Amazing reefs: how corals 'hear', an interview with Steve Simpson
By Laurel Neme, special to mongabay.com
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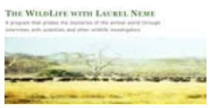

This interview is an excerpt from The WildLife with Laurel Neme, a program that explores the mysteries of the animal world through interviews with scientists and other wildlife investigators. "The WildLife" airs every Monday from 1-2 pm EST on WOMM-LP, 105.9 FM in Burlington, Vermont. You can livestream it at theradiator.org or download the podcast from iTunes, laurelneme.com or laurelneme.podbean.com.

Dr. Laurel A. Neme is also the author of ANIMAL INVESTIGATORS: How the World's First Wildlife Forensics Lab is Solving Crimes and Saving Endangered Species.

Steve Simpson, Senior Researcher at the University of Bristol's School of Biological Sciences, spoke with Laurel Neme on her "The WildLife" radio show and podcast about ocean sounds and how reef fish and corals use these cues to find their way home.

This interview originally aired June 28, 2010. The interview was transcribed by Ed Tickle.

Corals aggregate to form vast reefs, which are home to numerous species and provide vital ecological services such as protecting shorelines. However, coral reefs are one of the most threatened ecosystems in the world due to many factors, such as global warming and ocean acidification.

Recent research by Simpson and his team of scientists has shown that corals, rather than drifting aimlessly after being released by their parent colonies and by chance landing back on reefs, instead find their way purposefully to reefs by detecting the sound of snapping shrimps and grunting fish on the reef. However, that discovery also means that the larvae might struggle to find reefs when human noises, like drilling or boats, mask the natural ocean sounds.

Steve Simpson is a marine biologist and fish ecologist, with particular interests in coral reef fishes, commercial fisheries, climate change, fish behavior and aquaculture. Specifically, he works on: the effects of climate change on European fish communities, underwater noise and its influence on fish behavior, fish population biology and dispersal, and population connectivity and marine protected areas.

His work combines overseas fieldwork, often in remote and challenging developing country environments, with laboratory-based behavior experiments and computer modeling. His research has appeared in numerous research journals as well as the popular press, including the LA Times, the UK Guardian and The New Scientist, among others.

In his interview, Simpson takes us through the life cycle of reef fish and corals and discusses strategies from their perspective. He notes the incredible variety of reproductive strategies that make reefs very interesting places and

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says, "If you ever wanted to write a new soap opera, then that would be the place to go. … they've got every trick sewn up." Simpson also reveals what a reef sounds like and how he and his team discovered that these sounds help entice the fish and coral larvae back – which ultimately is critical to the health of the reef.

Dr Steve Simpson - Heading out from Opunohu Bay, Moorea. Photo by: David Lecchini.

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INTERVIEW WITH STEVE SIMPSON

Laurel Neme: *: How did you first get interested in sounds in the ocean?*

Steve Simpson: During my PhD, which was at the University of York, I'd set up a collaboration with the Australian Institute of Marine Science, out in Australia, I was actually working with them in Western Australia, and we were trying to address the fact that if you try and model how coral reef fish will disperse during the early part of their life when they spend time out at sea, if you use ocean currents to make predictions, you find out that the actual reality is very different. That gets people thinking about whether these fish have behavior that might influence dispersal.

Coral reef off Mexico's Yucatan Peninsula. Photo by: Rhett A. Butler.

Then, just about the same time, there was the first evidence coming to light that some fish even self recruit, that means they come back to the reef that they started on. So there was quite a gold rush, I guess about ten years ago, in terms of people starting to look at these fish in a different way and start to think, "hang on a minute, although they're small, although they look pretty fragile, can [fish] actually use behavior to get to places that they prefer?" So some people went off and started working on swimming behavior and how well these fish can swim. There were actually some amazing studies done with coral reef fish in that line. The assumption had been that fish got washed around by currents. That's probably true for the fish we're more familiar with in the northern hemisphere—things like cod and herring which hatch from the egg very small and then drift around while they grow. But coral reef fish tend to come from a bigger egg and they grow quickly, so they're actually fairly feisty little creatures by the time they're about a week old.

