[MCGEE:] So, well, thanks so much for the opportunity to be here. I'm really thrilled to be representing the Chesapeake Bay Foundation.

We do environmental education. Maybe some of you have gone out on our school trips. I know you're largely from Maryland and Virginia. And as Mark mentioned, we also do environmental advocacy and policy, and that's the side of the shop that I work on. I like to say I'm not--I don't do real science anymore. I do a lot of policy work. And a lot of the questions today were sort of, what can we do. That's sort of the space that I operate in. But I rely on folks like Mary and Brian, the good science that they do, in order to inform our policy decisions. That work is critical to the mission of the Bay Foundation and other conservation groups who are working to save various resources. In our case, it's the Chesapeake Bay.

So you live in the Chesapeake Bay watershed. Hopefully, you are aware of that. It is comprised of actually six states. So it starts actually in New York. The Susquehanna River is the largest river feeding the Bay. It starts in Cooperstown, which is the home of the Baseball Hall of Fame. You can see a lot of Pennsylvania is in the watershed, and Virginia, Maryland, D.C., a little bit of Delaware, a little bit of West Virginia. So that's one of the reasons why restoring the Bay is such a challenge is it's multijurisdictional.

Also another important feature of the Bay is it's very shallow, so we have a lot of land feeding a very shallow water body, and that makes it really susceptible to pollution. It's very diverse because of that shallowness, so folks estimate there's somewhere around 3,000 species of plants and animals in the diversity of habitats within the Chesapeake Bay and its tidal rivers. And we have a lot of people. One thing you all know from living around here, we have a lot of people. A lot of people like to live near the water. And that's another stressor on the Bay.

So when we think about the main stresses of the Chesapeake Bay, the first is dissolved oxygen. This is showing you the Bay on its side. And I guess I have a pointer here. This is the north. This is where the Susquehanna River comes into the bay, the Atlantic Ocean, so it's an estuary where fresh water and salt water meet. And this is showing you what we call the dead zone. This is an area that, during the summer --this is from July of this year, but I could show you from July of last year, the map would look pretty similar-- we have areas that basically have no oxygen.

And Mary touched on this in her presentation on the eutrophication of systems. That is clearly what we have going on here in the Chesapeake Bay. This is not natural. What is shown here is a vertical of the Chesapeake Bay. And you can see that the dead zone is concentrated in the deeper waters. And I'll talk a little bit more about that. It kind of builds on what Mary was talking about. But what this means is that, during the summer, there's a lot of the bay that is pretty much off limits for critters. Critters need oxygen just like we do. And so when you have this much of the estuary that's basically not suitable, that has implications.

Again, I'm going to talk a little bit about some of those. The other main issue in the Bay is we have... water is very cloudy. This is showing you over time, since we started first collecting information in the mid-eighties through to... last sampling period was 2015, showing you where we would like sites to be is at this 100%.

And this is showing you sort of over time water clarity in the Bay. So it's well below targets that we would like to see. The main impact of that is that one of the more important ecological features of the Chesapeake Bay are the underwater grasses. These are different than the grasses that Brian talked about. Those are marsh grasses. These are actually underwater grasses. Submerged aquatic vegetation is another name for them. They're important for a variety of reasons.

One is they're really good hiding places. So larval fish rely on it to hide. Brian's favorite blue crab relies on it when it's shedding its shell, and it's very vulnerable to predation. It's hanging out in grass beds to be protected from being eaten by fish while it's vulnerable, while it's shell is soft. And so what this is showing you over time is the acres of underwater grasses in the Chesapeake Bay relative to a goal of about 185,000 acres. And you can see the trends over time. And they largely track water clarity. When we have clear years, the last couple of years of...

I don't know if any of you get out on the Bay or the tidal rivers, we've had remarkable clarity in the last couple of years. And not surprisingly, underwater grasses are responding to that. So what's the cause of these issues? Dissolved oxygen, water clarity. It's three pollutants. It's nitrogen, phosphorus, and sediment. And we've already heard about those. And we have too much of them. There is always going to be a natural amount of nitrogen, phosphorus, and sediment going into systems.

But in the Bay, we have too much. We have a system that has a eutrophication problem. And the space where I deal in is... here are the sources of pollution. So we have agricultural runoffs. This is farm fields, cropland. And that's showing you from the nitrogen and phosphorus how much is coming from agriculture, watershed-wide; sewage treatment plants are in gray here, so about 20%.

On the nitrogen side, about a fourth is coming from the air. So that's, if you drive your car, and it's assuming it's a gas-generated car or coal-fired power plants are adding that nitrogen from the air. And then runoff from areas like this, urban and suburban runoff. And so this area where I dwell is, how do we reduce pollution from these various sources.

So I spend a lot of time, particularly in agriculture, since it is the biggest source of both nitrogen and phosphorus, trying to find funding for farmers, trying to invoke policies that can help get more pollution reductions from all these sources. That's sort of where I dwell these days. So this, I think, is building on what you've heard already today in a couple different scenarios. What we have in the Bay is too much nitrogen and phosphorus, which causes these algae blooms. When they die and decompose, oxygen is used up. That's what causes the dead zone.

