CEPHALOPODS - Curated Transcript of BBC In Our Time podcast
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In Our Time is hosted by Melvyn Bragg. Melvyn's guests on this podcast are:

Louise Allcock
Lecturer in Zoology at the National University of Ireland, Galway

Paul Rodhouse
Emeritus Fellow of the British Antarctic Survey

and

Jonathan Ablett
Senior Curator of Molluscs at the Natural History Museum

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Transcript:

[Melvyn Bragg] Hello. The octopus, the squid, the nautilus and the cuttlefish are some of the most extraordinary creatures on this planet. Intelligent and yet so unlike other life forms. They are cephalopods and are part the mollusc family, like snails and clams and they have some characteristics in common with those. What sets them apart is the way members of their group can change color, camouflage themselves, recognize people, solve problems, squirt ink, power themselves with jet propulsion and survive both on land, briefly, and in the deepest, coldest oceans. And without bones or shells, they grow so rapidly they can outstrip their rivals when habitats change, making them the great survivors and adapters of the animal world. With me to discuss cephalopods are Louise Allcock, Lecturer in Zoology at the National University of Ireland, Galway, Paul

Rodhouse, Emeritus Fellow of the British Antarctic Survey and Jonathan Ablett, Senior Curator of Molluscs at the Natural History Museum.

[Melvyn Bragg] Louise Allcock, I'm outlined here very generally, but can you give us more detail of the range of cephalopods and where they are found in the oceans?

[1:17]
[Louise Allcock] So the main groups of cephalopods that people would be familiar with are octopuses, squids and cuttlefishes. But there's also nautiluses that have the shell, that we find in the IndoPacific. And there are more obscure groups like the vampire squid that we find in the deep sea. And you find cephalopods everywhere, really. They are in the intertidal, they are in the subtidal, just below our shore level, they are in the deepest oceans. We haven't actually found them in the Hadal trenches, so if you went to the Marianas Trench, we don't know that they're there, but we've hardly looked there, so there's probably a good chance they are. But they're on the sea floor, they're in the water column. Of course, different cephalopods are in different places, so octopuses tend to be on the sea floor, although there are pelagic octopuses as well. And you find squids up in the water column and you find cuttlefishes in coastal areas, on reefs. So different groups of cephalopods are in different places, but overall, anywhere you look in the ocean, you'll probably find a cephalopod.

[Melvyn Bragg] Are there clusters in particular places? Octopuses have preferred regions and so on?

[Louise Allcock] They do. Well, they're always on the sea floor, or a certain type of octopus are always on the sea floor and they tend to be there are a lot of them in coastal regions, a lot of them in the tropics, but they get to all areas because they are both poles as well. They're in the Arctic and they're very diverse and abundant in the Antarctic as well. They don't tend to cluster in large groups of organisms because octopuses actually tend to be territorial and solitary. So you won't go somewhere and find a whole host of octopuses, but everywhere you go you'll probably find them, except perhaps on the deepest seafloor. The abyssal plains, octopuses are not really known from. In fact, we didn't think they were on the abyssal plains at all until a couple of years ago when an ROV team actually found one at about 4000 meters. And that's an indication that we haven't explored the whole ocean yet. And there may actually be cephalopods where we don't expect them.

[Melvyn Bragg] Can you give us some idea of the range of their habitats and how we know that?

[Louise Allcock] We know where a lot of them are from fisheries. So if you trawl on the sea floor, you will bring up octopuses and squids, squids that live just above the sea floor. So squids live in differing habitats depending on which group of squids they're in. So you'll find some just above the deep sea floor and in fact they will migrate at night. So you can catch those with a bottom trawl in the day and you can catch them by jigging and with pelagic nets at nighttime. But you also find squids right in the wide open ocean. So we've collected them from nets there. And so a lot of our knowledge comes from fisheries. But in the last few decades, with the development of technology, we've had ROVs in different places in the ocean

[Melvyn Bragg] ROVs being ...

[Louise Allcock] Remotely Operated Vehicles. So these are submarines that are connected to the mother ship by a fiber optic cable. So there's not actually anybody in the submarine, but it's got cameras that are being operated from the surface and we can deploy these now to almost any depths and we're seeing parts of the ocean that we've never seen before and we're finding cephalopods everywhere.

[Melvyn Bragg] Is it surprising of the range of their habitats?

[Louise Allcock] I think there are not many organisms that get everywhere. Fish are one of the creatures that gets everywhere. But apart from fish, cephalopods are perhaps unrivaled in where they get to. And it's probably because they are so flexible in their body shape and their lifestyle. They've really diversified hugely into different forms and they've found unique ways of dealing with buoyancy and that's allowed them to be both on the seafloor and in the water column. And so they've been able to get to places which many animals haven't.

