Under Pressure: The Ocean Show

Intro

Hello everyone and welcome to our ocean show, Under Pressure. Today we are going to put you in the flippers of actual marine scientists - let's dive in!

(Lots of floating bubbles appear around us in space)

Sorry for the mess, but before we head to the Earth we need to talk about where the water is in our Solar System. We are in a planetarium after all! Floating above you here are bubbles representing nearly every large object in our solar system. The only thing missing is our Sun. We have worlds such as planets, dwarf planets and the biggest moons.

These larger bubbles here are the gas giant planets. They're pretty much completely made from clouds so there's no liquid water there. Let's pop them out of the way! Many of these worlds may have some ice on or beneath their surfaces. However, this is a show about the oceans – we want liquid water! So, let's pop those bubbles too. What we're left with here are worlds which have at least a little evidence for massive amounts of liquid water on them. These moons and dwarf planets have subsurface oceans where the water is very deep down. Yet, these oceans are incredibly hard to reach for us and so these, sadly, get popped too!

All we're left with is Earth, the only place in our solar system that has liquid water on the surface. Our blue marble. The only place in the Universe we know of, so far, where that water sustains life.

(Planet Earth dangles in front of us, ocean water drains into a ball on the right of Earth)

(Music plays: He's a Pirate – Klaus Badelt)

While we're still in space, let's have a bit of fun and take a closer look at just how much water there is on Earth. Water covers 71% of the Earth's surface and it's essential to all life here. Watch what happens when we begin to drain every drop of water in our ocean. As we suck the water away from the planet we start to see the edges of the continental shelves, where the drop-off to the deeper ocean begins. Next we start to see the abyssal plains, the most common areas of the ocean, at around 4 km down. The last bit of water you see here belongs to the narrow ocean trenches. The very deepest part of our ocean is 11 km deep. That may sound like a lot, and it is, but compared to the thickness of our planet it's really a very small fraction of the whole thing.

This ball of water here is it. All life on Earth depends on it! As we start to refill the ocean, keep an eye out for signs of seamounts. These are isolated volcanic mountains that rise up above the seabed. You can also make out the mid-ocean ridges, where two of Earth's crustal plates are slowly pulling apart. With all of that water back where it belongs, a literal ocean of possibilities and adventures awaits!

Dive!

It's time to take a closer look at our oceans and see how it is we're exploring them. What is it actually like to be a marine scientist these days? For those of you who have been to our shows before you'll know that we like to start in an observatory, a place where astronomers can use big telescopes to look out into space. We usually skip the telescope and use our shiny planetarium to fly out into the rest of the Universe!

(Observatory surrounds audience)

However, today we're not going out of the top door. Hold onto your seats everyone, because we're about to drop into the ocean and we're going to keep dropping until we hit the bottom! How long can you hold your breath for?

(Flashing red light as alarm sounds, observatory rotates to view bottom doors as they open)

Now we're in the water I've brought in our depth and pressure meters on the left-hand side. The first thing you'll notice is that we can still see plenty of sunlight, but as we start to drop that's going to change pretty quickly. Every so often I need to speed up or it'll take us too long to get to the bottom. Watch out for that jellyfish! Already, it's starting to get dark. Below two hundred metres there really isn't enough sunlight to see much at all – we're relying on the lights from our camera now. Look at the top-right there – another jelly! If we wanted to do some science on the way down we could take water samples and measure temperature, salinity (how much salt is in the water) and pH (how acidic the water is).

Here comes jelly number three! You'll notice this one is swimming down with us as we overtake it. That creaking sound you can hear is also reminding us that the pressure on us is still increasing with every metre we drop. We now have the weight of all that water above pressing down on us. Poor visibility is one reason it's tricky to go exploring in the ocean, but these massive pressures make the engineering challenges a lot greater if we want to send scientific instruments to the seabed. Fragile things like human beings and delicate equipment can be easily crushed.

