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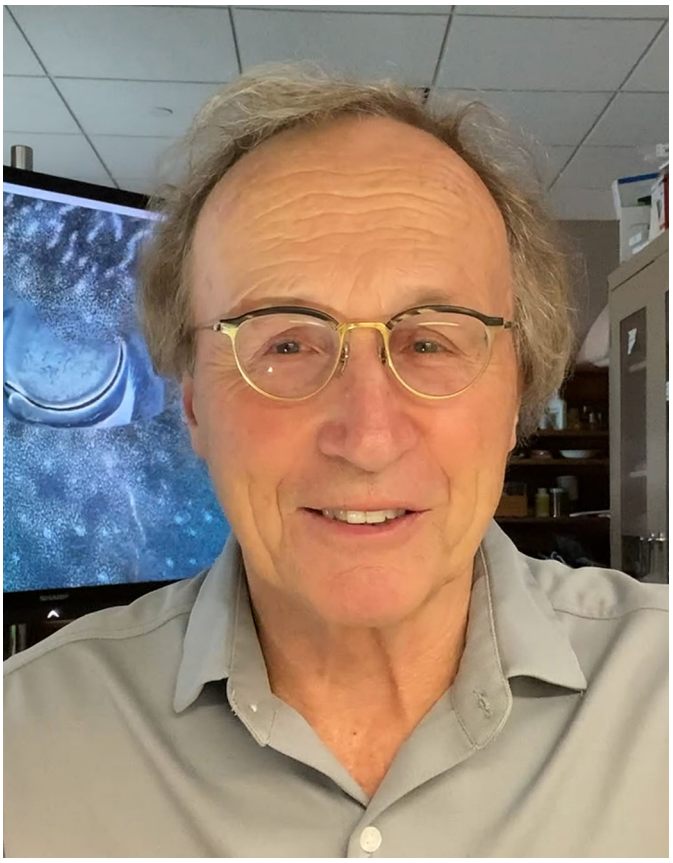
CONVERSATION

In the field: an interview with Roger Hanlon

Roger Hanlon is a Senior Scientist at the Marine Biological Laboratory, USA, where he investigates body patterning and colour change in cephalopods. After his undergraduate degree in 1969 at Florida State University, USA, he joined the US Army and travelled before completing his MSc (1975) and PhD (1978) at the University of Miami Rosenstiel School of Marine and Atmospheric Sciences, USA. After a NATO Postdoctoral Fellowship at the University of Cambridge, UK, in 1981, Hanlon joined the Marine Biomedical Institute, University of Texas Medical Branch, where he became a full Professor, before joining the Marine Biological Laboratory in 1995. Hanlon talks about the seminal experience in his early 20s that inspired his career and the methods and equipment he uses to study cephalopod camouflage and communication across the globe.



How did you become a scientist?

I grew up in Cincinnati, Ohio, and I was athletic, but I was always attracted to nature. I was a nerd; I had an organic garden when I was 13 and I was interested in astronomy and plants. When I went to college at Florida State University, USA, I majored in Biology and it just grew on me. I saw the crystal-clear water and beautiful fishes and I was hooked. I learned free diving first, breath hold diving down to 40 feet (12 m), in Wakulla Springs, Florida, where the 'Tarzan' films were made in the 1930s and 40s. Then I tried SCUBA diving when I was a senior (4th year) at university.

Where did you go after university?

When I was in my late teens and early 20s it was the Vietnam War era, so there were no choices. After I graduated from college in Marine Biology, I went to be a lieutenant in the army. I spent two years on active duty and ended up in Korea, but when I was decommissioned from the army, I decided that I didn't want to go home. I wanted to go travelling and diving for a year. I spent almost 5 months diving in some of the most beautiful places on the planet like the Palau Islands in Micronesia. There, by a stroke of pure luck, I ran into a diving scientist and entrepreneur named Walter Stark, who was pretty famous and had written several articles for National Geographic. He had a beautiful new research boat, so I showed up, said I wanted to learn diving and he hired me. I dived with him for 4 months and learned underwater photography and ichthyology from him. At that time, he was on contract for National Geographic to film sharks, so he gave me the questionable job of holding the giant arrays of underwater video lights hooked up to a generator in the boat and I had to follow him around with his big camera and film sharks. I was in heaven, but it was dangerous.