[Melvyn Bragg] ...Paul Rodhouse, what does the fossil records tell us?

[5:11]
[Paul Rodhouse] Well, the cephalopods go right back to the beginning of the Paleozoic era, the Cambian period, ... about 600 million years ago. That starts and they first appear in the fossil record as developments from the primitive mollusc, which would have had a conical shell. And the first cephalopods started to grow septi, or chambers in these shells, which could be gas filled. And as they evolved, they grew a tube that connected the chambers ...through which ran a thread of living tissue and that enabled them to pump water and gas in and out of the chambers and so adjust their buoyancy. So right back in the beginning of the Cambrian, that evolutionary process started.

[Melvyn Bragg] So we can see you can track the evolution through from the fossil records?

[Paul Rodhouse] Absolutely right from that period, which was when complex life really first appeared and started to diversify. The cephalopods were there right at the outset and they diversified through the paleozoic and mostly with external shells. But by the time we got to the end of the paleozoic, there were forms appearing that had internalized the shell and the shell had started to become reduced. And those are what led to the coleoid cephalopods, the squids, octopus and cuttlefish that Louise has just talked about. But then at the end of the paleozoic, they moved into the...

[Melvyn Bragg] Can you just give the listeners the odd date?...

[Paul Rodhouse] Yes... The end of the paleozoic is about 250,000,000 years ago. There was a major extinction event worldwide. About 60% of life forms were wiped out at that time.

[Melvyn Bragg] Do we know why?

[7:11]

[Paul Rodhouse] Well, it was a period when the Earth, planet Earth, was at a more primitive state than it is now. There was a lot more volcanic activity, and it's thought that there was a major period of extra volcanic activity that would have caused changes in the atmosphere and changes in climate and that led to this major extinction about 250,000,000 years ago. But critically, ... many of the shelled cephalopods died out at that time, but a few made it through. And also these early forms that had internalized or lost the shell also made it through.

[Melvyn Bragg] Was that because of the way they were? It must have been. So can you just tell us the characteristics that enabled them to see through not only this extinction event, but others that followed?

[8:03]
[Paul Rodhouse] Yes, it's hard to say precisely why, but clearly...there would have been dramatic changes in the environment. And so species that have ... that evolved and specialized for particular environments at that time, that environment might have changed so radically that they would have simply not been able to survive. Some possibly less specialized forms will have made it through. And so we see as we come into the Mesozoic at the Triassic-Jurassic period, which was the age of the dinosaurs, we had a few shelled cephalopods and a few of the non shelled cephalopods made it through. And then there was a major radiation and the shelled cephalopods evolved into the ammonites and belemnites and nautiluses that we see in the fossil record and in the cliffs at Lyme Regis, the fossil record in that part of the world. Then there was another... at the end of the Mesozoic period, 65 million years ago, there was another major extinction, this time possibly due to a meteorite, a large meteorite hitting the Earth. And this is when the dinosaurs went extinct. And again, there was a major extinction, something like 30 or 40% of all life forms disappeared. Many of the shelled cephalopods disappeared - the ammonites went completely. But critically the non-shelled types that made it through and one shelled type, the nautilus that Louise has already talked about, made it through into the Tertiary period. And from then on we've seen evolution towards the fauna that we have today.

[Melvyn Bragg] Thank you very much. Jon Ablett, they're molluscs, what do they have in common with other molluscs?

[10:05]
[Jonathan Ablett] So, I mean, they're very diverse group of animals, the molluscs. We have, of course, the slugs and snails, the squid and the octopus, the cephalopods, and sea slugs and sea snails. But there are features that link your snail and your squid. So some of those are the kind of nervous system, although it has varied throughout, they have a very similar nervous pathway. They are bilaterally symmetrical, so if you fold them half, they look vaguely similar. They have a mantle. So this is an area of tissue that surrounds the visceral mass that surrounds the digestive and reproductive systems and it's often modified for breathing, so for a lung in terrestrial and as gills in aquatic species. They have, all except the bivalves (there's always an exception to the rule,... bivalves things like clams, mussels and oysters),... a structure called a radula. And this is kind of the rasping tongue, so if you see a snail eating your lettuces or your flowers, that kind of rasping action, the pulling off of that vegetation. There's a very similar structure called the same thing, a radula, in cephalopods. They're not eating your plants, they're predatory, but they're also breaking down the food, they're rolling

this tissue over and that's also how they're feeding. And of course, the other structure is, as has been mentioned, the shell. So it's very obvious, a shell in a snail or a sea snail. And as it's already been said, the nautilus is the only [cephalopod] species currently that has an external shell. Whereas in cuttlefish they have the internal cuttle bone. In squid we have the internal pen or gladius. And in the octopus, where there's two main groups, one has completely lost the shell, but their ancestors had it. And in another group they have a very small sort of vestigial shell. So there are similarities between all these very diverse groups.

