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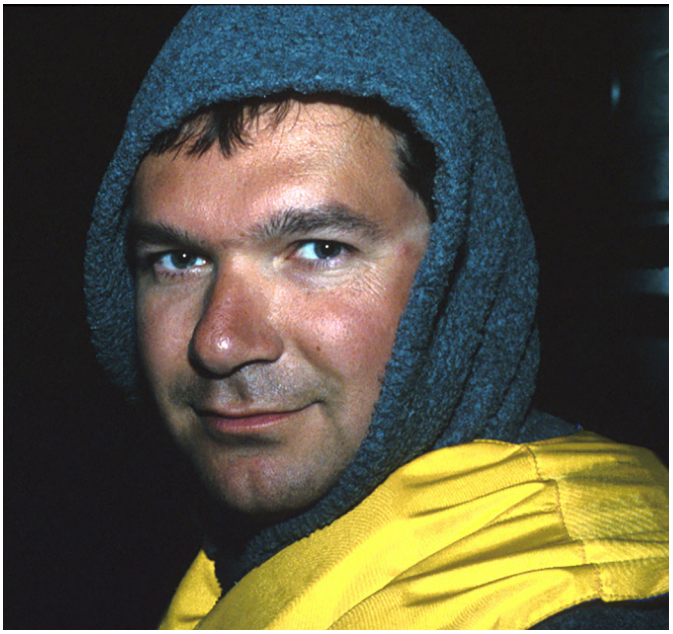
CONVERSATION

In the field: an interview with Sönke Johnsen

Sönke Johnsen is a Professor at Duke University, USA, investigating visual ecology. After completing his degree in mathematics at Swarthmore College, USA, and a PhD with William Kier at University of North Carolina at Chapel Hill, USA, Johnsen worked as a post-doc with Edie Widder at Harbor Branch Oceanographic Institution, USA, and Larry Madin at Woods Hole Oceanographic Institution, USA. He remained at Woods Hole as an Assistant Scientist before moving to Duke as an Assistant Professor. Johnsen talks about his experiences of collecting transparent animals while blue water diving and in a submersible, as well as outrunning Hurricane Katrina in 2005.



How did your research career begin?

I originally thought I was going to be a physicist, so I went to college and I was profoundly unhappy, so I switched to mathematics and then I switched to art and dance. Eventually, I left college and after a host of different jobs decided to go to grad school. I applied to three, having taken only one biology course, and joined Bill Kier at University of North Carolina at Chapel Hill, USA, but I struggled. At the end, Bill asked what I was going to do next. I said that I was interested in clear things and optics and he told me about transparent animals that live in the ocean and are as clear as glass. That blew my mind. I knew that this had to be what I was going to do. I applied to two oceanographic institutions to do a post-doc and they turned me down, so I cleaned fish tanks for a year and then I applied again and got into both places. That's when my fieldwork career started, because I did both post-docs. First, I went to Harbor Branch Oceanographic Institution in Florida, USA, and worked with Edie Widder, who was into bioluminescence at the time. She hired me to solve a problem with a computer program she was using to categorise bioluminescence, but I solved the problem before I showed up, so she gave me free rein to work on whatever I wanted. The second was at Woods Hole Oceanographic Institution on Cape Cod, USA.

Tell us about your first field experience

If you worked in Edie's lab, you had to go to sea whenever she went – and she went quite a bit – so my first field experiments came very quickly. The Harbor Branch Oceanographic ships held 15–20 scientists, in addition to crew, and we basically brought the entire laboratory along. In fact, we brought at least two of everything, because you never knew what might break. Before the cruise, I had been 'playing with Tinkertoys', as Edie called it: building equipment that would allow me to measure the transparency of animals, using metal posts, different mounts, lenses and a camera. My job was to make sure that it worked on the boat hundreds of miles from shore. What I hadn't realised was that we were going to sail the ship up the Gulf Stream, which is always rough, to Cape Cod from Florida. We were there during 4 days of quite high seas. It was beautiful, clear with stunning skies, but the waves were in the order of about 15 feet [4.5 m]. The ship was moving in ways that I'd never experienced before and I'd never been somewhere where I couldn't get out when I was motion sick. Eventually, I found the centre of the ship, because that was moving the least, and I just sat there staring at the horizon. When I went outside, the waves were also smacking into me, so then I was cold, covered in saltwater and seasick.

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How did you collect animals from the boat and measure their transparency?

