INTERVIEW WITH A RESEARCHER

Let's Talk With Mark Siddall About How Marine Organisms Eat

DENIS FINNIN / AMNH

Why are the feeding habits of marine organisms interesting to study?

Marine animals were the first animals. All of the ways that animals living on land feed are adaptations away from the way animals originally ate. One of the great things about being an animal is that you can coordinate movement among cells. For example, you can create a water current that will draw in suspended nutrient particles and shoot them out through a different hole. Most marine invertebrates take advantage of suspended particles in the form of single-celled algae or bacteria.

How is this different from the way land animals eat?

Trying to feed on suspended particles in a terrestrial environment is incredibly inefficient. Most falls to the ground. Spiders are probably the only terrestrial organisms that bother with things suspended in air; they put up webs. Another thing you can do in water that would require a lot more energy to do in air is to use suction. Some fish, for example, have developed muscles that allow them to create an incredible suction force that sucks up little prey items as they get close a huge negative pressure zone that smaller organisms can't escape, like a tractor beam.

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MORE ON MARK SIDDALL	
FIELD OF STUDY	"I am an invertebrate systematist: I study how organisms are related in order to understand how they evolved. I'm also a specialist on leeches and some kinds of parasites."
WHERE HE GREW UP	Georgetown, Ontario, Canada
FAVORITE MIDDLE/ HIGH SCHOOL SUBJECTS	"Of course, I loved biology. Biology is incredible because you have to learn how whole systems function. I also loved English class."
LEAST FAVORITE MIDDLE/ HIGH SCHOOL SUBJECTS	"I went to a Catholic school, so we had to take religion class. It wasn't about learning for oneself, but rather about obeying someone else."
THOUGHTS ON SCHOOL	"A piece of science that we do in my lab doesn't exist unless we write it up. I can't be a scientist unless I read and write, and I can't be a good scientist unless I can use both of those incredible tools very, very well."
INTERESTS IN MIDDLE SCHOOL	"My summer holidays were spent walking around in the woods and the meadows, catching frogs and snakes, climbing apple trees, camping and canoeing, and basically exploring the natural world."
INTERESTS TODAY	"I still ski. And one of the great things about my job is that I get into the woods and the wild, and I take my students as well."
LIFE LESSONS FROM THE FIELD	"Given the tens of millions of species on the planet, that means there's a heck of a lot more to figure out. But what are they? Where are they? You have to go into the field and figure it out for yourself."
RECOMMENDED READING	"In the end, studying invertebrates means being fascinated by something most people don't have much interest in, and that's pretty cool. So I'd say, read things that other kids aren't reading."
MAJOR INFLUENCES	"Sheila Patterson was my favorite English teacher in high school. She challenged me to read and to become engaged in the creative process. The scientific answers that you arrive at are only as interesting as the questions you ask in the first place. That's where creativity comes in."

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AMNH: How do marine animals feed on stuff suspended in the water?

MARK: Protozoans are tiny little organisms that are responsible for more photosynthetic conversion of the sun's energy into organic matter than all of the tropical rain forests combined. A lot of tiny little animals, zooplankton, feed off them, reproduce, and provide most of the nutrients that organisms, whether sponges or jellyfish or shrimp, then eat. These tiny animals are mostly water and live in water, so they're what we call neutrally buoyant: they don't sink or rise too much, they just sort of sit there. Water suspends a lot of organic matter in it, whether it's alive or dead, whether phytoplankton or zooplankton. Feeding on it means filtering a lot of water, and there are two ways to do it. The first is to be big, like the sea fan, a kind of coral. It has this huge fan of tentacles, and as ocean currents waft through them, the tentacles pick up the particles that float by. Another big filter feeder is a humpback whale. It sucks in an enormous amount of fluid ocean water, with shrimp and things that are one step up the food chain from phytoplankton suspended in it and spits it out through modified teeth-like things called baleen with little hairs on them, catching all of the krill (the shrimp).

Suction is another mechanism, which sea horses are incredibly good at. They can suck in shrimp that are larger than the size of their mouths, and crush them as they come in.

AMNH: How do different ocean habitats link to different feeding behaviors?

MARK: The open oceans are enormously vast. Most of that is not very well populated. The majority of life exists fairly close to land, on the continental slopes, where deep ocean currents draw nutrients that have fallen to the bottom up towards the surface. When those nutrients reach the photic zone, regions where light can penetrate, organisms like diatoms and other phytoplankton can use them and multiply. They support the next level of the food web, bacteria or other protozoons, which then are fed on by small zooplankton and tiny shrimp. Those in turn feed larger plankton and smaller fish, which in turn feed larger fish, which in turn feed birds and us. It's all connected.

In the open ocean, where there are relatively few nutrients, you have to be capable of long-distance swimming, either to chase your food or to get to where the food is. You'll see things like tunas and dolphins that are incredibly powerful swimmers. A Portuguese man-of-war, on the other hand, has an adaptation that allows it to drift huge distances. It's actually a colony of individuals. One is a huge bubble that acts as a sail. Another individual makes the long tentacles with a toxin that paralyzes fish. Then they reel in the fish and eat them.