[Melvyn Bragg] Before we knew what we know, about the cephalopods, what were the myths and stories that grew around them?

[11:48]
[Jonathan Ablett] So this is something I really like. So lots of cultures around the world have these kind-of giant squid, giant octopus legends. You get them all across Southeast Asia. You have the lusca in Caribbean mythology. You have the scylla in the Odyssey in Greek mythology. You have the Kraken in Northern Europe.

[Melvyn Bragg] And these are all octopuses?

[Jonathan Ablett] These are all octopusy-like tentacledy sea monsters. So I think all cultures share this kind of fascination with these huge, unknown beasts. And I think the reason is that octopus and squid narratives, they are unusual. They're very different to the life forms that we generally see in the water and on the land. They're very alien to us. I think alien is a good word when you think of describing them. So if you imagine you were a sailor or someone who worked around the coast and you would come into contact with something or maybe a bit of a squid washed up on the beach, it's very easy to imagine that these were parts of some gigantic, terrible beast. And even in modern culture, in 2016, the film Arrival that came out, which was about an alien species landing on Earth, and the form that the film took for the aliens was of a kind of very cephalopody-type creature. They had seven arms, they squirted ink to communicate. So still today, we're still seeing these creatures as alien like and fascinating.

[Melvyn Bragg] Then, when you talk the arts, Minoan art, as I understand it, can you tell us how they figured there, Louise?

[13:14]
[Louise Allcock] Yes, I was at Knossos not long ago, and the Minoan art has very stylized octopus with bulbous eyes and very long arms that they twist around the jars. It's very, very common to find them on jars and pots in Minoan pottery.

[Melvyn Bragg] Let's get down to the detail, both of us. Which of them change color and how do they do it and perhaps why do they do it?

[Louise Allcock] Okay, most of them can change color, and they do it in different ways depending on what sort of cephalopod they are and where they live. So if we think first about octopuses and cuttlefishes, they tend to live on reefs where they have a distinctly colored background, which they would like to camouflage themselves against. And they are masters of camouflage. They do this using particular organs and cells in their body. So they have these things called chromatophores, which are basically little colored cells in their skin surrounded by a ring of muscle. And in the relaxed state, the muscle closes over the little colored cell. And when the muscles are contracted, they pull back and the colored cell is exposed. But what's interesting about these is that the colors in these cells are only three colors, really. They're yellow, red or brown. And that doesn't mix with what we know about the colors that octopuses and cuttlefishes can show off. So they have other structures deeper in the skin than this. Firstly, they have iridophores, and these reflect light. And they've got this interesting protein in them called reflectin. And reflectin is a sort of self organizing molecule, and it stacks itself in layers. But depending on how closely packed those layers are, it reflects a different wavelength of light. Now, what the octopuses can do is they can release a neurotransmitter acetylcholine, and that causes phosphorylation of these little molecules, the reflecting molecules, and that affects how closely packed they are. So it affects what color they are reflecting back. So they firstly have these chromatophores that show some basic colors, and then they have these iridophores that they can alter the color that they're reflecting. And below that, they have leucophore, which just reflect back any color that is coming onto them, which obviously, in certain respects, you wish to reflect back the light of your environment. And at the same time as all this, they can actually shape the papillae on their body, so they can make their skin go all bumpy. So if they're on a rocky surface, they can make themselves look much more like a rock and completely blend in. And the beauty of this color change is, because it's all innovated by nerves, it can happen really, really fast. So they can do it in about 200 milliseconds. They can completely change color.

[Melvyn Bragg] And it is for predatory purposes?

[Louise Allcock] This is mostly for camouflage.

[Melvyn Bragg] They use it for other not so much eating as being eaten.

[Louise Allcock] Yes, to prevent being eaten.

[Melvyn Bragg] Who are their biggest eaters?

[Louise Allcock] Other fish.

[Melvyn Bragg] You got to be a pretty big fish to swallow an octopus, I assume. So we're talking about whales, are we?

