Abby Malinowski: 00:02 I'm Abby Malinowskii. I am in ninth grade, and I had oatmeal for breakfast.

Sam Bodary: 00:06 Just plain oatmeal?

Abby Malinowski: 00:07 Yep. Just plain oatmeal.

Sam Bodary: 00:09 Wait.

Abby Malinowski: 00:11 I had some sugar, but-

Sam Bodary: 00:12 Okay, good. Okay.

Abby Malinowski: 00:12 ... I was, yeah.

Sam Bodary: 00:20 Hello, everybody, and welcome to Greater Than STEM, brought to you by Battelle, the largest nonprofit research and development organization in the world.

 STEM commonly stands for "Science, Technology, Engineering and Math," but to solve real world problems, we believe it takes a lot more than just four subjects. That's why we think STEM education is really about clever people working together to make the world a better place.

 So every month, we focus on one real STEM student and a problem that they're trying to solve in their own community. So this month, we're talking about ocean pollution.

Abby Malinowski: 00:56 My teacher, she calls herself a tree-hugger. I'm kind of like that, but more towards ocean and aquatic life.

Sam Bodary: 01:03 An ocean-hugger?

Abby Malinowski: 01:04 Yes. An ocean-hugger. I don't think you can hug water, but that's okay.

Sam Bodary: 01:10 Two things about Abby Malinowskii. One, she lives in northeast Ohio. And two, she's passionate about solving ocean pollution. Those two things don't normally go together, because a geography lesson: there are no oceans in Ohio. But there's a story that explains why she cares so much about the ocean, even if she's so far away from it. And that story starts in a town on the southern coast of Mexico.

Abby Malinowski: 01:35 It's called Acapulco. My mom said her father grew up in Mexico, and he lived by an ocean. I guess, I don't know, that you can't really inherit traits that you like about the ocean biologically, but I just always had that feeling to me that I had to do something. I really like ocean life, and I really like the way they work, the way they breathe, the way they eat, the way they have children, or whatever. But I guess that just kind of always stuck with me, especially since my grandfather always talked to me about that.

 One time, we went to a beach in Mexico, and my grandfather woke us up early one morning and told us to get dressed. "Come on, because we're going to go swim out in the ocean." And then he was going to take us as far as he can where the current can't really pull us. It was pretty dark, and then as soon as we got to where he wanted - it was pretty far - and as soon as we got there people started coming out to the beach.

 There was some rocks nearby, so he told us not to get near it because there's algae and barnacles on there that could really hurt. So, I was like, "What are barnacles?" So, I kind of went under and looked around, and I also saw on the ocean floor a bunch of fish and stingrays swimming around, so it was really cool. This is really cool. I want to stay here forever. Of course, I couldn't do that but that was really one of the best memories I had.

Sam Bodary: 03:02 So this early morning dip in the ocean changed the whole direction of her life.

Abby Malinowski: 03:06 I want to be a marine biologist. So, I guess it kind of relates.

Andrea Grottoli: 03:10 Do you want me to hold it? Or are you going to speak into it?

Sam Bodary: 03:10 No, it's all good. Yeah.

Andrea Grottoli: 03:10 Okay.

Sam Bodary: 03:12 I'm just going to have you speak right into that, and ...

 So, I found one.

Andrea Grottoli: 03:16 The first time I knew I wanted to be a marine scientist, I was already in my first year of grad school. I had already completed the first year of a master's, where I thought I was going to do some work in a marine environment, but the lab I ended up in studied coral and I did a summer graduate field course in Hawaii at the end of my first year.

 Excuse me. I was leaning over the tank of my corals in my experiment, cleaning the tank, in my bikini, and I thought, "I can do this for a living." And that was my first kind of "aha" moment that I wanted to be a marine scientist for a living.

Sam Bodary: 03:56 If I read this correctly, if I did my research right, you still work out and do fieldwork out in Hawaii. Is that right?

Andrea Grottoli: 04:00 I do. Hawaii is my first love when it comes to research and science and sort of that part of my life.

Sam Bodary: 04:09 What's your name, and what do you do at OSU?

Andrea Grottoli: 04:11 Yeah, yeah. I should have started that way, right?

 My name is Dr. Andrea Grottoli, and I'm a professor at Ohio State University in the School of Earth Sciences.

Sam Bodary: 04:19 Okay. So, now that we've met everybody, Abby is going to shine a light on ocean pollution and what we need to do about it. And then Dr. Grottoli, our big, fancy expert, is going to help explain things along the way. Sound good?

