Young Scientist Spotlight 19: Amy MacIntosh

-Blue Dot Sessions - Sandy Shuffle-

Cindy :
Hi there! I'm Cindy and you're listening to another installment of Carry the One Radio's Young Scientist Spotlight series, where we highlight the stories of early career scientists. Late last year, I spoke to Amy MacIntosh, a PhD candidate in environmental sciences at Macquarie University and the Australian Nuclear Science and Technology Organization. Amy studies the toxicological impacts of decommissioned offshore oil and gas infrastructure and the effects on marine animals in Australia. She also works directly with the industry to provide expert advice on the science behind the closure of these structures to conserve and protect marine animals and the environment. So, without further ado, let's dive right in.

-CTOR tag-

Amy:
So my name's Amy Macintosh. I'm based down in Sydney, Australia. I'm at ANSTO - that's the Australian Nuclear Science and Technology Organization. I go by she or her, and I'm currently just past the halfway mark of my first year, so I've still got two years to go.

And my PhD project is based around looking at the impacts and risks from naturally-occurring radioactive material that's found in offshore oil and gas structures, and I basically look at the impact to marine organisms. So I use a lot of nuclear techniques to really look at radioisotopes or elements that have a radioactive site to them.

Cindy:
So, what is radioactivity? Amy says, "Put simply, radioactivity is when an object has tiny particles emitting or releasing energy that is also known as radiation". This describes radioactive elements, like uranium, which can be used in nuclear plants, but it also refers to cosmic radiation (including sunlight) - and thermal radiation (like heat from an incandescent lightbulb).

Can you tell us a bit about your trajectory?

Amy:
I did my Bachelor of Science in Zoology - I'm a zoologist by trade - in New Zealand, where I'm from, in the south Highlands. And then I hopped over to Tasmania - so the little island just off the mainland of Australia - and I did my Honors. That was one year. And then from there, moved up to Sydney and I did a one year Master's by research, and then just continued on to doing a PhD.

Cindy:
So have you always been interested in environmental sciences?

Amy:
I always wanted to do zoology. I feel like every zoologist or wildlife scientist would be like, "oh, Sir David Attenborough and Jane Goodall are my heroes". And so that was pretty much me as a child growing up in the UK, Southwold and Scotland, so I was surrounded by wildlife. And then moving to New Zealand, I really grew fond of the animals and the environment because it's completely different .And then kind of

along the journey in zoology, you learn about all different types of animals, like physiology and the behavior.

And I'm a terrestrial person, so I do not like the ocean at times. I was not fond of marine animals because sharks and rays and whales, that could, like, kill you in an instant if they whacked you. But during my zoology degree, like marine biology, I took one course. And I actually enjoyed it.

But then I wanted to do something that's out of my comfort zone. Like I feel if you know what you're wanting to do since you were a child and you reach that goal and you know you're going to get it, there's so much more out there that you don't realize. So I did an exchange at the University of Exeter.

And so there I was based near the ocean, and I grew fonder of it as well. And I also learned more about geology through rocks and I, again, grew fond of rocks for some strange reason. And then the documentary about Chernobyl came out and I was like, "Oh, that's interesting." Not many people research it, so I wanted to try and find some very similar kind of research field. And so, I kind of just contacted a random person here in Sydney who was an expert in radioecology – so, looking at the impact of radiation on the ecosystem, like the animals, the plants, soil, and water. And I got offered this opportunity to move to Sydney and focus on the decommissioning of structures.

Cindy:
Like offshore oil rigs.

Amy:
So, in Australia, it is a kind of issue at the moment where, what to do when an oil and gas structure ends operations and we need to close it down? So they have to go through a very long and tedious process that involves the risk assessment looking at what would the impact for short term and long term would be on the environment if the structure was going to be left in the ocean.

