INTERVIEW

DR. ROGER HANLON

BY RHONDA MONIZ

Dr. Roger Hanlon is one of the world's leading experts on cephalopods. Hanlon works out of the Marine Biological Laboratory in Woods Hole, Massachusetts. While seen here obs erving a cuttlefish (above), examining his video footage (right), and preparing a subject for testing (far right), Hanlon is one of few scientists at the MBL who does most of his research in the field.

PHOTOS BY ETHAN GORDON

Try to guess who I'm about to describe. He is an academic type, a college professor turned researcher. From time to time he packs up all of his adventure gear and heads off to far-flung regions of the earth in search of knowledge. He is cool under fire and has found himself in quite a few dangerous situations, yet he has come away without a scratch. Would you guess Indiana Jones? I would have. However, I'm describing Dr. Roger T. Hanlon of the Marine Biological Laboratory in Woods Hole, Massachusetts. While most of the researchers at the MBL spend all of their time in the lab studying marine specimens down to the molecular level and beyond, there is one researcher who is more of an Indiana Jones. In stark contrast to his fellow researchers, most of Hanlon's research is conducted in the field. He regularly packs his bags to head off in search of knowledge, specifically knowledge pertaining to one of the sea's most intelligent and invisible creatures—cephalopods. His expertise on this subject is well sought after. If you are like me and regularly watch the Discovery Channel and National Geographic Channel for underwater programs, then you've probably already seen Dr. Hanlon. He is a regular guest and cameraman for shows relating to cephalopods.

I was fortunate to catch Roger, as he prefers to be called (he hates being referred to as "Doctor"), at his lab. He was preparing to leave the very next day on an expedition to study cuttlefish off the Australian coast. Scientist, filmmaker and don't forget adventurer, Hanlon has traveled the world on a quest to study the many elusive species of cephalopods. From following octopus in the Caribbean, to engaging in tugs of war with 100-pound Humboldt squid in the Gulf of California, and chasing the elusive colossal and giant squids, Hanlon knows his cephalopods.

FM: Roger, tell us about your specialty?
Hanlon: Behavioral Ecology is my scientific specialty. I study animal behavior, but I do it in an ecological context. What that really means is that I'm not interested in the behavior of an animal just to study its behavior in a laboratory. I want to see how it works ecologically. How it works relative to getting food, avoiding predation, finding mates, and reproducing.

Most of my work has been with cephalopods. A cephalopod is a mollusk. It's related to an oyster, a clam, a whelk, a conk, whatever you want to call them, all those shelled mollusks. The cephalopod is of the class cephalopodan. It means head foot. It's got this weird anatomy where its head is on its feet so-to-speak. It's a very ancient group. The modern cephalopods diverged off and took a different body plan. They got rid of all that shell and all that armor. They evolved this fabulous brain and sensory systems and this magnificent skin. So they don't hide. Their defense is not crawling inside a shell and being protected. Their defense is outwitting the predator and using their color change and their speed. Their closest relatives are clams and oysters. The one cephalopod that lets you see the link is the nautilus. The nautilus has a big, coiled armored shell. That's an example of one line of the cephalopods that has not changed. The nautilus had the first scuba tank in a sense. They pump gas in and out of their shell chamber to maintain their buoyancy and they can draw oxygen out of the air inside those chambers.

> Bright white, high contrast things in a pattern are not thought to be camouflage. In fact, under many circumstances they are.

FM: What made you first become interested in this area? Where you interested in the ocean as a child?

Hanlon: Well, I grew up in Cincinnati on the Ohio River. I guess the green murky, turbid water of the Ohio River inspired me to look somewhere else. My father took me on a trip to Florida when I was about nine or ten years old. We went deep-sea fishing and I never forgot looking over the side and seeing a kingfish being pulled up on a line. I could see it when it was still 30 feet down. I never forgot that.

But the real inspiration came when I was in college and I went to visit my brother who was in Panama. He wanted to get rid of me one day so he took me to the beach and handed me a mask and snorkel and said "don't get sunburned, I'll be back in five hours." So, I jumped in the water and just went snorkeling out on a coral reef. Within 10 minutes I swam over a tide pool that was only three feet deep and something blew water on my stomach and scared me to death. I went leaping right out of the water. I gathered my courage, went back and saw an octopus in a hole. I'd gone right over the top of it and it jetted water on my belly. This one-pound octopus had scared the crap out of a 190-pound college athlete and I thought, "Wow, I really am wimpy," then I wondered, "what's this animal doing?" After about 15 minutes it came out and started moving across the reef. It was changing colors and I just thought to myself, "that's really bizarre." That's what hooked me. I mean just pure fascination, nothing else. No plan. I just saw something that I couldn't get over. Eventually I went on and finished a biology degree in college and went into the Army for a couple years and traveled around the world diving myself into oblivion. I finally went to grad school to study octopus color change and behavior.

FM: Please tell us a little bit about your specific areas of interest with regard to cephalopods.

Hanlon: Well the one thing that has persisted is my interest in this color change system they have. They don't have a "poker face" so-to-speak. They show some kind of pattern for almost every behavior they have. That's certainly a different way to conduct your life. That means you have to have changeable skin and pattern. You have to have good control of it. They use it for essentially two things, camouflage and conspicuousness or signaling. Those are polar opposites of course. If you're going to be fully conspicuous the signal has to be unambiguous and easy to see by almost everybody. Camouflage is anti-communication, I'm not there, and you don't see me. They use the camouflage to avoid predators. That's the first line of defense. I'm interested in how that happens and why that happens. The how is a very mechanistic approach of how does the system work. How does the eye get the information to turn the right pattern on, whether it's to signal a mate, to scare a predator or hide from them? The communication side of it is different. I've done a lot of the communication work characterizing how these animals fight, and how they use visual signals to do that. Because they have elaborate fighting displays, visual signaling and posturing do all of the actual fighting. Nonverbal communication is really what these animals do with all their patterning with one another. So I'm interested in that whole system and how it's used throughout their entire lifecycle. They all live in different ecological niches. So every time you study one of those systems, they're always different but I'm looking for the threads, the general principles.

My main thesis relates to how camouflage works. That's what I'm mainly interested in. We all think we know what camouflage is but after 35 years of studying it, I'm sure we don't know what camouflage is. We've discovered a few operating principles that are very different. We're trying to quantify camouflage so that we understand it well enough to be able to predict what an animal is going to show when it moves from this visual background to that visual background. That sounds easy, but it's not, because the visual environments that these animals live in range from brightly lit coral reefs in three feet of water, to deep muddy places, to complete darkness.

