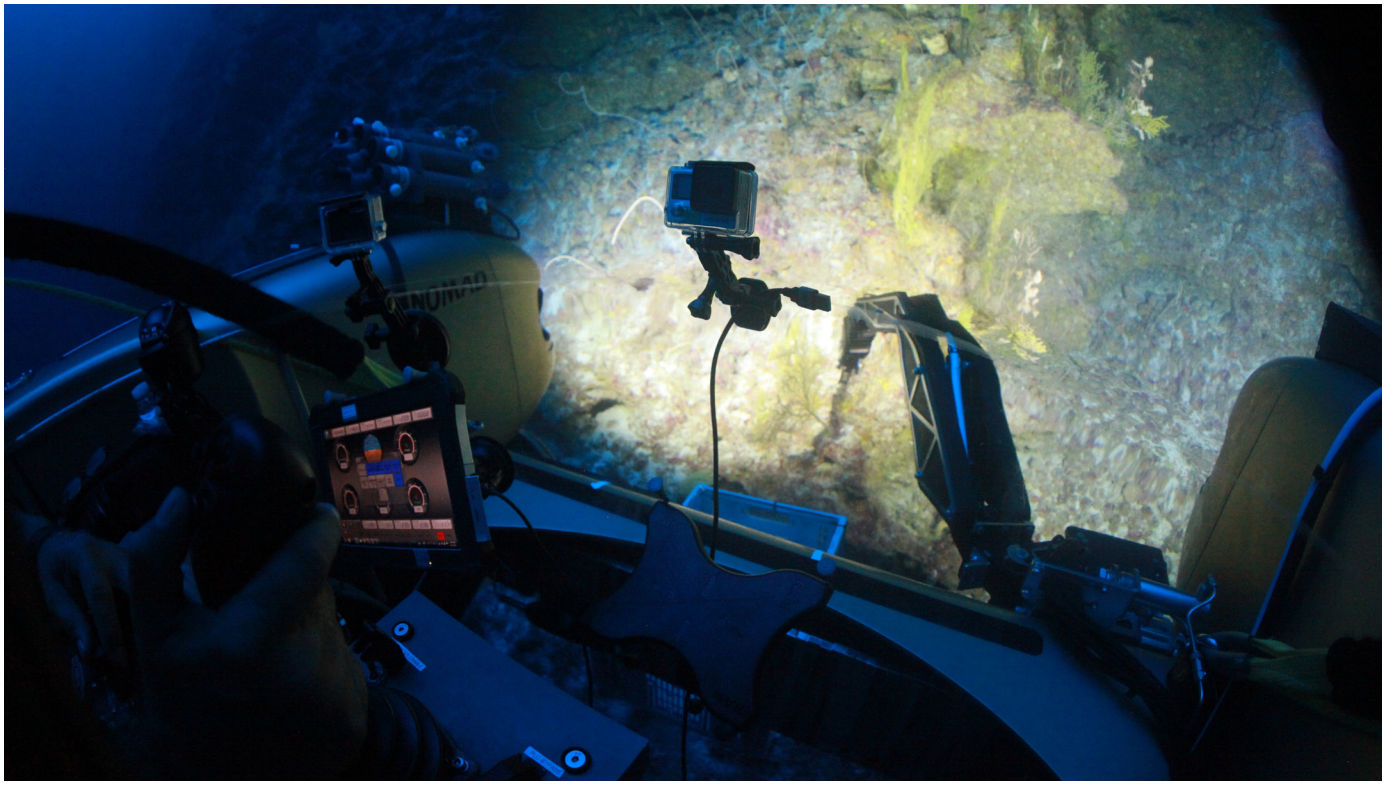
360VR EXPEDITION GUIDE: SUBMARINE SCIENCE



About your 360VR Expedition

How do scientists research and explore underwater? Studying the deep ocean is not as simple as studying environments on land. Researchers first of all have to deal with surviving below the surface, using a combination of dive teams, manned submersibles, as well as a range of deep sampling tools and robotic vehicles.