One part of that is looking at contaminants that would be in the structure. And so one of the main contaminants that I deal with is scale. So this is kind of like buildup of fat in your arteries over time that can cause disease; kind of like that, but in a pipe. It's like the buildup of this kind of rock that actually decreases the diameter of the pipe. So that's when the oil and gas becomes very slow and they become a lot of issues and that's when they're like, "No, we need to stop". And within that scale, you've got the build-up of radioactive material that's been brought up from the crust.

And then all of a sudden, it's just like this potential hotspot. And then also on top of that, you've got metals, and these could be potentially toxic, um, so your mercury, your iron, your copper, your cadmium. So I'm trying to help provide the bias not only to oil and gas operators directly, but also other stakeholders, so, federal government …um … state government, and then also other research institutions as well. Yeah, that's how I kind of got from animals to a rock pretty much.

Cindy:
So I've read about structures being found, like sunken boats, where there's lots of like, marine life that's kind of sprung up around it and made the boat their home. But I feel like that must be a very rosy picture of human structures being left behind in the ocean. So what you do, is it like an assessment of both the short and long-term impact and then also how to remove a structure safely or trying to clean it?

Amy:

This is the Rigs to Reef program in the US, so there's that kind of, um, conversion of oil rig or platform, um, to artificial reefs. And the majority of the research looks at the ecology of these structures and says, "this increased biomass is increased productivity". Um, but that's just one half of the story, but it's the things that you can't see, 'cause you can't see radiation, you can't see, like, the particles bouncing off things.

You have to really look at it as the very, very, very, very atomic scale of things. You can't just say, "the ecology is great, we can leave it in the ocean", but looking at what are other factors that we need to account for that includes contamination. And it's such a hot topic at the moment, like, microplastics, oil spills, like hydrocarbons. They're just as important as looking at other things as well. And plastics can be in structures, um, so when they manufacture them, there's a plastic film and then over time that structure is left in the ocean for 100 years, 200 years, they have such a long life, but once they reach that potential to just release some plastic, and then you've got fish around and they're taking up those plastics, um, and, and going up to human consumers, um, there's that reaction effect that goes up.

Um, and so the cleaning process…so they use a pig. Um, so it's like a big drill that goes through the pipe and then up to the surface. So we collect all the scale, brings it up, but the issue is, even though they may be a risk when it's there, when you clean it, you're bringing it up to the surface and you've got human workers that need to deal with that. And that poses risks as well. You've got a big tub full of this potentially radioactive scale, and you've got a Geiger counter, so the meter that goes "beep beep beep beep beep" -

Cindy:
- when it detects radiation -

Amy:
- um, and they get a number, but they don't actually know what that means for their health. Um, it becomes that issue as well, since it's being able to, um, be complimentary of that, but also to inform that there's some risk to animals around these structures, but the potential greatest risk is to humans.

Cindy:
Would you ever advise against cleaning out the structures or removing them?

Amy:
It really depends on the science, um, that justifies why a structure should be left or should be removed and that science needs to be, uh, recent. Um, so in the five or 10 years prior … but then also for oil and gas operators to follow a process, making sure that there's no risk at points. So that's kind of my big kind of ambition for my PhD project, is to provide that kind of process or provide input and data. It's like providing, like, counseling for them; like, making sure that they're gonna be maximizing the environmental outcomes but also looking at economic outcomes and social outcomes.

So I do a lot of laboratory exposure experiments, modeling, um, characterization work. So I actually look at what's inside the scale, um, if there's any radioactive hot spots, and where exactly, um, or how the crystals grow in it and how long it would need to be in the ocean to cause an effect to an organism.

Cindy:

So I’m wondering what it’s like to work with for-profit companies, especially in a field that is so, like, contentious and controversial. , a for-profit company and especially… what's it like to interact with them, I guess, also, who is “them”? Like who are the actual people that you talk to?

Amy:
So I'm kind of sponsored by an industry partner and we meet up monthly. So I provide, like, a monthly report on what I've been doing. Um, and then I also am able to ask questions directly to them. Um, and they're very open with their answers as well.