We just published a paper showing that, at night, they camouflage differently in every microhabitat they move into. That's stunning because it means that their vision is phenomenally good under what we would call "full darkness" conditions. It also means that they wouldn't go to all that trouble if there weren't visual predators out there who had such good vision that they could see them in those conditions. That was a big surprise to a lot of people, but it wasn't a surprise to me or anyone else who's

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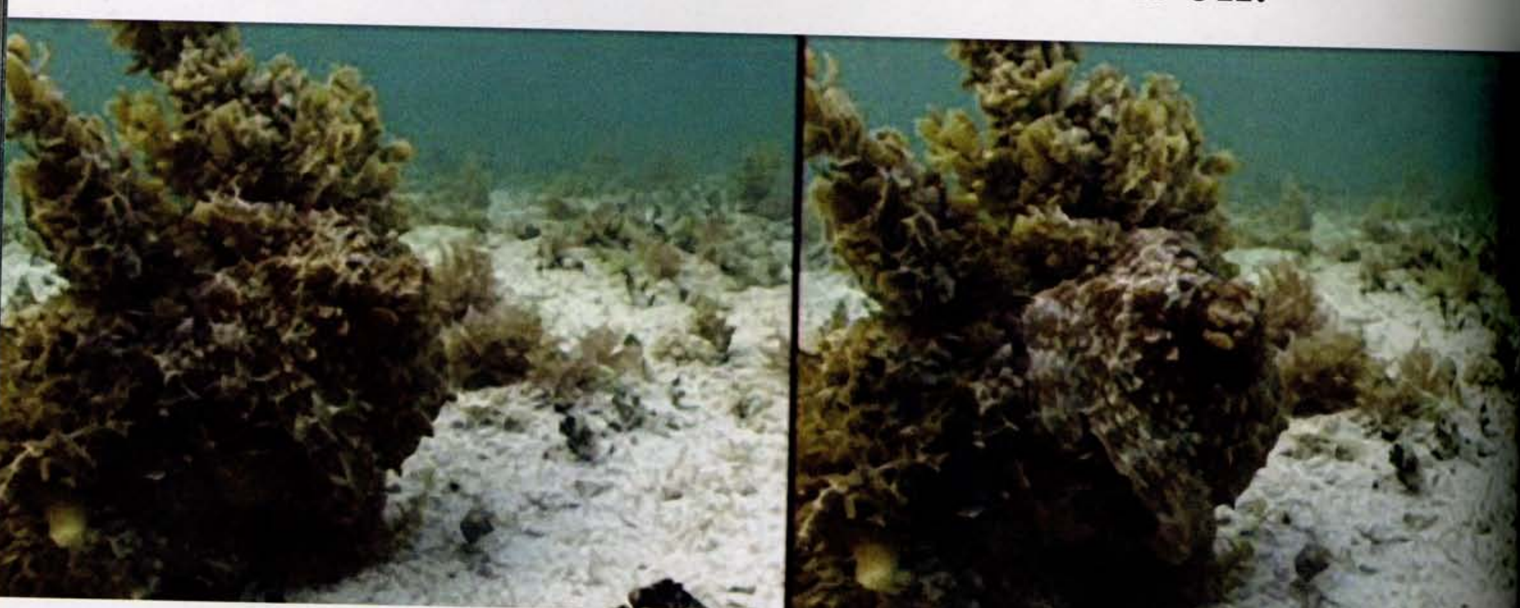

done a lot of night diving because you know there's a different fauna out there. There are different predators, different prey, and they're all moving about. They all have great visual systems that are mainly unstudied.

I'm interested really in the basic principles of how camouflage works but I learned the tricks from the animal group that does all of the change. There's only one animal on earth that has a great diversity of camouflage patterns and does it on every visual background and does it within a second—that's the cephalopods. If you learn how that works then you understand how a flounder that takes seconds or minutes to change and has limited repartees, is going to use the same general principles because the predators all are the same. So as we begin to learn the changeable animals, they've taught us how to study camouflage. That's what the cephalopods have done. It turns out that we're now doing a very broad study about camouflage on earth because if you can understand how many camouflage patterns there are and how it works, it should apply to animals large and small, wet and dry, and that's what I'm doing, I'm gathering images and information on all animals. I think we've begun to understand the universal principles of camouflage in this biological planet. That's the thing that really excites me, that's what has been driving me for a long time. Now we have a lot of experimental and diving data that are showing us how this works.

FM: You are somewhat unusual among scientists in the fact that you do most of your research in the field. With that much time spent witnessing the underwater world, you must have some unusual stories?

Hanlon: Probably the most stunning thing I have seen is a film clip I took in Grand Cayman in 1997. I was following an octopus very carefully, which is to say I was allowing it to habituate to me. I had followed it for an hour. I was interested in what it would do when a predator attacked it, so I took on the role of a predator. I had been swimming fast at the animal many times to get its fast response. I mean, I am a slow predator, but at least I would do it as fast as I could. On the fifth simulated attack I came in extremely slowly. I knew where it was, it was on a rock. As I got close, the camera was almost touching it. It showed the most remarkable thing I have ever seen. It went from totally camouflaged to blanching white, inked me in the face and swam off. That one clip showed me the full range of dynamics of what the animal was doing. When you play it in slow motion and especially in reverse, you begin to see exactly what the animal is doing to match the pattern and background three-dimensional texture, brightness and color. It was a surprising thing. I literally screamed under water. I knew I had gotten something that was one in a million. It has launched a whole new set of programs. I think that is the most stunning thing I have ever witnessed and it came through persistence and the approach. The technique was everything.

The second thing, and it was very close, was diving in the Gulf of California with the Humboldt squid, which is one of the big ones, it gets almost as big as a human. When they approach you it is a very aggressive act. They show this flashing, pulsing body pattern in their skin. It's a frequency of about four flashes per second. Just flashing white, red, white, red, white, red, white, red, the whole animal. It's like a neon light show that's just gone wrong. When you see five or six of these animals and they're all going light, dark, light, dark, light, dark, it just screams aggressiveness at you and some high state of alarm. It's hard to get used to it. I mean you see them night after night and you know these animals are so keyed up when they start flashing and they are so big and potentially dangerous. I know next time I go diving with them that display is still going to scare me. It's something you don't quite get used to.

FM: There are one or two companies now offering recreational dives with the Humboldts, do you think that's a safe activity for recreational divers?

Hanlon: Well, I've said many times we know the Humboldt squid is a very high-level predator. It is extremely fast and very strong. It could essentially grab and consume a diver anywhere it wants with little or no effort. Now that's assuming the animal is quite large. A 100-pound squid could handle a human like an hors d'oeuvre or a pretzel. That's how strong they are. An ordinary squid can take a fish as big as they are and handle it with no problem at all. So I know a squid that big could grab us. In fact, they come up and grab divers and their equipment all the time.

