here is of Dino Shield, which uses a naturally occurring bacteria, which has a high specificity for dinoflagellates and has shown no adverse non-target effects on organisms. And this picture is showing how it would be deployed.

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The ELLA is encapsulated in hydrogel beads and then deployed in bags in strategic areas such as aquaculture beds or marina basins. And important to note is that there's no one size fits. All of these strategies are going to be needed. And I also want to point you to this Anderson et al 2025 reference because this is a brand new paper that summarizes a lot of HAB control. It is fantastic. It was just published in Harmful algae and if Dale is on, thank you very much for sending that to me. And then this is my last slide. To ensure HAB control technologies are safe and effective, their development undergoes a long multi-step process beginning with evaluation of a new technology. Here, these technologies undergo lab testing to assess efficacy, specificity, dose, contact time, non-target impacts, target, non toxin release, and how water chemistry affects performance. Successful or promising products then move on to research and development. And here, mesocosms or small confined fields, trials of less than one acre are used. This phase assesses environmental complexity, weather effects and non-target impacts, as well as application timing, methods, storage, stability and geographic differences and limited use permits and safety protocols are usually required. The next stage is demonstration and validation, and in this phase, larger, longer duration field trials are conducted and the regulatory review process becomes central as does making sure researchers are communicating with potential end users. This phase also evaluates scalability costs, logistics, supply chains, application feasibility and site access needs. And then finally, once the effectiveness and all of the regulatory approvals are secured, a product can transition to implementation, of course, standards of practice, licensing, reporting, and all of those in place. And with that, I'm going to say thank you and stop sharing and turn it over to Siena. Thank you.

Siena Fouse (21:14):

Thanks Betty. As I mentioned earlier, my name is Siena Fouse. I'm an ocean and coastal law fellow at the National Sea Grant Law Center in Oxford, Mississippi. I graduated with my juris doctor from University of Maryland, Carey School of Law with the concentration in environmental law and am licensed in the state of Maryland. Today I will discuss permitting challenges of harmful algal bloom control technology in marine environments. I've been working with the US harmful algal Bloom Control Technologies incubator or US Hab, CTI since the beginning of this year. US Hab, CTI is a partnership between NOAA, university of Maryland, center for Environmental Science Institute of Marine and Environmental Technology and the Moat Marine Laboratory in Florida. US Hab CTI's goal is to streamline the vetting process of novel hab control ideas. As part of this effort, we are developing a clearinghouse website to provide guidance to researchers on the permitting process for field testing, registration, and use of products to control habs.

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To this end, my team and I have been conducting research on statutes and regulations applicable to the development and use of HAB control technology. The first few research teams are working through the permitting process now for testing and use in a marine environment. So today I'm going to discuss statutes and regulations involved in this process and the major challenges to getting the required approvals for testing and use of HAB control products in a marine environment. While my research has been focused on guidance for product researchers, I think it is also beneficial for federal and state agency staff as well to understand the different laws and agencies involved in this permitting process.

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These are the themes I'll discuss today regarding permitting challenges for hab control products in marine environments. I'll start with why it's important for researchers to understand what's involved ahead of time before getting into the permitting process. Then discuss how to manage significant requirements under certain statutes, and finally talk about what the researchers' responsibilities are under relevant statutes versus the agency's responsibilities. As a disclaimer, this is not intended to be legal advice. These are just some of our observations so far from our research and from following a couple of case studies. Questions about specific circumstances of a project should be directed to the federal and state agencies with relevant authority.