We either used a trawl net that was about 100 feet [~30 m] long, or we used the submersible. The net had a very fine mesh, so you could catch creatures all the way down to copepods. The animals that I was looking at were about the size of my thumb up to the size of my palm: gelatinous zooplankton, which includes different kinds of jellyfish, ctenophores (comb jellies), worms and snails. We'd pull the net back on deck, pour the contents into a trawl bucket and I would scoop out the animals I wanted with a cup, put them in a container and then shine a beam of light through to see how much of the different colours of the rainbow went through using a spectrometer. In my initial version of the equipment, the light went up and down, which meant it went through the surface of the water, so, as the ship rolled back and forth, the surface of the water tilted and sent the light in all kinds of directions. It was a mess. My original attempt was more or less a failure.

How did you identify the animals that you found?

The scientists who had been to sea before helped, so we would narrow down roughly what kind of animal it might be and then

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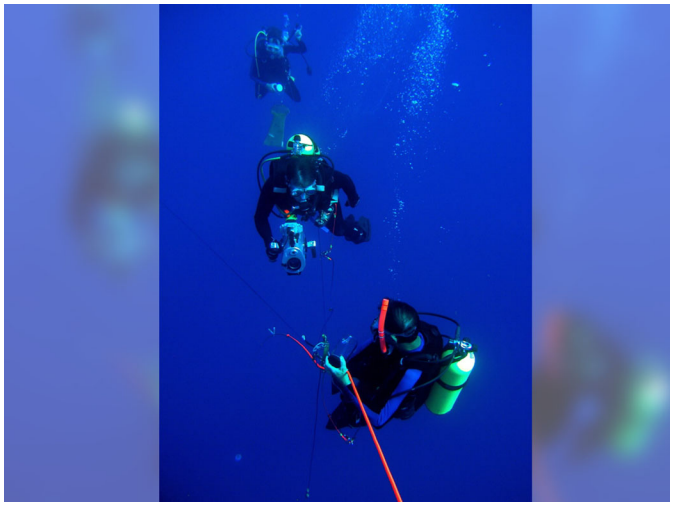

Sönke Johnsen (top) and colleagues blue water diving. Photo credit: Mark Schrope.

we'd break out the miniature on-board library, which included guidebooks for a number of these things. If we really didn't know what the animals were, we preserved them, brought them back and then sent them to an expert at the Smithsonian's National Museum of Natural History for identification: even professional biologists had never seen some of these animals before. We found worms that were really clear and beautiful with little swimming appendages, some transparent swimming snails, a group of animals that are our closest relatives (called the urochordates), doliolids and things of that sort. Some of the transparent crustaceans look like glass sculptures, filled with fluid with a few organs hanging inside.

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What special training do you need to work underwater?

First, you train as a regular scuba diver at the local dive shop and then you train as a scientific diver, collecting samples, taking measurements and doing experiments. But for blue water diving out in the open ocean, you have to be trained by people that do it and there's only about 20 in the world. We start from a small boat about a mile from the main ship. If you just dove underwater and started swimming you'd drift away and be lost. Also, it is very easy to sink too deep, because the water is so clear, it doesn't get dark and it doesn't get cold quickly. If that happened, you'd be dead, because you couldn't come back up; you'd get the bends, suffer from oxygen toxicity, do something fatally stupid due to nitrogen narcosis, or simply run out of air. We use a homemade complex trapeze system with a big float at the top and a line that goes down to a large ring with a whole bunch of counterbalanced ropes coming away from it that we all get tied to. Then we learn how to dive in a group so we don't tangle the whole thing up and get in a mess. One person is the safety diver in the middle – they keep track of where everyone is, untangle the ropes and look out for sharks. Mostly, when we go down, we're trying to collect transparent animals and sometimes we do imagery with cameras that can only see ultraviolet or polarised light. Then we use math and other techniques to figure out how visible the animals are to other animals.

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How visible are transparent animals with polarised and UV light?

Actually, they are mostly visible in the UV, especially the ones that are in shallower water within the top 10–15 m. A number of them have UV-blocking pigments to keep from getting 'fried' because UV enters the ocean when the water is clear. Effectively, they have sunscreen, which makes them dark in the UV and easier to see. The musculature can also stick out because it causes light to change polarisation, making them visible to animals that can detect polarised light.

What are the practicalities of arranging fieldwork in the ocean?

First, we write a grant and put in a ship time request saying what we're going to need. Then, if the grant is funded, they tell us what ship we're going to get and when. Usually, it isn't the exact time we requested; we always ask for it not to be in the middle of hurricane season. The ships are run by individual universities and institutions. Each institution has a marine operations centre, which handles the food, the fuel and the personnel for each ship they manage. When we show up, the ship is ready to go with a full crew from cook to captain. But there is also a huge amount of organisation ahead of time. Typically, we start emailing everybody months before we go, telling them what sort of visas they need, how to get to the port, what kind of equipment they are going to bring. It's an endless email train back and forth. The chief scientists are also in contact with the captain. There's usually a research technician assigned to the ship, to make sure that the computer systems work and that we have all of the equipment that we will need, such as specialised sonar. If you're running the operation, you're also paying for everything and if anything goes wrong, you have to figure out how to deal with it. It's a nerve-wracking job.