As researchers explore deeper, they have to contend with increasing pressure and decreasing light. At the deepest point on the planet, Challenger Deep, the pressure is an incredible 15,000 pounds per square inch: the same as an elephant standing on your big toe. Darkness is also a feature of the deep. Below 600 feet, very little light filters through from the surface and below about 3,000 feet, there is no sunlight at all.

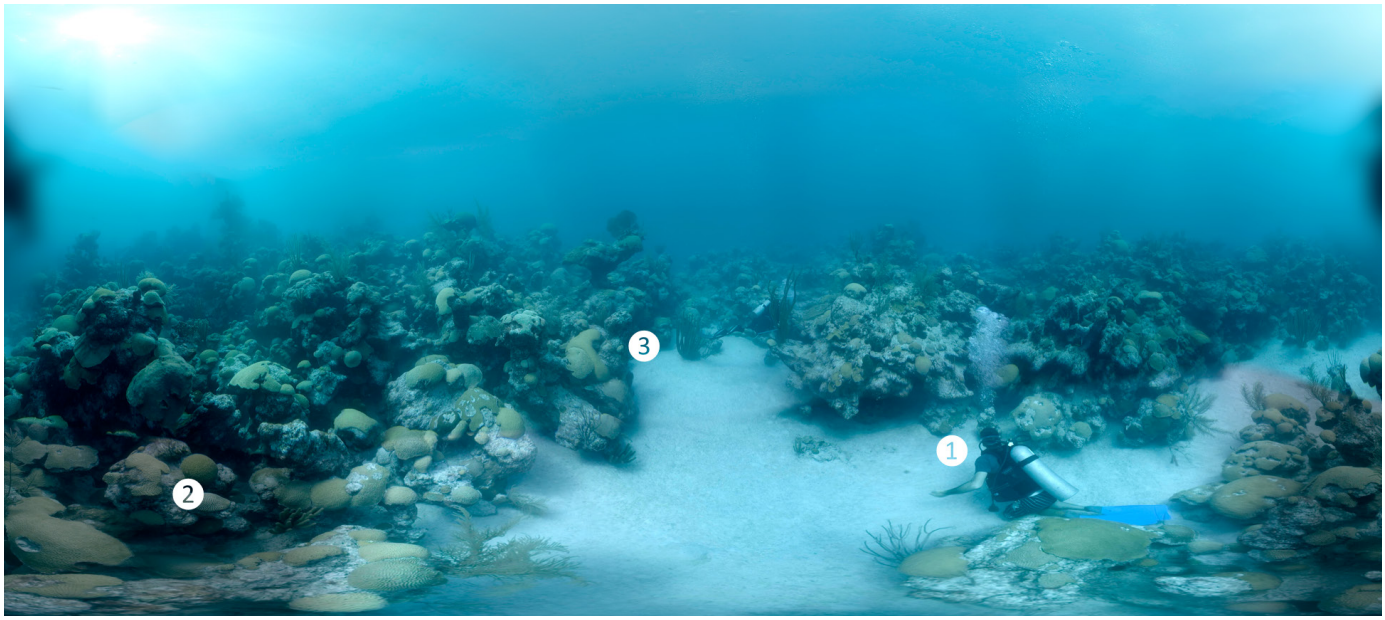
In this expedition, students will learn more about the science and technology needed to explore the deep ocean, joining the Nekton Mission team as they research the waters off Bermuda with submersibles, deep dive teams and a host of scientific equipment.

How to view this 360VR Expedition

This 360VR Expedition can be viewed at **http://encounteredu.com/discover/images/submarine-science** or via the Google Expeditions app **http://edu.google.com/expeditions/**, search for 'Diving in a submarine'. For more guidance on using either 360VR or Google Expeditions, please see the Subject Updates: **How to: Quick start to 360VR in the classroom, How to: 4 ways to use 360VR in the classroom,** and **How to: Use Google Expeditions.**

This Expedition Guide provides detailed information about each of the 360˚ photos, known as panoramas, included in this expedition. Each 360˚ photo will have the following information to help you guide your students on the expedition:

- Description – to be used to introduce each panorama.
- Point of interest overview – points of interest is the term given to specific details on a panorama. These are numbered on an overview photo.
- Point of interest descriptions – a description of each point of interest allows the teacher to guide students around the panorama.
- Class discussion questions – a differentiated list of questions for class discussion is included at the end of each panorama section.