That, then... because of this zero oxygen at the bottom, that also means that less nitrogen and phosphorus are being taken up. And so they're more available for algae again. So, its... and Brian touched on this, this sort of feedback loop. When we expect the Bay to respond, we don't expect it actually to respond in a linear fashion. It hasn't degraded in a linear fashion.

And it's because of these feedback loops. What we would like to see--and we're hopeful that we will see in the Bay--is we have clearer water, less nutrients coming in, so we're controlling the sources, less nutrients coming in, clear water. You have more nitrogen and phosphorus--less algae, more oxygen. And that oxygen at the bottom of the bay actually means that, A, there's benthic algae that are taking up nutrients, and so less is available to feed these pelagic algae. But also, there are processes that are going on in the sediments at the bottom that also are holding nutrients in place when you have oxygen in the water. So in this case, we get sort of a positive feedback loop. The more we reduce nutrients, the less algae we'll have. We have more oxygen in the bottom waters, and then you get a sort of positive, as opposed to what we have right now, which is negative.

So this is, like, a really complicated food web, and not even as complicated as the bay food web is. This is showing you... starting at the base, we have our producers. Some are floating around on the water. Some are living at the bottom. We have the grazers that have been talked about already. So these are generally eating the algae. And these are in plankton, so they're floating around. These are ones that are at the bottom.

Here's the blue crab we heard a lot about. And in the bay, the blue crab's sort of feeding on a variety of things. And then we have fish, from sort of smaller fish, some of which are-- I'll talk a little bit about what they're feeding on. But the one I want to focus on is striped bass. That's a really important commercial and recreational fish in the Chesapeake Bay. A lot of people like to go out striped bass fishing or rock fish, as it's also called, very important fish species. And it really likes a fish called menhaden. Raise your hand if you've actually heard of menhaden before. Okay, so a few, not as many.

So it's a really oily fish. It's actually, by weight, the largest fish species that is harvested out of the Chesapeake Bay. And it's mostly used for fish oil, because there are human health benefits of fish oil. And there's actually only one company that does the harvesting, so they hit menhaden, which is a favorite food of our favorite striped bass. But striped bass also eat blue crabs. They eat bay anchovies, eat some other smaller fish. So they have a sort of diverse thing that they feed on. And then, you know, we can take it the next step. And we see all the connections between the menhaden and all the other parts. So this is...from the striped bass, if you look at what the striped bass sort of relies on, going from the producers all the way to striped bass, these are sort of the various ones that are involved.

So it's just showing you one part of the food web. Pretty complicated, as I think you've probably gathered from listening to Mary and Brian talk. So I mentioned that menhaden tend to be fished. Many believe that they're overfished. So striped bass no longer being able to eat menhaden, they actually have focused a lot on blue crabs. And blue crabs is also a really important fish species in the Chesapeake Bay. I like to eat them. Brian says he likes to eat them. And what we have... there have been, blue crab variation in numbers is attributed in part --there's a lot of things that affect blue crabs, but part of it, they believe, is predation from striped bass.

Another is something that I mentioned earlier is when the underwater grasses aren't doing well in the Bay, you can often see crabs not doing well in the years that follow because again, they're losing their hidey holes. So these are just a couple of ways, taking what you all learned this morning, but providing, I think, some local examples of our food web. The other impact that this changes in the food web, either the overharvesting of menhaden or the loss of under grasses that's going to reduce our crab populations is that striped bass are a migratory fish. They spawn in fresh waters. They spend part of their life offshore. But for about the first six years of their life, they're living pretty much in the Chesapeake Bay. And scientists who study striped bass have found that there's a really high prevalence of a disease called mycobacteriosis that they think is due in part to food stress, that they're not getting their favorite food, the menhaden, which is a really oily, and therefore high-fat, good for striped bass food, as well as the stresses related to the dissolved oxygen problem that I mentioned. So really high prevalence of disease in striped bass due to the man-made impacts that we're having, either because we're overfishing or because of habitat quality.

So again, that was sort of a whirlwind overview tour of the Chesapeake Bay. I guess I can take two questions, if anybody would be so bold as to ask any. Yes, up there in the white shirt.

[STUDENT:] I'm aware of several agricultural targeted government programs specifically to fence out these creeks that will eventually lead into the Chesapeake and restoring riparian buffers. In your dealings with environmental policy, are you finding these programs to be cost effective?

[MCGEE:] Are you in Virginia or Maryland?

[STUDENT:] I'm a Virginian.

[MCGEE:] Okay, Virginia. So Virginia is spending a lot of money on stream fencing. In fact, they're offering farmers up to 100% of the cost of putting in a fence. Most of the programs that pay for agricultural conservation are cost-share programs. So usually, farmers have to pay a certain percent and then either state or federal agencies will pay a certain percent.

To answer your question, yes. We like stream fencing. In fact, we have staff in Virginia, Pennsylvania, and Maryland who work with farmers to do fencing. But in particular, you mentioned forested buffers, which are trees planted next to streams. They are really good for reducing pollution. They're filters. They are good carbon sequesterers. They're shading streams-- a lot of benefits of buffers. And we have focused for more than about 15 years promoting buffers. So both of those are great practices, and we'd like to see more of them on the ground.