So you put these guys into a swimming flume, which is basically a long swimming pool, and you fire water at them, and they can swim for hours or even days against the current. So it became evident that these fish could swim really well. But obviously swimming is only any use if you've got some way of controlling that motor on the back of you, and so people then started to think about behavior of coral reef fish in the early stages of their lives, and we got very interested in sound, partly because there was evidence coming from declassified navy reports that coral reefs are very, very noisy places.

The navy had been listening to the ocean for 50 years or so. [They were] really just trying to work out whether they could hear submarines or torpedoes, so they actually did quite a lot of work characterizing the natural soundscape, as we call underwater environments. But all of that information was classified. [The navy] was actually trying to take a recording so that they could filter it out, so that they could get a better recording of the submarine. [When] that information [on ocean noises] started to get declassified, biologists got interested because when you look at the noise, you realise that it's of biological origin. Basically, [it allowed scientists to] eavesdrop on habitats and on communities that you might not be able to see.

So then the question started to be asked about whether this noise could act as a cue for orientation of larval fish at this very early stage, particularly at the stage when they're returning from open water and trying to pick and find habitat that they can land on and start to develop as juveniles. There was evidence that fish could hear, and people had been working on fish hearing for many years, so we had some idea that fish would be able to hear these sounds for tens, hundreds or even thousands of meters. So that's really how we got interested in trying to look at whether the reef noise could be a cue for orientation.

LIFE CYCLE OF REEF FISH

Laurel Neme: *: Take me through the life cycle of coral reef fish, from when their eggs are laid in the coral reefs.*

Steve Simpson: There are many different coral reef fish, and with that diversity you have many different life history strategies. Some are very bizarre, but most of them can be classified into two main groups. There are those that produce eggs and broadcast spawn them, that means they release them up in the water, often up at the surface. These eggs get fertilized by the sperm and the eggs start to develop. That [method] accounts for about two-thirds of the species of fish that you find on coral reefs.

Damselfish recruits on a reef: newly settled damselfish on the reef crest in Hoga, Sulawesi. Photo by: Steve Simpson.

The other one-third of species produce eggs demersally, that means they lay the eggs onto the reefs, like [in the film] *Finding Nemo*. That then normally is accompanied by parental care, that is where you've got the male and sometimes the female both looking after the eggs as they develop.

Laurel Neme: *: What needs to happen for the eggs to develop?*

Steve Simpson: They develop whether they're up in the water column or down in the seabed on the reef, and after a period of a few days they hatch out. Some will only take two days or so to hatch out. These could be very tiny eggs. At the other extreme, like for a clownfish, you might actually get nine days or so of development in the egg before the egg hatches.

Laurel Neme: *: So not very long in any case, two to nine days...*

Steve Simpson: It's not very long. It's a fairly rapid embryonic developmental period. And when the eggs hatch, even whether they're out at sea already or not, the tides will take the larvae further off shore—we call it the pelagic larval duration. Pelagic is out in the open blue water, and the larval duration is the amount of time they spend as a larvae. Pelagic larval durations can vary from about 10 days for a clownfish, that's fairly quick because they've already developed a lot in the egg, to up to several months for some species before they then are ready and big and developed enough to return onto a reef and have any chance of surviving.

Laurel Neme: *: So being out in the open water is safer for them?*

Steve Simpson: That's what we think. It's perplexing, in a way, as to why these fish go offshore, as you'd think as a parent the best thing to do if you're in a habitat that is good for your species is to produce offspring that stay there. [But] almost every single coral reef fish produces eggs which then develop in the plankton out in open water. There are several arguments as to why that may be the case. One of them is that it might be much safer. We've done some studies playing around with simulation models where we can vary predation risk in different environments, and we find that very quickly species evolve the need to go out to sea if the reef is a risky place to be. And certainly, when you're maybe one millimeter long, there are a lot of things waiting to eat you on a coral reef. If you consider that every coral polyp is basically a tentacle with a mouth, it's a dangerous place to be. [Being in the open water also] means that the young can exploit a different food source from the parents. Out at sea there are free swimming plankton, and that could be a good place to develop.