Panorama 1: Divers hunt lionfish

We start off our expedition, investigating the shallow coral reef off Bermuda. At depths of 60-90 feet, the shallow reef is relatively easy to research, requiring standard scuba equipment. The focus of this part of the science was to look at the impact of invasive lionfish on the coral reef environment. Lionfish come from the Indo-Pacific region, but have now 'invaded' other reef habitats, where they have no natural predators. Their feeding habits are having a negative impact on local species.

Point of interest 1: Science diver

Science divers conduct transects. This means that they follow a set route, making observations about the reef environment. On this dive, the scientists and volunteers are looking for lionfish and recording their number and size, as well as trying to catch them.

Point of interest 2: Shallow coral reef

This shallow tropical coral environment is what most people imagine when we talk about coral. Globally, the three-dimensional shapes of the coral reef provide a habitat for 25% of marine species. However, corals also live deep in the ocean and in cold waters.

Point of interest 3: Hidden lionfish

Lionfish are hard to locate on the reef and hide in nooks and crannies. Hunting and sampling the lionfish has the added benefit of removing this invasive predator from the reef.

Questions

Beginner

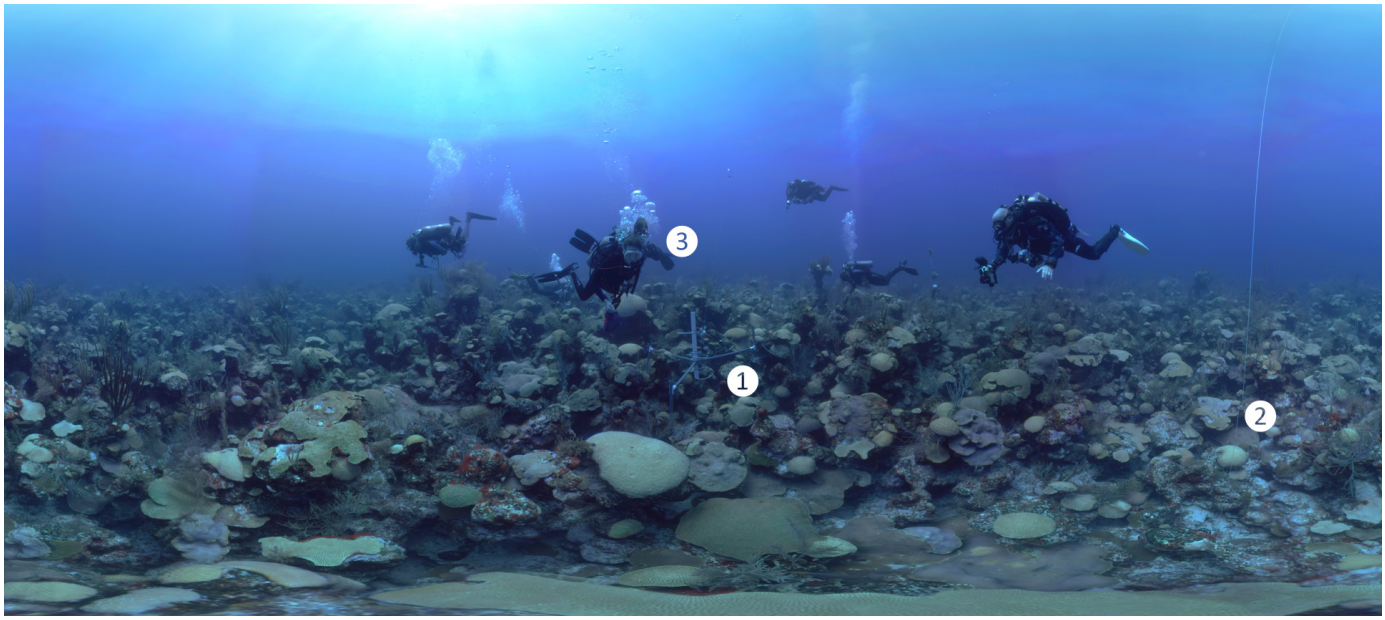
Question: How do the scientists study underwater?
Answer: The scientists use scuba (or sub aqua) equipment so that they can breathe and research underwater.