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On one occasion, we were diving an underwater cliff with a beautiful coral reef. Walter popped over the side of the boat and went straight down to about 150 feet (45 m), which is a very deep SCUBA dive. I had to follow with the lights, so it took longer to get there. As I drifted down with the tethered light array, I could see him filming something below me, but when I was about 15 feet (5 m) above him my foot hit something quite hard. I looked down and it was the dorsal fin of a huge hammerhead shark. Walter was filming the shark coming right at him as I was drifting down into the scene – scared me senseless and also ruined the shot. He was furious and the shark just swam off.

That interim year gave me the opportunity to find out whether I wanted to have a career in diving and photography or a career in marine biology. In the end, I was able to study biology – I applied for graduate school at the University of Miami, Florida, after working with Walter – but I've incorporated diving and imagery work into my research, so that experience had a lasting influence on me.

Where did your interest in cephalopods come from?

That happened when I was in college and my brother was in the army in Panama. He invited me down for part of the summer and one afternoon he left me snorkelling on a coral reef for a couple of hours. I glided over a little depression with beautiful coral on it when

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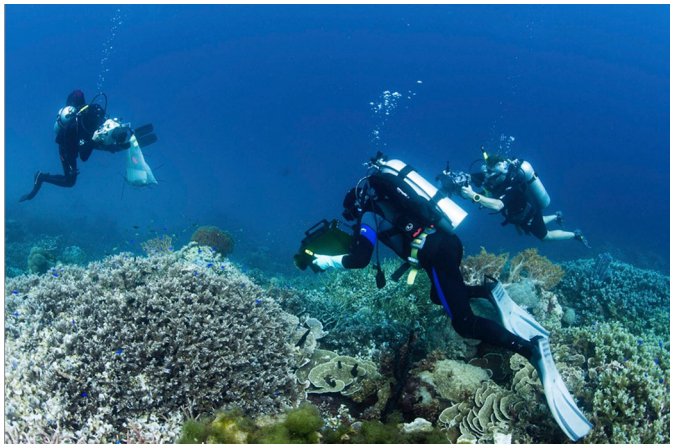

Roger Hanlon (centre) filming with the HyperSpectral Imager while diving in Raja Ampat in Indonesia's West Papua Province. Photo credit: John Pierce.

some water was blown forcibly on my stomach; this totally shocked and scared me. I turned around, came back and looked into the depression, but I couldn't see anything except coral. Finally, I saw a slight movement and it was the funnel of a sizable octopus in beautiful camouflage. After about 5 min, it just got up, moved about 2 feet (less than 1 m) away and camouflaged again. It disappeared in front of me. I was hooked for life right there and then. I couldn't imagine how that animal could vanish in plain sight, not 3 feet away. I'm still trying to figure out how they do it. That inspired a lot of my work throughout my career.

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How did you learn to do research underwater?

I had great biology mentors, but no one taught me how to work efficiently underwater. For the most part I learned that on my own. However, I was strongly influenced by Patrick Bateson at the University of Cambridge, UK, where I did my postdoc with Martin Wells. Pat was a pioneering ethologist, he published widely and he taught me the basic principles of how to collect animal behaviour data. Then I applied those land-based ideas of how you accumulate quantitative data, behavioural data, to my diving years later.

Can you take us through how you would approach doing a behavioural experiment underwater?

I start out with a purpose for the dive; that could be: 'I want to see how an octopus forages, how often it camouflages and how effective camouflage might be as predators approach from different viewing angles'. First, I find a diving locale where there are enough octopuses and I dive with a digital camera, so I can acquire a lot of data quickly and see what I have filmed immediately. I image animals under natural light – I don't use artificial light – from the four points of the compass, before I move up and view them from a 45 degree oblique angle. Finally, I swim slowly over the top of the animal and go face down, to imitate different predators; porpoises come straight down, barracudas come in at 45 degree angles, groupers come in horizontally. After I have gathered those image sets, I go back to the lab and analyse them to see if the camouflage pattern and the colour were effective from all angles of view.