Finally, we come into view of the seabed. It's about to get very bumpy so if anyone gets motion-sick now is the time to close your eyes until you hear the thunk of us hitting the seafloor. We're now one thousand metres down. Very few humans have ever ventured to this depth and bear in mind that we're still less than one tenth of the way down to the very deepest parts of our ocean. This one patch of seabed you can see here may look pretty barren but the more you look at it, the more you realise it's teeming with life. You can see sponges, anemones, shelled creatures and more. Marine scientists might spend a long time staring at hours of footage like this.

Plankton

(Music plays: Deep Blue Day – Brian Eno)

Let's take a closer look at some of this life in our oceans, from the very smallest creatures up to the very largest. We're going to head to the top two hundred metres of the ocean where that jellyfish just swam back down from to meet the most important forms of life in our ocean – plankton. Up here there's enough sunlight for these microscopic plants – phytoplankton. They do just what plants on the surface do, using sunlight and carbon dioxide to survive. They are also food for just about everything else in our ocean. The very smallest living animals are these zooplankton here. This particular type is known as a copepod. They then get eaten by bigger creatures and so on and so on until you get to the very biggest creatures in our ocean – like this blue whale here!

(*Blue whale appears in front of us, swimming from right to left before vanishing)*

That blue whale is the largest animal ever to have existed on Earth, about the size of a jumbo jet plane. It needs to eat more than 1000 kg of krill every day. So many ocean creatures migrate from the deep, dark waters, where they're safer from predators, up to the surface at night to feed.

As we sink into those dark waters you'll see one other source of food – hydrothermal vents. These were discovered about fifty years ago in the 1970s and are the result of leftover heat from volcanic activity that enriches and heats seawater, providing a source of food that doesn't rely on plankton at all. They're also great habitats and you might just be able to spot a crab there. It's possible the very first life to emerge on Earth may have been at a vent site like this.

Tools

(Music plays: Teardrop – Josh Cohen)

It's been 150 years since the very first marine research vessel, Challenger, took to the seas. Technology has moved on so much since then, so what are the tools of the trade modern researchers get to use?

(Carrousel wheel of tools in front of and behind audience)

We've learned how to journey into space since then and it turns out that space is an incredibly useful place for learning about our oceans and the general health of our planet.

(*Satellites orbiting around Earth above)*

Putting satellites into space requires rockets to put them into orbit, where they follow a circular path around the planet. The two best places to park Earth-observation satellites are low-Earth orbit, where you travel fast and can take high-resolution pictures, and geostationary orbit, where you travel at the same speed that Earth rotates at. Geostationary orbit is perfect for keeping an eye on one whole side of the planet all day, every day.

(*In front, video of fictional supercomputer)*

Another recent technology has been the invention of supercomputers. These are essential for filling in many of the unknowns about our ocean and an incredibly powerful tool. Because the ocean is so vast and dark, we can use these to make predictions and simulations of things that we can't go and see for ourselves.

(In front, video demonstrating an Argo float plays)

We also have robots these days, something the Challenger crew could never make use of. There are some clever ones like Boaty McBoatface, which is an autonomous submarine, but there are many thousands of these things called Argo floats in our ocean at this very moment. These are much simpler robots. They sink for more than a week at a time and when they surface, they radio in the data (ocean temperature, salinity, etc.) they collected. We can actually plot what all of these floats would look like. If you look closely here, you might be able to make out the darker regions. There are more than 3000 of these little things constantly telling us about the health of our oceans.

(In front, video of a submarine in the ocean)

Next up are submarines with human explorers onboard. The one you're seeing here is a bit of a record holder – it can fit two humans inside and it's the only one ever to have visited the five deepest parts of our ocean. Because it's so difficult to survive the pressure at those depths, in many ways it's harder to design these submarines than it is to design spacecraft. Only a tiny fraction of marine science is done in this way.

(In front, picture of Challenger vessel fades into a video of modern-day Amundsen vessel)

Lastly, but most importantly, we have crewed research vessels like this amazing Canadian icebreaking one here. 150 years have passed since Challenger and now ships like these have so much technology to play with. Remotely-operated submarines, cameras and all sorts of equipment lowered on sables to take samples of seawater, sediment and rocks.