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The first major challenge is to understand what is involved in the permitting process ahead of time. This was especially difficult for teams pioneering these products. Luckily, this is what my team and the US Hab CTI clearinghouse are working on to address with our website, which is scheduled to go live next summer. This is so important for developing hab control products in marine environments because there are many federal and state statutes and agencies involved. Onscreen is a list of federal statutes that might be relevant to this kind of project. I'll provide more details on what may be required under these statutes once we move into our next topic. I know it's a long list, but I don't want researchers to feel too overwhelmed because as I'll explain more later, it's often an agency's responsibility to check for compliance under a number of these statutes rather than the researchers. This list is just to build an understanding of what laws might be involved and why this process can be complex. Testing and use in coastal waters is complicated, as Betty talked about earlier. This is a newer process for being in marine environment. It's an area that's affected by tides. It involves multiple federal agencies with overlapping authority. It's more complicated than freshwater applications where testing sites tend to be more contained and jurisdiction is clearer. Additionally, algaecides benefit from an advanced existing framework for aquatic plant control and freshwater systems.

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There are relevant state components under federal laws as well as state laws and regulations to consider when permitting HAB control products in marine environments. States may have different unique requirements, but look out in most states for Clean Water Act, national Pollutant Discharge Elimination System or N-P-D-E-S permits issued at the state level in most states under the Clean Water Act. EPA can also approve state's plans to issue their own pesticide experimental use permits under fifra. States also have their own pesticide product registration requirements. Additionally, states may have pesticide applicator license requirements or other state specific environmental protection laws and regulations such as Florida's environmental Resource Permit program. Finally, local approval of testing sites will probably be required. This isn't necessarily an exhaustive list of what's required and what's involved. Just what we've been seeing come up with our case studies that I mentioned.

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Another thing to know ahead of time is which agencies are responsible for administering which statutes, so researchers know who to contact to ensure compliance with these laws. This is also good for federal and state agency staff to understand what other agencies the researchers might be in communication with or still need to talk to. A problem cited by researchers is that not all agency staff they have spoken have been able to provide correct initial instruction or point them in the right direction, but recognizing that these are products with novel application, we're all learning what this process looks like and hope for more clarity and consistency moving forward. So on screen are some laws that researchers could have responsibilities under and the agencies that administer them. Pesticides are regulated at the federal level under FIFRA and the F-F-D-C-A by the US Environmental Protection Agency. The Rivers and Harbors Act and Clean Water Act, section 404 are administered by the US Army Corps of Engineers. The Clean Water Act, section 404, the NPDES program that I mentioned, is run by EPA only in Massachusetts, New

Hampshire, New Mexico, Washington, DC and US territories, but it's otherwise administered by state agencies such as the State's Department of Environmental Protection. Other state environmental protection laws and regulations like Florida's Environmental Resource Permit Program may also be administered by the State's Department of Environmental Protection. For experimental use permits at the state level, state registration of pesticide products or pesticide applicator licensees go to the state agency that regulates pesticides such as Florida's Department of Agriculture and Consumer Services.

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Onto my second theme, the challenge for researchers to manage significant requirements under statutes. Now that you have an idea of the range of laws and agencies involved, you may be wondering where should I focus my attention? Again, we are still learning from the pioneering teams going through this process for the first time, but we are seeing FIFRA and the F-F-D-C-A requirements come up as possibly the most demanding in the permitting process in terms of time and cost depending on the type of control product. Thorough vetting of pesticide products and their environmental and ecological impacts is very important and this is reflected in the robust testing and data requirements of different applications under FIFRA. Pesticides are broadly defined under FIFRA. Generally a pesticide is any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest or intended for use as a plant regulator, defoliant or desiccant or any nitrogen stabilizer.

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The F-F-D-C-A authorizes EPA to set pesticide tolerances for all pesticides used in a manner that will result in residue in or on animal feed or food. This limits the residue level on those products. So testing products in coastal waters where fish might be exposed to the treatment and be caught and consumed is considered a food use and requires established tolerances or tolerance exemptions for every active and inert ingredient in a pesticide product under the F-F-D-C-A. Alternatively, researchers might be able to provide EPA with robust data on accumulation of test substances in fish and degradation in potential aquatic environments to support a non-food determination. Figure out whether and which tests will be required of you under FIFRA based on the applications or exemptions you're interested in. There may be fewer requirements if your product is a device or is categorized as minimum risk.