The key thing is to make sure that you are not influencing the animal's patterning or its behaviour. It takes immense patience to learn the behaviour of the animal. Some cephalopods can be approached very quickly, others take hours or even days. For example, I have studied the giant Australian cuttlefish (*Sepia apama*) in southern Australia over an 11-year period and these animals aggregate, up to 180,000 cuttlefish all in one spot, spawning. They pay no attention to you, so you get camouflage behaviour when they're not spawning and you can also film and quantify the dramatic sexual selection interactions between the animals. It's really marvellous. In contrast, *Octopus cyanea*, known as the day octopus, is one of the most interesting and sophisticated octopus species on the planet, but also one of the hardest to study, because it is wary, wily and shy, and it lives on well-developed coral reefs throughout the Indo-Pacific. It's really hard to find and it takes a lot more time to acclimate to the presence of a diver. I might go down on a single dive, find an animal in its den if I'm lucky and just stay underwater at a distance watching until it eventually starts to move. But sometimes the octopus is patient, nothing happens, and I run out of air.

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I also work with citizen scientists, who, along with local guides, help me to find animals. For example, *Octopus vulgaris* in the Caribbean is one of the best camouflage octopuses, but it's relatively shy. Once we find a den with an animal in it we wait until the next morning and then place divers 16–26 feet (5–8 m) away. Then we just sit and wait until the animal comes out. If it doesn't, another dive team comes down after an hour and replaces them. When the animal finally emerges, their job is to wait until it sees them, habituates to their presence and begins to forage. Then they send a buoy up to the surface and we go down and follow the animal at a distance, filming it and quantifying its behaviour as it forages naturally. That's a typical day's study and we exhaust a lot of divers; they get cold and bored when nothing is happening.

Do you have one dive buddy that you typically dive with or can you buddy up with any good diver?

My first preference is to have a very small team: myself and an assistant. That assistant has to be an experienced diver that I can trust. I demand to see their logbooks and they need to be knowledgeable and preferably a biologist who studies these animals. They also have to be vigilant and stay behind me, so that the cephalopod only sees one big object, not two. It's hard to get people to do that. When we're diving, my assistant holds the equipment that we need and when I give them a signal, I cautiously pass the small camera that I started out with behind me to them – so that the octopus doesn't see what's going on. The assistant then gives me the big video camera for behavioural sequences, or I might ask for a spectrometer to take colour readings. Sometimes if I'm busy fixing a camera, that person has to keep their eye on the target cephalopod, so the teamwork is very tightly linked.

What are the key pieces of equipment that you take down with you on dives?

A camera is my main instrument. Today's digital cameras can acquire high-resolution still images and they can switch and go into 4K HD video. We have also designed and built a prototype

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HyperSpectral Imager, which is scientific jargon for a camera that will record many colours in every pixel for colour data; not just red, green and blue like a digital camera. In the visible spectrum, from 400 to 700 nm, there are 300 colours technically, but human cone receptors are based generally on red, green and blue peak sensitivity; we 'see' other colours thanks to our visual cortex mixing those up. Standard digital cameras can't perform such sophisticated calculations with only three colours. Our hyperspectral camera is 'colour rich'; it has 16 colours in every pixel, which are spread across the visible spectrum and a little into the ultraviolet, because some animals can sense UV. But it's a big, bulky, expensive instrument that is not ergonomic and it's not high resolution. We use that camera to learn how colours look to animals with different visual systems under natural light conditions. For example, a fish with trichromatic vision (three photoreceptors that might be all in the red end of the spectrum) will have different colour perception than another fish species with only dichromatic vision (perhaps two photoreceptors tuned to the blue end of the spectrum). In each pixel we remove the 13 (of 16) irrelevant colours for the trichromatic fish and 14 of those for the dichromat and begin to process how different a colour-camouflaged prey might look to each predator.

Have you learned to think like an octopus?