Andrea Grottoli: 04:30 All right.

Sam Bodary: 04:31 Let's jump into the problem.

Speaker 4: 04:33 Jump. Splash.

Abby Malinowski: 04:34 Okay, so the ocean is kind of like a big part of our planet and it's been around for longer than probably most things on earth. We haven't really been taking care of it, and that's one of the things I really wanted to focus on, was trying to clean it up and make sure that the animals in there were living safely and not suffering through pain, like by our garbage.

 People, I guess, they're not really respected ... respectful, I guess, of what they should, or what their actions are doing.

Sam Bodary: 05:17 So, what are some of those actions that they're doing?

Abby Malinowski: 05:23 They do what they want. They think they rule the world, and they think that other people can just clean it up for them. But I think they don't really know the background around that, so if there's no people that care about the ocean and want to clean it up, then there's no way that that can happen. So, you can't just rely on others to do it. You have to step up for yourself.

Sam Bodary: 05:47 All right. So, we're going to step up and learn about two big problems in ocean pollution. Starting with number one, the Great Pacific Garbage Patch.

Speaker 5: 05:59 That's me.

Abby Malinowski: 06:01 Just kind of, just this big place in the ocean that just ... I guess people think it's okay to dump their garbage there, which it's really not. Because a lot of animals swim through there, and they get caught in that, they eat that. They look from above and they think it's food, but it's really not. It's your garbage. So, I guess that's just not something that's cool around the world, that we should really be taking a look at and fixing it, I guess.

Sam Bodary: 06:32 And as serious as all that sounds, it's actually even worse.

Andrea Grottoli: 06:36 There are actually several patches.

Speaker 6: 06:39 Hey, man.

Andrea Grottoli: 06:39 The largest one is twice the size of Texas-

Speaker 7: 06:44 Hey, y'all.

Andrea Grottoli: 06:44 ... and it's off the coast. It's in the North Pacific.

Sam Bodary: 06:47 Okay, so I'm making these big, scary monster voices because this stuff is, frankly, terrifying. But these are monsters that we created. They didn't come from somewhere else, right? They wouldn't exist without us, or the trash that we create every day.

 Abby mentioned earlier people loading up a boat, going out into the ocean, and dumping their trash at the Great Pacific Garbage Patch. That's not actually how it works, and that is sort of what I thought the first time, as well. It's easy to imagine some big company-

Speaker 8: 07:20 Business is booming.

Sam Bodary: 07:21 ... buying a big old cargo ship, loading it up with trash, sailing it out into the ocean-

Speaker 8: 07:28 Garbage ho.

Sam Bodary: 07:30 ... and dumping it at a garbage patch.

Speaker 4: 07:32 Thank you. You're the best.

Sam Bodary: 07:34 And maybe that's a comforting thought, because then we could just blame other people. Because I'm not sailing a ship out into the middle of the ocean, so my trash isn't there, right?

Speaker 4: 07:45 Well ...

Sam Bodary: 07:46 The way it actually works is a lot more interesting. Patches don't just appear at random places.

Andrea Grottoli: 07:52 It's where surface ocean currents have a sort of a circular pattern, and so it accumulates there.

Sam Bodary: 07:59 So, it doesn't matter what you dump or where you dump it. From plastic bags at the public beach to the little plastic beads in your facial cleanser at the sink at home, that water is going to flow out into the ocean carrying the trash with it, and then the currents are going to gather it all into a garbage patch. And then it floats around until some animal takes interest.

Abby Malinowski: 08:21 In Science, we were doing this one thing, and they showed us a picture of a turtle. It had a ring of the six-can of pop and it had it on its shell, and I guess it got that when it was little and then when it grew up, the shell kind of looked like an hourglass. So, it was like that the whole time, and I guess ... I'm not sure if it lived a good life, and it probably didn't. So, we kind of want to give it the life it deserves.

Sam Bodary: 08:46 And getting caught in one of those plastic soda lassos is the least of their worries.

Andrea Grottoli: 08:50 Because they ingest it. It's shiny, it looks like a fish. They eat it, and it actually clogs their digestive system and it kills them that way. Birds are the big one right now, but you find it in fish guts. You find it in whale guts. You find it in dolphin guts. Those plastics can be leaching toxins, and so certain chemicals in plastics, those chemicals are being found in higher concentrations in the tissues of large mammals and things like that, and birds, that are ingesting them. That's not good.

Sam Bodary: 09:21 So, there's trash in the ocean, and then there's trash inside the animals. And then, when you go to the beach, you can bet that there's trash washing up on the shore.