[Louise Allcock] Whales would take squid, they wouldn't be taking octopuses and you wouldn't have whales that turning on the reef.

[Melvyn Bragg] Rather discerning, whales. [laughter]

[Louise Allcock] Yes. But they also do color change for mating purposes, so they signal - particularly cuttlefishes.

[Melvyn Bragg] Can we develop this, Paul, this changing color?

[16:44]

[Paul Rodhouse] Yes. A lot of the interest around this is in the eyes of the cephalopods.

[Melvyn Bragg] The eyes are enormous. Can you tell the listenters?

[Paul Rodhouse] Enormous, yes. Well, the largest eye of any animal is a giant squid eye. But all the collioid cephalopods have a very sophisticated eye, which is very similar in function to the vertebrate eye. But it's actually a spectacular example of convergent evolution where very different structures have evolved to do the same thing. And so the eyes of the cephalopod are ... they have a pupil, but it's not round, it's square, and if they need to reduce the amount of light going in, they make it into a small rectangle. They have a lens. But again, it's different from the lens of a vertebrate eye in that it focuses the image onto the retina by moving the lens back and forwards rather as we do in a camera, rather than the vertebrate eye, as we have, where the lens changes shape to focus. And they have a retina with very different cells that can have high visual acuity. But most of the cephalopods that have been looked at are actually color blind. And this is really why this is the interest in relation to these fantastic color changes that the cephalopods can do with their skin. They can't see those colors, they can see light and dark, and they can also see polarized light. So the iridiophores, that Louise referred to in the cuttlefish, are used for patterning and changing patterns and communicating with other cuttlefish. And those iridiophores reflect polarized light. And so the other cephalopods, the other cuttlefish, can see those changes, but they're invisible to the fish, which can't see polarized light, so they can signal to each other without giving the game away to the fish. There are one or two squids... there's one species of squid that does see color and that's a species which, again, it has light organs, a vast number of light organs, on its skin and it flashes these and uses them to communicate. And that species can see, we think it can see three colors in a way that the others can't.

[Melvyn Bragg] Jon, how do they show they're aggressive? What signs do they have that can tell us they're going to be aggressive?

[19:36]
[Jonathan Ablett] Well, I guess the warning coloration they show, so as we've said, they can change color in order to communicate and often we see bright red flashes associated with aggression. If I think about aggressive species of squid, I think of the Humboldt Squid, Dosidicus gigas. These are predatory squid. They live on the eastern Pacific from California down to Chile. And these are living in quite large numbers, they're quite unusual in the size of groups they live in and they attack in a coordinated manner and they have been known to attack fishermen and divers as well, and actually been responsible for some fatalities.

[Melvyn Bragg] Why would they do that? Have you nailed a reason why they attack certain divers?

[Jonathan Ablett] Well, they're not known to be aggressive all the time. It's thought that they get into a kind of feeding frenzy and if a human gets in the way when they're in these kind of huge feeding clusters, then they just kind of don't stop and they get attacked this way. But I don't always think of cephalopods as being aggressive. You know...you might think of the myths and legends of them dragging down boats, but there's some ... they're obviously predatory animals, so they need to be aggressive, but they also need to defend themselves. As we were saying, the octopus, for example, are venomous. All species of octopus that we know of are venomous. They have venom in their saliva and when they bite their prey, it injects this venom into them. And this venom often helps to sort-of paralyze the prey and also to break down the tissue around it to make it easier to digest. And if you think of something like the blue ringed octopus, this is the most venomous species of octopus. And the cocktail of toxins in its saliva is so great that if they bit a human, they will actually die. There's been three recorded fatalities and possibly many more, and lots of near misses. And this is because the toxin affects the voluntary muscle, so it stops you from being able to breathe. And unless you're given assistance to breathe, then you will die. And of course, that is not just aggressive, but it's defending against aggression from predators. But I actually think that some of the more interesting behaviors are, as we touched on earlier, these courtship rituals, these flashes of light, the way that these animals mate. And things like parental care as well. many octopus look after their eggs, they stop feeding, they kind-of keep them safe. They waft them to keep them oxygenated and look after them. So although they are seen to be aggressive ...sometimes, they of course, exhibit a whole wide range of behaviors.

[Melvyn Bragg] Louise, ...one of the notable things [is that] they move very quickly. How do they do it and what advantages...? Well, let's talk about how they do it first.