[STUDENT:] Thank you so much.

[MCGEE:] Yep. Good question. Yes?

[STUDENT:] My question is, how does invasive species affect the complicated food web of the Chesapeake Bay?

[MCGEE:] So, good question. There are many species that we're dealing with in the Bay. There are some underwater grasses that are invasive. Particularly around the Washington, D.C., area, there's a species called *Hydrilla* that can really take over. And it sometimes will outcompete some of our natives. That's often an impact that you see is that we're outcompeting... invasive species tend to outcompete our natives, so that can screw things up. In the case of *Hydrilla*, it's s sort of a good news/bad news. It is helping clear water, but it's also, again, replacing a species that would be preferable for habitat as well as for things that are feeding on it. And I can't give any other examples off the top of my head, but that is one. And certainly, there are scientists who have studied this issue, and it is something that's on our radar screen. So...

[Applause]

[CARROLL:] Does anyone know how the Chesapeake Bay formed? How about this? Did you know it's formed by an asteroid impact? I'm sorry. I didn't see the hand up. There you go. This is a giveaway. I'm sorry about that.

[STUDENT:] I'm not sure if this is right, but I'm pretty sure was a glacier, right?

[CARROLL:] So glacier was one answer. I don't have a Kahoot! for this.

[Laughter]

[CARROLL:] Anyone else want to take a stab, since I sort of muttered it away? Beth, do you want to talk about the deep history of the Chesapeake Bay?

[MCGEE:] Well, the Chesapeake Bay is actually the historic River Valley of the Susquehanna River. You know, when you think about estuaries across the country, we have Delaware River, Delaware Bay. We have Hudson River, Hudson Bay. We have Susquehanna River, Chesapeake Bay, and there's a reason for that. But historically, there's a deep part of the Bay that I showed in my dissolved oxygen slide. That's the historic river valley when it was, when all the water was tied up in glaciers. And then when the glaciers melted, it filled in that river valley, and that's why we have the Bay. Is there...

[CARROLL:] Well, this may be called stump the MC, but there was an asteroid impact that...

[MCGEE:] Right, yes.

[CARROLL:] --shaped the Bay. So what's that with respect to the geology of...

[MCGEE:] So that's at the mouth of the Bay. If you kind of overlay, like, Hampton Roads, Virginia Beach area, you can see the rivers in that area take kind of like a little jag. That is from where that bolide, I guess, hit. Brian, you may know from your work in Virginia...

[SILLIMAN:] It created a suppressed area.

[MCGEE:] Right, right. But I don't think that was the whole bay. I mean, that was the lower part of the Bay is my understanding.

[CARROLL:] All right. So it's a combination of a couple of very interesting geological forces, so we're actually semi- both right.

[Laughter]

[CARROLL:] Okay. I think I'm going to give myself partial credit for that one, but not full credit.

[Laughter]

[CARROLL:] So let's start with questions oriented to the Chesapeake Bay, just to keep that conversation going, or Chesapeake Bay in the context of other things you've heard. And I see a hand up way in the back, and I'll try--the lights are bright here, so we'll try--always put your hand as high as you can while you're waiting. Go ahead.

[STUDENT:] So I just wanted to know in the case where unknowingly an invasive species is introduced to an area artificially, what exactly goes wrong for that to happen? Like, if you didn't know that the species would become invasive, but it happens, so that does happen, how exactly is that calculated?

[MCGEE:] I'll take a... I don't know if this is answering your question. A few years ago, because of the fact that the natural, the native oyster in the Chesapeake Bay was not doing well. There was a lot of interest in introducing the Asian oyster. And maybe you guys can probably speak to it better than I. When you think back through the history of time, and we've intentionally introduced things, it often has not worked out as we anticipated.

So at the end of the day, in that scenario, they did an environmental impact, and they said the risk of it having negative consequences was too great. But that's sort of, I think, a success story of us thinking about intentionally introducing a species. We went through the right process. We looked at the pros and the cons. And... besides not allowing that new species to come in, the benefit was that we've now put a lot more energy and resources into restoring our native oyster. And there are signs that it's coming back. But I don't know if you guys have anything to add to that.

[CARROLL:] Do you want to answer that, Brian?

[SILLIMAN:] Sure. Invasive species will show up for both intentional and unintentional reasons. For instance, the oyster's a good example of wanting to bring something in and having cascading effects. On the West Coast they brought in oysters in clumps. They didn't clean them. And so all the other organisms from Japan on those oyster reefs showed up as well. And there was an invasive species meltdown.

[POWER:] Yes.

[SILLIMAN:] And there's also unintended consequences. So from an intentional introduction, you can also have unintentional. So that can cascade. And then unintentional could happen by itself; for instance, in the ballast water of ships. Before we knew that was happening, the ships go back and forth. And the extra weight they needed to travel, they would actually grab water at one of the ports, take it across the ocean, and dump it in the other one. At the same time, they didn't filter it, and all the baby larvae from, like, crustaceans and mollusks would be housed in that boat and be transported. And so that's how a lot of organisms in the marine environment, it's on commerce. As people move around, and on your clothes, it's taken around, so that's unintentional.

[CARROLL:] This gentleman right here. You've got it, yep.