On the first night we saw one, we did a giant stride off the back of the boat. I had a video camera and Brian Skerry had a still camera. As soon as the bubbles cleared Brian was screaming bloody murder. In midst of all the bubbles, the squid rushed up and grabbed his camera. I saw Brian in a tug of war with this squid for his $30,000 dollar camera equipment, and he wasn't going to let go. It was a really amazing moment.

So they come up, and when they do they are very inquisitive. A lot of their sensory capabilities are in their suckers so they grab something in order to get the taste and the texture. They are sensory sampling this strange diver and his equipment. So far that's happened to every diver that has gone in with us. They've been touched or gently grabbed by the squid or they have had a tug of war to keep their equipment. But the capability to be taken by one of those squids is definitely there. I think it is.

Brian said it best when he said, " I just finished a shoot with killer whales, but nothing scares me like these big squid." And me either, they really are scary. I have seen them just tear something apart and swim away. These Humboldt squids petrify me. The one thing we saw that was the most psychedelic thing underwater was when we were floating at about 20 feet at night in the pitch dark off the coast of Baja California. These animals hate the lights, so for Brian to get a few still pictures we had some video lights and we turned them off. Just sitting out there at 10 to 20 feet. The water is very deep. We were miles off shore. Our eyes acclimated after a while. The boat light was dimmed so there was just a faint halo of light and we patiently waited for the squid to show up. Then, looking straight down, I saw these illuminating patterns in the water. I didn't know if it was an illusion or not, because it was such a weird visual field. I suddenly saw some white trails. They just started getting bigger and bigger and all of a sudden they stopped. As my eyes acclimated I realized it was five very large Humboldt squids that had shot up from probably 100 feet. As they came up they were pushing a wake of bioluminescence in front of them and that's what I was seeing. When the white trails stopped, I suddenly saw these five pairs of eyes. They had come straight up to us. I just couldn't put it all together in my brain because there was no light and form that I was used to. So there we were just sitting there and I was just waiting for one of these squid to shoot its two tentacles out at me. I just didn't know what was going to happen. They just sat there for a few minutes. Brian took a picture or two and then boink! They were gone. We both came up and said "Did you see that?! That was

bizarre." It just fooled my visual system—there's no scale. There's nothing and they were big. I got out of there and said I really don't want to do that anymore. I felt like a little hunk of bait just sitting there.

FM: As far as diving with an apex predator would you rather dive with a Humboldt squid or a white shark?

Hanlon: I think I understand squid behavior better than white shark behavior so I'll stay away from whites. But this brings up a very important point that understanding the behavior of animals

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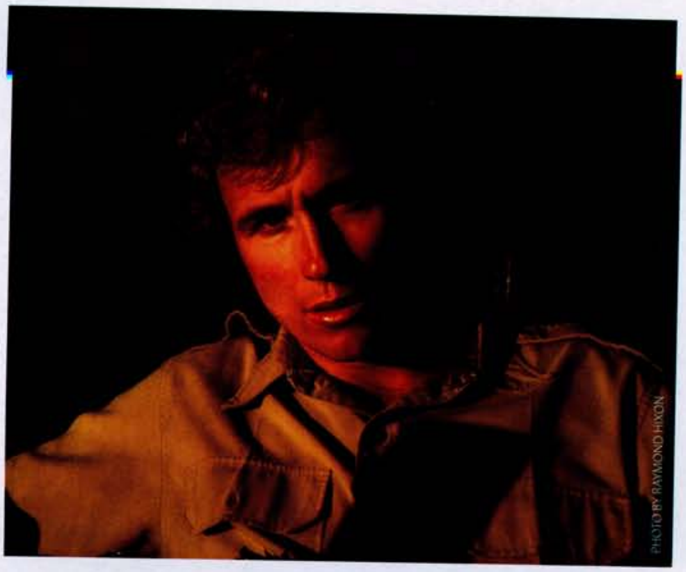
in their environment is key to everything for a diver, filmmaker or a scientist. Because you need to truly study these animals, and I am not talking about reading one magazine article, but really spending time with these animals and studying the published literature and really learning what an animal does. Thirty years ago people didn't jump in the water with a lot of the animals that are being filmed today. Its because there are smart divers now who take the time to really study the behavior of the animal and then step by step they begin to do things like look at the reaction of the animal. That kind of savvy is critical. I think a real regimented study of the animal will help you understand what to do. The other thing is patience. One of the biggest things I have learned through photography and studying animal behavior is to introduce yourself to the animal's environment according to their time schedule and their behavioral needs… not yours.

The type of data my colleagues and I have gathered is very special because we take the time to understand the behavior of the animal and to introduce ourselves to that environment over long periods of time. Then we do what is called focal animal sampling. That's essentially telling you, as a diver, to go underwater, get a calm approach to the animal so it accepts you in that



Portrait of Roger Hanlon taken in 1978.

environment and then follow and film only that animal. You focus on that one individual and get all of its behavior. We know in animal behavior studies that this technique allows us to quantify what any one animal does but we also get those rare behaviors. There is a lot of down time. It's a very disciplined thing to do and very hard, but that's made a huge turn around in our scientific productivity. If you do these focal animal studies you tend to get really good scientific data, but it takes forever. What I have done for 15 years is take volunteer groups out. The idea is to have 15 to 18 divers in small dive teams. If we are going to study octopus we find out where the octopus are. We mark their dens and then we come back at dawn the next morning. We know they are day active and still in their den. Then we will put a dive team on a hole and we'll wait at a distance, like a rock that blows bubbles. We wait until the animal naturally emerges. That usually takes anywhere from one to five hours in a given day. The divers wait until the animal comes out and then they film it at a distance. Eventually the animal habituates to the diver and does all its normal stuff. One dive team after another comes and supplants the previous team and then they rotate back later in the day after their surface interval. By using this technique and getting down there to film, we have gotten phenomenal information. We watch one animal for eight or 10 hours a day.

In the course of doing that you quantify what any one animal does. You also pick up those rare behaviors because you don't know when a predator strike is coming. I've used ROVs and things like that a lot, but they can't do this very well. It sounds like an ROV would be perfect for this job, but you've got currents and tethers and it's not the awareness of a diver with a camera. Sometimes we use the ROV to be the diver's partner— to augment one another. The key thing here is we tend to dive almost exclusively in shallow water because that gives us nearly unlimited bottom time, which we need to get this kind of rare footage. That has really revolutionized our approach and it is why, if you look at the papers we have published, we have made a lot of discoveries by leaving the human convenience factor out of it and going to the animal convenience side of it. We have enormous patience and that has paid off very well. This is no different than a good nature photographer who goes into the middle of nowhere and follows animals day and night.