Intermediate

Question: What is meant by the term 'invasive species'?
Answer: Invasive species are living things that are introduced to a different environment. Often they cause ecological problems as they face no natural predators.

Advanced

Question: Why are the scientists 'hunting' lionfish?
Answer: Scientists are hunting lionfish to understand the scale of the problem (recording abundance and size), to capture specimens for analysis of what they are eating and to kill them to reduce their environmental impact.



Panorama 2 Coral health

For a better understanding of the submarine environment, scientists need to study a range of physical and chemical factors, including light, pH (level of acidity), oxygen, salinity and temperature. The team deploy a piece of equipment called BEAMS (Benthic Ecosystem Acidification Monitoring System). You can learn more about this from the video made by the science team at https://youtu.be/Kdg5HG2Ebfs.

Point of interest 1: BEAMS

BEAMS equipment... Benthic = seafloor; Ecosystem = all the living things; Acidification = the changing pH of the water caused both by natural processes of respiration and photosynthesis, and changes in atmospheric carbon dioxide; Monitoring; System.

Point of interest 2: Healthy coral

A healthy reef requires balance. Too much carbon dioxide and the coral has difficulty growing its structures. Too little carbon dioxide and algae cannot produce enough energy to power the coral. Carbon dioxide levels alter the pH level of the seawater and so acidity measurements tell scientists about reef health.

Point of interest 3: Seawater biogeochemist

Heidi Hirsh is a seawater biogeochemist, meaning she is interested in the relationship between bio- (living things), geo- (minerals, especially the calcium carbonate - simplify as chalk - needed for corals to grow their structures, -chemist (the salinity and pH of the water).

Questions

Beginner

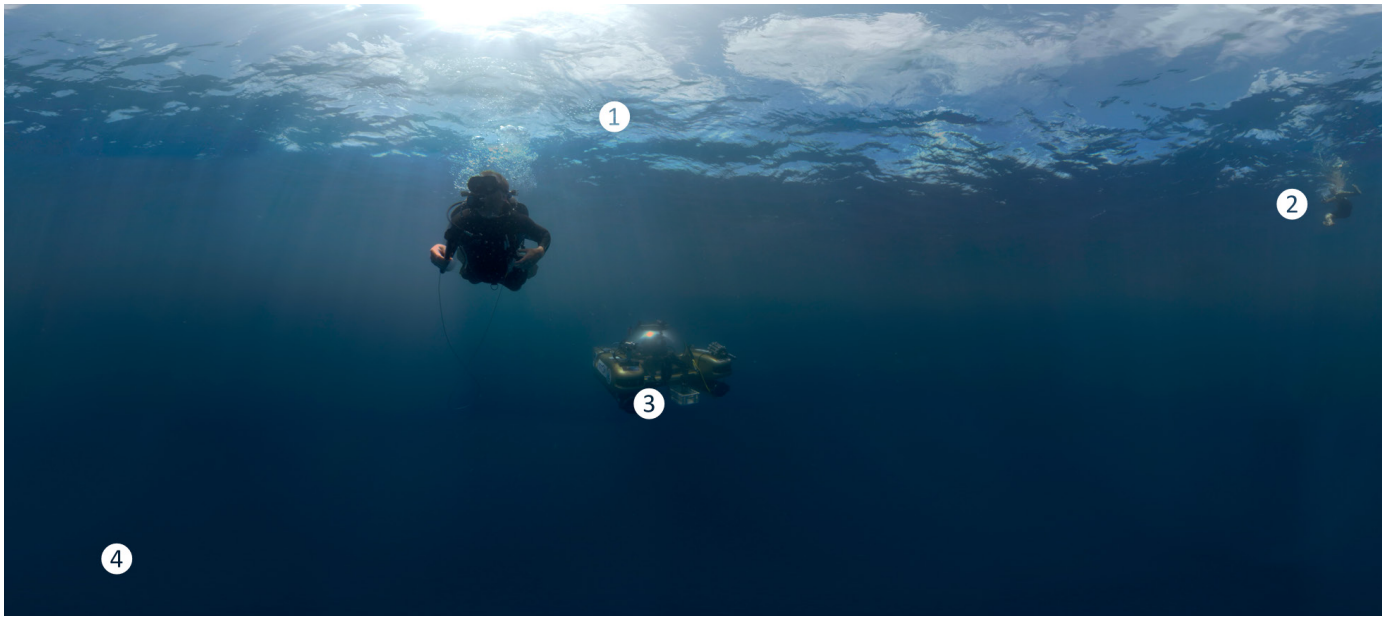
Question: Name two of the physical or chemical factors that the science team are measuring.
Answer: Any two from pH (acidity), light, oxygen, salinity and temperature.

