INTERVIEW WITH A RESEARCHER

Let's Talk With Paula Mikkelsen about Marine Invertebrates and How They Move

What's systematics—and why study it?

Systematics involves learning how organisms are related to one another. We study systematics because we want to know how organisms evolved and what they might be evolving into. Their characteristics, what they need to stay healthy, their anatomy and natural history, how they reproduce, what they eat and who their predators are are all a part of systematics.

R. Bieler

Why is the way different organisms move around in the ocean an interesting thing to study?

Locomotion how organisms get around is part of this big picture. Invertebrates, and mollusks in particular, have a great variety of types of locomotion. Very broadly defined as animals without backbones, invertebrates are a huge group that includes corals, sponges, mollusks, echinoderms, crabs, lobsters, shrimps, worms, and jellyfish. They often move very differently from the way we do, because most don't have an internal skeletal structure. They do have muscles and support for their muscles, not necessarily in the form of bones but in the form of an outer shell or other structures.

Q&A INTERVIEW WITH A RESEARCHER | **Let's Talk With Paula Mikkelsen about Marine Invertebrates and How They Move**

MORE ON PAULA MIKKELSEN	
FIELD OF STUDY	"I'm a malacologist—a person who studies mollusks."
WHERE SHE GREW UP	Auburn, Maine
FAVORITE MIDDLE/ HIGH SCHOOL SUBJECTS	"I was always interested in biology. I liked the natural world and loved animals."
LEAST FAVORITE MIDDLE/ HIGH SCHOOL SUBJECTS	"I hated gym. I'm not a team sports person, although now I scuba dive."
INTERESTS IN MIDDLE SCHOOL	"My mother claims I spent all of my spare time doing homework, so I must have been a very boring child. I loved to work on science fair projects, and I was always collecting things and trying to figure out what they were, trying to classify them."
INTERESTS TODAY	"I love my work so much I don't really have what I would call a hobby, although I still collect postage stamps which I shared with my father as a child."
LIFE LESSONS FROM THE FIELD	"Unpredictability. Things in the natural world, and especially in the ocean, do not stay the same. This is true from day to day, and from year to year."
RECOMMENDED READING	"There are lots of good books on seashells, but relatively few that tell something about the living mollusk. Seek these out. It's important to remember that a living animal built that shell and lived in it."
MAJOR INFLUENCES	"I had wonderful, very inspiring science teachers."
FAVORITE THING ABOUT OCEANOGRAPHY	"There's so much in the ocean that is yet unknown. You don't have to go to the deepest part of the ocean floor where no one's been before. There are surprises on sand flats in ankle-deep water."

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AMNH: Do you have a favorite example of a way that invertebrates move through water?

PAULA: We normally think of mollusks, especially snails, as being very slow, but many actually move very fast. One of the most dramatic examples is jet propulsion by squids and scallops. Squids will pull water into their body cavity and then jet it out a cone-shaped organ called the funnel, which allows them to zip quickly backwards. (It's away from where they're looking, so we perceive it as backwards, but they probably don't.) A scallop is a bivalve mollusk, which means it has two shells, or valves. If you've eaten scallops in restaurants, you've eaten the very powerful muscle that holds the animal's two valves together. Normally scallops sit with valves gaping so they can feed and breathe (extract particles and oxygen from the water). When they want to move, or need to escape from a predator such as a starfish, they open and close their shells in a clapping motion and move away very quickly. (Again, this would seem backwards to us because it's opposite the direction they're "facing.")

AMNH: What are some other ways that marine invertebrates move around?

PAULA: Maybe the most common method of moving in mollusks is using what we call cilia — little "hairs" that we see on the surface of a cell. The foot of some kinds of snails is covered with a virtual field of cilia. Garden snails glide over a surface by moving the field of cilia. They have to make it wet first, and do that by producing a slippery liquid called mucus (that most people call slime). Other snails move by muscle movement. You can sometimes see virtual waves of muscles in the foot from underneath when a snail crawls across the wall of an aquarium.