Cindy:
Amy also works with different government agencies and regulators, including the National Decommissioning Research Initiative, as well as individuals in non-institutional roles, like fishers and local First Nations people to understand their point of view. Ultimately, the goal is to understand contamination and be mindful of ecological and societal views.

-Blue Dot Sessions - Taoudella -

So I’m assuming you have some kind of fieldwork. What would you say is the proportion of time that you spend on these meetings vs in the lab vs in the field?

Amy:
I don't actually have field work. [Cindy: Okay.] Um, I'm all lab work, desktop work. The only time I get into the field is collect, um, like, sediments for my lab experiments. Another thing is because I deal with very sensitive material like, I can't just go to any university like, “oh hey, here's some radioactive material”. So unfortunately, I have to be in an allocated lab, and I deal with marine animals and that just has another layer of complexity. So I have to either make my own sea water, get my sea water, maintain the conditions of a marine environment.

I deal with prawns. The experiments that I do are month-long. So radiochemistry takes a very long time. Um, not only to prepare a sample, but to process it, you need to wait three or four months and then you can analyze it.

Cindy:
And so is there a reason that you use prawns?

Amy
It's being able to find an appropriate species that’s likely to be found around a structure, that can live in a lab, that’s easy to take care of, that’s not a cannibal. So it's trying to make it more relevant and applicable to what would actually be occurring in the natural setting.

So I use juvenile giant tiger prawns. They’re found in Asia, Southeast Asia and Australia. So the prawn’s either migrating or they're feeding or they've just been magically settled there because of larval settlements. And it’s very relevant because having a prawn means you can get a fish that’s small enough to fit in the tank and you can feed it and see if anything gets transmitted up the food chain.

One of the things I'll be looking at later is looking at potential biomarkers that would be kind of triggered, or can be biomarkers for exposure to radiation, because I'll be looking at genetic effects,

basically dosing up animals of different degrees of radiation, which a lot of studies have been done, um, mainly looking at like Chernobyl, but also Fukushima.

Cindy:
(aside) Okay, quick pause here, because we need to talk about “nuclear accidents” - and pay attention to that wording, because we’ll come back to it later. So for different reasons, the nuclear power plants in Chernobyl and Fukushima failed and caused explosions that released nuclear contaminants - fallout - into the surrounding environment. Chernobyl and Fukushima are two of the worst nuclear plant accidents ever because of how many people were impacted - not only during the evacuation, but also because fallout can travel and linger in the environment for years after. So, basically, Amy eventually wants to look for genetic markers that would indicate whether an individual - or in this case, a prawn - has been exposed to radiation in the past.

Could you walk me through this experiment? From, um, you get your prawns, you get your seawater, to doing analysis, and then, cool any result that’s popped up?

Amy:
So, basically what I was looking at was, if I was to see juvenile organisms - prawns - different concentrations of scale within this food pellet, um, would they take anything up? Would it go past the gills, into the body? So I had a control group, they were fed just brine shrimp. Um, I had a 0.1%, so 0.1% of this pellet was scale and then 1%, and then 10%. So the 10% was representative of the lethal dose ‘cause it was the highest concentration.

Then they were fed one pellet every day at the same time for a week. And during that week exposure, I took some random seawater samples as well, just to see if there was any kind of leeching. Um, so anything from the food pellet going into the water, anything through the guts and the feces. And just basically I then took all the prawns out, um, and euthanized them.

Cindy:
(aside) From here, Amy dissects the prawns so that she can analyze the level of metals and radioactivity in different tissues and organs. She does the same analysis for the water from the prawn tanks, to see if anything passed from the prawns who ate food pellets containing scale.

Amy:
So I started the experiment in January. Um, I got everything ready for analysis in February, and then I didn't get results until May, June. So it's very sensitive. Um, and unfortunately you have to separate every single radionuclide that you want to look at. So I was looking at polonium and lead and radium and borium. So I spent three weeks in the lab separating everything.