Intermediate

Question: Explain one of the factors that needs to be in balance for healthy coral.
Answer: The level of carbon dioxide in the seawater needs to be in balance, so that corals can create their structures and algae have enough energy to power the reef ecosystem.

Advanced

Question: Why does Heidi study the relationship between the marine biology, geology and chemistry?
Answer: Marine organisms, such as coral, are very dependent for their health on their surrounding environment. If the geology or chemistry of the seawater changes, this affects coral health. So, she studies all the factors to gain an all-round analysis of this environment.



Panorama 3 Diving deeper

The deep dive team had a depth limit of 300 feet. To explore the ocean below this, the team used manned submersibles. These Triton 1000/2 submersibles are rated down to 1,000 feet, and some submersibles can travel to full ocean depth at 36,070 feet. With their clear pressure hulls, these submersibles give scientists unparalleled views of the subsea world.

Point of interest 1: Reflective surface

Looking out over the ocean, it is impossible to see the wonders deeper below because of this reflective surface and because water absorbs the sunlight. This means that scientists have to travel below the surface to find out what's down there.

Point of interest 2: Swimmer

A 'swimmer' is essential for submersible operations. They are on the outside of submersible on the surface to ensure that everything is ready to dive and to detach or disentangle any ropes or other obstructions.

Point of interest 3: Triton submersible

The Nekton Mission team had two submersibles that carried a pilot and researcher to investigate the seafloor. These Triton submersibles provided an excellent 360 degree of the ocean and seafloor for the researchers.

Point of interest 4: Dark depths

Diving deeper into the ocean, darkness becomes an issue for researchers. The Triton submersibles have bright external lights to illuminate the seafloor. Without tools like the Triton, scientists would not be able to discover what lives in the deep.