Abby Malinowski: 09:31 I don't really go to the ocean much, but when I do, if I see a piece of garbage I throw it away, you know. I mean, it's just the right thing to do. And I see other people just walking around it. Do you really want to swim in a dirty beach? Do you want to swim with a bunch of trash? I mean, that's your trash.

Sam Bodary: 09:48 So when it's on the shore, we can follow Abby's example and pick it up. But that only helps when you can see it, and most of the plastic waste is nearly invisible.

Andrea Grottoli: 09:58 So as plastic breaks down, it doesn't just dissolve. It breaks into smaller and smaller and smaller pieces.

Speaker 9: 10:03 Regular plastic. Mini plastic. Micro plastic.

Andrea Grottoli: 10:07 And the microplastic is everywhere. In fact, there's new evidence to suggest it's in the fish we're eating.

Sam Bodary: 10:12 And then if the fish are then eating plastic, which then potentially leaches toxins, then we are consuming those toxins as well. Is that right?

Andrea Grottoli: 10:19 Yep.

Sam Bodary: 10:22 Okay. So, ocean pollution - issue one. The Great Pacific Garbage Patch. It is no good for anybody, animals or humans. We're going to circle back to solutions in a little bit, but for now, let's learn about the other big issue: coral bleaching.

Abby Malinowski: 10:38 I have another story, actually.

Sam Bodary: 10:40 I'm all about stories. I want to hear this other story.

Abby Malinowski: 10:42 All right. So, I went with my siblings and my dad. He took us to Aruba when my sister graduated, and we went on this boat trip.

Sam Bodary: 10:50 So they're out, and they're snorkeling, and they're seeing the sights, and they're having a pretty good time.

Abby Malinowski: 10:55 And then the second stop was a coral reef.

Sam Bodary: 10:57 Pause. Coral reef. I have to admit, I know what a coral reef looks like. I know that it's important for plants and animals, and maybe I know a little bit about bleaching. But I don't actually know what a coral reef is, so let's get up to speed.

Andrea Grottoli: 11:14 Coral reefs are these highly bio-diverse oases in the ocean.

Sam Bodary: 11:22 And what are coral?

Andrea Grottoli: 11:24 Coral are animals that are symbiotic with an algal cell. These cells live inside the animal, so they're a symbiosis. They're both plant and animal. They photosynthesize to get food, like a plant and they also eat zooplankton, like an animal, to get food. They do these two things.

Sam Bodary: 11:40 So then, the coral reef is made up of coral, right?

Andrea Grottoli: 11:44 Of corals' skeletons that grow over decades and centuries and millennia. And the growth of that skeleton builds reef structure, like the Great Barrier Reef.

Sam Bodary: 11:56 So the coral in the coral reef, that's what we're concerned about.

Andrea Grottoli: 12:00 If coral reefs degrade, one-third of all marine species lose vital habitat.

Sam Bodary: 12:06 Back to the story. What did Abby think when she got to see a coral reef?

Abby Malinowski: 12:11 Honestly, I was pretty sad when I went there, because the coral reef was so white. The only thing I could really point out was the black sea urchins.

Sam Bodary: 12:23 This is coral bleaching.

Andrea Grottoli: 12:25 Coral bleaching is a physiological response whereby coral, if they get too hot, they are stressed and they start to break down. They kick out the algae, and so they're partially starved because they can't get food from photosynthesis. When bleaching events last too long, coral start dying, and there have been mass bleaching events globally. It's one of the leading causes of coral reef degradation globally, and it's caused by global warming.

Abby Malinowski: 12:53 We actually did a project on this in Science about global warming, and stopping the coral fish from bleaching and dying. And so, mainly the problem is CO2. So, we really should cut back on that, and use less CO2.

Sam Bodary: 13:08 So once again, Abby is spot-on. CO2 is the key to the coral bleaching puzzle, and a piece of that puzzle is a process called ocean acidification.

Andrea Grottoli: 13:18 Ocean acidification is a product of atmospheric CO2, so as we burn fossil fuels that produce CO2, CO2 is increasing in the atmosphere.

Sam Bodary: 13:26 So the more CO2 we have, the more heat gets trapped on the earth, making it hotter.

Andrea Grottoli: 13:31 Warming the planet and the ocean. But it also interacts with the ocean chemistry.

Sam Bodary: 13:36 So, not the temperature of the water, but the water itself.