Can you tell us about your first submersible dive?

It was awesome. The submersible looks like a fat helicopter; it's got a big Plexiglas bubble in the front and a metal chamber at the back. Two people sit in the bubble and you get an amazing view in all directions. The people in the back are basically in a double-width coffin made of steel with two little portholes, so their view isn't as good and it's a tight fit, but it's still fun. At the beginning, the submersible crew lifts the sub off the deck with an enormous A-frame and tilts it over the water to lower the sub down. When it's that warm and everything's rolling around in the water, you just want to vomit. Once you get cleared to go down, it's the most peaceful thing in the world, because submersibles don't drive up and down, they float like a hot air balloon. The original concepts for submersibles came from balloonists and are based on buoyancy. The submersible also has propellers, about 12, for going forwards and backwards. You don't even realise that you're moving, because the light levels change very gradually and eventually you start seeing bioluminescence as animals strike the bubble. It's pretty much dead quiet, except for you and the pilot talking. Once it's dark, you need the lights and you see things flitting about. Sometimes, you see a big squid or fish just hanging there as if nailed to the wall of the abyss,

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just pulsing its fins. It's extremely peaceful and utterly beautiful. It's a little different at the bottom, because you have a frame of reference and you can only see about 10 m ahead, so it's like a continually unveiling landscape; suddenly, there's a cliff or a mountain in front and you had no idea it was there.

What are the key personality traits that you look for in colleagues on a research cruise?

A few; we sometimes call it the 'lifeboat test'. I look for a bombproof sense of humour. I want somebody who's got the flexibility and the humility to put up with anything that happens, no matter how crazy, and doesn't take themselves too seriously. Also, the ability to accept everybody for who they are, even if you don't agree with them, because we have to work as a unit. If a person has some political or social beliefs that don't agree with yours, it's just tough, you have to find a way to make it work. I look for people that will accept, find and create communities, wherever they are. We could be a couple of days from shore and if somebody is badly injured, or something really crazy happens, we have to solve it on our own. The mates and captain are trained as emergency medical technicians. In theory, they can take out your appendix with advice over the internet from a doctor if necessary. We're also looking for people with practical sense, because nothing ever works. We always say 'plan A's a complete joke, plan B's never going to happen, plan C you have a chance of doing and you're definitely doing plan D', which means you're going to have to build things out of whatever is on the ship when your $10,000 piece of equipment fails. I'm looking for people that can look at a pile of aluminium foil, a gallon jug of milk and a cardboard box and see how to fix the next thing.

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What's the most difficult situation you've ever been in during a research cruise?

We were out during Hurricane Katrina; that scared us. We were doing work in the northern Gulf of Mexico when Katrina formed. Your average hurricane goes about 10–15 mph [~16–24 km h^{-1}], but our ship goes at 10 mph, so, if we guessed the wrong direction, we weren't going to be able to outrun it. Initially, it looked like Katrina was going to hit Mobile, Alabama, so the captain decided to go to Fourchon oil service port in Louisiana. We got permission to pull in, but then the hurricane changed course and it started coming for Fourchon. By this time, it was a couple of days closer and it was one of the great hurricanes of the age. Then we had to decide whether to go back to Mobile or go in the other direction, but we were having trouble finding a port, because every ship in the Gulf was heading for safety. In the end, the captain used emergency money to pay for us to tie up in Galveston three ships out from the shore to ride out the storm. We guessed right, but a lot of the ships in Mobile were destroyed by the surge that went up Mobile Bay. After the storm, we went back out to pick up our work and the water was opaque, like paint. Every single animal in the top layer had been churned up and the water was full of debris: a chair, the side of a house, a life preserver. That was a dicey experience.

The captain used emergency money to pay for us to tie up in Galveston… to ride out the storm

What are the most important pieces of equipment that you take with you on a field trip?

I would say duct tape. I know that sounds like a joke, but we could not survive without duct tape. We also bring reams of black plastic, huge rolls 8 foot [~2.5 m] wide. We make dark rooms out of it in the big lab, because we do low-light work studying deep-sea vision. But those temporary rooms are nasty, because they may not have an air conditioning vent. Basically, you're stuck in a plastic bag. One year we didn't have enough plastic, so a poor grad student and I ended up doing bioluminescence measurements with a large trash bag over our heads, working inside it for an hour at a time. Imagine life inside a trash can; it was miserable.

Sönke Johnsen was interviewed by Kathryn Knight. The interview has been edited and condensed with the interviewee's approval.