[22:11]
[Louise Allcock] So they move in different ways. That the thing that they're famous for is jet propulsion. And we would have seen that in fossil cephalopods, in ammonites and in early nautiloids. And ...those groups have a rudimentary funnel. And the colioids, squids, octopuses and cuttlefishes, that we have today have developed this further. And as part of their mantle, the mantle is open at the neck of the octopus, and the only other opening from it is this funnel. So what they can do is they can squish the muscles of their mantle to suck water inside the mantle sack over the organs, and then they can constrict those muscles around the neck so that the water can't come out of the collar of the mantle. And then they squeeze all the rest of their muscles and squirt that water out through the funnel. And that makes them jet propelled. And the beauty of the funnel is that it can point it in any direction. So they can jet propel forward and they can jet propel backwards as well. But it's not very efficient because the funnel is quite narrow. And squirting a big volume of water through a narrow tube is not energetically efficient. It makes them very fast and it's great for being predatory or for escape, but it's not very efficient. So they swim in other ways as well. They can undulate their fins. And those species which have long fins can send a wave of undulations along their fins. And if they reverse the direction of that wave, the squid will go in the other direction. Or they can send a wave down one side one way and a wave down the other side the other way. And the squid will turn around just like if you reversed one motor on a twin motored boat. But they move in other ways as well, because, of course, octopuses live on the sea floor, so they just crawl. And their arms are fantastically maneuverable. Their arms are like our tongues because most of our muscles attach to bones somewhere to pull on. But if you think of our tongue, if you wiggle your tongue, it's a free moving muscle. And that's what octopus arms are like. So they crawl around using their arms. And their arms are actually amazing as well, because they've got mechanore receptors, so they feel with their arms and they've got taste receptors, so they taste with their suckers on their arms. So they have all sorts of ways of moving which are exploring their environment at the same time.

[Melvyn Bragg] ...Paul Rodhouse, how methodical is the study of these creatures at the moment?

[24:24]
[Paul Rodhouse] Well, a lot of the problems with studying cephalopods has been the fact that they are soft bodied, they have very few, what we call taxonomic characters, characters that we can use to define particular species and other taxonomic levels, family and genus levels. So going right back to Aristotle and his "History of Animals", there are descriptions of cuttlefish and octopus and squid which were all found in the Mediterranean, and Aristotle had access to them. And he made a very good job of defining the main groups and describing them and discriminating between some of the species of octopus. Then we have to fast forward 2000 years to the 18th century and Linnaeus and the age of enlightenment. And Linnaeus started this process of binomial classification of animals where each animal has two names. So the common squid would be Loligo vulgaris, the "common squid". But that was followed by a period of a lot of other people doing the same sort of thing. But with these very poor taxonomic characters, it created more confusion than it solved. And then by the mid 20th century, we had a couple actually, Gil and Nancy Voss, two Americans, who between them really took a very systematic approach to looking at the taxonomic characters [features] that were being used, deciding which were useful, and really sorting out ... the problem. As we move into the 21st century, we've now got the technology, the gene sequencing technology, that arose in the Human Genome Project. And so now there's another, a whole new way of classifying and identifying and determining the relationship between cephalopods. And that is really opening up a whole new area.

[Melvyn Bragg] Thank you very much. ...Jon Ablett, what specimens have made their way to you recently at the Natural History Museum, and what have you learned from them?

[26:50]
[Jonathan Ablett] So we have about 80 million objects in the Natural History museum. Of those, we think about 8 million are molluscs, and of those, between a quarter of a million to half a million are the cephalopods. And we're getting specimens in all the time. I mean, we're saying that the collection started in the mid 1700s, but every week we get new specimens added to the collection. When I think about recent things that have been added to the collection, I guess a personal favorite for me would be a giant squid specimen. So ... in 2004, some fishermen from the Falkland Islands caught a specimen of giant squid. They donated it to the fisheries.

[Melvyn Bragg] Why..I mean, how big? Why does it earn its keep as a giant?