And the result came out, uh, really poor, unfortunately, um, and it was something to do with how you separate each of them. So I've been trying to redevelop the method. After I did the last experiment, I did another one and all my prawns died of a virus, uh, which was the most ironic thing to happen. So everyone calls it COVID prawns.

Cindy:
Well, I’ll, uh, keep my fingers crossed for your next round of experiments.

(aside) Five months later, Amy says that the prawns have all died and that she's waiting on the "juicy" results from another experiment using clams.

So I know you're really early on in your PhD, but are there any policy changes that have come directly from your research? Or are there things in the pipeline?

Amy:
I do have things in the pipeline. I always use, like "I've got things in the pipeline", um, and then people just like, "hahaha"... um, it's more related to, like, policy or like guidelines and thresholds. Um, so looking at how much an organism can take, um, before there would be some sort of associated effects. Um, so that can be anything from a genetic effect, like on reproduction, behavior, but it can be positive and negative.

So I'm not only looking at all negative effects, uh, "are the reproductive system like, abnormal", I'm kind of looking for positive things as well. Like, animals have this incredible thing where they can adapt to anything. So you have worms, um, that can adapt to very contaminated sites or areas, like very high levels of nitrates and nitrogen, or even like toxic metals like arsenic and cadmium. And so it's being able to look at both the positive and negative effects, um, that will come out with some of these experiments, but nothing really at the moment.

Cindy:
Do you have any thoughts about the state of science or PhD training in general? Like, do you think the, uh, like scientific training that you've been through and that your contemporaries go through, do you think that's fair for what you get out of it and how much time you spend?

Amy:
I think it depends on what your PhD is, but what I understand as a PhD student, and I feel like most students don't get told this enough, is that if you're going from your Bachelor's straight to your PhD, that's such a shock because you're going from being dependent on someone to tell you everything, to, "okay, everything's up to you now; you have to do everything yourself". You have a supervisor that's kind of like your coach.

But at the start, um, for me, I knew that I didn't really want to go to my PhD just yet because I wanted more exposure to what it means to do research. Um, not only how to actually do an experiment right, but also how to actually do good, ethical research as well. And just another thing is, I love collaborations. I love talking to more than just my supervisors. Being able to look at different people's perspectives as well and what you're doing and come from different points of views on how you can actually make your science better as well.

But your PhD is your own thing, it's independent, what you want to do at your own terms. Your supervisors are only there to guide you through that, to give you recommendations and suggestions, but at the end of the day is what you decide. Like the you're the first author, the primary author, you can choose which direction it wants to go to.

Cindy:
The realization that a PhD is yours, and it is so fundamentally different from being an undergrad researcher… That was, like, the most important thing I had to realize. And it just took me a lot longer than you seem to have realized.

Amy:
Yeah. It's being able to say to yourself, at the end of the day, you were accountable for what happens, the responsibility is on you. And I got exposed to that during my undergrad in zoology,. Each semester, we would go through the process of creating a research question, what are your aims, what are the methods you're going to do? And being guided through that by a lecturer or professor and actually doing the hands-on work.

And then that kind of made me realize, okay, I, I enjoy this a lot. Um, and so that's why I wanted to continue on that research journey... And yeah, I feel like a lot of people don't get exposed to that during their undergrad. They don't get the opportunity to do hands-on experiments or doing, maybe, ethical work, where you need to go through that long process of getting approval to be able to talk to people, same as animals. But if you're doing a PhD and you haven't been exposed to that, it becomes so overwhelming.

Cindy:
That sounds like an amazing undergrad experience.

Amy:
Yeah, zoology was the best.

Cindy:
Do you have an idea of where you want to go after your PhD? Like, do you want to stay in academia? Do you want to do, like, strictly more policy work?