FM: Have you thought about using rebreather technology to extend your depth and continuous time underwater, and to be more stealthy?

Hanlon: We tested rebreathers for behavioral things all the way back in the seventies. I think rebreathers do have some application, but I have been able to do fine without them. The habituation process is different for every species, every single one. The place I am going in Australia with these giant cuttlefish, they couldn't care less. You could get in the water and beat them over the head and they would just go back to their behaviors. They are in a spawning aggregation so they are there for fighting, mating, egg laying and all the rest. Whereas you go to the coral reefs of the Caribbean to study the reef squid, you had better have a huge amount of patience and the approach is entirely different.

FM: What is it like working with giant and colossal squids? That has to be pretty awe-inspiring.

Hanlon: What's awe-inspiring about it is if we get any glimpses of natural behavior that's going to be pure discovery. That's the excitement. That's what drives all biologists I think, is the discovery. That's what drives me. With that said, these animals have to be about the hardest animals to study because they are down deep and it is very hard to find them. Colossal squid have hardly ever been seen. I think that species is particularly hard. The giant squid, Architeuthis, is mainly known only because they have a weird buoyancy mechanism. Nautilus will pump air into their chamber to go up and pump it out to go down. A cuttlefish will do the same with a cuttle bone, which are negatively buoyant all the time. Architeuthis (or the giant squid), which mostly live from 3,000 to 5,000 feet down, regulate their buoyancy differently. Instead of blowing gas into some kind of container or chamber, what they do is pump ammonium chloride into their muscle tissue, which creates some buoyancy throughout their musculature. When the animals die there's this funny catabolic thing that happens that pumps ammonium chloride into their muscles. The dead ones will often float to the surface instead of sinking. That is how all the specimens have been collected. All we know about these animals is this big

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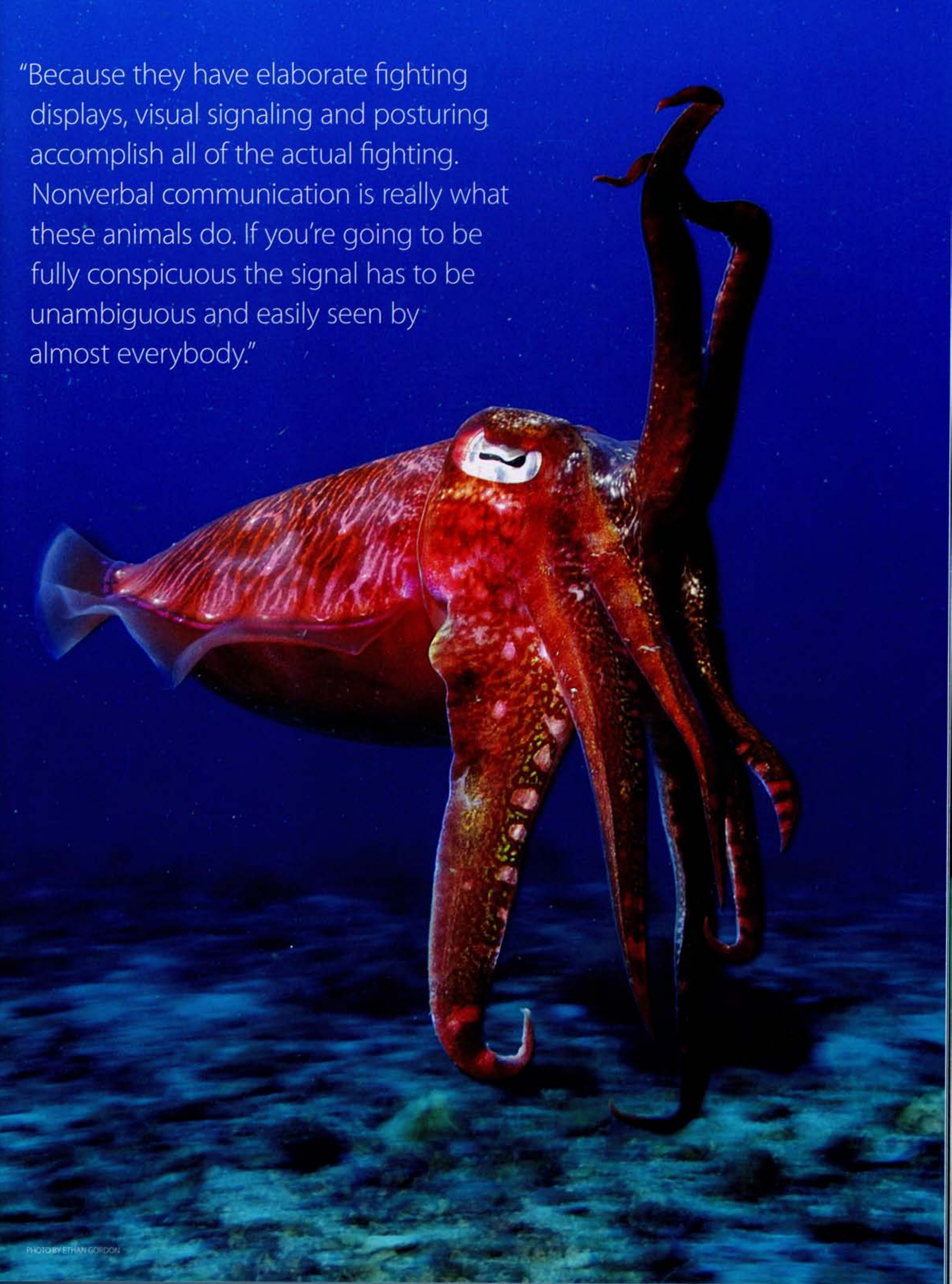