In addition to using muscles to move, bivalves — more commonly known as clams — use what we call hydrostatic pressure. Most don't have what we call a closed circulatory system, consisting of networks of vessels. Instead, the blood in their bodies flows from one large open space to another, and can be used to inflate and deflate parts of their bodies. A clam will quickly pour blood down into the tip of its foot, which lengthens the foot and inflates it like a liquid-filled balloon. This serves as a big, round anchor, and the clam then uses its muscles to pull itself downward toward the foot. (Most clams live burrowed in the sand.)

The bubble snail *Acteocina canaliculata* uses cilia and mucus on the sole of its foot to glide across the substrate. | P. Mikkelsen

Starfish also move using use hydrostatic pressure; they have suction cups on the bottom of their arms, which are extended and retracted by the same method. Starfish are echinoderms, in a completely different phylum than clams, which shows that it's not possible to generalize about locomotion among invertebrates. There are certain methods of locomotion that work very well in a three-dimensional liquid such as seawater, and they're used by more than one type of animal. These may be very primitive ways of moving, so how an animal moves does not necessarily imply relationship with another kind of animal. An

amoeba, which is one of the most primitive organisms commonly studied in school, moves by circulating liquid in its body, and also by cilia. So we're talking about both one-celled organisms and complex invertebrates getting around in the same sort of way.

AMNH: What do different kinds of locomotion tell us about different marine habitats?

PAULA: Think about what you'd need to get around on soft sediment versus getting around on rock. In many cases it's exactly the same method, as with snails that glide around on a cilia-covered foot. Clams that live in soft sediment and somehow get exposed need to be able to bury themselves again for protection. But certain clams don't move much at all as adults, like mussels. They attach themselves to hard rock surfaces with a bundle of elastic threads called a byssus. They've adapted to a different habitat.

AMNH: Are certain kinds of locomotion necessary at different points in an organism's life cycle?

PAULA: Most marine mollusks in the ocean have what we call planktonic veliger larvae. (A larva is a very juvenile life stage.) When this type of very tiny larva first hatches, it's free-swimming, although it mainly drifts around in the plankton. Instead of a foot for crawling, each has a velum: a large flap of tissue with long cilia along the edge. This extends out of the larval shell, the cilia wave in the water, and as a result the larva can swim. Why does a mollusk need this life stage? In fact, not all do. Many hatch into crawling juveniles, just like a miniature adult. But those that have veliger larvae have the advantage of being able to disperse into new areas of habitat and food sources.

AMNH: What do malacologists study?

PAULA: Mollusks. In my research, mollusks are sea shells and the animals that make them. But many mollusks, like land snails and the snails and clams that live in freshwater, are not found in the sea. Malacologists also study squid, octopuses, chambered nautilus, mussels, scallops, and oysters.

AMNH: What got you hooked on studying mollusks?

PAULA: I started out wanting to be a veterinarian. I grew up in Auburn, Maine, where I went to Walton Junior High and Edward Little High School, and I loved animals. I had a cat and a dog of course, and guinea pigs, and a very lovely rat named Maggie who was one of my favorite pets. But in 1975, when I was 20 years old and halfway through college, I moved to Florida so that my husband could go to graduate school. There we of course started collecting shells on the beach. I still wanted to be a vet, but I finished my undergraduate schooling at the Florida Institute of Technology, which had very good marine biology and oceanography departments. I learned to snorkel and eventually to scuba dive, and I joined a shell club a group of amateur shell collectors that get together to "talk shells" and go collecting. In Florida there's practically a different shell club about every ten miles! Shell-collecting turned into passionate hobby, and eventually into a career.