[STUDENT:] From what I've heard, there's an overpopulation of white-tailed deer in the Chesapeake Bay area. And I'm wondering what's being done to fix that and what should be done, in your opinions.

[MCGEE:] So they do a lot of hunting, frankly, the way that the Department of Natural Resources--at least in Maryland, and I'm sure Virginia is the same way--that's one reason why they have hunting, and they try to keep track of how many deer are hunted so that they can try to manage the population that way. They're also, I think, intentionally, in some areas introducing something that will make them sterile, something that they eat. So those are--it certainly is a problem in terrestrial ecosystems. And those are a couple ways that it's being addressed.

[CARROLL:] Anybody want to add to that?

[POWER:] Was the problem that you don't have enough deer, or you have too many deer?

[SILLIMAN:] Too many.

[STUDENT:] Too many deer.

[POWER:] Too many, yeah. I guess there's the missing predator that Brian would probably be thinking of as well. I know that, when we get mountain lions show up at the reserve that I manage in northern California, it's an instant three-level food chain in the meadows where the deer all disappear. And some of that's behavioral. But these animals used to be hunted by more human hunters, but also a lot of wolves and mountain lions and other predators that are missing.

[CARROLL:] Right here.

[STUDENT:] I was wondering what would be the most effective way to reduce runoff in concrete jungles like D.C. and Baltimore, since you don't have the space to plant riparian buffers.

[MCGEE:] Great question. So a lot of what D.C. is working on is what they call green infrastructure. So, infiltrating storm water, having things like rain gardens or rain barrels or even green roofs that have benefit to allow rainwater, instead of just running off, to actually infiltrate back into the ground waters. And the other benefits of those are, it's a nicer visual landscape. It has some carbon benefits. It reduces the sort of heat island effect. So the challenge is, as you point out, though, it is space-constraining, and it's actually the most expensive thing we need to do to save the Bay is reducing pollution from urban areas. That's a challenge.

[STUDENT:] So--sorry --I've actually seen permeable stuff like that, but the problem in this area, since we have cold winters, it's going to freeze and crack the road, so it's going to be very expensive. So is that the only solution you're looking at to...?

[MCGEE:] Well, when you think about urban storage, there's lots of different practices that they're implementing. I mean, as I mentioned, there's infiltration, but there's lots of different things that that looks at. So we're not just talking about one practice, a full suite of things. But sort of the freezing, I can't speak to that.

[CARROLL:] Go ahead.

[STUDENT:] My question is, with major companies such as Nestle, Coke, and Pepsi pumping water--like, a lot of water, even in times of drought, how does that affect ecosystems, and what is being done to prevent it?

[MCGEE:] Don't look at me.

[Laughter]

[MCGEE:] It seems like a drought question to me.

[POWER:] Pumping water from the Great Lakes or from groundwater?

[STUDENT:] Yeah.

[POWER:] So overtaxing the water?

[STUDENT:] Yes.

[POWER:] Well, they certainly should be watched. And is this the case where they're pumping water and selling it in bottles?

[STUDENT:] Yeah.

[POWER:] May I recommend a book?

[CARROLL:] You may write one if you'd like.

[Laughter]

[POWER:] I want you to read a book by Peter Glick called Bottled and Sold. I think the figure is that our safe tap water is often more pure than bottled water, and it's about a thousand-fold less expensive. So commercialization of fresh water does undermine public safe water infrastructure in a very... well, it's a threat, I think. And I think we need to keep our public water supplies safe and appreciate how safe they are and then address problems like what happened in Flint right away. And the bottles water are creating a big problem. They aren't inspected, so they don't have the same safety standards that our public water supplies have. It is drying up areas that shouldn't be dried up, springs in some cases. But mostly, you just get all this plastic. It's energy-intensive to make it, and then it's a mess to dispose of it.

[Crosstalk]

[SILLIMAN:] Just to follow up on that, I think it's important if we want to investigate that to get the numbers.

[POWER:] Yeah, it is.

[SILLIMAN:] How much water is being taken out? And then ecologists need to be involved in that. Two examples, one Mary gave... agricultural demand for water is changing those ecological systems. And one I know about and have worked on is in Venice. So the industry built up over the last 30 years around Venice, Italy, and they got their water for the industry, the generation of manufacturing goods, for underneath this. And so they're bringing all this water out.

Venice is built on a marsh. And so it's sinking at about 2 centimeters a year relative to sea level rise. When they started drawing it down, that changed to 15 centimeters per year. Now, you can no longer live on the first floor. You have to allow that to flood. And so the stairs that once took you down to the gondolas, that's the intertidal zone. And so algae is growing on that. And so they made them stop that pumping and try to inject it back in, but they couldn't. There was too much weight, so they couldn't create a force. So getting the numbers on that requires a scientist, but it can have big effects.

[CARROLL:] Right here. You have the mic, right?

[STUDENT:] I was wondering for invasive species how do you go about to manage them and remove them from outcompeting native species?

