

SCIENTIFIC AMERICAN FRONTIERS PROGRAM #1207, "Beneath the Sea"
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TEASE
EARLY PIONEERS
SCIENTIFIC REVOLUTION
DEEP OCEAN ARCHEOLOGY
REMOTE CONTROL EXPLORATION
CREATURES OF THE MIDOCEAN

TEASE
ALAN ALDA I'm on the deck of the Titanic, 12,000 feet below the surface, inside the Alvin -- thanks to the wonders of video technology.

ALAN ALDA (NARRATOR) But it was the wonders of ocean exploration -- and the imagination of

BOB BALLARD -- that allowed the Alvin to reach and explore the Titanic. On this edition of Scientific American Frontiers, a special profile of a true pioneer in the last great age of exploration on the earth. It was the age when humans finally reached the furthest depths of the ocean.

BOB BALLARD We're going to a world that's totally dark -- complete darkness. We're going to be within a few feet of it. And there's no roads.]

ALAN ALDA (NARRATOR) We'll see how there was a revolution in understanding our planet's inner workings... How we discovered a whole new world of living things... And how we glimpsed a treasure trove of human history, just waiting to be explored.

BOB BALLARD All my life I've had these ideas, and people say you're nuts.

ALAN ALDA (NARRATOR) I'm

ALAN ALDA. Join me now as we go Beneath the Sea.

EARLY PIONEERS

BOB BALLARD ...be anywhere you want through telepresence, so I decided why not here?

ALAN ALDA (NARRATOR) One recent afternoon, I found myself walking along a hillside overlooking the Connecticut River, in the company of one of the world's greatest explorers -Bob Ballard.

ALAN ALDA How long do you think it will be before you're under the ocean and never leaving your house?

BOB BALLARD Right now probably anytime I want to do it.

ALAN ALDA Really?

ALAN ALDA (NARRATOR) After 30 years of extraordinary successes opening up the mysteries of the deep ocean, Ballard now advocates a new kind of exploration, using remote control. It's the latest phase of a career that spans more than a hundred ocean expeditions, including at least a couple of scientific revolutions. We're going to devote this program to those expeditions, to those revolutions, and to revealing the inner workings of our planet.

ALAN ALDA You seem to have been present at some of the greatest discoveries and not only about the ocean but about the planet.

BOB BALLARD My strength is in the technology that I developed. I've sort of used the technology as my passport to explore anything. And so, I have a love of geology, but I have an equal love of anthropology. And, fortunately, they're all under water. I got the only key to the car, so to speak, and that's been how I've been able to be at a particular point in human history when we've gone beneath the sea.

TECHNICIAN Have a good one.

TECHNICIAN Sealing the hatch.

TECHNICIAN Hatch is secure.

ALAN ALDA (NARRATOR) This is the Alvin, a three-place submersible that's made more deep ocean discoveries than any other sub - often with Ballard on board. Launched in 1964, Alvin's still going strong, diving for the Woods Hole Oceanographic Institution. Alvin's sister ship, the Turtle, was retired from the Navy in 1997.

ALAN ALDA Why is this called the Turtle?

BOB BALLARD Well, it was really one of the earlier submarines, the first submarine ever built in America was the Turtle .

ALAN ALDA Oh, really?

BOB BALLARD And it attacked the British in the Revolutionary War.

ALAN ALDA (NARRATOR)

BOB BALLARD was a Woods Hole scientist for 30 years, while also a US Navy officer, so he knows both subs well.

BOB BALLARD Alright. So this is the sail and this actually floods, once you get out at sea, so this is the important part, this is the hatch. Two inches thick,

ALAN ALDA So, what keeps the water from going in here?

BOB BALLARD Well it's actually tapered. If you look at the hatch, it's like a porthole, the pressure pushes them down. In fact, you're most vulnerable at the surface. That's the most dangerous time because you don't have the pressure seating it. Alright, well let's get down inside here. So watch your step.

ALAN ALDA (NARRATOR) The heart of these deep-diving subs is the crew compartment - a 6-foot diameter steel sphere, built to withstand enormous forces.

BOB BALLARD Absolutely a sardine...

ALAN ALDA Oh my God! It's tiny!

BOB BALLARD Oh, yeah.

ALAN ALDA (NARRATOR) Alvin can dive to 14,000 feet, where the water pressure outside is two and a half tons on every square inch of the sphere.