Questions

Beginner

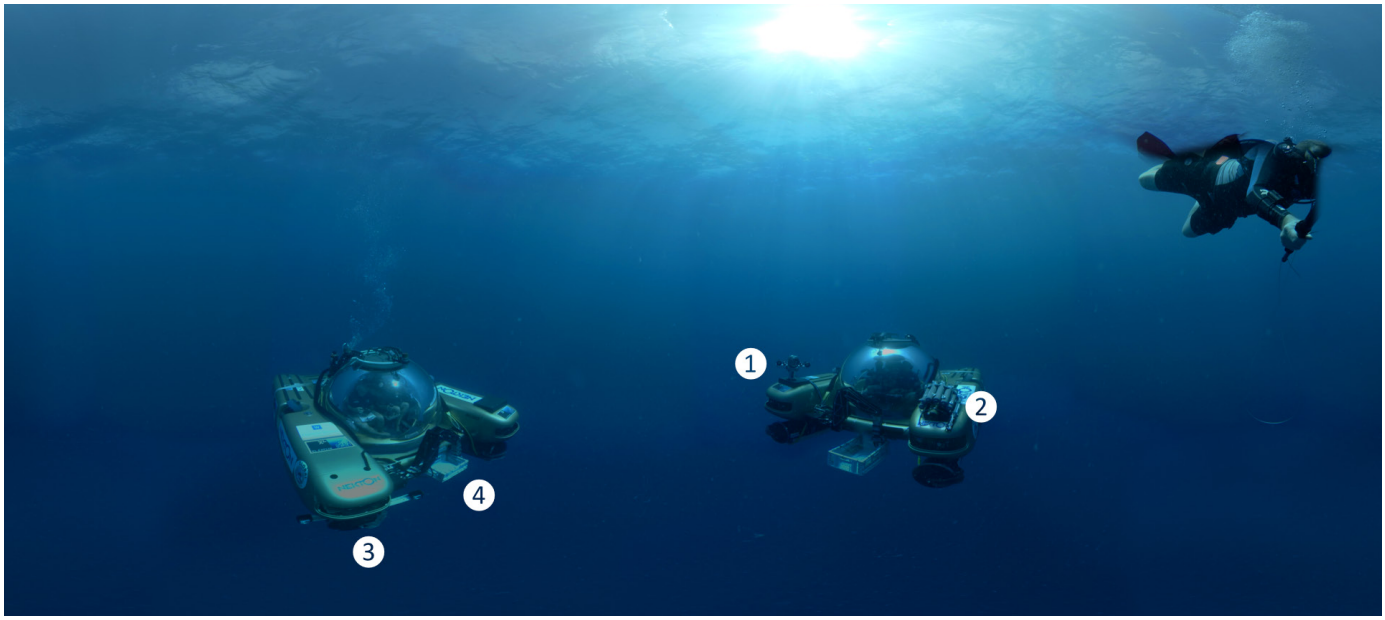
Question: How deep could the team explore in their submersibles?
Answer: The Triton submersibles used by the team can dive to 1,000 feet, although three people have used submersibles to reach full ocean depth at 36,070 feet.

Intermediate

Question: What problems do scientists face in exploring the deep ocean?
Answer: The ocean's reflective surface make it difficult to see down into the depths. Water also absorbs light, so that researchers need to find a way of illuminating the deep sea environment.

Advanced

Question: How are the submersibles designed to aid scientific research?
Answer: The submersibles provide a pressurized vehicle for scientists to descend deeper into the ocean. The clear pressure hull means afford a 360-degree view of the deep sea, and bright external lights show this habitat and the living things there more clearly.



Panorama 4 Submarine science tools

The Nekton Mission used two submersibles, Nomad and Nemo. Nemo was the transect submersible, equipped with a GoPro system to conduct video transects. A video transect involves piloting along a set route at a steady speed, recording video. This recording can then be analyzed by researchers back at university. Nomad was the sampling submersible equipped with a range of tools for taking further samples, as well as a specialized video camera. Both submersibles have hydraulic arms for collecting physical samples.

Point of interest 1: Teledyne camera

This high resolution camera is directed by the pilot or scientist to record specific sites of interest or the behavior of deep sea creatures.

Point of interest 2: Niskin bottles and CTD

The 'rosette' of Niskin bottles are hollow tubes with remotely operated stoppers at either end. These can collect water samples at specific depths. In the middle is a CTD (Conductivity Temperature Depth), that records salinity and temperature at different depths.

Point of interest 3: Video transect cameras

The cameras are mounted in a special rig that gives a stereo view of the seafloor. A computer program is used for further analysis that can calculate the exact size of deep sea creatures, using the spacing and angles of the two cameras.

Point of interest 4: Hydraulic arm

The collection of physical samples such as of algae and coral complement the video record. By taking actual samples of life in the deep, scientists can send these for genetic analysis to see what species live here and also to see if some of the living things are in fact species unknown to science.