[Jonathan Ablett] So giant squid, we think, get to about 13 meters total length, and there's probably one squid bigger, the colossal squid. But we haven't found a fully grown member of that species yet, although when we find the kind of juvenile members of that, they get to, well, I think one about 9 meters was found in 2008, and so we think the adults get much bigger. But 13 meters is still pretty big to class as a giant squid. The specimen was donated to the Falkland Island Fisheries, and then it was sent to the museum to me in London. It was 8.62 meters in length, so not quite fully grown, but a pretty good sized squid. And it's still the largest, what we call wetpreserved specimen, so a specimen preserved in alcohol, that the museum has ever done. And, I mean, animals like this are amazing for the kind of public interest of science. When you've got a huge specimen like that, you can talk to people just about how amazing it is. You can talk about evolution, you can talk about adaptation to environment. You can talk about things like the chromatophores, the behavior, and just how much we don't know about these creatures. But actually, one study which I think you were involved with, Louise, was using this to try and suggest how many species of giant squid there are. In the past, it was thought that there were many different species of giant squid. They live in all the world's oceans apart from the polar regions and around the equator. So it would be obvious to think that there is a European species, a South African species, an Asian species. But actually, using this specimen of giant squid, taking DNA and comparing it to other freshly caught and well preserved specimens around the world, it actually suggested there's only one species of giant squid worldwide, which wasn't what we expected at all. And it's not just the new donations that fascinate me. I sometimes get very excited about the older things that we find in the collection. We have a nautilus specimen that was the property of Richard Owen, who is the first director of the Natural History Museum, and he wrote an early work on the nautilus. And actually, a lot of the time on my desk, we have an octopus collected by Charles Darwin.

[Melvyn Bragg] Wow. Louise, what about the nervous system?... And what about their intelligence? We read a lot about how very intelligent they are, how smart they are. Can you just give us some evidence for that?

[29:37]
[Louise Allcock] Yes, well, their intelligence is connected with the development of the nervous system. It is, as Jonathan said earlier, on a moluscan plan. But what has happened in octopus and squid is that the various nerve ... ganglions, have come much closer together and concentrated in a brain, which is unusual in a mollusc. And it was very important that they come closer together because octopus neurons do not have a myelin sheath like ours. Our neurons are enclosed by a fatty acid called myelin, which helps the speed of transmission. So the speed of transmission down an octopus neuron. Is quite slow. So if they were all spread out, the transmission would be slow and the various neurons talking to each other would be slow and octopuses wouldn't be able to be as smart as they are. So this coming together of all the neurons in the brain has really aided this.

[Melvyn Bragg] So can you give some examples of how smart they are? I mean, you've heard about them being able to open jam jars. Yes. What else?

[30:39]
[Louise Allcock] So they're very good at finding their way. So if you think an octopus mostly lives in a den and it goes out hunting and they can explore their area hunting for a long time and then they can find their way straight back in a beeline and we don't really know how they do this, but somehow they're mapping the way they're going. They can also learn through mazes. And it's quite interesting. Octopuses who have a den and always return to it are better in mazes than cuttlefish who don't have a den and don't have to be able to find their way home. So there's clearly learning capabilities that go with their natural behavior.

[Melvyn Bragg] Anything else?

[Louise Allcock] I think, on their intelligence...not so much on their intelligence, but on their nervous system, rather. One of the reasons that they're so adaptable to all their environment is because of their senses. They have senses, really remarkable senses. They've got taste sensors in their suckers, but they've even got light detectors in their arms. They've got opsin molecules in their arms which are detecting the light. And this is feeding back to their neural system again, which is helping them with their camouflage. So their developed nervous system isn't just about how clever they are but it's about how they behave and react to the rest of their environment as well.

[Melvyn Bragg] Paul, what do we know about their life cycle?

[32:05]
[Paul Rodhouse] The life cycle of the collioids is one of "live fast and die", basically. Nearly all the temperate species that we know about have a one year life cycle. Some of the small tropical species have a shorter life cycle, they may be a few months. And some of the bigger species and cold water ones may live for a year or two, or two or three years. But they all live for a short period and they all have one spawning event, one reproductive event, and then they die. They have a very high metabolic rate, they're voracious feeders, they're all predators, they grow fast, they produce, in all cases, a relatively large number of eggs. And then when they spawn, the squids in particular make quite long migrations, so they use up a lot of energy during the migrations, they then have ritualized courtship and activities, then they spawn and then they die. And the body is depleted of nutrients and energy and they simply keel over after they've spawned. Or probably in most cases, they get snapped up by a predator. And that life cycle is really an adaptation to being able to colonize areas and grow populations quickly when conditions are good. And then when conditions aren't so good, they simply tick over and the populations reduce. But you do get this ecological opportunism. They can move in when the conditions are good.

[Melvyn Bragg] Jon, can we just talk a little bit more about, which was mentioned earlier by Pau,l about the ability to survive the mass extinctions, so on and so forth? Is there a common factor that says, "oh, they survive because of X or X and Y"?

[Jonathan Ablett] I think one of the reasons probably they survive these is their intelligence. They are often seen to be this really intelligent creature, and often most intelligent invertebrate... and they have about 500 million neurons in their brain, which is about the same as a dog. And they don't just centralize this nervous system, it's actually a kind of pseudo brain in each of the arms. And this gives them much more adaptability to their environment. So I think adaptation very quickly to an environment is one thing, and another thing is the short lifespan as well. They're very resilient creatures because they live quickly and die, they can adapt very quickly to changes that happen in the environment.