ALAN ALDA How long does it take you to get all the way down?

BOB BALLARD Well the average depth of the ocean is twelve thousand feet. It takes you two and half hours each way. So you're talking five hours just commuting to work, and if you go even deeper its even longer.

TECHNICIAN I.D. light on, request permission to dive.

TECHNICIAN Roger you're clear to dive. Depth is 25-20.

TECHNICIAN Roger Alvin diving.

ALAN ALDA (NARRATOR) With two 500-pound ballast weights, the Alvin sinks at a steady 80 feet a minute.

TECHNICIAN Gary can you give me a vector to the target please?

ALAN ALDA (NARRATOR) Sub and mother ship communicate with an echoing acoustic phone, broadcasting sound directly into the water.

TECHNICIAN Ninety meters away. Eight zero degrees.

TECHNICIAN Roger. Thank you.

ALAN ALDA (NARRATOR) On the way down there's very little to do, and nothing to see unless you use the lights, but that consumes battery power you'll need at the bottom. Eventually the pilot slows the sub's descent by dropping first one weight, then the second.

PILOT OK altitude is about 18 meters, drop the second weight. You'll be able to hear it. Boom...

BOB BALLARD You pop this and then if you've done your ballast calculations right, you should stop. But everyone lies about their weight,

ALAN ALDA Well, it can be personal.

BOB BALLARD Yeah, everyone lies so I say, "Wait! Wait, Alan you told me you were 180 pounds..."

ALAN ALDA And we're still going!

BOB BALLARD So then you have to go to what's called a variable ballast system, and that's where you make up for the lying. And you start pumping ballast and that will then take water outside and put it in a bag and then the bag, like a bladder, will expand and makes your volume bigger, and that slows you down until you finally get what's called "neutral trim."

ALAN ALDA Yeah...

BOB BALLARD Now you're completely neutral, you're not falling or rising and then you spend the last hundred feet and you drive down.

ALAN ALDA When you get down there, you're really cold, huh?

BOB BALLARD Oh, freezing! See, this hull is just two inches of steel and outside in the deep sea it's 4 degrees centigrade, I mean, just above freezing. And the ocean is like a giant heat sink. It just sucks the heat out of the submarine. The only thing that keeps you warm is your instrument panel. We can't afford the power to run a heater, because we're battery operated.

ALAN ALDA (NARRATOR) Maneuvering just above the bottom with their multiple propellers, deep submersibles like these have given scientists their first good look at the mysterious 70% of our planet that's covered by deep ocean.

PILOT This is Alvin. At the bottom.

ALAN ALDA (NARRATOR) It's been a slow process - sometimes too slow for

BOB BALLARD - but since the 1960s, it's truly a whole new world that's been revealed.

BOB BALLARD We're going to a world that's totally dark-complete darkness- we're gonna be within a few feet of it, and there's no roads. So we're off track. We're going through over the ground and up and over. And cliffs and walls and things. You don't want to go fast. In fact, the typical speed is like a half a mile an hour, and that's why it's so painfully slow. You get down here and if you're lucky in three hours of bottom time you'll cover a mile.

ALAN ALDA (NARRATOR) In 1869, a hundred years before Alvin's launch, the French writer and ocean sailor, Jules Verne, published his classic story of the renegade scientist who travels the world's oceans in his fabulous submarine, Nautilus. None of Captain Nemo's technology existed at the time, of course, although in Hollywood's 1916 version the self-contained diving suits were a genuine technical advance. The adventures of Captain Nemo and his crew were an inspiration for generations of ocean explorers, including Jacques Cousteau and

BOB BALLARD. While some features of the Nautilus brilliantly foreshadowed later developments, Jules Verne did get one thing wrong - the question of pressure. The design of submarines like the Nautilus, capable of accommodating large crews, developed rapidly during the Second World War. Yet even the best of the German U-boats were limited to a depth of about 700 feet, and today's large submarines can go no deeper than a few thousand feet. It was Otis Barton, an engineer from Massachusetts, and his collaborator, William Beebe, who first solved the problem of how to reach extreme depths. The solution was to dive in a small, massive sphere - they called it a bathysphere. A spherical form offers the most effective resistance to the crushing pressures at depth. In a series of dives