There's also the argument that, although a coral reef might seem to be a very

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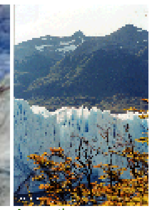
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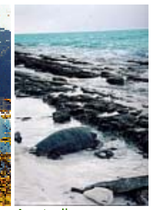
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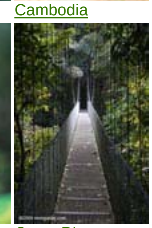
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stable environment and it might look very pretty, it’s actually a place that is constantly changing—and sometimes it can change for the worse, whether it is from natural causes or human causes. A hurricane could come and knock the reef over. If you can’t produce offspring that can get away and find new habitat, you’re going to struggle. So, it’s probably an evolutionary stable strategy to produce dispersing offspring. That’s why we think there is a pelagic phase in the early life of coral reef fish.

Laurel Neme: *: You mentioned earlier that there were a few coral reef species that were really strange. Can you tell me about some of them?*

Steve Simpson: You trawl the Internet and you think that humans are strange, these coral reef fish get up to all sorts. There are plenty of different species that can change sex. Some species will start off as a male and then turn female. A clownfish is an example. In fact, a clownfish actually starts off without any sex when it’s juvenile, but when it lands on an anemone, it can spend up to years waiting its turn to either become the male, which is the second biggest fish in that colony, or to become the biggest ,which is the female. So that’s a species with what’s called sequential hermaphroditism, it means that through a sequence you can change sex. You also see that sequential hermaphroditism in other fish that aren’t so attached to a particular location. Many parrot fish will change sex, many wrasse will change sex, and it all varies whether the ultimate goal is to be male or female depending on whether they are species that build nests or whether they are species that control a harem. So you might get a single terminal male which is very dominant, and it can then control a territory and have several females living amongst it. But, of course, if you have this terminal male that controls its territory and looks like the real deal, he might be a totally different color. He might look very different. That means that there is limited opportunity for many of the other males to breed, and so these [other] males might "dress up" as females and put on all the same colors and swim around with all the females and wait for mating opportunities that we call sneaking, which is really looking for a lucky break when the terminal male has dropped his guard.

There is a lot of that that goes on. There is two way hermaphroditism, which is where two species may even have both sexes within them so they are able to form different roles at different times. [A coral reef] is a very interesting place. If you ever wanted to write a new soap opera then that would be the place to go. Every time you spend time watching fish you learn something new, they’ve got every trick sewn up.

SOUNDS OF CORAL REEFS

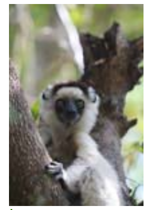
Laurel Neme: *: You’ve discovered that the fish come back to the reef specifically because of its sounds. What does a reef sound like? What is attractive about the reef sound?*

Steve Simpson: We’re only just starting to work out what it is that’s attractive. If we put a hydrophone, which is an underwater microphone, into the water around a coral reef, then we hear first of all a real crackling noise. It sounds like the sound of rain hitting a tin roof. When you break it down, it is actually lots of individual snaps that come from snapping shrimp, which are small crustaceans that live in a little burrow and they have a huge adapted claw that allows them to fire an air bubble forward very rapidly. That air bubble will then implode in the water and create a big bang, which they use to communicate or for territorial behavior. If you put all of those big bangs together, you get this crackling noise. Once [mariners] stopped using wooden hulls and started using metal or fiberglass hulls, [they] couldn’t work out where this sound of frying bacon was coming from when they were moored over a coral reef—and it was actually this sound of the snapping shrimp that they could hear. That’s the first part of the noise. But then when you listen to it, you also pick out individual noises that are lower frequencies—within our audible range but also within the audible range of fish—which are all sorts of bizarre noises, hops, whoops, and grunting noises. These sounds have now been discovered to be sounds produced by fish. So, fish have various ways of producing noise themselves and they can do that to communicate with each other.