[Melvyn Bragg] Louise, we're told that they can survive out of water, but only very briefly. Is there any development there? Are they just slithering from one rock pool to another and they're caught on the rock instead of in the pool?

[35:16]

[Louise Allcock] Well, they're no different from us in that to live they have to breathe. They just breathe a little bit differently from us. And their gills are inside their mantle cavity. So this is the sac that seawater is filtering through all the time. And in fact, they use their musculature to pump seawater constantly through their mantle sack so that they're getting fresh oxygenated seawater over their gills. So when they crawl out of a rock pool, their mantle sack, they'll probably tighten it a bit around the collar so that it holds that seawater in. And they've got therefore oxygenated seawater on their gills until such a time as they've used all that oxygen up out of that seawater. And at that point they need to reflush their mantle cavity so they can survive out of water for as long as that oxygen in that seawater lasts. And that's enough time for them to crawl from rock pool to rock pool.

[Melvyn Bragg] So you're talking about a few minutes?

[Louise Allcock] That's right. Maybe slightly more than a few minutes, but probably not more than ten or 15. There are some species that live in tide pools and they tend to hunt at night or in twilight. And if you walk along these rocky shores at night or twilight, you will see octopuses walking between tide pools. Not in this country, because we don't have these species, but elsewhere in the world you will see this.

[Melvyn Bragg] Octopus taking a walk...

[Louise Allcock] That's right.

[Melvyn Bragg] Paul, how are they related to fishing stocks?

[36:37]
[Paul Rodhouse] The cephalopods have been exploited by fisheries for millennia, probably going back to the late Minoans, but they've been a relatively low catch, a small part of the world catch. But about 20 years ago, a study was done where the 15 statistical areas that the Food and Agriculture Organization in Rome used to collect data on fisheries demonstrated.... a study of these data demonstrated that as the fish stocks have been declining, at worst declining, and at best holding their own, in all of those areas but one, the numbers of cephalopods being caught and exploited by the fisheries was going up. And in three particular cases off West Africa, in the Adriatic, and the Gulf of Thailand, there was a very clear correlation between the decline in groundfish... catches and the numbers of cephalopods being caught. And this really goes back to what I was saying about them being ecological opportunists. The idea that arose from this is that as you take out the slow growing big groundfish, these ecological opportunists can come in and fill the vacant niche in the ecosystem. If they were plants, we call them weeds. They're able to grow fast. They don't produce heavy skeleton in the way that weeds don't produce any woody structures, and they can move in when the conditions are right and take over. And this seems to have happened in these fishery areas. And interestingly, only about two years ago, another major study was done by a collaboration of scientists looking at both scientific sampling of cephalopods and fish and also fishery data from new data on fisheries. And both scientific data and fisheries data are showing a continuing trend of increasing cephalopods and decreasing numbers of fish. And this seems to be a function of overfishing and changing the habitat and the conditions available for cephalopods to move into.

[Melvyn Bragg] So they don't seem to have many threats to them at the moment then, Jon?

[29:21]
[Jonathan Ablett] There are still threats to cephalopods. Of course, pollution, like many aquatic animals, will be harmful to them. The change of their environment. So as we damage coral reefs or as the bottom of the ocean is damaged through trawling, you are going to ... cause an effect on the cephalopods. Things like ocean noise pollution are interesting factors as well. So things like drilling, boat sonar, fishing sonar, these can have an effect on cephalopods. And we think that possibly some of the mass strandings we occasionally seen where you get large numbers washing upon beaches could be caused by the effects of this noise on the animals. And lab studies have actually shown that when statocys develop, and this is the organ of balance that the animal uses to get its pinpoint, its 3D point in the environment, loud noises actually cause this organ not to develop fully and to develop abnormalities. So so noise pollution is a problem to them. And of course, climate change is a big problem. Firstly, if you change the seawater temperatures, you're going to get changes in metabolic activity. So the activity of the squid may change, they may be forced out of areas where it's too warm or too cold. And also the effect of increasing temperatures means that you change the seawater chemistry, you change the PH of the water. And this can affect the shell development, it can affect the statocys, the organ of balance, development, it can change the development of the cuttle bone and the inner caecum [?] of the squid. So really there are still threats. But as we said earlier, they are a very resilient group of animals - they have been around for 600 million years or so.