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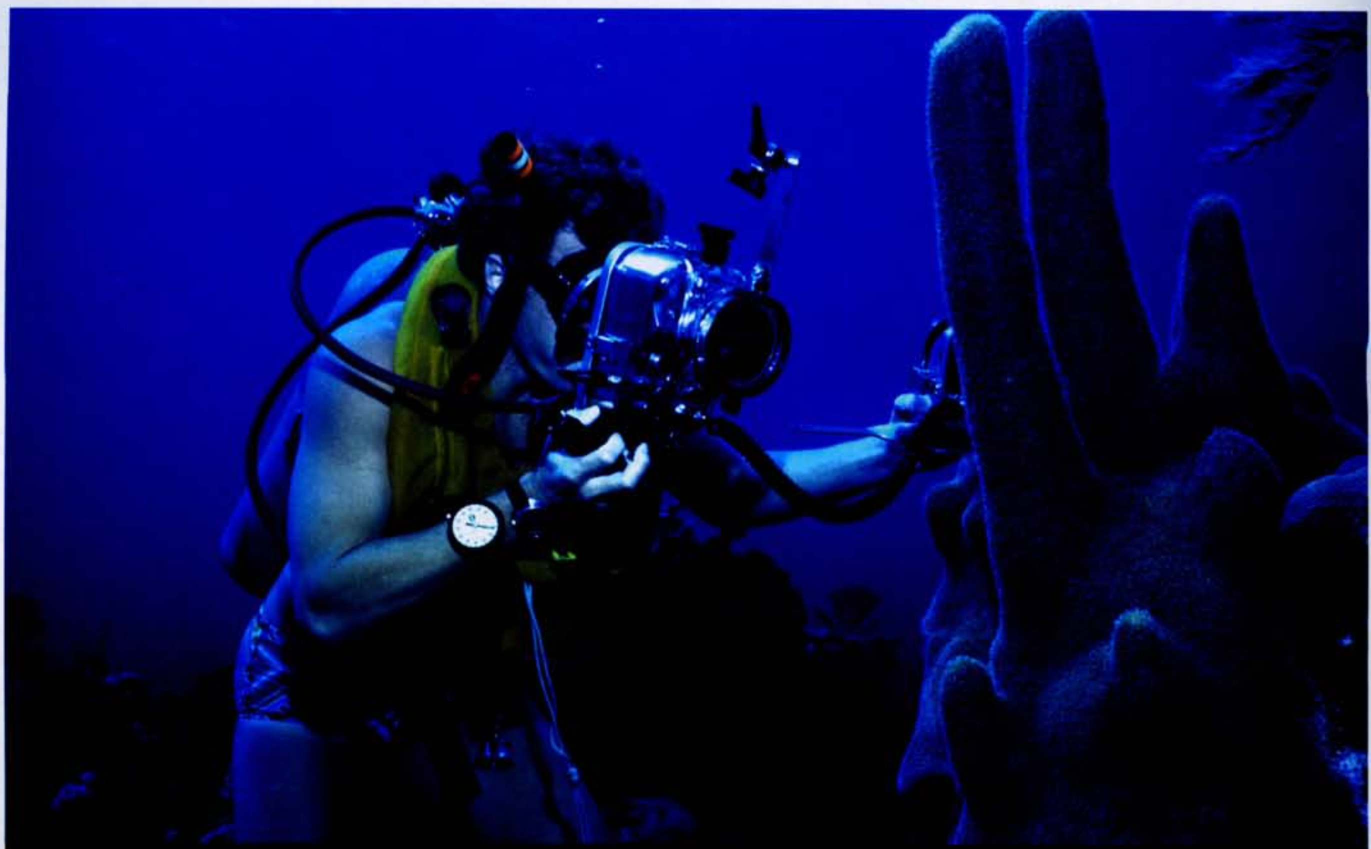
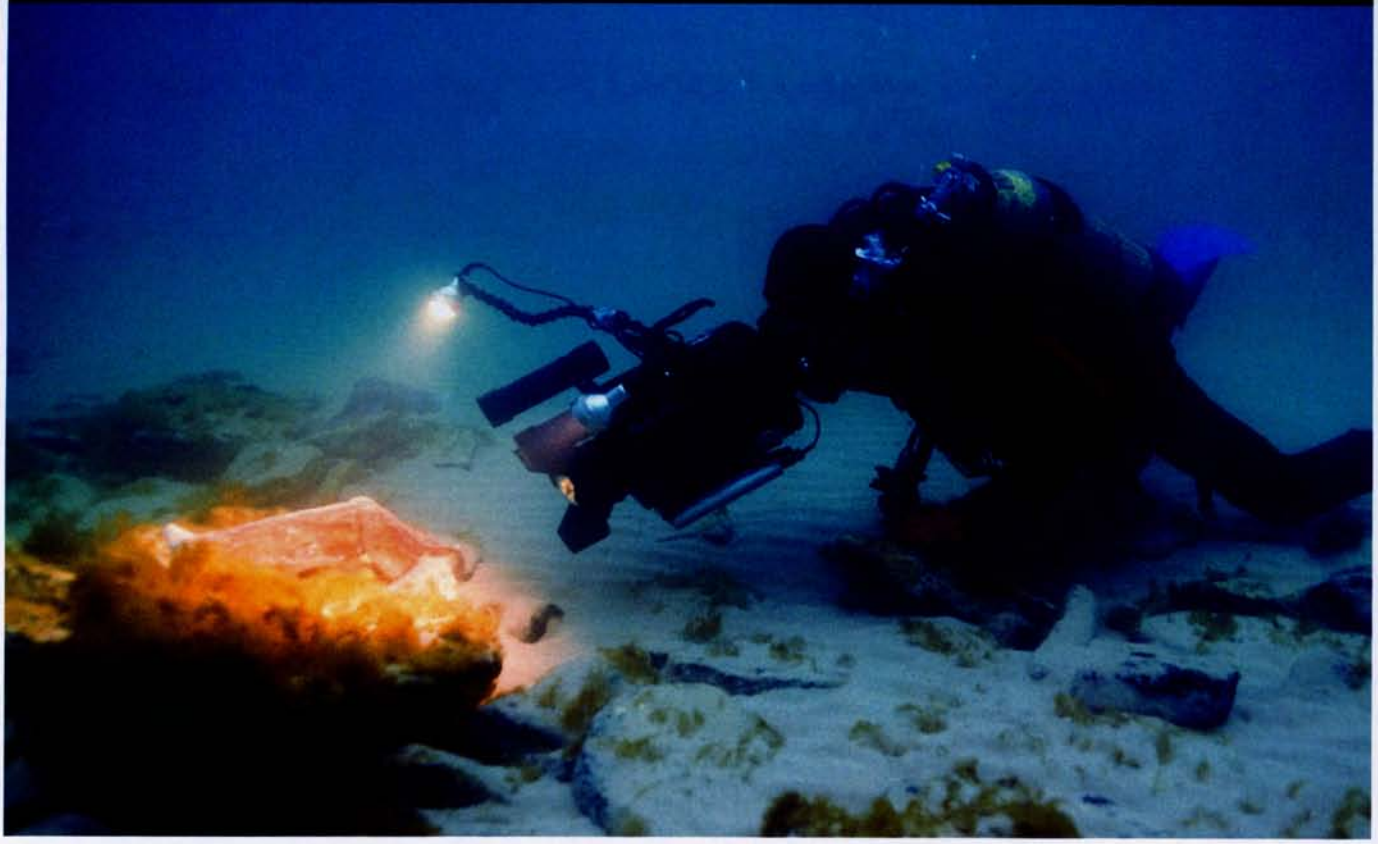