A pajama cardinalfish nestles in the coral in Bohol, Philippines. Photo by: Steve Simpson.

Laurel Neme: *: How does a fish produce those sounds?*

Steve Simpson: Some fish have these teeth in the back of their jaw that they can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grind, while many [other] fish have swim bladders, which is a gas-filled balloon inside their body which they can alter to control their buoyancy and to control the depth that they're at. These swim bladders might actually be divided into different sections, and they can squeeze air from one section to the next through a tiny opening, and that then resonates so they can produce grunting noises. There are a lot of very interesting different ways that fish produce noise.

When you listen to a coral reef, what you're really doing when is listening to a lot of communities that are living there. We think that is what is forming this "cue" that fish use for orientation.

Note: To hear the sounds of the coral reef for yourself, you can listen to the podcast.

HOW FISH HEAR

Laurel Neme: *: How do fish hear? Do they have ears?*

Steve Simpson: To look at [fish], they obviously don't have ears on the outside, they don't have holes leading to eardrums or anything like we do. [But] they actually have a fairly similar ear to us when you break it down. Obviously, we and fish are distantly related anyway, so we didn't both come up with ears separately. The fish ear is basically a set of bones called otoliths, which are these dense solid bones that sit and basically float in fluid in the center of the head of the fish. …You [can] imagine a balloon with a stone inside of it, but on the inside layer of a balloon you've got all these little hair cells which can touch onto the otolith. When the otolith moves or vibrates, then these hair cells get tickled, and that then gets turned into an auditory response in the nervous system. So [fish] have this hearing mechanism inside. What we are now realizing is that some fish have even gone one trick further. So, if you think [about] when you walk into a nightclub, and there's a really loud bass noise in the music, you know how your chest can vibrate? Well, these fish that have swim bladders, they get that same resonating in the swim bladder. Then [these] fish, that we call specialist hearing fish, have a tube that leads up from the swim bladder to [a place] almost touching onto the otoliths. So they are basically using this swim bladder as a huge underwater hydrophone, which they can then use to pick up sound much more clearly than if they didn't have it.

RESEARCHING MARINE SOUNDS

Laurel Neme: *: How do you record all these sounds?*

Steve Simpson: The simple answer is with the hydrophone and with a recorder. A hydrophone is basically an underwater microphone that we can drop over the side of a boat, or we can set in some equipment that we can leave on the seabed, and then we just take a simple data recorder—the sort that a journalist would use if they were going to an interview, or that musicians [use when] they want to go and sit in the park and write songs and record themselves while they are doing it. So that's our equipment, it is pretty simple. Then, depending on where and how we're taking our recordings, we might put the equipment in to some underwater housing that we can leave on the seabed, so we'll dive down and leave it there for weeks or even months. Or, if we're trying to get an idea of how the sound varies over a reef, what we've recently been doing in Moorea in French Polynesia is using kayaks—which is great as you can get into very shallow water—and then we carry the equipment with us and take recordings over the side of the kayak.

Steve Simpson takes a recording of a coral reef in Dhofar, Oman. Photo by: Jen McIlwain.

Laurel Neme: *: How do you filter out the sound of the boat, like water slapping against the side of the boat?*

Steve Simpson: Yes, that's a real problem because, obviously, although you'd like to imagine that we're always on flat calm seas, it can be pretty rough out there. If we're working in very rough weather, then we've gone to all sorts of methods. One has been to use kayaks. We'll drop a kayak off the back of a boat. But I've found one of the best ways to do it is to go to your local garage, and get an old car inner tube for the tire, get them to pump it up, and then you can swim out towing that to the reef, and sit inside it while you are taking the recording. We've tried everything. We've even had the joy of trying to claim for an inflatable bat mobile that we took our recordings from in the Middle East.