[Louise Allcock] I think there are some threatened deepwater octopuses as well. They got very low fecundity, the finned swimming octopuses, and they've been taken by fisheries that are targeted at deepwater fish and they've been taken out at quantities faster than they can replenish themselves. So there are actually some on the IUCN Red List as endangered octopuses.

[Jonathan Ablett] And of course, we have the nautilus, which last year made it onto the CITES list. So these have been collected for their tourist value for their shell, and of course, now they're added to the CITES List. Hopefully it'll give them an extra level of protection.

[Melvyn Bragg] Well, thank you all very much. Thank you to Jon Ablett, Louise Allcock and Paul Rodhouse.

And the In Our Time podcast gets some extra time now with a few minutes of bonus material from Melvyn and his guests.

[41:51]
[Louise Allcock] We talked about camouflage in octopus and cuttlefish, but I could say something more about squid, which are a little bit different because they're out in the open ocean and so they're not trying to camouflage against the background of a reef. They're actually trying to camouflage against maybe light coming from above or a

darker background below. So they have two things that they can do. They can countershade their top surface, making it slightly darker, so that for any predator coming from above, they look darker - like the seafloor. Or they can counter-illuminate their bottom side, so that for anything coming below, they look more like a moonlit surface. And they do this with photophores. And so they actually produce their own light. And they do this it's chemical reaction. Some species do their own chemical reaction and other species have symbiotic bacteria that do the chemical reaction for them. So they actually have light emitting photophores. And some of these even have a little sort of almost eyelid that they can shut off the photophor so they can signal with it. But they also have photoreceptors very close to these so that they can detect how bright they're shining, so they can moderate how much they're signaling and how bright they are to perfectly match the surface light coming through. So as the sun sets and the moon rises, they can affect how much light they're putting out with their photophores and become perfectly camouflaged from a predator that's below them.

[43:24]
[Jonathan Ablett] That just kind of shows... cephalopods: there's so many amazing things about them. One of the things that really amazes me, and we think it back to the intelligence, is the tool use. We think of tool use as a symbol of intelligence. You think of crows and ravens, you think of dolphins, you think of apes using tools. But when you read that cephalopods use tools as well. I was reading recently about the veined octopus using picking up coconut shells and carrying them around as a kind of mobile defense system. That thing that's just fascinating. And there's other species of octopus that gather.

[Melvyn Bragg] Where does he get coconut shells from?

[Jonathan Ablett] So they live ... these are a tropical species, so as they wash into the water, they pick them up and they hold them like a kind of a shield to prevent them from being attacked. And I read about another species of octopus that actually makes piles of stones around their dens as extra barriers to stop predators from attacking. So I just think this is really amazing, such an amazing group of animals.

[Louise Allcock] I've been fascinated by size because we have the giant squid, but we also have pygmy squids, which are a thumbnail size. And there's not many animals in the animal kingdom that have such a disparity of size in their species. And it's not just modern cephalopods that do this. There have been giants through time. There were ammonites that had a diameter of two and a half meters and probably weighed a ton and a half. And there were belemnites, these early squid that Paul mentioned earlier, that had a mantle of 2 meters long, which, all in all, by the time you had mantle, head, arms, tentacles, that's probably the size of giant squid today. So we've had these giants through time as well. And there are not many animal groups I think we can say this about.

[Jonathan Ablett] People often ask me, "What would you like in the museum? What's your dream one?" And I have to say, "I'd like a fully grown Colossal Squid". It'll be a job to preserve it. But do they get to these 18 meters more...the figures that people have quoted throughout the literature and who knows what size? But, yeah, that was my dream specimen. If someone could give me a fully grown Colossal Squid, it'd be a job to preserve, but it'd be a fun job.

[Melvyn Bragg] Do you think you could raise that, Paul?

[45:25]
[Paul Rodhouse] Well, it's an Antarctic species, and I normally make myself unpopular with journalists when I'm talking about giant squid (and even colossal squid) ... because these lengths that people talk about are the total length, including the tentacles. And a squid consists of the main body, which is the mantle, the head and the arms, and then these tentacles that extend out beyond. And the largest body that's been found is about 3 meters. And if you add the head and the arms onto that, you might add another meter or a meter and a half, and then the rest is tentacle. So by comparison with some of the big sharks and the big tunas, they're not quite the colossal beasts that people writing about them sometimes crack them up to be. That's not to say they're not highly impressive animals, and extremely interesting, and it would be fantastic to get hold of some.

[Melvyn Bragg] Thank you all very much.

In our time with Melvyn Bragg is produced by Simon Tillotson.