[POWER:] I have a good answer for that one in rivers. But in the West, we have a lot of invaders from the Midwest. So when you're in the Midwest or here, you have to love bullfrogs and catfish and all these beautiful sunfish you have. But they are invasives in the West. They can't deal with our scouring floods and our dry summers as well as the natives. So this is, whenever... from Arizona to the Canadian border, probably beyond, when you get big floods, all of the invasives are pushed downstream, and the natives have smart behaviors, like they know how to sidle over and get into the undercut so they can stay put. So they get released from invaders. And that's been well-shown in little streams and big rivers. Peter Moyle just took... if you look at the picture, you'd think we can never bring this stream back. It's a straightened stream called Putah Creek, and it goes through laser-leveled agricultural land as far as the eye can see, right near the town of Davis, which is near Sacramento. And it used to be 30% native, 70% Midwestern invasives. And then, a court case happened because they accidentally withdrew too much water and dried up the creek. So they had to... when they settled, they had to make a hydrograph that was quasi-normal. It had winter floods and summer drought. And they literally reversed it to 70% native, 30% invasive. So you probably will never get rid of invasive species from a lot of ecosystems. But you can make the ecosystem more suited to the adaptations of the natives. And then you'll favor them in many cases.

[CARROLL:] Do you want to add to that?

[SILLIMAN:] Sure. One of the invasive species that people on the Chesapeake Bay really care about is a giant reed that's been introduced from Europe. It's called Phragmites.

[MCGEE:] Phragmites, yeah.

[SILLIMAN:] We have a native version of it, but there's a haplotype in Europe that was introduced about 2-300 years ago, and it happens to proliferate when there's a lot of pollution. And it does really well in high-nutrient environments. And so it's a grass that's very different from our natives, especially in height. And this grass gets 10 to 15 feet tall, versus a native in the high marsh, which is about a foot or two foot tall. So what it does--it's a little bit pesky--is in the areas where you have a lot of development, we don't have watershed protection from forests. We get more nutrients coming into these marshes, and it takes hold, and it blocks people's view. It makes people pretty angry, and it actually lowers property values.

So they've got to mow the lawn, which they're not supposed to do. So people have invested a lot of money: how do you control that. And if you get to it early, you can do it locally. Somebody can go out there with a lawn cutter and a little herbicide and kill it. But once it takes off, its root mat goes down 2 or 3 feet, and then you have to come in with crop dusters. It gets very expensive, a lot of pesticide, and you have to use bulldozers to get out. And we tried one method, because--one of the things we have to do in ecology and conservation is try to come up, increasing efficiency of conservation and think about it in a business manner, like agricultural has done for hundreds of years. We need a revolution in restoration ecology and in conservation, where you bring in different minds who don't work in the field. Say, like, oh, you have this... how can you get the most invasive species protected. And I was over in Europe thinking about this, and I saw that that native species there was eaten by the animals over there. They feed it to their goats, and they like that species. It's really important.

So we did an experiment in Maryland with the University of Maryland professors, and we brought goats over. We fed them--it turns out all of these agricultural animals like this. And so we started taking those animals to the marsh, and they knocked it down over a couple months' period, and they exhaust resources. And then we go in with a little bit of herbicide, and the combination, that provides benefits for farmers. It's much cheaper. It takes a little bit longer. So that's one way of being inventive and trying to deal with a really invasive species.

[MCGEE:] Interesting.

[CARROLL:] Right here? Yeah.

[STUDENT:] What effects do you think plastic microbeads have on the Chesapeake Bay? How do you think it filters through the trophic levels?

[SILLIMAN:] So I have undergraduate students who took a course and who were interested in this question last semester. And we looked it up, and there's not much information on that. It's just exploding that they're so abundant and really small, and that's a great question. It's a cutting-edge question. We worked with them to look at some of the corals that occur here. There's three species. And we said, what will corals do when you hand them a plastic bead. They don't reject it. They actually bring it into their bodies for 6 to 12 hours. And if it has a biofilm on it, they keep it in there longer, and those chemicals then can be released. And so it's a paper these undergrads are now--they just submitted. So it's an active area of research. But we were surprised that they pick it up and just keep it in their bodies for a while. They will eventually reject it. But how the oysters respond...

[MCGEE:] Yeah, I think it's a great question. And we know there have been surveys where we definitely have a micro bead problem, as does every place in the world, frankly. But yeah, I think it's a question that we don't really have a good answer for. One, we presume that oysters are taking them up as well. I mean, they do some sorting, but I'm not aware of any studies, so it's definitely...

[SILLIMAN:] And whether it bioaccumulates, that's a question that's...

[MCGEE:] Right, the chemicals that are, like you said, on the biofilm.

[POWER:] So may I say just one other quick thing? This is just a what can we do. Berkeley passed this law maybe three years ago that if you got new bags at the supermarket, you'd have to pay for them--25 cents a bag, and they were paper. They weren't plastic. So it took us, maybe, as a community, maybe six months to remember to bring all of our cloth shopping bags. And now, just everybody does it, and it's the easiest thing in the world. Every single grocery cart is full of reused cloth shopping bags. And I think that's a very painless thing to do at the community level, to get rid of at least the soft plastic sources.

[MCGEE:] D.C. has a plastic bag ban...

[POWER:] Yay. That's great.

[CARROLL:] Go ahead.