off Bermuda in the 1930s, they shattered the existing depth record of 525 feet, established by a diver in an armored suit. The bathysphere was simply lowered from a barge, a risky business since any fault in the cable would lead to a fatal plunge to the bottom. Beebe, who was a curator of birds at the Bronx Zoo, was greeted with disbelief when he reported seeing strange new creatures in the depths. We'll have a story about how right he was later in the program. It was the peculiar subs called bathyscaphs, conceived by the Swiss balloonist Auguste Piccard in the 1930s, which finally reached the deepest part of the ocean - the 35,000-foot Challenger Deep off Guam. A huge tank of gasoline provided flotation, so you didn't need a suspension cable. Bathyscaphs were safer, but very unwieldy, as Bob Ballard discovered.

BOB BALLARD We were going in slow, but it's like if I just sort of took my hand and I had enough force to go right through this couch. You'd just see this...well, that's what happened. The front of the submarine came down and I'm looking at it, and it's just the metal and everything, its just twisting in my eyes, like a giant... just slowly, just very slowly, taking the submarine and just ripping it open. And then I see av gas coming out.

ALAN ALDA What's that?

BOB BALLARD That's the flotation gasoline. We ruptured our tank.

ALAN ALDA How did this turn out? Did you live?

BOB BALLARD Well here's what happened. We then, he dropped the whole- then you could drop the whole door and he dropped ten tons. When he saw that, I said "av gas!" When I yelled "av gas," he dropped the doors open and we dropped ten tons. Now we're at 20, 000 feet. It's a six hour trip home and here's what happens. You're leaking your gasoline and you start decelerating and then you start back down. Well, they had in the sub a little calculator- you know one of those little LED displays? Freezes up on a number? And so every few seconds, it was telling you your ascent rate. Well ,there was enough uncertainty in the calculation that it depended on whether you were an optimist or a pessimist. You could get whatever you wanted out of those numbers.

ALAN ALDA You didn't know whether you'd make it to the top before you lost your gasoline which gave you the buoyancy?

BOB BALLARD Exactly. And then you'd go negative. No one spoke. The most silent experience I've ever had, and we all looked at those numbers...

ALAN ALDA For six hours?

BOB BALLARD For six hours. And we were decelerating, because we were losing flotation. But we had enough to get home.

SCIENTIFIC REVOLUTION

ALAN ALDA (NARRATOR) It was a technical breakthrough in the 60s that allowed the Alvin and her sister ships to shrink down to a practical size. Instead of a huge gasoline flotation tank, they used a new material called syntactic foam, packed inside the fiberglass shell.

BOB BALLARD What they were able to do is get rid of the gasoline by taking silicon and they atomized it and they made these little microspheres of glass with a little air in them. Billions of them. And it's sort of like a powder, but it's has tremendous strength, but it weighs less than half of what seawater weighs. So, by adding this foam, this is what basically makes the submarine float.

ALAN ALDA (NARRATOR) It turned out the small, deep-diving subs were the perfect answer to a big question - how to explore the vast undersea mountain range called the Mid-Ocean Ridge. During the decade of the 1950s, depth-sounding surveys had gradually revealed the Ridge as a 42,000-mile-long mountain range, sometimes rising 15,000 feet above the sea floor, snaking around the globe between the continents. It's the largest geological feature on earth.

BOB BALLARD It really wasn't until 1960, that we knew that there was a great mountain range beneath the sea. But we didn't know how it got there. We didn't know the role it played in the earth -- until plate tectonics came along in the late 60s -- that we realized that it was actually the site of crustal creation. That it was along the axis of this great mountain range that the earth creates its outer skin, through this process called sea floor spreading. And so we were the first human beings to go down in submarines and explore this mountain range.

ALAN ALDA (NARRATOR) The pictures of lava formations on the mid-Atlantic ridge that Ballard filmed from the Alvin, left no doubt that the Mid-Ocean Ridges are volcanoes, which create the earth's crust. Next the question was - where's the heat? In 1977, Ballard provided the answer with the discovery of hot water vents, 8,000 feet down on the Galapagos Rift. Then came the totally unexpected. Clustered around the vents were what seemed to be giant clams - life, in the black ocean depths. It was the dawning of a scientific revolution, which Ballard and the Alvin would pursue for the next several years.

ALAN ALDA This picture you have on the wall. What is that a picture of?