Questions

Beginner

Question: Can you name the two submersibles and say what the differences are?
Answer: The two submersibles are called Nemo and Nomad. Nemo is the survey submersible mainly creating a video record. Nomad collects a different range of samples and more specific video.

Intermediate

Question: How do scientists use conductivity to measure the salinity of the water?
Answer: An increase in salinity means that there are more ions in the water to conduct electricity. Measuring current through the water is the easiest way for scientists to measure the salt content.

Advanced

Question: In a digital age, why are physical samples still important.
Answer: For proper analysis of species, a physical sample is needed. It can be sent for further genetic testing for full species identification. Every species known to science has a single type specimen. This is the specimen on which the name and description of this species is based. How many might the team have found?!

Panorama 5 Initial analysis

The science work during the expedition did not stop with sample collection and video recording. On the research vessel were two science container laboratories. The science worked here, conducting initial analysis on some of the samples and also preparing them for storage. It is important that the samples are properly preserved so that they do not alter before they can be analyzed further at more specialized facilities back at universities.

Point of interest 1: Prepping water samples

Heidi Hirsh prepares water samples collected from the Niskin bottles and the technical dive team by adding mercuric chloride. This is a highly toxic substance that kills all life and stops any biological processes altering the chemistry of the water.

Point of interest 2: Glass bottles

Melissa Price assists with the prepping of the water samples, ensuring that glass bottles are used. Plastic bottles could react with the seawater, changing the chemistry of the water. Strict processes are followed to ensure that these samples are valid.

Point of interest 3: Accurate records

Dr Thea Popolizio ensures that careful notes are made of the position where each of the sample were taken. This is all part of the scientific process that means that these bottles of water can be used as data to understand the workings of the deep ocean environment.

Point of interest 4: Digital camera

Digital photographs are taken of all the physical samples collected. These act as a record and also mean that the work can be shared effectively and quickly with other collaborators and experts.

Questions

Beginner

Question: What kinds of samples are Heidi and Melissa preparing?
Answer: They are preparing water samples from the research sites. These contribute to understanding ocean chemistry.

Intermediate

Question: What steps do the science team take to ensure the samples are valid?
Answer: They add a toxic substance (mercuric chloride) to ensure that the chemistry does not change. Non-reactive glass bottles are used. They also keep accurate records of where each sample was taken.

Advanced

Question: Why is validity an important factor in the scientific method?
Answer: Valid samples form the data for analysis and the publication of results. For a proper understanding of the deep ocean environment, the team need to base their results on samples that have been collected and stored using a strict method.

Panorama 6 Storing samples

The path from collecting samples to sharing with results in a peer-reviewed scientific paper can take up to 18 months. The samples are collected, prepared and stored on board before further work is conducted back at the researchers' universities. To ensure that the samples do not decompose or alter, they were stored in this refrigerated container (at 2˚C / 35.6˚F). Chemical preservatives such as ethanol were also used.

Point of interest 1: Physical samples

Physical samples of coral, algae and rhodoliths (a specific type of red rock-like algae) are lowered into a container full of ethanol. These can then be sent for genetic analysis.

Point of interest 2: Preserving in ethanol

High concentration ethanol works by pulling the water out of the tissue of the samples collected. Without water, the microbes (bacteria) that can break down (decompose) the tissue cannot survive.

Point of interest 3: Science container

This is a view of the outside of the science container viewed in the previous panorama. These standard shipping containers mean that the whole science lab can easily be transported to and from base.

Questions

Beginner

Question: Why do the scientists have a big fridge?
Answer: The scientists have a big fridge to preserve their samples, much like you might have a fridge at home to keep food from going bad.

Intermediate

Question: What methods do the scientists use to preserve samples?
Answer: The team use chemicals such as mercuric chloride to stop biological processes, ethanol to kill bacteria and a low temperature to stop bacteria multiplying.

Advanced

Question: Describe how ethanol preserves tissues.
Answer: Ethanol mixes well with water and takes up further available water to dilute itself. By removing water from the tissue, bacteria can no longer survive and the sample does not decompose.