Andrea Grottoli: 13:39 As CO2 increases in the atmosphere, about 25% of that CO2 dissolves in the surface ocean, reacts chemically with the seawater, and produces acid.

Sam Bodary: 13:49 So, that surface ocean is like a buffer from the deeper ocean. It's kind of like a protective layer. However-

Andrea Grottoli: 13:55 We are increasing CO2 at such a rate that it cannot fully buffer it. And so, ultimately, we are getting ... the oceans are getting more acidic. It was thought, like 30 years ago, that there was no way we could actually change the pH of the ocean because it's so big. But we are.

Sam Bodary: 14:14 That is the sound of a seriously concerned and supremely annoyed scientist, and there's a lot to be worried about. Dr. Grottoli says that by the end of this century, the 2000s, the oceans will be another 100-150% more acidic. Acidification is bad for coral reefs. It mostly interferes with their growth. However, it's not as destructive as temperature. Dr. Grottoli has some more bad news about that.

Andrea Grottoli: 14:41 Ocean temperatures warmed by about a degree over the last century and will warm by, depending on how much we burn, two to five degrees Celsius over the coming century. Corals are affected by temperature increases of one degree Celsius for as little as 10 days.

Sam Bodary: 14:59 None of this is good news for our reefs.

Andrea Grottoli: 15:02 It will actually start dissolving.

Abby Malinowski: 15:05 That's where fish go to breed, and other animals do. Destroying that is not really fun for them, I guess, but I don't think it's fun for us, either.

Sam Bodary: 15:15 Abby's exactly right. It's not fun for us. We don't do all the same things that marine animals do in reefs, but we depend on them for a lot, including food.

Andrea Grottoli: 15:25 Reefs are associated predominantly with developing countries, where they have subsistence lifestyles. But they are also increasingly responsible for large portions of the GDP in countries where reefs are found, because of ecotourism and tourism in general. They protect beaches from erosion and storms. They provide sand to the beaches. The fishing and the swimming. Hotels and restaurants. The taxi driver, the cleaning ladies, the guys that bring people out to go fishing and snorkeling and scuba diving.

 All of that amounts to a massive amount of money, to the tune of over 300 billion dollars annually. In Ohio people often think, "Well, that's a tropical problem." But it's not a tropical problem, because if those people cannot live where they're living, they're going to move. And they're not going to move to another tropical country that can't subsist anymore, they're going to move to the west. They're going to move elsewhere, and it does become an Ohio problem. And the climate change that's driving these problems is caused largely by western nations.

Sam Bodary: 16:29 So, we've talked about two specific parts of ocean pollution. One, the Great Pacific Garbage Patch. And two, coral bleaching. Now, after telling me all about the problem, Abby had a couple of requests. She wanted me to go out and find somebody who could tell her-

Abby Malinowski: 16:46 If the plastic makes a difference in the pH with the oceans or doesn't? And what solutions there are to do it, or to help with changing them. Kind of making it better and returning it back or making it better than it was before.

Sam Bodary: 17:04 That first question is pretty quick: Does plastic in the ocean affect the ocean's pH?

Andrea Grottoli: 17:09 To my knowledge, it has nothing to do with ocean acidification.

Sam Bodary: 17:12 Okay. So the Pacific Garbage Patch, ocean acidification, different issues but still both really important.

 Let's go a bit deeper on Abby's second question: What are some solutions to these problems? How can we make it better, or put things back the way they were? Well, for one example, there's the work that Dr. Grottoli does every day.

Andrea Grottoli: 17:33 I study what makes some corals survive. What makes them either not bleach in the first place or, if they do bleach, they can tolerate it and then they recover. Over the last 25 years, off and on, I've been doing experiments and so we will collect coral from the fields, we put them in tanks where we try and simulate the reef environment as much as possible, and then we stress them. And we measure what changes in their biology, and we then look at who did better and who did worse, and we try and figure out why.

Sam Bodary: 18:15 Okay. So, scientists do science experiments, just like we do in Science class. But they get to go to Hawaii. So, what does that actually look like? What's a day in the life of a marine scientist?

Andrea Grottoli: 18:29 It starts at 8:00 in the morning just to set up, get all the equipment set up and running, get the coral ready that we're going to measure that day. We measure their photosynthesis rates, we measure their respiration rates. We have to do cleaning, we make daily measurements in the tanks about the conditions. Sometimes they get weighed to figure out how much they're growing. We get a tiny break of an hour or two in the afternoon, and then we go back right after dinner because they feed at night. So, we measure how much they're feeding and their respiration at night.