After I finished my undergraduate schooling, I was hired by the Harbor Branch Oceanographic Institution in Fort Pierce, which is a private oceanographic research company that's very famous for its Johnson-Sea-Link submersibles and its marine science program. I was literally hired to wash bottles in the Harbor Branch museum, but because I knew shells this was about nine years after

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I'd moved to Florida, so I had learned quite a bit I began identifying their specimens so they could be cataloged. I also took care of their collections of fish and worms and corals and starfish that were preserved in jars. It was my job to make sure that the alcohol stayed full, to find particular specimens that scientists needed for their research, to pack and mail specimen loans or invite scientists to come study them there basically the same things we do here at the American Museum of Natural History.

I stayed at that same job in various forms for 17 years, and about 10 years into that I started going to graduate school part-time. I wanted to conduct research on mollusks, which by then was the subject I was most interested in scientifically. Grad school teaches you how to do research properly.

AMNH: How often do you go into the field?

PAULA: Usually two or three times a year; none of the trips are very long, but I return home each time with thousands of specimens. Right now my research is centered in the Florida Keys, where I've been documenting the biodiversity of marine mollusks for about 10 years, and working to classify them.

AMNH: How do you obtain specimens?

PAULA: By scuba diving, snorkeling or wading, depending on how deep the water is. We look around for mollusks that are obvious, but not many are. Most of time we're looking for samples that will contain tiny specimens of mollusks: a large bag of sand, or a bag of seaweed, or a chunk of dead coral rock with mollusks that have burrowed into it. And of course we pick up loose seashells, and look into crevices and turn over rocks which we always put back in place to look for living specimens. Back in the lab after the dive, we spend hours and hours going through all that rock and sand and seaweed to discover what we've found.

AMNH: What kind of tools do you need in the field?

A sieved sand sample from the ocean floor can contain more than 100 species of mollusks. | L. Funkhouser

PAULA: A wet suit, a tank, and a plastic bag or jar. Much of the time that's about it, although sometimes we use more sophisticated equipment. I just finished a project studying offshore mollusks off the Florida Keys for which we had to rent research vessels. These ships had to be capable of sending a small grab or scoop to the bottom in 600 feet of water, in order to pull up that same old bagful of sand.

AMNH: What's the most important lesson you've learned in the field?

PAULA: That things in the natural world, and especially in the ocean, do not stay the same for long. That's partly because we're using it,

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fishing, diving, having an impact just by being there. But often, even in remote areas, when I've said, "OK, we need to go back and collect more of that animal and I know I found it in quantity off this tiny little island," we go back and the animal is not there. Why? We don't always have an answer. So many variables affect how animals live, like changes in water chemistry, especially in areas where septic tanks or chemicals from golf courses drain into the ocean. An especially cold winter can affect where the larvae end up settling, or perhaps the water temperature doesn't warm up enough for larvae to hatch at all. And you can't always tell what's changed from year to year. Things may look very similar, even identical, yet something has obviously affected where the animal is distributed. But they usually come back. Many changes are due to natural cycles that are not well enough documented for us to fully understand.

AMNH: Did you ever find something really unexpected during the course of field work?

PAULA: While I was working at the Harbor Branch museum, a visitor from the Smithsonian Institution arrived who was studying mantis shrimps large crustaceans that burrow holes in the sand flats that come out of the water in the estuary at low tide. He was using a suction device that looks like a slurp gun for mud, and he discovered little blobs that's what he called them about half an inch in diameter. He brought them in alive, and when we put them in water they got up and started crawling around. We'd never seen anything like them. You doesn't normally think of clams as crawling around, but these did. Over the next few years, a colleague at The Field Museum in Chicago and I ultimately described five new species of these clams.

This didn't happen in a remote environment;

The unusual yoyo clam *Divariscintilla yoyo*, which lives commensally with mantis shrimps in sand burrows, has an internal shell and crawls on its foot like a snail. | P. Mikkelsen

this was in ankle-deep water in Fort Pierce Inlet. But it was such a cryptic, or hidden, habitat that it's hard to sample, and the clams stay in the burrows for protection. It was complete serendipity, such a surprise! This was one of my first research projects in malacology, and it really gave me a taste for it.