AMNH: Do many marine animals use toxins?

MARK: You see a lot of toxins in the ocean, used for eating or for defense, especially if you're smaller than what you're adapted to eating. For example, many jellyfish and sea anemones can use their toxins to kill fish that normally would feed on them. The cone snail, a very pretty marine snail a couple of inches long, packs a wallop. It has a special organ, effectively a harpoon, in its tissue that it can jab into a fish that gets close enough. Then it reels it in. There are also things like the blue-ring octopus, a very, very small octopus with brilliant blue rings over its whole body, which are a warning to predators to stay away. It has a neurotoxin sting that can kill a human, and it also uses that venom to paralyze its prey.

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AMNH: How do other octopi eat?

MARK: Octopus and squid are capable of fantastic camouflage. They can change their color as a chameleon can. Fish, too, use camouflage in several ways. One is by being shiny. What looks like a silver-sided fish to us is almost invisible to other animals from below, even from the side. Most fish, whales, and dolphins are light-colored underneath and dark-colored on top. This way they look dark against the dark ocean floor and light against the light sky. It's a way to be stealthy.

AMNH: What are some other feeding strategies in different marine habitats?

MARK: Schooling traveling in huge packs is another strategy. The advantage of schooling is that if you are one fish among many, the odds of being captured are lower. It's like herding on land, a parallel strategy. Predators will select the weaker ones or those on the outside. On the other hand, if prey items learn to school across evolutionary time, predators can adapt to hunting in packs. Squid traveling together, for example, can more effectively corral and chase down prey. Take the Rojo Diablo, the Humboldt squid, a very, very aggressive predator that's even been known to take out the occasional fisherman. You find several dozen in a school.

Whales also hunt cooperatively. They will blow bubbles in a circle to create a barrier that contains krill, then breach the corral and eat them. Dolphins hunt in packs to chase and corral a school of small fish like capelin more effectively. What do tuna do? They chase along with the dolphins. And rather than looking for hard-to-find fish, pelicans and gulls and other seagulls seek out dolphins, which are big and easy to spot, and feed in front of them, where the capelin or herring are swimming. This has an unfortunate side effect, because fishermen run a 20-mile net around the tuna and capture the dolphins as well.

Some animals hitch a ride, just like the ticks and fleas that hitch a ride on land animals. Remoras that attach to sharks aren't feeding; they're not really parasites. When the shark makes a kill, they dislodge and eat some of the scraps. They're more like hyenas waiting for lions to leave their kill.

Other fish have weird behaviors, like cleaner fish and cleaner shrimp. These walk around the mouths and gills of larger fish, cleaning out little parasites. The larger fish will wait in line at these cleaning stations. We see behavior like this on land, with ox-picker birds that pick parasites off buffalo and giraffes.

But it's awkward to make too many generalizations about habitat and feeding patterns. Most of the behaviors we see are constrained by evolution, not by geography.

AMNH: You started your research in science being interested in parasites. Why?

MARK: Because it's cool that there are all kinds of completely unrelated organisms nematodes, flukes, tapeworms, malaria, African sleeping sickness–that have figured out a way to steal life from another organism. They're basically living at the expense of another animal or another plant, and this behavior has evolved over and over, at many different times. It finds its extreme in the viruses, which don't even code for all of the genetic elements they need for their own replication. They completely subvert the operational machinery of their host cells.

I thought that was pretty cool, although I was

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interested in it from an ecological, evolutionary perspective, not from the disease point of view. When I started my research, at the University of Toronto, I went back to Algonquin Park, in Ontario, where I'd spent at lot of my childhood canoeing and camping, to study malaria-like blood parasites in frogs. It turns out they were transmitted by leeches, just the way mosquitoes transmit malaria among humans or monkeys or lizards. Different parasites in snapping turtles turned out to be transmitted by leeches, too. And I did my Ph.D. on a similar system in marine fishes. The role of leeches as vectors got me interested in the life cycle of these parasites. Their diversity is amazing. I was surprised to find out that there are leeches in the ocean, lots of them. So it wasn't so much that I decided to study these organisms as that I pursued questions that interested me.

AMNH: Invertebrates make up 99 percent of all animals on the planet. What are some of the attributes that have made such diversity possible?

MARK: They've had a lot more time than vertebrates to become diverse and they are. Take nematodes. These are very long, thin worms "nematode" actually means thread that we call roundworms because they're round in cross section. It's been said that if you got rid of all of the rocky material on the planet, and all of the vegetation, and left only the nematodes, from space you would still be able to see the contours of the most of the Earth's geography. There are that many of them, and they are everywhere. They're parasitic and free-living; they're found from the mountaintops of the Himalayas to the depths of the ocean bottom. They're fantastic, and very poorly studied.

AMNH: Why do you think they're so poorly studied?

MARK: Because they're not furry, are they? And they're not very big. People like to work on big furry things. Our knowledge of the diversity of animals on the planet is mostly about terrestrial vertebrates and terrestrial arthropods (insects). I think it's because butterflies are pretty and echiuroid worms are not. Pompeii worms live in superheated water near hydrothermal vents on the ocean floor, and I think they're pretty cute they're furry like a teddy bear, after all but I don't think a lot of people are going to agree with me.