Laurel Neme: *: Where have you gone recording reefs?*

Steve Simpson: Before I leaf through my passport, I should just say the reason that we're working in lots of different parts of the world is partly because we want to be trying to describe a global phenomenon rather than something that is very specific in one area. So, we started working in Australia, and since then I've worked a fair bit in the Middle East, which is great from the UK because it's probably our nearest coral reef, and particularly in Oman. I've also done some recording work in the Philippines and in Indonesia and in Sulawesi.

But my hydrophones and equipment live even more glamorous lives, really, because they get posted all over the place. I've got several sets of equipment. At every conference I always give a call out for any potential collaborators who are interested in being a part of what we're trying to do. It is very cheap obviously to post the equipment, and it's fairly idiot proof. So we can then build up this library of reef noise from around the world and look for patterns that may be a much more generalized patterns than you might find if you only worked in one area. That was how our coral story, that we'll talk about in a bit, first came to light—from a collaboration in the Caribbean.

DIFFERENCES IN CORAL REEF SOUNDS

Laurel Neme: *: Do different coral reefs have different sounds?*

Soft coral in Mexico. Photo by: Rhett A. Butler.

Steve Simpson: Yes, they do. That was part of the reason for our work in French Polynesia just recently. It actually came from a PhD student who was working on whether we could use this noise to influences fish behavior. So, for different types of management, [the question was] whether we could try and attract fish into areas by using playback recordings. We got some very strong results in Australia, where we took a recording of a reef, we played it back and we caught twice as many fish in different types of traps. [Then] we went to the Philippines and tried to do the same thing. What we actually did is we took a recording of a very nice coral reef, went to an area where overfishing was a real problem, so they might need management, and we gave this big seminar to the local fisherman, explained to them all about what we're doing, and they took us out and we put our traps out and played that reef noise, and we caught a fraction of the number of fish in our noisy traps compared to those in our silent traps. So it's totally opposite to what we were expecting.

What we realized from that is that it is possible that fish will only respond to noises that they're familiar with. So that really started us thinking about how variable reef noise is. We've been working in French Polynesia most recently, and we've been taking recordings on lots of types of reefs. On a coral reef, you've got the barrier reef, you've got the reef slope which goes off into deeper water, you've got the behind the reef crest, you've then got the barrier reef plateau, and then you often have lagoon and some fringing reef, little pieces of reef right up on the shore line. We've been taking recordings in all of these different environments, and looking, because you find different species of fish using these early on in their life. That's what we've been working within coral reefs. But then, with my Caribbean collaborators, they've been thinking one step further. We've got a paper we're about to submit which is looking at how important sound is as a cue for fish that come in and spend their first few weeks in mangrove environments or on sea grass beds.

Laurel Neme: *: And is it important?*

Steve Simpson: Turns out that you can give us a recording that you've taken somewhere, and we could tell you pretty reliably what kind of habitat it is. With the student in Panama, we've realized that there is a relationship between reef noise and the number of fish you find on the reef. The percentage of live coral cover is a good measure of how healthy the reef is and the sound it produces. It turns out that [its sound] is actually a pretty reliable cue about lots of different things, it conveys a lot of information about the habitat.

CORAL HEARING RESEARCH

Laurel Neme: *: How did that lead into your investigation into how corals use the sound to find out where to go? This completely turns on its head the way one thinks about how corals propagate.*

Steve Simpson: The assumption that we're challenging now is the same assumption that we made with fish ten years ago. It's often called the simplifying assumption, which says that you can probably treat these early stages of fish, or now corals, as passive particles. You can [then use] simulation models, and you can take oceanography measurements, and you can then simulate where things will be likely to disperse.