(In front, bathymetry of a patch of seabed)

Perhaps one of the most interesting things modern research vessels can do is use sonar to map the seabed. The coloured regions we're flying towards have been mapped in this way. We're currently off the coast of Scotland, near the island of Mingulay. From the bottom of the ship you reflect sound waves off the seabed and the echoes allow you to 'see' the ocean floor. This is amazing for getting around the fact that visibility in water is usually very poor. This hilly, lumpy and bumpy patch you can see here isn't rock. It's a coral reef! I had no idea that coral existed just off the coast of Scotland like this. These animals anchor to the seabed and can grow hard outer shells. It's called Lophelia Pertusa. Unlike the coral you might have seen before at the Great Barrier Reef, or in Finding Nemo, this stuff likes deep, dark, cold waters. Coral is really important to our ocean story today, forming habitats for many ocean creatures.

Simulations

(Music plays: Brooks Was Here – Thomas Newman)

There are still many things we don't understand about Lophelia. How did it end up off the coast of Scotland? How does it spread around our vast ocean floor? Let's take a closer look and find out.

(In front, detailed look at a coral polyp)

Here's a close look at a single coral polyp. You can see it has lots of tentacles and on those it has stinging cells to catch small prey, but it's not a fussy eater. Once a year it has a chance to make new coral, releasing its egg cells out into the ocean. If we could track these, perhaps we could follow where this coral spreads to. However, these cells are thinner than the width of a human hair. Even if we had microscopic eyes, the ocean water is so dark down here.

This is where our supercomputers come in. In order to answer this question, we first have to understand our ocean and its currents – how does the water in the ocean move around? Let's put ourselves inside of a simulation here.

(All around, simulation of ocean surface currents in northern hemisphere)

We're in the northern hemisphere here and all the land is coloured in grey. Scotland is up here in front of us and America is off to the left. You're seeing a simulation of surface currents using data from our Argo floats, colour coded by temperature. Simulations like this give us a chance to piece together all the observations and ask the seemingly simple question – what is our ocean doing? The gulf stream shows up nicely here. This is the warm surface current that helps to keep our climate here in the UK milder than it would be for other places this far North.

(All around, simulation of ocean surface currents in southern hemisphere)

Let's flip things upside down for you next. Straight above your head is Antarctica, here's South America to your right and Africa is just here. We're only able to show you surface currents here, but don't forget that the ocean relies on what sometimes gets called a conveyor belt. This is where warm water cools, sinks and heads South where it eventually warms up and comes back to the surface. This conveyor belt Is so important for recycling nutrients around our oceans. Simulations like this help you see other things like these strange swirls, large slow-moving whirlpools of water that sometimes get thrown off as this current turns a sharp corner. These things can become seeds that feed Atlantic hurricanes a little more energy. We need simulations such as these to understand longer-term things affecting our climate too.

(In front, simulation through time of Lophelia coral movement in ocean)

Now that we have a rough idea of what our ocean are doing, let's use that simulation to answer that question about coral – how far can those tiny little eggs make it around our ocean? We can pick a few starting locations and, with the clock running, predict where they will end up in the future because of those ocean currents. Place your bets! Which patch of coral d'you think is going to travel the furthest? You can see that here the larvae are drifting with the gulf stream but in other places you see really narrow paths. This is where the larvae are getting carried along by a deep-water current, those conveyor belts. Maps like this are useful for telling us how easy it is for this slow growing coral to find new sites to grow, and which ones might be vulnerable to climate change in the future.

Changes

(Music plays: Under Pressure – Rockabye Baby!)