AMNH: Can you talk about opportunities for discovery in marine zoology?

MARK: There are certainly a lot more opportunities for discovery in the ocean than there are on land. We know a lot about animals and plants that live in what we call the intertidal zone between high and low tides and just below that on the continental shelves. And we know a fair bit about the very, very bottom of the ocean because that's cool research and you can get support for those expensive trips. Where we've got a big gap is between the two. What's living in the middle of the ocean?

Just a couple of years ago, a group of people decided to do some sampling in this region, which we call the mesopelagic zone, on a group of organisms called Archaea. These look like bacteria but are actually quite different, and we used to think they weren't diverse, that they only lived in extreme environments like molten lava or salt pans. But it turns out that at the mid-level depths, they dominate! They're more than half of the biodiversity at those depths.

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AMNH: What are some of the interesting questions a marine biologist could tackle today?

MARK: Some of the most interesting questions are about the diversity of organisms that live out there. If you spend the time looking closely, even at the invertebrates, you'll see that they're colorful, they have patterns you wouldn't expect, and behaviors that you'd never even have imagined. Take sea cucumbers. All the ones that we know near the inshore area are sedentary; they just sit there. Well, there's a sea cucumber at the bottom of the ocean that is brilliant red, first of all, and has these huge wings that allow it to fly off the bottom of the ocean and swim away. It's completely different from any other sea cucumbers.

They've recently found anti-tumor and antiviral agents in sponges from the bottom of the ocean. Who knew that you would find them there? And you wouldn't even think to look at these sponges unless you had already found them and characterized their diversity. No one studies anything that you can't put a name on.

Someone came along and decided to study the proteins that make a particular jellyfish light up in the depths of the ocean. It turns that you can stick it on just about any other protein. So if I want to know whether a particular gene produced by a cell is related to cancer, I can stick this bioluminescent protein on it, put it back in the cell, and see what happens. If the cancerous cells light up and the others don't, I've just been able to prove that that gene is involved in the development of cancer. It's been used in numerous experiments as a tagging element what we call a reporter molecule and it has revolutionized biochemistry in the last 10 years.

AMNH: Is there any reading you'd recommended for kids interested in invertebrate zoology?

MARK: Some of the best books about the natural world are A.A. Milne's The House at Pooh Corner and Now We Are Six. Off go Pooh and Piglet, searching for heffalumps, not because heffalumps are important to someone else but because they're fascinated by them. Of course they never do catch one, but it doesn't really matter. It's about trying, just like going fishing isn't really about catching fish.

A really cool book about doing fieldwork is The Log of the Sea of Cortez, by John Steinbeck. Most people don't know that "Doc," in Steinbeck's Cannery Row, was a real person named Ed Ricketts. Steinbeck and Ricketts used to hang out together in Monterey, where Ricketts had a small business providing invertebrates to schools and laboratories all over the country. Each day he'd wade out in the tide pools to collect anemones or starfish or whatever, preserve them, and ship them off. Steinbeck wrote The Log of the Sea of Cortez about a boat trip he and Ricketts took, collecting all the way down past the tip of Baja and up into the Gulf of Mexico and all of the trouble they got into on the way. To this day the best field guide to invertebrates on the West Coast is Between Pacific Tides, by Ricketts.

AMNH: How much of your time is spent doing fieldwork? Where has it taken you?

MARK: I spend about a third of the year in the field. That's a lot, too. Being away for six weeks at a time is about the limit. I've been all over the world. Most recently, I've visited Bolivia, South Africa, Chile, Madagascar, French Guyana, and the Seychelles. But each year my students and I get out in the field

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right here in North America, in Canada and Connecticut. There's still plenty to discover right here in our own backyard.

AMNH: What was the most exciting or unexpected thing to happen to you in the field?

MARK: The thing about exciting events is that they don't seem exciting at the time. It's only afterwards that you pretend they were exciting. Like when I had to help wrestle a 20-foot crocodile in Madagascar with a makeshift rope and a wet towel, so we could get a blood sample. We had to get the blood sample so that my friend Evon could find out if the population was healthy or not. You don't want to do it and the crocodile doesn't want you to do it, and both of you are scared witless. You just screw up all of your courage, grit your teeth, and try not to get bit getting the job done. It's important work. I just wish it weren't so exciting.

One of my best days in the field was also in Madagascar, in Perinet. The whole day was magical, starting in the morning with the melancholy, haunting, plaintive call of the indri. Perinet is one of the only places where these four-foot lemurs can be easily seen in the wild. We met a lot of Malagasy people that day, who came with us and in the afternoon helped us find what we were looking for: bright orange and metallic green leeches.

AMNH: Ideally, what traits should a really good scientist possess?

MARK: Patience, of course, especially if you go around collecting animals like I do. Sometimes you can go for days without finding anything, and you have to wait. It's frustrating, but it makes the discoveries that much more sweet.

I can't overstate the importance of being creative, either. Good science comes from good questions, and these only spring to mind if you're a creative thinker. And a little silliness. It's hard to be an eccentric leech biologist if you're no good at being silly.