Sam Bodary: 19:05 This sounds like a lot, but she's not alone. She takes a small army of grad students and undergrads, some fresh out of high school, working close to 12 hours every day. So it's important that they're all on the same page.

Andrea Grottoli: 19:17 If the whole team isn't working together, it doesn't work. It takes longer to get things done, more things break, samples don't get run right. You end up having to redo things.

Sam Bodary: 19:29 So if you want to do research like Dr. Grottoli, you're going to need a lot more than just good grades in Science class. Here's what it takes.

Andrea Grottoli: 19:36 You have to be resilient. You have to be dependable. You have to be able to tolerate these long hours. Sometimes it's really hot, sometimes it's wet and cold, sometimes it's raining, sometimes it's sunny. You have to be able to work outdoors, all day. Sometimes it's buggy. And you have to be able to work under those very tight, coordinated team conditions for long periods of time. And every student I have brought out there thinks it's the best thing they've ever done.

Sam Bodary: 20:05 That's fantastic. And also it's so important for me, but then also students that want to go into this sort of thing, to hear what doing science actually is and is like. And for Dr. Grottoli, science has one central function in society.

Andrea Grottoli: 20:20 It really is about telling a story, and the story is shaped by the data you have. What scientists are not as good as doing, but we're getting a lot better at, is making sure that when we have all this data, that the information is telling a story in a way that pushes the science forward. Not just to our small group of people who understand the scientific literature, but to a larger audience, so that they can make informed decisions as voters, based on information that they can understand.

Sam Bodary: 20:55 This brings us back to Abby's second question about the ocean.

Abby Malinowski: 20:59 Returning it back, or making it better than it was before.

Andrea Grottoli: 21:02 We can mitigate and we can manage, and my research can help to save patches of reefs in small areas, and to kind of limp along for a while.

Sam Bodary: 21:12 So if you wanted to be a marine scientist, that's one way that you could make a difference. But if you don't happen to be a professional scientist yet, there's still other things you can do in your day-to-day life.

Andrea Grottoli: 21:23 You recycle. You don't keep your house as warm in the winter or as cold in the summer. You try and commute to work on a bicycle, or walking, or carpooling. All of those things that make very small reductions in CO2, but multiplied by everyone in the U.S., Canada, Europe, Australia, this becomes a very large number.

Sam Bodary: 21:45 We don't even have to do that much. Like, recycle? Easy. Not too much A/C? Done. Carpool? We can do that.

Andrea Grottoli: 21:53 But ultimately, the only solution is to reduce CO2 emissions, and that happens at a legislative level.

Sam Bodary: 22:00 And for Dr. Grottoli, that means voting. But it also means more than voting.

Andrea Grottoli: 22:04 Contact your representatives. Email them, call them, show up, sign petitions. They need to know that their constituents care, and even if you're not eligible to vote, you are still allowed to contact your constituent. You're still allowed to talk to your parents about how strongly you feel. You're still allowed to share with your parents what you think is important about the world, and the world that you are going to be left with.

 And so you can influence your parents' votes, and then when you are 18, register to vote and immediately vote. If 18-35 year-olds voted en masse, they would determine the outcome of every single local, state, and federal election. Their ideas would determine the fate of our political system.

Sam Bodary: 22:51 So, what can you do right now? Well, you can learn about climate policy issues in your region. You can drive a little bit less and walk a little bit more. You can go lighter on the A/C in the summer, and lighter on the heat in the winter. And of course, you can recycle. And then maybe we can all take a day off and we can go to the beach. And we can keep making memories right by the ocean, just like Abby.

 Can we close with, maybe, your favorite memory of your grandfather?

Abby Malinowski: 23:25 My favorite memory of my grandfather. Probably, he took us out to the beach another morning, and we were there and the waves were huge. So, he actually taught us how to go under the waves so we wouldn't be taken back by the current. So, I guess that was one of my favorite.

Sam Bodary: 23:48 Abby and Dr. Grottoli are solving ocean pollution. What problem are you solving? Tweet us at Battelle with the hashtag greaterthanstem to tell us all about it. Or, if you want your voice to show up on an episode, send a voice memo to education@battelle.org. While you're at it, subscribe, rate, and review the show on iTunes. It helps a lot more than you think.

 A big thanks to Dr. Grottoli and Abby Malinowski for chatting. She's in ninth grade, if you forgot. And thanks, as always, to Glenn Davis for mixing. Find him at glenndavisaudio.com. That's "Glenn" with two "n's".

 I'm Sam Bodary, and this is Greater Than STEM.