Amy:
Some days I feel like I would like to keep going down that research kind of road, just because... I won't be able to finish everything that I want to do. On other days, I would like to go more into kind of like a scientist role, potentially working within oil and gas, as an environmental scientist or someone who looks at environmental risks, um, kind of like that policy work, but in the off-days, and they're becoming a little more common, I really enjoy academia, like wanting to be in universities and teach.

Cindy:
What are people in your field, I guess, environmental science, uh, most excited about and most worried about right now?

Amy:
The elephant in the room that is climate change or any kind of impact from human activity at the moment. Um, so ongoing mining, atmospheric condition, just anything and everything that impacts the environment in a negative way. Positively, um, good things, quite rare…

Cindy:
Increased awareness, even if it's mostly greenwashing…?

Amy:
Increased awareness slash some greenwashing, yes? Yeah. Um, and also to see some improvements in some areas of the world in terms of more renewable energies, um, animals coming back into different

environments that they were originally found, um, new environmental policies, and also just becoming more together.

And I feel like there's two different types of environmental scientists. There's the ones that are so passionate about everything that, um, they're as green as you can get. And, uh, and then the people like me that are very mindful of everything that's going on, that some countries have to keep extracting more minerals. And you can't just switch that off overnight because you've got thousands to millions of people impacted like India, China, even Russia as well. And then I don't live a sustainable life, like I have to buy things covered in plastic. There's just plastic in everything. So I just do the science at the end of the day.

- *Blue Dot Sessions - Taoudella* -

Cindy:
So you've mentioned Chernobyl and Fukushima and Hiroshima, which I do think are what the lay person - including me - immediately thinks of when they hear anything about radioactivity, and of course that's not a very positive association. But I'm assuming that there's more to the story when you talk about radioactivity and radiation?

Amy:
A lot of people say, "you're dealing with radioactive material - Chernobyl?, Fukushima?" It's just, like, no, that's different, um, those are *man-made*, uh, like kind of radioactive elements and materials, and that comes from a power plant, this is from the earth, this where we live, on the ground, like me. But I feel like those documentaries really affect people. They just think, oh radiation's a bad thing.

But at the end of the day, for Chernobyl, it was human error. It was us, it was people, that did something wrong. Um, and at the end of the day it cost us lives. On the other side, we got Fukushima. That was a natural event, and a tsunami, and that tsunami just managed to hit the one place where there was a nuclear power plant. And the Japanese knew how to run power plants. And it was the most sophisticated power plant. And it was just an accident. And it's the same with Hiroshima, um, on the same scale as Chernobyl - that was an outcome of humans. Um, so you, you have to account for what actually happens *before* the event. And you have to really think it's all bad. Like "it's horrible. Can't have nuclear energy. We can't do that."

And it's like, well, there's a big ball of, um, radiation that's not too far from Earth that gives you radiation on a daily basis. If you get too much radiation from the sun, the rays, you get burnt, uh, happened in Chernobyl, if you become too exposed, you get burnt. And then, then there's this kind of like, humorous kind of topic that comes up in conversation about, "oh you, you work in nuclear sciences. Microwaves and phones: do they give off x-rays?" And it's like, "um…no? I use a microwave, I use a phone", um… kind of like a difference between the different types of radiation that you're exposed to.

So I feel like people become paranoid about it, but there are so many things that other people could focus on. Um, I feel like radiation is just the big, bad boy in the conversation. I mean there's radiation in bananas. There's potassium, and then there's potassium-40. I think if you eat so many bananas a day, you do get a dose. It's not lethal or anything.

Cindy:
Yeah but you would also have to eat….Like, I'd be worried if you ate that many bananas, for *any* reason.