Roger does most of his research in the field. Above, he is seen photographing pillar coral in Roatan, Honduras, 1975. Below he is filming in South Australia in 2006 with his high-def video system. Unusual for his research, he is using lights here. Normally he captures all natural-light footage to simulate exactly what the predator's eye would be seeing.



stinking hunk of ammonium chloride. It's like calamari that's gone bad. You get the whole animal but the retina is totally gone. The animal tissue is still there, but of course the fishermen then throw them on ice because that is the only means of preservation they have and that just destroys every cell in their tissue. You can't get any data off that. So what do we know about giant squid? Very little. We don't know much about its eyes or it's behavior or almost anything. It is all just wild speculation. We know even less about the colossal squid that is even bigger.

FM: How do you feel about the collection methods of baiting these animals?

Hanlon: From a scientific viewpoint you have to get these animals in view in order to study anything about them. The idea of putting an odor out there is one way to attract them. I don't have any problem with that unless it gets too widespread. If people want to learn about something you've got to get to the animal, so putting out a chemical trail takes advantage of their olfactory capabilities. A lot of people have put other things underwater to take advantage of their reaction to visual prey. But then people are guessing at how that works. They are putting all sorts of bioluminescent patterns out there assuming that the animal will be attracted to some prey organisms with a certain bioluminescent signature. I think it is the only avenue these scientists have to visualize these animals. It is more important to me what they do afterwards. If you want to learn about an animal you have to have some tissues, some video, something to go by. I think getting a few animals in order to learn about them is fine. It is what happens in human medical studies as well.

FM: I know in addition to being a scientist you are also a filmmaker. How do you feel this medium has helped or had impact on your research?

Hanlon: Video is a technological gift to me. I study animal behavior, which comes in streaming sequences. For years I tried to study animal behavior with a still camera and you may get a little bit but you mainly don't get anything. Video as a tool is a much more functional device. It has revolutionized how animal behavior folks do their studies. Video to me is wonderful and digital video is particularly useful because it is easy to take frame grabs and now with high definition I can take a frame grab that's a two-mega-pixel image. With that resolution it is high enough quality for me to then put it in my scientific paper and that's what I do. That is tremendously important to me. I can use the same camera in the laboratory to do behavioral studies. Each of those frames we take has real data in it.

In studying camouflage you have to have as much resolution as possible because you would like to equal the visual acuity of the predator so the digital cameras—both still and video—get higher resolution. It's absolutely wonderful because you can take the film grabs and use them as you like, or take the video sequences and analyze them statistically in the sequential data. So as a tool, video is phenomenal. Biologists and scientists have learned that. People are using it for every field that there is. For me in studying animal behavior and the skin, video has revolutionized it all. The jump from mini DV to high def is a quantum leap in capability in the sense that you are getting five to six times as many pixels per frame. You have much more information you can pull out of each image. Video and photography in the last fifteen years has changed how I study animal behavior.

FM: Through your studies you have developed a theory on camouflage in which you break camouflage down into three different patterns. Could you explain how that works and why it is so ground breaking?

Hanlon: Cephalopods are the only animal we know that can go anywhere in its natural habitat and camouflage itself. It's got good diversity and it's got a cool capability. But, the speed with which they do it is stunning because they can make that decision of how to look against any visual background and they can do it within milliseconds. Within a second and at the most within three or four seconds, they can camouflage on any visual background we've filmed them on... and that's a lot. So the question is how do they do that quickly and is there some other underlying principle there that helps explain camouflage patterns for any animal. The answer simply put is that these animals have magnificent eyes. First of all they have huge brains. Two thirds of the brain is optic lobe. So that's what we'd call a visual animal. It's doing a lot of visual processing in the central nervous system. With those large optic lobes, they're taking all that visual information and they're making this very rapid decision. It took me decades to figure this out, but I think they don't have enough brain or computing power to look at any visual scene and really analyze it carefully. If they did they'd be all brain and there wouldn't be room for a body. So they haven't done that. I reason that they are looking at complex visual backgrounds and they're picking out just a few salient visual cues to make their decision about which camouflage pattern to put on.

The second part of the story is that by analyzing tens of thousands of pictures it finally dawned on me back in the late 1980s when I started to analyze a huge data set, that there aren't 10 or 15 or 20 camouflage patterns which you might think when you start looking at 10,000 images. It dawned on me that there are only three pattern types—sort of a general template upon which there's a lot of variation. But the pattern template is what's key here because if there are just three pattern templates, it means that all these visual predators are being fooled by just three basic tricks. Yes there's a lot of variation on a theme but what's