These species are now known as "yoyo clams," because in addition to crawling, they climb up onto a vertical surface (like the wall of the burrow), spin a thin byssus thread (just like the mussels), and hang from their long skinny foot. Every once in a while, to clear out their gills and clean out their systems, they contract everything their whole body, all their muscles, all at once and bounce up and down like a yoyo. How did I figure this out? I simply put them in a bowl on the countertop and watched them for hours. One species was actually named *Divariscintilla yoyo*.

As these yoyo clams show, there's so much in the ocean that is yet unknown. You don't have to go to the deepest ocean floor where no one's been before. It's just a matter of looking at a habitat very thoroughly, perhaps with

new equipment, or just with a fresh pair of eyes. Someone who can observe, without any biases about where things should be and what they should look like, often shows me things that I wouldn't normally have seen.

AMNH: How did you come to the AMNH?

PAULA: I ended up here by taking advantage of an opportunity, which is something you need to do if you want to be a biologist. There's not a ton of money in the field, or a lot of jobs although I love what I do and it's worth it every minute so you need to be able to seize an opportunity when it comes up. I didn't intend to leave Harbor Branch, but after I finished my PhD in 1994, a research position opened up at the Delaware Museum of Natural History and I applied and got it and moved to Delaware. Two years later a position opened up here. Again, I had no intention of leaving Delaware so soon, but the prospect of working in one of the world's great institutions for natural history was too good to pass up.

At AMNH, I'm called a curator. My job has two aspects. My research on the systematics of marine mollusks is my primary job. I also take care of the Recent mollusk collection, which is a very large one of about 3 million specimens. I'm still washing bottles the way I did at Harbor Branch (though here we use a dishwasher), and I'm still answering questions about what we have in the collection, and taking care of visitors.

AMNH: What's your favorite thing about your job?

PAULA: There's nothing more exciting than going into the field. But coming home is important too, because you have to take care of the specimens you collect, to use them in research, to publish the results. If you don't publish, you might as well never have done the research, because nobody will ever know your results. You have to enjoy writing, and I do. When I first start working on a project I start writing about it from day one, instead of waiting until all the data are in. That helps a lot to prevent "writer's block."

AMNH: What books would you recommend for kids interested in mollusks?

PAULA: For younger students I love *Shell*, by Alex Arthur; it's part of the Eyewitness series. For older readers, *Living Marine Mollusks* by C. M. Yonge and T. E. Thompson is very good. The newest synopsis of what we know about mollusks is the two-volume set *Mollusca: The Southern Synthesis*, published in Australia.

AMNH: Did anyone have a major influence on you as you were growing up?

PAULA: Both my parents were very supportive. Neither one graduated from college, and my mother didn't even finish high school. It didn't take very long for them to stop understanding what I was telling them. But both had the patience to listen and encourage me to pursue what I was interested in, regardless of what kind of salary or job lay at the end. That never came up. It was whether I was going to be happy going to work each day, and that became very important to me too.

AMNH: What advice would you give to a student interested in studying marine biology?

PAULA: I always tell students to take advantage of opportunities. If you can, spend a summer volunteering at a marine lab or some kind of science facility instead of flipping burgers. Try out different kinds of scientific work in different places. It'll give you a taste of science that you can't learn in school, and also give you legitimate credentials. Remember that you won't be doing the hard core research at this stage. You'll be assisting somebody, and a lot of the work may be tedious–sorting and writing, data-basing, looking things up in the library. Much of it is sitting at a computer typing. But it's worth it when the "big picture" develops.

AMNH: What's the best moment in your work day?

PAULA: At the end of a wonderful dive, when the water is flat calm and you've collected some really fascinating animals and seen things you've never seen before, that's the best moment. You come back to the boat, take all the gear off, jump back in the water for a brief swim, enjoy the sunshine and the peace. And then get back to the lab.