Laurel Neme: *: Sort of like a bottle drifting?*

Steve Simpson: Yeah, exactly. People have done it, like oceanographers, but some of the great studies have been done by following floating oranges. And there's even a global study that came from a container falling off the back of a ship that was carrying running shoes, and these things gradually floated around and dispersed and landed—so they had this big database about where these things were arriving. So that's the sort of models that you might use to make predictions.

For fish, we now realize that [these types of models] are a bit naive because these fish are strong swimmers and they have good hearing capabilities and they've got a keen sense of smell, which they use too. For coral larvae, until last year if you'd have asked me, I'd have said there's a limit to how far through the animal kingdom you can go, and not be expected to say that's likely to be a passive process. Certainly the fact that corals produce larvae, which develop fairly rapidly before they settle, means that probably they have to make sure the larvae don't spend too long at sea, otherwise they'll never return.

Great Barrier Reef in Australia

It was really this collaborative group that I've got out in Curaçao—who are affiliated with the Carmabi Foundation in Curaçao and a Dutch university—who had started thinking and using my equipment to try and look at whether the fish had preferences for mangrove sounds or sea grass sounds. One of them was out there working on coral spawning. I don't know if you know, but corals can often produce mass spawning events, which may be limited to one or two or a few nights per year, which is obviously then tied in with the lunar cycle. They talk about these mass spawning events on the Great Barrier Reef as firework displays. They're just the most amazing visual spectacles.

Laurel Neme: *: What is happening to produce that? Corals releasing eggs?*

Steve Simpson: They're releasing all of their egg bundles, or clouds of sperm, or even some corals will have fertilized larvae inside them that they release alive (already developed larvae). There's all sorts being drifted and being thrown up into the water column. As a result, all the plankton and worms and squid, all the way through to whale sharks, come in and start feeding on this great abundant food resource.

Anyway, the Dutch team was working on coral spawning in Curaçao and had tanks full of these coral larvae that they were watching grow. They were working out ways of feeding them, and watching them moving around and looking at various aspects of their biology, and one of them said, "Well, hang on a minute. We've got these choice chambers that we've designed that we can put fish into and we can play sound through the chamber to see whether the fish move to one end or the other. Why don't we try it with coral larvae?" So they contacted me (I was sitting at my desk in Bristol) and I thought, "You guys have got to be crazy. I mean, these things look like a floating blob—about a millimeter long, the shape of an egg, covered in these tiny hair cells that they use to swim around and to feed." But, fair enough, they decided to plug away with it. So, they adapted the choice chambers.

Laurel Neme: *: Can you describe the choice chambers?*

Steve Simpson: A single choice chamber is a tube, which has plankton mesh on each end so that nothing can escape out of it. The tube would be about ten centimeters in diameter. You can put coral larvae into the center of it, and then the idea is that you play sound from one end of that chamber. The sound travels through the plankton mesh and then through the chamber, producing a gradient in terms of how loud that sound is before it leaves at the other end. That's the idea of the chamber. You've basically got a more noisy end and a less noisy end. So [the team] then released these larvae into the chamber and left them overnight and came back to see which end they'd moved to. And, sure enough, these larvae were moving towards the speaker.

Now, if you'd just had one of these chambers, you might think, now hang on a minute, maybe the moon is behind the speaker, or maybe the currents are washing in one direction or another. So, to control for all of these other factors, they came up with this very neat design which looked like basically a wheel with three spokes leading out of it. They then had three speakers pointing in different directions with chambers facing towards them, so they could then look at the results and make sure that it wasn't just that the corals were all moving in one direction, irrespective of the speaker. But, sure enough, they were moving towards the speaker.

Laurel Neme: *: So you had this little blob of eggs moving?*

Steve Simpson: Well yes, it's a larva, so it's fertilized. But it's just swimming along. Now, when you look at these things you might think, how can they even swim, let alone hear anything or respond to any acoustic environment?

