MODULE 4, LESSON 3

ENVIRONMENT AND ECOSYSTEMS ASSOCIATED WITH EACH DEPOSIT TYPE

LECTURE NOTES

Hello everyone and thank you for joining me today as we explore the different environments and ecosystems associated with each type of deposit of interest for seeded mining in areas beyond national jurisdiction.

My name is Kirsty Mcquaid and I'm a postdoc research fellow at the University of Plymouth and the South African National Biodiversity Institute let's dive right into it.

I'm sure you will already have learned in previous modules about each of the different deposit types of interest for seabed mining in areas beyond national jurisdiction. Just to recap, these are polymetallic nodules, polymetallic sulphides and cobalt rich ferromanganese crusts. Each of these deposits is found in a different environment and each supports a different ecosystem and a whole different world of animals. Over the course of this lecture, we will look at each of these deposit types in detail, so that by the end you'll understand the key differences between the environment and ecosystems associated with each. And we will explore them in the order that's shown on the screen.

So first, let's look at polymetallic modules. These are roughly potato sized mineral concretions, although they can be smaller and bigger, and they're found on the sea floor. They're the deposit type that is receiving the most attention at the moment. Modules contain high concentrations of commercially valuable metals like nickel and cobalt, copper, manganese and they're sometimes also called manganese nodules. These modules are not attached to the sea floor, but rather they lay on top of it. They're found at great depths of around 3000 to 6000 metres in what we call the abyssal environment and they occur in, well they can occur in very dense fields where you can barely see any space between them or they can occur less densely with a bit of space and sediment between them, like you can see in the pictures here.

They generally occur on flat soft sediment, abyssal plain sea floor or on very gentle slopes and they occur over vast areas in the order of many hundreds of square kilometres. These are the deepest deposit type and the environment they occur in is dark and cold and has very high pressure. This is important to keep in mind when we consider the animal communities that live here. So where these nodule fields occur, they provide some of the only hard substrate or surface in an environment that's otherwise generally just soft sediment. And some animals, like corals or sponges, are reliant on hard substrate to attach to, and so larvae will land on these nodules and

attach and an animal. Will grow there. And you can see an. You can see an example of this in the pictures shown here.

The modules themselves have lots of grooves and little crevices in them as well, and so we get smaller animals found living in those spaces and these are often things like nematodes or polychaetes, which are different types of small worms or copepods which are small crustaceans and they're many different other types. And these animals that are found living within the nodules, and sometimes those living on the nodules are different to those found in the surrounding soft sediment environment and some are unique to that module habitat.

Other animals occur either within or on top of the surrounding sediments, so many different types of tiny little creatures are called infauna lived within the sediments of nodule fields and they play a really important role in sea floor food waves by providing food for other animals and the functioning of these systems. They're also larger animals that live on top of the sediments, some of which are mobile, so they can move around like a big sea cucumber. You can see a purple one on the top there, and you also have sea stars, brittle stars, urchins or shrimp. But others are stationary and so they're not able to move, like corals and sponges that are attached to the nodules. Many of the species that are found associated with nodule fields appear to be rare and based on scientific studies, there's still many, many different species that are to be discovered.

Through marine scientific research, we're beginning to build a picture of what these animal communities associated with polymetallic nodules, look like but there's still quite a lot to do in terms of understanding how they behave how they reproduce, how they interact with one another, and how different populations are connected. Scientists are also trying to understand what role these environments and ecosystems play in providing different ecosystem services, which are the direct and indirect contributions that ecosystems provide for human well-being and quality of life. And these can be things like providing food and water or regulating the climate. So we get to build a clear picture of exactly what services are associated with this ecosystem type, but we know that it's things like nutrient and carbon cycling and climate regulation and there's value to the overlying water column as well, not just the sea floor. So, for example, if it supports important migratory routes of animals like turtles or whales.

So let's look now at polymetallic sulphides. These are mineral deposits found on hydrothermal vents at around 1000 to 4000 meters deep, so generally a large, shallower than polymetallic nodules, and they contain metals like copper, zinc, gold, silver. Hydrothermal vents are fissures or cracks on the seabed from which water, which has been heated by hot magma within the earth, is released into the water column and you might have seen these in nature documentaries before. - they look a bit like underwater chimneys, where you have this hot water streaming. And these vents are found in all ocean basins, primarily at mid ocean ridges and back arc basins, where there's more tectonic activity. Multiple hydrothermal vents that occur close to one another form what we call a vent field. Hydrothermal vents can be classified as active, inactive, or extinct, and this just differentiates between active vents, which are still releasing that hot water into the water column inactive events which are not currently releasing hot water, but they may have been recently active or they may be near a hot water source and they might become active again and then finally you

have extinct events which are unlikely to become active again.

Vent fields can consist of active, inactive and extinct vents, and they can be the size of several football fields, but active fence themselves are confined to much smaller areas of a few square kilometres of seabed. Mining for polymetallic sulfides will focus on inactive and extinct fence, that vent fields may consist of a combination of active, inactive, and extinct friends, and so we need to keep this in mind. Hydrothermal vents are really extreme environments, with waters up to 400°C Celsius, and the water is rich in metals and toxins, and it's low in oxygen. Having said that, generally animals that are living in these areas are living in waters that are below 50°C because of the diffusion of heat as it goes into disperses into the water column. But this is still a lot a lot warmer than the surrounding waters, which are normally closer to around 2°C, so it's a lot warmer. And importantly, hydrothermal vents create their own food source, and this is really unique for habitats in the deep sea.