This really gets to the key of it and my answer is a strong and enthusiastic, yes! Going underwater enables me to immerse myself into that animal's sensory world, which is a key to understanding ethology. You have to be where the animal interacts, you have to know and understand their sensory capabilities, only then can you begin to understand the animal's behaviour. Field work is the key thing for me, because then you can begin to understand how animals operate from day to day. My lab experiments are almost all developed and inspired by my fieldwork, which is known as sensory ecology. Once you go into their environment, you view their behaviour in a different way, you begin to understand why they're doing things that may at first seem counterintuitive. Diving down quickly, taking a bunch of pictures and dashing up again is not the same as spending a lot of time with them and understanding that an octopus doesn't see what we see. Octopus, squid and cuttlefish do not have colour vision, but they can see polarised light, which we can't see. Yes, they have very good visual acuity, yet they can also see in moonlight or starlight, when we're totally blind. What the world looks like to those animals is very different.

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What tricks do you use to extend dive times?

We breathe Nitrox, instead of breathing standard air, which is 78% nitrogen and 21% oxygen. Nitrox goes up to 32%, or even 36%, oxygen. That cuts down the amount of nitrogen, which can cause decompression sickness when it gets into your system and is why you have to decompress before surfacing after longer or deeper dives, because it doesn't come out of tissue and blood quickly. Breathing Nitrox allows you to spend a longer time on the bottom of the sea without decompressing. Another thing that I do is wear dry suits almost always, even on coral reefs. Most people think dry suits are just for cold water, but I sit still for so long and spend such a long time on the bottom that wetsuits can't keep you warm. Using dry suits on coral reefs looks odd, and I get some snide comments from other divers, but then I'm underwater much longer than they are and I can get more data. Commonly I can stay down for 90–120 min in 20 feet (6 m) of water and be warm enough to do three or four dives a day, although doing three 90 min dives per day is exhausting. See how well you sleep after that!

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How has the marine environment changed over the course of your career?

In my experience, the major thing that has changed is the amount of dead coral, coral degradation and bleaching. There are large tracts in the Florida Keys where I learned to dive that no longer have live coral. There has also been a lot of coral degradation throughout the tropical oceans where runoff and human activities pollute the water and dredging affects coral health. And that's combined with climate change. People also used to do thoughtless things like drop anchors on coral reefs and damage the corals. There are some places where corals are coming back, but it's a slow process and mostly in remote locations. Also, it is well demonstrated that seagrass beds and estuaries have also been altered by human activity, such as freshwater runoff that's loaded with salt from roads in the winter, homebuilding too near the water and people using pesticides and too much fertilizer. Those things all affect nearshore waters. Kelp forests are suffering too and plastics are everywhere. We were in Raja Ampat in 2019, a very remote part of Eastern Indonesia with some of the most pristine untouched islands in the world, and you even find plastic on many reefs there. It's very alarming to me, and other stewards of the oceans, who realize how much we need and depend on them. Things are not good underwater.

What is your best field experience anecdote?

In 1997, I had a citizen science project going on to study octopus behaviour in Grand Cayman Island. I was following octopuses to study secondary defence, which is what an animal does once it's been detected and predation is imminent. I would 'attack' an octopus by swimming as fast as I could to it and jam my camera right down to it, like a big grouper descending on it. I was filming the whole sequence to find out how many patterns, postures, manoeuvres and inking they would perform. I was following an octopus that I had 'attacked' four times in the course of 45 min. On the fourth 'attack' it swam off, but I could still see where it was more than 30 feet (10 m) away. I was totally out of breath, so I rested for a moment and it got behind a little piece of coral; we were playing hide and seek. I took a few breaths and decided to come in from the side, super slow until the video camera was only about 5 inches away from it, but the animal was momentarily indecisive and didn't react. It stayed camouflaged until the dome port was just a couple of inches away and then suddenly blanched bright white in my face and took off. I literally screamed, 'wow!'. I was looking through the viewfinder and it surprised me; it was visually stunning. That video (https://www.youtube.com/watch?v=JSq8nghQZqA) has gone viral on the web many times over 20 years. People still get surprised by it and that scene explains without a single word how phenomenal these animals can be. The octopus had made a decision and flashed white to threaten or startle me. These

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animals can do that within 200 ms to startle the approaching predator and make them hesitate. Camouflage is not a reflex, it's a decision-making process and the animals are doing it up to 200 times per forage, which is a surprise key finding. We still have a lot to learn and appreciate from these strange and marvellous creatures, no matter how inconvenient or uncomfortable the field work conditions may be.

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

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