(In front, map of carbon dioxide absorption/emission in ocean)

On that note, it's time to talk about the fossil-fuel burning elephant in the room, us human beings! We're burning too much fossil fuel, releasing carbon into our atmosphere that had been locked away for millions of years. This is causing our atmosphere to warm, but at the moment it's our ocean that is taking up most of that extra heat. If you turn up the carbon dioxide in our atmosphere the ocean also absorbs more of the gas. This is what you're seeing now, where the blue tells us that the ocean is absorbing more carbon dioxide than it's releasing. This simulation is mostly blue and this picture has been mostly blue for decades. Because of us, slowly but surely, we're changing our oceans. It might feel slow to us, but these changes in our ocean are happening faster than at any time in the last few hundred million years. The ocean is getting warmer, more acidic, and fast changes like this don't give slow growing species like our Lophelia much time to adapt.

The solution is simple. The sooner we stop releasing extra carbon into the atmosphere, the sooner our oceans can start to stabilise. If this makes you anxious, that's understandable and okay. Try to turn that anxiety into anger, it'll help spur you on to make changes, or change minds, to help us get humanity and the rest of the planet back on track.

Unknown

(Music plays: Under the Sea – Digby Jones)

(In front, relevant images fly past as we travel to bathymetry map of coral at Rockall)

There's a good point to be made here. There's still so much to learn about our ocean and we're already seeing many aspects of it struggle, in ways the ocean was never struggling with when Challenger hit the waves. Don't forget just how much ocean there is! Remember our ball of water? It may have looked small next to the whole planet, but the ocean is vast. We're cruising along the seabed, heading out into remote waters well off the west coast of Scotland.

Here's something as seemingly simple as ocean floor mud. We need to learn more about this too because it's full of creatures like worms that haven't been well studied. We are still to accurately map our entire ocean floor with that sonar technology you saw earlier.

We know we haven't found all the ocean floor hydrothermal vent fields, like this one that was discovered recently. Each one is potentially a unique biodiversity hotspot!

We are still looking to fully understand many of the basics of deep ocean coral. How will our Lophelia cope with the changing ocean?

Speaking of species, we know that there are literally hundreds of thousands of new species just waiting to be discovered out there! It's a bit like Pokémon - gotta classify them all!

There are places on the seabed which are poorly studied but are rich in precious metals. We're in a race to better understand them!

This underwater formation we're swimming towards here, which was mapped by a research vessel, may look like just another mountain but this is actually a deep city of coral. It's been growing here for a very long time, probably more than 100,000 years. The new coral grows on top of the old coral and the reef provides a habitat for so many other ocean species. Imagine being the researcher who was able to pilot a remote camera submarine down here and see this massive coral mound with human eyes for the first time. So many unknowns, so much more to discover!

Outro

(Music plays: November – Max Richter)

(In front, Schmidt Ocean Institute footage of various sea creatures)

We don't have much time left, but I'm going to leave you with some beautiful video from our friends at the Schmidt Ocean Institute. Remember, with everything that you're seeing here, there was a human being at the control of this remotely operated submarine. Try and put yourself in their shoes and imagine seeing these sights for the very first time. What other amazing discoveries await us in the deep?

Credits

Dynamic Earth's: Under Pressure

Digistar 7 – E&S

Music:

He's A Pirate – Klaus Badelt

Deep Blue Day – Brian Eno

Teardrop – Josh Cohen

Brooks Was Here – Thomas Newman

Under Pressure – Rockabye Baby

Under the Sea – Digby Jones

November – Max Richter

Orinoco Flow – Vitamin String Quartet

Additional Videos:

2001: A Space Odyssey – MGM

ARGO cycle – AU Bureau of Meteorology

Azores vent – EMEPC Portugal

Black smoker – EVNautilus

Limiting Factor – Caladan Oceanic

Ningaloo Canyons – Schmidt Ocean Institute

Reefs of Belize – MIT, Charles Hayden Planetarium

Additional Imagery/Data:

GEBCO bathymetry – NASA

Lophelia imagery – Susanna Strömberg
Lophelia larval dispersal simulation data – Alan Fox, University of Edinburgh & SAMS

Mingulay & Rockall bank data – J Murray Roberts, University of Edinburgh

Ocean Circulation/Carbon Flux – NASA SVS

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