[STUDENT:] In what circumstances, Dr. Power, would the armored catfish eat the bathtub ring around its pond. And if it was starving, would it die, or would it eat the bathtub ring? And also, if the fish don't go into the bathtub ring, what brings the heron--why do they keep coming there?

[POWER:] Those are all such interesting questions. And I did some really fun experiments. I'm not sure the fish found them so fun...

[Laughter]

[POWER:] But I took groups of catfish, and I starved some for over a week. And then I had a similar cage, and I fed those fish canned green beans. And you might try it on the fish in the lobby, but they love canned green beans. They just graze them like they're algae. So that was easy. And so I had fed fish and starved fish that I then released into their home pool. They were all individually marked. And the fed fish and starved--the fed fish were quieter, and the starved fish grazed more actively. So they were definitely hungry. But neither of them ventured into shallower water. They still abided by that. And one of the starved fish did... My mother was helping me, and she has the Guinness Book of World Records for watching an armored catfish for the longest time of any human, which is probably 6-1/2 hours. It paid off because she saw this starved fish shoot out the riffle.

So it's doing what it's supposed to do if it's unhappy at home, maybe feeling too hungry; it's going to try elsewhere. But we were surprised it actually didn't happen more. So the answer to the first part of your question, then maybe I'll quickly talk about the herons, is that the fish depend on making a bonanza. The bonanza for these armored catfish is when the river first floods, and they get access to the algae that was formerly too shallow to graze, but now it's okay. So they make a big pulse of growth then. And many other fish do the same thing. They get maybe one good month a year, and they can maintain positive growth, even on 11 poor months after that. They're just very good at averaging pulses and then not even paying much of a cost at all, and certainly not dying when they have to starve. They're used to that. The herons--good question, but there are frogs and bugs, and there are little... the fish that are fast are being chased by the predatory fish, and they get crowded into the shallow waters. So they might be smaller than the herons would prefer. But there is alternate prey in the shallow water for them.

[Laughter]

[CARROLL:] Behind you, go ahead.

[STUDENT:] Hi, I know that ocean acidification is increasingly becoming an area of research. And I was wondering if you guys had seen any evidence of ocean acidification in your research and sort of what your thoughts on that problem were.

[SILLIMAN:] Sure. So the pH, and you can mention something about the Chesapeake Bay. Some examples... we're investigating this right now, whether the pH is affecting organisms, especially those that need a calcium-based skeleton. And if the acidity is going down in those environments, it may be more difficult for them to form their skeletal structures. And we find that to be the case, both with corals in experimental studies, and also with oysters. And it's thought that... experimentally, we've shown that, if you grow oysters in a more acidic environment, they grow a little bit slower, but their shells are less thick.

And so when they land, they don't build up their defenses as fast, and they're more vulnerable to predation. And so in Puget Sound, there's been big, catastrophic failure of recruitment of oysters. The babies are coming in, but they're not surviving. And it's thought it's not directly killing them through lower pHs, but they have soft shells, and they're very vulnerable. So there's the situation. And the mussels are showing a similar pattern as well. They don't have as strong of shells, and they're more vulnerable to predation. And so it can be a multiple stress. The corals are less... can grow less, and so if there are predators around, it's a problem. If not, if the predators aren't around, it may not be a negative effect. So you have to have both factors there.

[CARROLL:] Right here in the pink jacket.

[STUDENT:] I have a question for Dr. Silliman. I was wondering, when you were talking about whether climate triggering a grazer outbreak is common in other ecosystems, you said that, in 10 out of 16 examples, physical stress intensified predation pressure. But I was wondering why those other six examples wouldn't demonstrate that trend and what would be going on there.

[SILLIMAN:] That's a good question. So in some cases, there's... for instance, urchin fronts can form, either because of the physical stress because there's more storms that destroy kelps in localized areas. In that case, storm frequency, and the urchins then move to more the kelp areas. In other situations, you can get urchin fronts from the loss of predators.

In those systems, it's not climate-related. A lot of that has to do with whether or not more bottom-up resources are available. So it's not a physical stress. But for some reason, that prey has a bonus of the amount of resources available... gypsy moths outbreak when there's heavy rains. That could be climate change and not precipitation, but there's a lot more things for them to feed on, and they bloom. And then another situation, there's predator loss, and other consumer fronts form with invasive species. So a big introduction and a release from enemies. Great question.

[STUDENT:] Thank you.

[CARROLL:] Blue shirt right behind you, Aileen, on the bench. Right by the other side of the camera. Oh, I guess Javier's got it. There you go.

[STUDENT:] Do you think that mycorrhizal fungi would play a large role in stress thresholds and determining those, as they would help species be more resistance at first, but once you passed it, it'd make restoration more difficult?

[SILLIMAN:] Sure, I'll take that one. Do you want to?

[POWER:] No, go ahead.

[SILLIMAN:] Okay.

[Laughter]

[SILLIMAN:] That's an important positive interaction because that symbiosis needs...

[POWER:] Right.

[SILLIMAN:] ...allows the plants to access nutrients at a higher level. And so that's an interesting symbiosis that's mutualistic. It's an interesting dance because the plants provide sugars, and they go back and forth--it's iterative--to make sure that there's no cheaters. But making sure that symbiotic, mutualistic relationship is there is going to allow plants that you put back in the ecosystem to acquire resources faster and grow even more. And it's exactly right. It's not really thought about that much. But there's another example of positive interaction that could trigger and increase the yields for a given amount of resources we have to plant. So you can inject those into the soil. So it sounds like you've done some research. So I think that's important to include.

