[BRIAN SILLIMAN]: When I walk into the marsh, one of the first things that I notice is this vast, intertidal grassland of hugely productive vegetation. Salt marshes are found in protected coastal waters and temperate zones all over the world.

Salt marshes are world famous for being among the most productive ecosystems in the world. Their productivity rivals that of plant material in tropical rain forests and animals on coral reefs.

Marshes are very important for humans. They're pollution filters. They also protect our shorelines from erosion. They're really important for fisheries production. And because of those important services, people are not only interested in keeping the marshes around that are here, conserving them, but putting more out there.

I've been studying salt marshes for over 20 years to understand how they work. I want to know what forces keep them healthy and what we can do to maintain them.

The abundance of plants in an ecosystem can be controlled from either the bottom up or the top down. Bottom-up control means that abundance is limited by the resources available to the plants, such as water availability, sunlight, and nutrients in the soil. Top-down control means that it is controlled by the animals that eat the plants, herbivores, and their predators.

When I started my work, there were many examples of top-down control in terrestrial systems but not in marine plant ecosystems. So everything I read about salt marshes and their ecology before I came out here told me that this was a bottom-up system, where the plants that created this habitat were created by the amount of nutrients that were available to them, that was in the soil. But early in my research, I made an observation that got me to question this conclusion.

When I got into salt marshes, when I started walking through them, my boots were being filled with snails that were falling off the grasses. And I immediately started to look at these snails, and their super abundance, and ask what they were eating and how they could be affecting the system.

Here's a really nice one right here. They're called the marsh periwinkle snail. They're a medium-sized snail. They can get up to about an inch long. And if you look closely, it's a very interesting lifestyle that they have. They go up and down the grasses with the tides.

When I came out here, I found, for instance, this plant looks like it's very heavily grazed. And it was covered in all these snails. I picked every one of these snails off of this plant. There's grazing scars all over it.

So what I had read in the literature told me this marsh plant system was controlled from the bottom up. But given my field observation, I wondered if the marsh grass was instead controlled by the snails eating it. In other words, from the top down. Working with students and postdocs in my laboratory, we designed a number of experiments to test this hypothesis.

We set up comparison plots in the marsh. To test bottom-up effects, we added nutrients to some of the plots and not others. And to test top-down effects, we set up plots with and without snails.

One of the things we need to do is we need to add nutrients. So our ingredients for this part of the experiment are fertilizer, pantyhose, and then put it into the centrifuge tubes to be put into the marsh. We're going to weigh it. Then we're going to wrap it and stuff it. So these are the fertilizer stakes that we made in the lab for the nutrient addition treatments.

To manipulate the presence of snails in our plots, we use exclusion cages. They're one meter squared, roofless corrals made of hardware cloth and tomato stakes as corner anchors that keep the snails out. In this experiment, we place them in the marsh for six months. We'll pull all the snails out of that cage and look at how plants respond to both of those treatments.

So when we pulled the snails off the marsh, we saw 100% increase in plant growth. It was under strong top-down control. And we saw an interesting interaction with nutrients. Without snails, we got confirmation of the bottom-up theory. You put more nitrogen on there, just like in your backyard, you get more plant growth. It doubled or tripled in size. But if the snails were there, those fertilized plants were yummy. And they effectively wiped out the marsh in those plots.

In our experiment, it looked like the snails were eating all the grass. So we asked whether the same thing was happening in areas of the marsh where grass was dying and turning into a mud flat.

Wow, check out the snail front, Joe. There's like 200 snails on these six stems right here. So there must be tens of thousands of snails right here creating a big battlefront where they're killing the grasses.

Again, we use cages to test what would happen if we excluded snails from a die-off area. We saw a mudflat the size of football fields. And in the middle of that, we saw this "chia pet" of grass. Often there were snails piled on the edges trying to get into that cage of healthy grass. It looked like giant tufts of hair coming off of a bald head.

So these experiments told us that the abundance of grass and marshes, which are full of periwinkles, is in part controlled from the top down. But the experiments also showed that given the chance, the snails would eat all the grass. So the next question is, what is keeping the snails in check? Because whatever controls their numbers and suppresses their abundance is indirectly going to have a positive effect on the plants.

And one of the animals that utilizes the marsh the most to find its prey are blue crabs. They're freaky fast on their feet. And when they eat, they can grab a snail or a mussel, pull it towards their mouth, and eat it in about 15 seconds.

To look at whether or not blue crabs were suppressing snails, we tethered snails. That's when you glue snails to little pieces of fishing line that's tied to a little PVC pipe. And voila, we are now serving snail on a stick.

We placed these snails in areas where the marsh looked healthy, with lots of grass, and in areas with little or no grass. After a couple days, we checked the areas where the grass was healthy.

I'm going to start here, and then I'm going to make way down here to check the tether.

[SPEAKER:] Okay.

[SILLIMAN:] Yeah, number one.

[SPEAKER:] Okay.

[SILLIMAN:] Ah, look at that.

[SPEAKER]: I feel like I —

[SILLIMAN]: Got tagged last night. Snail is missing, small shell fragments. Number 10 is that we have a survivor. So one survivor out of all those dead. We have 90% of the snails were killed. Those blue crabs are voracious.

Next, we needed to go check the snails left in areas that didn't have much grass.

Okay, here's the last tether. Snails intact, still alive, no sign of predation. All the grass is dying, and there's lots of adult snails. And it really illustrates the interaction that we've been seeing. All of them survived, and just one died.

The experiment suggests that where marsh is healthier, there are fewer snails, because they are being eaten by the blue crabs.

But this is just correlational. It suggests that there's a relationship. But there could be another reason the snails don't like that area. So we then used an experiment. We put cages out again. And we excluded blue crabs from these areas. Baby snails came into the marsh. They have planktonic larvae. And over a two-year period, the snail numbers increased inside cages where we did not allow blue crabs access.

Here all the grass had died off. Hence, the blue crabs are protecting the salt marsh. We call these indirect effects from predators to herbivores to plants trophic cascades. In this case, the crabs protect the grass by controlling the number of snails, who, if left unchecked, would eat all the grass.

And so now we understand there is a connection between those grasses and the grazers and the predators in the system. When we lose blue crabs, potentially from overfishing or other processes, we'll see that those snail fronts can expand, and the numbers increase even more in these salt marshes. It's going to be important for predators to be around to keep those grazers in check. Because once they're unleashed, they can destroy the marshes and the services they provide.

It took a while for people to accept the role of top-down factors in salt marshes. Because it's the opposite of what scientists used to think. I think there are a couple of important lessons that I learned from my study of salt marshes. Sometimes, observations you make yourself don't match the theory. Don't be scared if those don't match up. Trust your instinct. And figure out ways to confront theory with data. Because that's how we move science forward.