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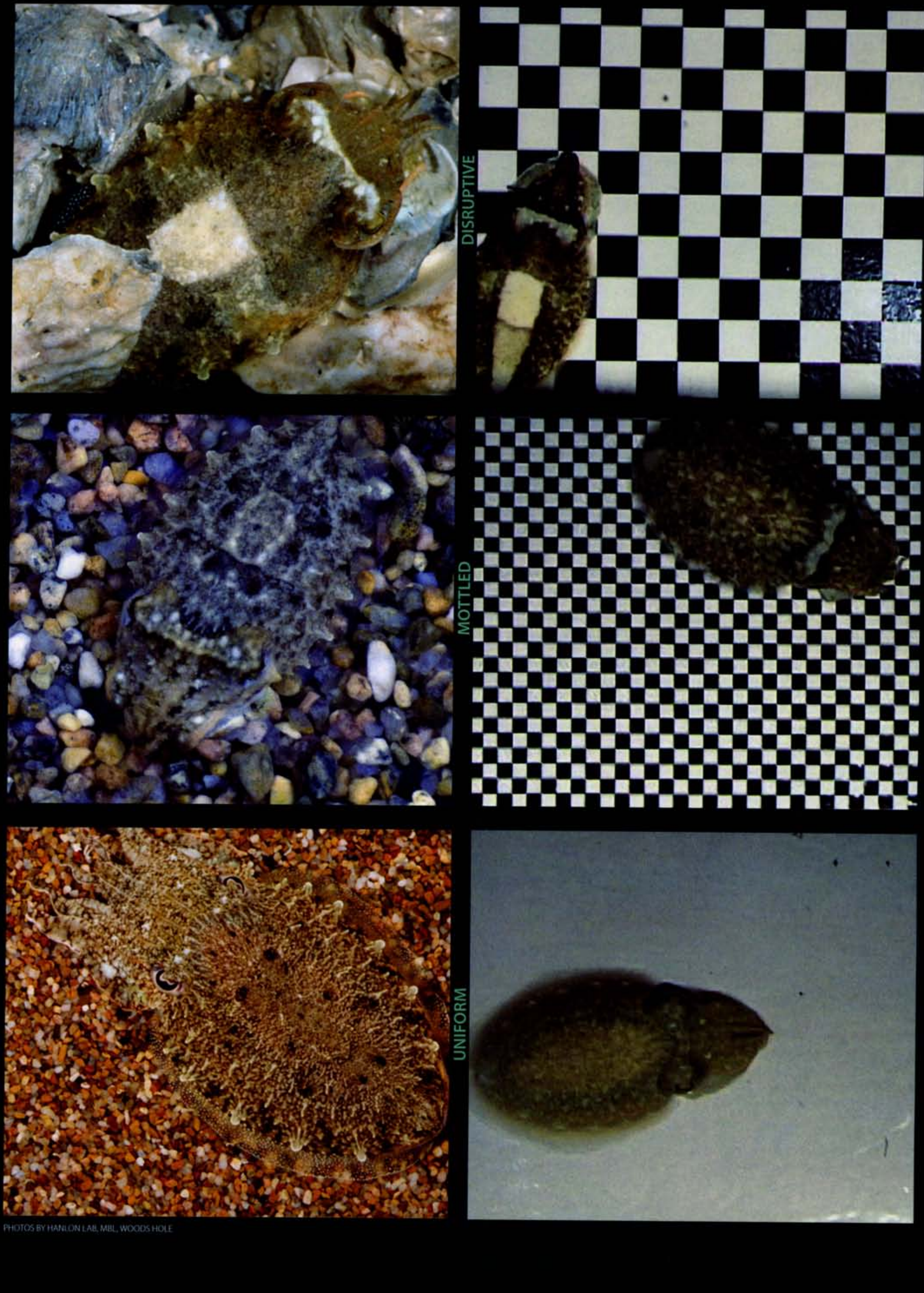
the main trick that's happening? That's what I'm after. So we discovered that they have three patterns: a uniform pattern, which means uniformly light or uniformly dark, defined as no contrast or little contrast; a mottled pattern, which is small-scale light, and dark splotches or mottled and there's some repetition of that pattern; finally there's disruptive patterns, which are very different. When shown against an inappropriate background a disruptive pattern looks like a computer video game that's gone awry. It looks hideous; it doesn't look like camouflage because it's made up of large-scale jigsaw components of very high contrast; light and dark shapes of differing size and orientation. Some are transverse, some are longitudinal, some are square, some are round. You look at that and you go "wow, what's this animal doing?" You put it on the right visual background and it just vanishes. So, we've settled on these three pattern types.

Okay, so that was a discovery. That means that the animals really only have three basic choices to make in visual backgrounds and they still do it quickly. Now it makes the problem more manageable. I reason they're not going to look at their entire environment and try to analyze all that optical information. They're going to look perhaps for one visual cue that says go uniform. Now that's a simple algorithm in a computer. If you see uniformity, you put on uniformity. Now you have the pattern in place, that's quite easy. You do have to adjust the brightness and the color, but they do that. To go to the mottle, they have to pickup another visual cue. Maybe it is small-scale light and dark like gravel with a certain contrast range and then they duplicate that in a way. The key here is that uniform and mottle patterns work by the visual trick of what we call general resemblance. It's what you traditionally think of as camouflage. Blend into the background by looking a lot like it. That's most people's definition of camouflage. Of course there are many features of camouflage that have to be matched that make it quite hard, contrast and edges and all that. Disruptive coloration works by a different trick. This is where it gets hard to understand. Disruption is meant to disrupt the recognizable outline or shape of the animal. It particularly draws attention away from the edge in the outline. If you look at an animal in a disruptive pattern, it might even draw your attention to parts of its body, like a cuttlefish puts a white square in the middle of it's back which we call a foveal trap. Your fovea (part of your retina) will pick up that high contrast white thing right there. A predator's vision is attracted to that. By being attracted to that, it's distracted from the real outline and the shape and the recognition of the animal is no longer there. If predators use search images to find prey, then you can overcome the search image technique one of two ways. You can create things that attract their attention so that they don't see the cuttlefish in this case and the second thing that you can do is if you happen to be moving—movement gives away camouflage —then you can change your appearance often so that picking up a search image becomes difficult. We actually measured this on octopus on coral reefs in Tahiti and Palau. We found out that when octopus are out in the open they're truly camouflaged and motionless only half the time, sometimes even less. The other half of the time they have to move. But when they move, they don't even try to be camouflaged most of the time. They change their pattern, their appearance and their shape 170 times per hour. If you were going to develop a search image and something is changing 170 times per hour you might have a tough task in front of you. Disruption helps in all of that.

So it turns out that the second part of the story is we've got three pattern types that all the cephalopods use. Two of the pattern types work by general resemblance of the background. One pattern type works by disrupting the outline and doing a little general resemblance of the details. Disruption is a very new and different idea and it's counterintuitive to most humans because when we show them the pattern, they look at it and they laugh. They say that couldn't possibly be camouflage, but I can show them hundreds of ways in which it is. Bright white, high contrast things in a pattern are not thought to be camouflage. In fact, under many circumstances they are. Any time you look up towards the light where you get a lot of brightness and shadows everything goes high contrast. It can disrupt a recognizable shape. A panda bear is an ultimate example, or an orca. These animals are bright white and black. Imagine an orca being viewed from below against a bright sky. The white part of their pattern will blend in to the bright sky and the black part will look like disjointed black odd shapes that do not in themselves represent an orca. A panda bear is the same way. Panda bears are arboreal and so looking up towards a panda bear against a bright morning-lit sky with lots of deep shadows is very hard on visual systems. You cannot see a bear any longer. The question is, "can you really fool all these visual predator systems with two tricks and three pattern types?" General resemblance works for uniform or mottled backgrounds and disruptive works for the rest. That's my thesis.

I got these ideas by diving and being in the natural habitat and spending a lot of time. It's fun for me to go underwater and just sort of stop and think for a while. Just watch really carefully. I don't want to go deep. I don't want to go fast. I don't want to do any of that stuff. I just sit there and think, "If I were a visual predator, what would I look for and if I were a yummy hunk of protein called an octopus what would I do to prevent being



PHOTOS BY HANLON LAB, MBL, WOODS HOLE

eaten?" If I understand which visual cues they use, I should be able to go back underwater and predict what an octopus, cuttlefish, grouper or flounder will change to on different backgrounds.