Most food webs on Earth rely on the sun to produce food through photosynthesis. This is the case on land and surface waters of the ocean; we all know plants need like to grow, so most animals that live in the deep ocean, where there's no sunlight rely on food sinking from surface waters to the depth to survive. But at hydrothermal vents, some of the highly specialized microbes have adapted to be able to convert chemicals in the vent fluid into energy or food and so these microbes are then eaten by things like mussels, clams or shrimp. These are then eaten by larger animals, like crabs, fish, jellyfish, octopus and because of this availability of food, animals here grow really quickly compared to other environments. Due to these extreme environmental conditions active events are a really unique ecosystem and so as a result they support a unique animal community that's highly adapted to living there. Unlike module fields, hydrothermal vent systems have a really high abundance and biomass of animals and there are fewer different types of animals, so lower diversity, but those that do occur there occur in very high densities and you can see in the bottom figure there those giant tube worms - there are loads of them found in a really small space. At inactive fence, although the conditions are less extreme or aren't as extreme, you'll still find long lived vulnerable animals living there like corals and sponges, as well as unique microbial communities, and these extinct hydrothermal vents or inactive hydrothermal vents are still providing as we spoke about with the nodules, a hard substrate for attachment.

Inactive and extinct hydrothermal vents are not actually very commonly studied, so we don't really know a lot about these systems, but we do know that they support important ecosystem services like potential new bio products through marine genetic resources and as I said, creating a habitat for animals to live on. Active hydrothermal vents provide these services and more. They're really important for scientific research and including on understanding the origins of life, and they have an educational and an outreach function as well, like I mentioned, the nature documentaries and these are just some small examples of what these services, these ecosystems provide.

So finally we have cobalt rich ferromanganese crusts and these are deposits found on the flanks of seamounts of some seamounts, which are like underwater mountains found all over the world. Ferromanganese crusts are at their thickest and their richest depths between 800 and 2,500 meters and they contain cobalt, vanadium, tellurium and other valuable metals. Seamounts may occur as individual underwater mountains or as part of a bigger range of underwater mountains, similar to

our land.

Seamounts are typically formed through volcanic activity and so like nodules and vents they provide hard surface in an otherwise generally softer sediment environment and this means that they provide attachment sites for animals that require a hard substrate or surface to settle and grow on, like sponges and corals. Seamounts also affect ocean currents and water flow by you know, the mere manner that they stick up into the water column and this ensures a constant fresh supply of food and nutrients in the water. So seamounts are associated with really high productivity. Animals which settle and grow on seamounts provide substrate for other animals to then live in or around, and they also act as a food source. So, for example, squat lobsters or fish may feed on these, and together these animals then provide additional food sources for other larger animals. Many seamounts associated animals are very long lived, slow growing and fragile like corals and sponges, and some can be really large up to five metres high. Some seamount creatures are not found elsewhere, for example on the flat sea floor, and these are called endemic species.

These two elements, particularly the availability of increased food and hard surface for attachment, means that you have high numbers of diverse creatures on seamounts, and they are what we call biodiversity hotspots. Because of this, seamounts provide a multitude of ecosystem services. They're important breeding grounds, spawning grounds where animals will produce their eggs and refuge. They act as refuge year, providing protection for some species, and they support the prey of many different commercially important species like tuna and orange roughy, so these are also found in abundance around seamounts. As well as providing habitat and food sources, they're important for climate regulation because they're associated with this increased productivity and so you have more blue carbon sinking to the sea floor. And they're also important culturally for their spiritual and historic and scientific value and these are again just a couple of examples of some of the services, but there are many more.

So to recap, we have polymetallic nodules which occur on abyssal plains at around 3000 to 6000 metres, which support low densities of very diverse animals. We have polymetallic sulphides which occur on hydrothermal vents at 1000 to 4000 metres, which support a really high biomass and densities of very specialized creatures on active vents. And we have cobalt, which ferromanganese crusts which occur on the flanks of seamounts at their richest, around 800 to 2000 meters deep, which are biodiversity hotspots and support a high biomass and diversity of animals from very small to large predators. For each of these mineral types, there's still gaps in our knowledge on some basic ecological information, and this includes simple things like what animals are found where, how big the populations are, how do these different animals behave and interact. We also know a little about the different life history traits of many of the different animals. So this means things like how quickly do they grow and reproduce, how many offspring do they have, as well as how the different populations that are spatially separated are connected and mix.

As well, finally, things like how far can the larvae produced in one area travel to reach another area. And then finally, we have some understanding as I've spoken about the ecosystem services, but we don't know exactly how all of these components of the systems function and how this translates into different benefits and how these flow to humans. So ongoing marine scientific research is really important to build a better picture of what these ecosystems look like, how they function, how

they're connected and how they support the planet and human well-being. Thing, if you'd like to learn more about these ecosystems and the animals and the ecosystem services that they provide, I'd strongly encourage you to take a look at some of the recommended readings, which are easily digestible and give more information on the topic. That's it from me. I hope you enjoyed learning about the ecosystems associated with different mineral deposits in this session.

Thank you.