Amy:
Yeah. Like 20, 30 bananas a day would give you a dose. I mean, it would give you constipation from too much potassium from too much fiber, but people just need those really strange facts to just bring them down to it. So like, uh, everything like, there's background, radiation everywhere. X-rays: you go and get your MRI, your CT. You're getting a dose. Um, and so that's why they cover up your extremities. And then cancer therapy; like, the only form of cancer therapy that there is, is, um, nuclear medicine, and it's being able to say all the good things that nuclear sciences do, and radiation do, just to get people off the kind of stigma of how everything goes wrong while there's so many positives and benefits from it as well.

Cindy:
Is there a single takeaway that has directly impacted or changed your life or mindset or actions? Maybe like, the obvious one would be maybe you don't eat shrimp anymore?

Amy:
Yeah. Like, I try and not tell people, like, "Ah yeah, like the mussel that you're eating? They're filter feeders, they take up anything that's in the ocean, including radioactive material and any potentially toxic metals" and people just put the mussel down and they don't touch it. Um, not necessarily that kind of action.

I've become more conscious about what I say and how I say it, because science can be very brutal. And if you speak up about something there's so much backlash. The amount of negative criticism that you get can outweigh, like, the good science. And I mean, it's everywhere, mainly in climate change research. Some people don't like to hear it, but it's the *right* thing to do at times.

And it's the same with science, that you have to tell your truth, but you have to be sincere of what people's opinions are as well. I've met a few people over the last two years that are against oil and gas and extraction. And they become very critical of what I do. "You're helping oil and gas. You're supporting them because they're supporting you."

And I take a step back and I say, "no, I don't support what they're doing. I'm trying to help them, like guide them." They're not the bad guys, they just need to learn a lot more about what they're doing because they might not have that knowledge to begin with. And so it's trying to bring that bridge over very slowly, in the right way to do it, because it's sensitive… not to get your personal opinions in the way of what you're doing as well.

Cindy:
So something we try to highlight with these Spotlight interviews is people's experiences as underrepresented scientists, or scientists who have had some kind of struggle of any kind. and you wrote that you've struggled with imposter syndrome and as a woman in science. So is that from your experiences working with the industry side of things? Like I'd imagine you're talking with lawyers, executives who are probably older men…

Amy:
I think I overcame that a bit last year, but I forget that I have degrees and I think, why am I doing a PhD? How did I get here? I mean, I almost failed chemistry in high school and now every day I'm doing chemistry and it's being able to actually speak up about my flaws and my errors to different people.

And I'm the first person in my family to do a PhD as well. And so there's kind of, overwhelming expectation that, "oh, she's, she's going to become a doctor. She's going to save us all, she's going to save the world. She's going to save the animals." And it's like, no, please don't put that pressure on me." There are times where I'm very silly or stupid, or I forget things like a human being ... Like I'm not Stephen Hawking.

And it's that pressure from society that says, "Are you going to settle down?" And yeah, I find that the world is still in that kind of mindset and stigma of women who have children, um, not only in academia, but in professional workplaces as well. So having more people being recognized for what they're doing and how they're doing it, and being able to actually have them on board and not be criticized just because of who they identify themselves as. And that needs to change, especially when you've got this new generation coming through and when they're replacing the previous generation that's built up on potentially traditional views of what it means to be a woman or a non-binary person.

Cindy:
Um, so you did mention that you had sort of gotten over your imposter syndrome in the last year or so. Is there any one specific thing that happened?

Amy:
Yeah. When I began to talk more and more and more, it just became more casual. And then I think it must have been overnight last year, where I realized that they're human, just like me, they sometimes don't know things that even I don't know. But imposter syndrome hits me when I meet new people who are very, like, high up, highly qualified. And then after like maybe a few seconds, I don't really care.

- *Blue Dot Sessions - Damaroon* -

How do you want yourself to be perceived, not only in the scientific world, but also in your personal life, do people, do you want to be seen as smart one? Do you want to be seen as this fun bubbly person? So I just want to be seen for who I want to be, and I won't take things to heart.

Cindy:
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Stay safe and stay curious.