HOW CORALS SWIM AND HEAR

Laurel Neme: *: How **can** they swim?*


Brain coral in Belize. Photo by: Rhett A. Butler.

Steve Simpson: [The larvae] can beat these hair cells to produce currents very locally to them. They can use that as a way of moving around, and they'll do that with chemical gradients if they are moving towards a food source or towards a type of habitat that they might want to settle on to. They can move and you've only got to watch one in a small dish under a microscope to see it moving around.

Laurel Neme: *: How do they hear sounds?*

Steve Simpson: Now, I shouldn't use the term hearing because certainly these things don't have a centralized nervous system. They don't have a brain. They don't have a specific auditory hearing apparatus. But, as I mentioned earlier on, an ear of a fish, or even your own ear, is basically a sheet of these tiny hair cells, which then pick up sound information which is amplified in the otolith, or in the case of humans across the tympanic membrane. Someone mentioned it to me the other day, and I wish I'd thought of it myself, but you can kind of imagine these things as little inside-out ears swimming around, because they're basically these little hair cells. So, near to a speaker, near to any source of sound, the water actually moves. There's particle motion in the water as an effect of the sound, so it's possible that these hair cells pick up that movement in the water, and then over time detect gradients by gradually moving around, and this gradient is then something that they presumably innately move upwards in terms of the intensity of the gradient.

Laurel Neme: *: So they can purposely move in one direction or another by the way that they move their hairs?*

Steve Simpson: Yeah, and clearly they do because the results are just so compelling that these larvae really do spend the majority of their time, by the time you come back the next day, in the part of the chamber that is nearest to the speaker.

CORAL SOUND PREFERENCES

Laurel Neme: *: Are they attracted to some sounds more than others?*

Steve Simpson: That's the question that we're all asking, and we haven't got that far yet with these coral larvae. It's quite exciting to think about some of the experiments we've done with fish, and to try and think about other animals that we might want to do them with. We've started to get a much better feel with which sounds attract fish and which sounds maybe repel fish from specific habitats. And what we find with fish, in different ages and different stages in their life history, you'll see a response to one sound that might be positive in the juvenile fish, but negative in adult fish.

Laurel Neme: *: Like adults not liking rock music?*

Steve Simpson: That's right, you see a gradual transition away from Guns 'n' Roses or something... We've only really just started to think about what we can do with coral larvae. Like I said, they don't have a brain, they don't have really any apparatus to process information, so it's likely to be a fairly mechanical response to what they are perceiving. Unless there's really very different information in reef noise that you don't find in some artificial sorts of noise, my prediction would be that you'd see a response towards noise from all sorts of types of noise—which is a bit of a worry, really, because we're obviously adding to this natural soundscape in the ocean now. If you take a hydrophone and drop it near a port, or around a tourist resort, or near to a drilling or a mining operation, then it's not the snapping shrimp and fish that you hear, it's lots of human noise in the ocean. If corals actually responded positively to some of those noises, then it might just be one more nail in the coffin for these poor coral larvae at their early stage in life.

FUTURE RESEARCH DIRECTIONS

Laurel Neme: *: Have you done tests yet to see if it's any noise that they respond to?*

Steve Simpson: No, we haven't. All we've done so far is to [use] several recordings of coral reefs, so that we made sure that it wasn't just a response to a particular recording, and then play back that collection of noises through our choice chambers. The next question which we'll be addressing this year is to now start looking at which sounds [they're attracted to], because it may be that there are certain frequencies of sound which are important, even if it is not particular sources of sound. That's something we're now starting to work with. It's actually not a very difficult experiment to do, apart from having a very specialized coral rearing facility, which is something they have out in Curaçao.

Aerial view of coastal rainforests and coral reefs in Costa River. Photo by: Rhett A. Butler.