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Also, state and local agencies might want to be informed if you're pursuing federal approvals for a product and will be going to those state and local agencies for approvals next. In contrast with FIFRA and the F-F-D-C-A, other statutes may not have as detailed requirements. The Rivers and Harbors Act applies if your proposed activities might affect the course, location, condition, or capacity of a navigable water. The Clean Water Act section 404 might apply if your planned activities constitute the discharge of dredged or fill material into the waters of the United States. By submitting information on your planned testing or use of a control product to the US Army Corps of Engineers, they can let you know whether you actually need a permit from them under either of these statutes. As I previously stated, the Clean Water Act NPDES permits for point source discharges into the waters of the United States are issued by a state agency in most states.

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In our research, we found that all states besides Maine have at least one pesticide general permit that could apply to hub control products either in freshwater or a marine environment. If a general NPDES permit might cover your planned activities, be aware of the permit requirements and confirm your coverage with the agency that runs the program. In cases with limited testing, additional submissions of things like a notice of intent to discharge that would be required for larger discharges may not be required in your case. Also, depending on the type of product and the scale of your plan testing, your project may qualify for an exemption under your state's experimental use permit.

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Moving into my third theme, researchers should know their responsibility versus that of the agencies in ensuring compliance under relevant statutes. I've already described which agencies researchers would contact to ensure compliance with FIFRA, the F-F-D-C-A, the Rivers and Harbors Act, Clean Water Act, and State Environmental Laws and Regulations. But there were six other federal laws that I listed as possibly relevant at the beginning of this presentation, and I did not explain who researchers should talk to under these statutes. That is because a lead federal agency may check for compliance with those statutes and undergo required interagency consultations. Projects that constitute a major federal action such as being federally funded, approved, or owned, have their environmental impacts analyzed under the National Environmental Policy Act or NEPA. The NEPA review process can also function as a procedural framework under which an agency reviews a project's compliance with multiple environmental statutes.

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When multiple agencies are involved in a project, one agency takes the lead role in evaluating a project's impacts under NEPA. Determining the lead agency can depend on the magnitude of an agency's involvement, project approval or disapproval authority and expertise concerning the action's environmental effects. For one of the pioneering HAB control projects that received federal funding from NOAA, NOAA was the lead agency and conducted a review for compliance under the statutes pictured on this slide. One note is that there are also individual obligations such as not to harm or harass endangered species under the Endangered Species Act, section nine that researchers should be aware of and could be penalized under for violations. Harm and harassment can also be indirect through significant modification of an endangered species habitat that significantly disrupts their essential behavior patterns. The Marine Mammal Protection Act similarly prohibits harassment and killing of marine mammals.

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Application of HAB control products in a marine environment is novel and products being pioneered now are testing out the logistics of getting the necessary approvals for testing and use. What I described today is not an exhaustive list, but is an overview of what we are seeing from the case studies and research which are both ongoing. To conclude, there are a number of challenges in the permitting process for testing and use of HAB control products in a marine environment. To navigate these challenges, researchers should understand the federal and state statutes and regulations that might be involved and which agency is responsible for which statute before starting the permitting process. Anticipate and clarify data requirements that may be significant under FIFRA and the F-F-D-C-A and know what a researcher's responsibility is versus the agencies in confirming compliance with other possibly relevant laws and regulations. It is our goal with the development of the US HAB CTR's Clearinghouse website to help with all of this and more that I didn't have time to cover today. So keep an eye out for that clearinghouse to go live next summer. I want to thank Betty Staugler from Florida Sea Grant for contributing her fantastic presentation to this webinar. I want to thank everyone so much for joining us on our webinar today, and I hope you all enjoyed it. We will be posting this recording on our website as soon as we can get it available. And the best way to stay tuned for future announcements from the law center is to follow us on our social media. Thanks everyone. Have a great afternoon.