[CARROLL:] Right here in the second row? Can we get one over here?

[STUDENT:] I was wondering if there's a reason why grazers are more resistant to the physical stresses that they have compared to predators and ecosystems, is there a specific reason for that?

[SILLIMAN:] Is there a reason that grazers are potentially more resistant than predators to physical stress as it comes up? And I put that theory up there, and when I saw that theory, I was like, that doesn't seem to be the case, what I'm seeing. And so we need to answer that question if that's true or not. And Mary and I have been talking about that.

[POWER:] Yeah.

[SILLIMAN:] I've done some survey --and you go to the picture of the library, and you go to look at all these other studies, and then you tally those. You do a little vote count--yes, no, in this case, and you can put up categories. And then you can also take characteristics of those studies, like, what ecosystem this was done in, what are the body sizes of the predators versus grazers, are they warm-blooded or cold-blooded, and see if any of those things can explain whether or not a grazer or a predator is more susceptible to stress. That could be simply based on physiological. But ecosystems are more complex. Is it worth studying? I don't think it's true, that theory. But we would like to be able to predict when. That would be very helpful in managing the systems, what kind of traits, things that Mary talked about, would help.

[POWER:] In this case, I think it would be very useful to get a better definition for science of what stress means, because it differs from organism to organism to organism. What stresses a cat would not stress a penguin in Antarctica. So that's a tricky word to define operationally. And an operational definition means we all agree so somebody else could go out and measure the same thing you're measuring when you say you're measuring stress. But I don't think we're there yet, actually.

[CARROLL:] Here.

[STUDENT:] My question is for Dr. Silliman, based on your last lecture. You were talking about how snails were killing off the plants and how afterwards, the mussels would help them recover. So if people chose to interfere in this natural process, which do you think would be the most beneficial for the environment: altering before the destruction takes place by introducing predators, or afterwards by introducing organisms that would repair the destruction that has occurred?

[SILLIMAN:] That's a great question. So somebody might ask you that and say we have a limited amount of resources. What do we do with it? I would go with the mussels because I think restoring the blue crabs, because it's not just overfishing in that case, is that once you put them back or drop them off in that area, they just won't... they will move back to fresh water, this drought that's pushing them off. That was in Georgia. We've had striped bass overfishing. They eat the blue crabs. There's also more fishing here. It's more complicated in the Chesapeake Bay of why blue crabs are declining. And fishing plays a greater role, so it's more difficult to manage that, as well. I would go for more mussels. Great.

And just so... and managing these systems is a great question. We have to look at the frequency of disturbance, how fast it--5, 10, or 15 years--and look at that in comparison to recovery rates. So if your recovery rate is faster than the return interval of your disturbance, you're going to have a system that blips but comes back up. The problem is, if the recovery rate's longer than the return interval disturbance, and then you have a gradual decline. So you want to push that recovery rate back to faster if you can't affect drought.

[CARROLL:] Blue shirt right there.

[STUDENT:] Me and my dad often go fishing out on the Chesapeake Bay, and we've been doing it for a while. And we've noticed definitely the regulation changes, as the striper population's been changing, on the length that you can keep and the number you can keep. And I'm just wondering what stage in recovery are we from there, and what steps, in your opinion, still need to be taken to reach the original levels?

[MCGEE:] Yeah, great question. So striped bass is actually one of the success stories, I think, in the Chesapeake Bay. Back in the mid-80s, population numbers dropped off hugely. They were teetering on basically not being around. And both Maryland and Virginia put in fishing bans that brought the numbers back. And arguably, the numbers now are pretty good. I don't know if, when you're out fishing, whether you notice... I mentioned earlier the mycobacteriosis. So that is a wasting disease. Scientists believe we are... it is increasing their mortality for the time and period that they spend within the Chesapeake Bay.

So I think... and they're doing a better job of managing. You mentioned the different sizes in the slot depending on the type of year and all that kind of stuff, and they're pretty good about it. I mean, there is some poaching that goes on. But I think from the management perspective, we're in a pretty good situation. And what we believe is that it's a lot habitat now. I mentioned the dissolved oxygen issues, underwater grasses that affect crabs that they eat. And so we're hopeful that if we also bring back the habitat, that that can help provide a more resilient striped bass population.

[CARROLL:] [whispers] Right here. And you'll be next.

[STUDENT:] There's been a lot of genetic engineering done lately on many organisms, such as the zebra fish, which is, like, glowing in the dark now. So I was wondering if there's been genetic engineering done on species and then introduced into ecosystems in order to improve the ecosystem, or if they became invasive species in an ecosystem.

[SILLIMAN:] There's a... In the Chesapeake Bay, there's a good example that's continually brought up, and people are passing on. It's the Japanese oyster. And you brought that up earlier. Remember they were thinking about introducing that, but with a genetic sterilized version. And so then there was debate, and I debated this when I was an undergraduate, like, 20 years ago, whether or not... and I was on the side of introducing it because they forced me to. But no.