Laurel Neme: *: How do you do that experiment?*

Steve Simpson: You collect eggs during this mass coral spawn and bring them into the lab. Then you can rear the eggs in controlled conditions—you can put nutrients into the water, you can put microscopic prey items into the water—and culture these larvae as they develop through larval life. Then we're looking for the natural point in coral larvae development where they start to swim down naturally and settle onto the bottom of whatever it is, whether it is the tank that you're growing them in or in the natural environment. Once we see a few of them heading down and starting to fuse onto the bottom, we know that they're ready to test and to look at their response as they would be naturally settling at settlements or as they're returning and landing on reefs.

Laurel Neme: *: Have you tested whether this reaction occurs before they're at that stage? Or if it is only when they are at that natural point in larval development when they hear and get attracted to the noise?*

Steve Simpson: We've only been looking at the settlement stage of these larvae. Now, it would be interesting, as it could give us some hints to what the mechanism is, if we actually work through coral developmental stages. Because it may be that you could actually look at the physiology and the architecture of these small coral larvae, and work out what adaptations or what physiology they have which gives them that ability to detect sound.

Laurel Neme: *: I guess my question was coming from fish at different stages in their development are more or less attracted to sound, so I was wondering if coral was?*

Steve Simpson: In fact, we've only been able to work with fish at the stage at which they settle onto reefs because, until recently, we've been working with fish that we collect from the wild. It's very difficult to collect fish out in the blue water as they're developing, as they're very rare and very


Steve Simpson monitoring the catch of a light trap at Lizard Island, Great Barrier Reef. Photo by: Mark Meekan.

spaced out, so you'd need a huge net to actually round any up. But what we can do with fish is to put light traps out in the water, which would work much in the same way that you'd collect moths using light. We can collect fish at the stage that they're returning to reefs and work with them from there. With coral larvae we actually have this advantage that we're rearing them through larval development, so we could start to do the tests with them throughout their larval development.

Laurel Neme: *: Do different corals react differently?*

Steve Simpson: Again, we've only worked one species at the moment. You can just start to see how many exciting directions there are to go in with this study. There're limitless questions that we could try and ask. Obviously, coming from the UK, we're not limiting ourselves to thinking about what goes on in coral reefs; as much fun as it is to spend time on coral reefs, the waters around the UK don't have hard coral colonies. But we do have lots of soft corals, as well as lobster and crab and different types of molluscs and clams and whelks and things. There's a huge diversity of invertebrates that nobody's ever really started to look at. What we have around the UK, like in much of North America, is very heavily used water in terms of what the contribution of the sound the humans are putting in. So it's actually a question that we're quite keen to ask in UK waters—to think about what animals are going to be affected, particularly at these critical stages in their lives by the sound we put into the ocean.

IMPACT OF ANTHROPOGENIC NOISE ON CORALS

Laurel Neme: *: We've all heard a lot about how navy sonar can disrupt the lives of whales and things. What about the implications of this man-made noise for corals? Would it disrupt their ability to hear the reef?*

Steve Simpson: Yeah. When people have thought about the negative impact of sound then there are really three different things that could happen. First is that you could get a negative effect, which is where a sound scares animals away. But you could get a positive effect, where it attracts them, and maybe attracts them to the wrong habitats—so that would be a worry. But even if you don't get a directional response, if there's a natural sound which is important, then if you add a lot of anthropogenic noise, then you are going to increase the levels of ambient noise so that you might not get the signal that is important—you get what is called masking, where you lose that ability to pick up the natural sounds.

Laurel Neme: *: Could that possibly be one reason for declines in coral reefs or is it way too early to know one way or the other?*

Steve Simpson: I'd say it's way too early to say. But, certainly, coral reefs need every bit of good news that they can get at the moment. With global warming where sea surface temperature rises, you're seeing increased coral bleaching as a result. You've got ocean acidification now, which people are realizing could be a real problem for corals. Anything else that might be causing problems, too, is something that warrants further attention.

Comments (0)

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