I'm studying groupers right now because they are big animals that use disruptive coloration, and they can also change to uniform and mottle. When a grouper or octopus moves from one microhabitat to another, I should be able to predict what pattern it will put on. That's a really hard problem. The only way I can see solving it is to know what the single set of visual cues are and I should be able to pull them out as well as an octopus eye does. We're not to that stage yet, but that's what I'm trying to do with my diving.

I have a grant to do the diving work and I'm using video to follow animals as they move very slowly at their pace across the bottom. This way I have an empirical record of what's in front of them where they're going, and then what the animal finally looks like when it gets there. I can begin to match those up and see if I can figure out which visual cues inspire them to change.

I'm gathering empirical evidence underwater to do this, but I'm learning what cues to look at from lab experiments. It's going to be a long process, but if I can match that up, this is what ecology is all about. You should be able to predict how the system will behave with different influences. When you get to the predictive stage, you know the system. That's what I'm after. It's the Holy Grail. I'll never figure it out before I leave this earth, but we now have a framework to go forward and take a complex subject, look for three basic things and test it.

FM: With all of your experience following these cephalopods, you must be better than most at finding them down there. Have you ever been duped by one of your subjects?

Hanlon: Well three years ago we were in Saba (in the Caribbean) and we found an octopus we began to study. Each day we came back and it was more or less in the same hole. We would wait until it would come out, and we would follow it. Well I got up one day and I had two assistants with me. One was a local dive master and another was a very experienced diver. They were instructed to stay behind me and stay out of the visual field of the animal. Their job was to hand the camera and spectrometer to me when I needed them. So, I'm following this animal with the cameras and I'm just sitting there. The octopus is right there (he motions a few feet in front of him) and I'm photographing it. Suddenly, the camera stopped working right and I looked down to adjust it. As I looked up again, I couldn't find the octopus. I was just sitting there looking and I was saying to myself, "I just put thirty minutes of time on this animal. I don't want to blow this." In an area about 20 feet by 20 feet, the three of us and one other guy from the boat searched and searched and searched. The only

Look closely and you will clearly see the octopus in the frame. Move the magazine slowly away from you and all of a sudden, it will just disappear. This is stealth behavior at its best: remaining camouflaged while moving. We call this the "moving rock" or "moving algae" trick – the octopus holds itself up like a stalk of algae, then assumes the shape and general coloration of the adjacent algae that are swaying in the surge . The octopus even sways the same way and is indistinguishable from the algae as it slowly progresses across the open sand plain.

fortunate thing I did was put my camera down where I had last seen it so we'd know what area to search. After 20 minutes we decided to call it quits. I went back to get my camera and knelt down. I kind of looked one more time and there was the octopus. Right where I had last seen it. We wasted all this time, everyone looking all over creation and the animal was so camouflaged that we just lost it. It was the craziest thing I had ever seen. We went up on the boat and they just started laughing at me, going "hey, you're quite the scientist, man. Your animal is right in front of you and you send us on a wild goose chase. That octopus must have been laughing his ass off. He was practically holding your camera while we used up our air searching the reef." I've never had anything quite like that happen before. They're so good that even when you're looking right at them, you sometimes just can't find them.

FM: Roger, you are very modest, so allow me… you are also quite the filmmaker. Where have some of your films appeared?

Hanlon: It's funny, I don't have a list, but my work has appeared on the BBC, Discovery Channel, and for National Geographic we've filmed the mimic octopus. We did a full half hour special. We've filmed two NOVA episodes. One very recently was just aired about a month ago. I really like working with NOVA. We also did a few things with Readers Digest TV. The thing is, I am down there so much with these animals that I am going to come up with footage that the filmmakers don't have enough time to get. That's the niche. It doesn't hurt that the animals are cool. I have a strong training in photography so I've got that eye. If I weren't a biologist I would definitely be a photographer or a video guy anyway. This is easy for me. It's the only artistic thing I get to

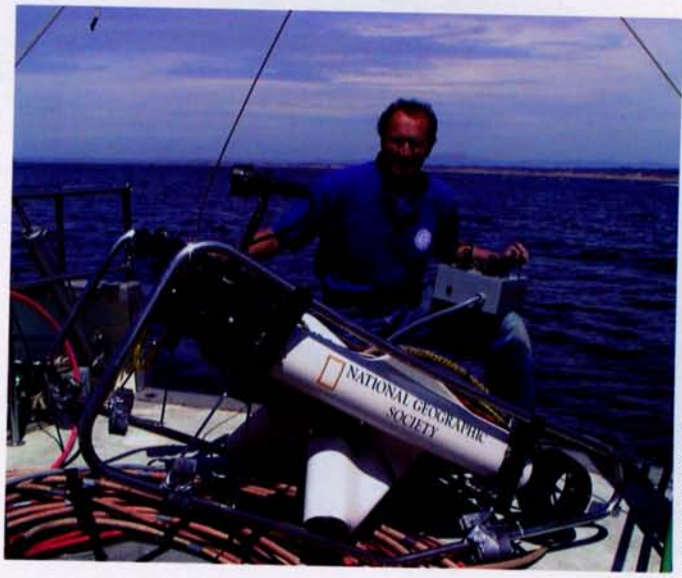


PHOTO BY JOHN FORSYTHE

Studying squid spawning behavior in Monterey, California, with a ROV loaned by Sylvia Earle after the NASA ROV blew its thrusters.

do. Incorporating this into my work is very nice and pleasurable for me. These days I am a bit pedestrian about it because I will shoot b-roll on purpose because I know what segues they need to better sell the stuff. I enjoy my interaction with the media in a bizarre sort of way. It is a competitive field, as you know very well, and I live in a competitive world too. My whole life here is grants and competition because we don't get free money from anywhere for anything. I am good friends with most of the underwater photographers. I know almost all of them. You know they are all scratching and competing for money, so that's the world that I understand, I live in it. I don't think I like it very well, but it's the way it is.

I went through academia, I worked in the medical school at the University of Texas and went through all the academic ranks to full professor and tenure and all that stuff. I left it all. I didn't like it. I came here. I was more interested in doing high-risk research so I was willing to make the leap. That was 12 years ago. My science has gotten better and I am doing a lot of diving. I do 30 to 70 scientific dives a year. I am spending a lot of time in the field, but that also means there is a lot of data on the back end. It's just like putting a film together—it's a monstrous amount of work. I am foremost a diving field biologist. That's really what my strength is. We do experimental things. You can't do this natural history research that just doesn't get published. You can't get money for that. You have to do experimental, highly controlled, statistically proven results. That's the world I really swim in. **FM**