[POWER:] You were assigned that...

[SILLIMAN:] That's right, yeah. So you defended it and say, all the data suggests that we're not going to make a mistake. And so you can use genetically modified invasive species that you can control from the get-go. That's one of the arguments. But it hasn't... we haven't introduced it. Nobody agreed to that and said, let's save our native oyster instead.

[STUDENT:] Thank you.

[CARROLL:] I just want to extend for a second, because implied in there is the issue of regulation. And I thought, we have a few minutes left. It's come up a couple times in the last couple of election cycles about eliminating the EPA. And I'm just curious, since we're talking about...

[Laughter]

[CARROLL:] Not kidding. It's a platform point. From your point of view, in terms of waterways and things like this, what's your point of view about the... what would the consequences be of eliminating the EPA in the United States?

[POWER:] I think it would be a terrible mistake. I think the EPA is doing very, very important work, and rather heroically working under duress, when the politics aren't favorable. But I've met the people doing that job at meetings. And they are taking in information on environmental change as best they can, trying to make the best decisions, trying to talk to people on the ground. So I think they do huge, important service in protecting our wetlands, our freshwaters, and our coastal oceans. And they're incredibly important. They've been quite heroic for terrestrial work, too.

[SILLIMAN:] I think it would be horrific. And I think it's important because the EPA--and it's constantly evolving--is deciphering those thresholds in these systems, the amount of pollution that they can withhold and trying to maintain a level of pollution in that system that's just below that. The best example is the Chesapeake Bay. In the 60s, it was so polluted, and then from a collaboration from the environmental protection agencies, understanding nutrients as best management practices were instituted at the state level, and also federal management changed. And through that collective action of environmental protection is that the Chesapeake Bay has rebounded from that nadir, and the aquatic vegetation is coming back. The striped bass are coming back. So it's so important for those ecosystems' recovery. Otherwise, there's not an incentive. There's not an incentive for businesses, because they don't have a consequence in that situation, although they're shared on society from pollution. We pick up the... it really costs us if we don't have that.

[MCGEE:] If I can just add, I mean, the Bay is a great example. We have... you know, it's interesting. You look at environmental legislation that the EPA implements the Clean Water Act, the Clean Air Act. They were bipartisan issues back in the day. I mean, it wasn't a right versus left. It was clean water, clean air. The Bay is a great example. We have a process that got kicked... I've been working on Bay restoration for a while, but 2010 really was a game changer in the Bay.

We have a regulatory framework. We have an Environmental Protection Agency that is holding the states accountable, from New York to West Virginia to Delaware, to implement these cleanup plans. There's nothing anywhere like it in the country. It's actually kind of pushing the boundaries of what's under the Clean Water Act. And we really have a framework here of success that we've been... for a while, we're calling the moment in time because it really can be a model for how to clean up a large ecosystem. And the Environmental Protection Agency, because they deal across states, they're a federal agency, they are a key player in that. And if they went away, we would really lose the hammer that we have as well as the... Yeah, so--

[CARROLL:] I may be wrong, but I think Clean Water, Clean Air, and Endangered Species Act all passed during the Nixon administration.

[MCGEE:] Right.

[POWER:] Yeah, isn't that interesting?

[CARROLL:] Yeah. Back there, yeah.

[STUDENT:] My question was, I'm a high school senior, and I'll be going to college next year. And my question was, as a college student, what are things that we can do to look better to future employers? I know this is such a typical senior question.

[Laughter]

[STUDENT:] But what would you as employers, potential employers, want to see in a potential employee having what they... in consideration to what they did in college?

[POWER:] Well, are you thinking about, like, summer jobs in college or getting into...

[STUDENT:] Yes.

[POWER:] So for research experiences. I think curiosity, being alert, being organized, having a good sense of responsibility, so you can be trusted to be part of a team. All those are pretty good qualities.

But I think you might just ask questions about what the group's doing, and if you're out in the field, what you're seeing out in the field. Just ask questions. That's often a sign that somebody's really switched on.

[SILLIMAN:] Somebody that's excited, willing to learn. And I think to build on what you said, it's really important, positive interactions. People working really hard, and so the team will focus on one person and help them out, and the expectation is that other points you will give. So not going in there and saying, I need help; everybody help me. So that's getting indications. And telling them about examples in your experiences where you've put the team ahead of yourself. This could be, for instance, camping. I asked people if they've gone camping, if they've been in the Scouts, if they've been on some kind of team where they have that experience. I always ask that question. It's very revealing.

[MCGEE:] Yeah, I think--but also what's on the resume because even to get the interview, I know I'll ask my... or I'll advertise for a pretty entry-level job. I got 400 applications, and they were all great. And so it's really hard to sift through that. So what I look for is experience, whether it's paid or not. Are you out there just trying to... there's internships. I mean, ideally, you want to be paid, I know. But just getting experience trying to work in different areas. And certainly, once you get an interview, showing that excitement and passion and inquisitiveness. But getting experience on your resume, even if it's just a month at some place, showing the interest in whatever field you want to end up in, I think, is important.

[CARROLL:] Well, thank all of you. We've come to the end of our time. Will you please join me in thanking all of our guests?

[Applause]