BOB BALLARD That is the moment of discovery of these life forms. I think it's my proudest moment. People think maybe it was the Titanic. Actually it wasn't. We didn't discover the Titanic, we knew it existed. It was the discovery of hydrothermal vents, these exotic creatures. See, prior to our discovery of hydrothermal vents in 1977, we thought all life on our planet was due to the sun - that the photosynthetic energy we get from the sun, that plants capture, turn into organic matter that animals then eat, then we eat the animals - was it. But then we discovered in the total darkness, in a world alien to anything we can think of, creatures that were living not off the energy of the sun but the energy of the earth itself.

ALAN ALDA (NARRATOR) It was not until 1979 that Ballard was able to get back to the Galapagos Rift, and uncover the tremendous variety of life that lives around the vents - the tube worms, mussels, crabs, even fish, that shelter in the warm, volcanic currents. On the '79 expedition, Ballard - who's a geologist - was able to bring astonished biologists to see the vent life-forms for the first time. It was the beginning of a whole new branch of biology, still going strong, which has figured out how the vent life makes a living down here in the dark. It's turned out that it's the composition of the water emerging from the vents that's the secret.

ALAN ALDA These creatures were living off of chemicals ...

BOB BALLARD Exactly! Poisonous, toxic ...

ALAN ALDA Poisonous to the rest of us.

BOB BALLARD Absolutely, particularly hydrogen sulfide. H₂S. Fill this room with H₂S, we're toast. So are the plants. Everything dies. But there was a creature, a bacterium, that had figured out over eons of time how to duplicate photosynthesis in the dark by oxidizing this poisonous gas. And a whole new life system came into being. A life system that is now we think where life began on earth.

ALAN ALDA (NARRATOR) It's believed the early earth contained widespread hot spring environments like this - both on land and in the ocean - long before the earliest photosynthesizing organisms, like algae, began to evolve. So perhaps the sulfide-loving bacteria we see at the vents might be related to the earliest life-forms on the planet. Hundreds of hydrothermal vent fields have now been found around the globe, even though only about 1 percent of the likely areas have been surveyed. The kind of bacteria which all vent life depends on a kind was new to science. They can extract energy from hydrogen sulfide gas dissolved in the vent water. There have now been many expeditions to ocean vents, with intensive

study of the life, often including raising samples of clams, tube worms, or crabs up to the surface, a mile or two above.

PILOT Both weights away.

ALAN ALDA (NARRATOR) Surprisingly,

BIOLOGISTS have had some success in keeping deep ocean animals alive, in special labs on board ship. In this system, the intrepid researchers remove the foul-smelling worms from their shell-like tubes. Plastic replacement tubes are then used - not without some difficulty. The plastic tubes can then be fitted into pressure cylinders, which are pumped up to simulate conditions at depth. The tube worms have what's called a symbiotic relationship with the sulfur-eating bacteria. In fact, the entire contents of the worm are just bacteria. Although it's still not clear exactly how these symbiotic relationships work, there's no doubt that sulfur-loving bacteria are at the base of the entire food chain at the deep ocean vents. Some animals, like crabs, eat the bacteria directly. Others, like tube worms and giant clams, shelter them in their bodies. Still others, like vent fish, are predators, feeding on everything else. In 1979, Ballard made yet another historic discovery, in an area called the East Pacific Rise, off Baja California. They called them Black Smokers - chimneys spewing out clouds of mineral-rich water, so hot that it must have come from deep in the earth's crust. It explained why the sea is so rich in minerals.

BOB BALLARD The seawater, which is under pressure, goes right down into those cracks, goes down to the magma chamber. The magma chamber is hot -- 1400 degrees, 1200 to 1400 degrees centigrade. And so it heats up the water, and then the water begins to interact with the magma chamber, and it changes its chemistry.

ALAN ALDA Now does the water turn to steam?

BOB BALLARD No, it can't because of pressure. It turns into superhot water.

ALAN ALDA Superhot water which means it stays ...

BOB BALLARD Liquid.

ALAN ALDA Liquid, but it's really...

BOB BALLARD Really hot. And it's now full of chemicals that it didn't have before. And it's those chemicals that are coming out of the black smokers that are responsible for the chemistry of the world's oceans. In fact we now realize that

the entire volume of the world's oceans is going inside the earth and out, every six to 8 million years.

ALAN ALDA Every six to eight million years.

BOB BALLARD The entire volume...

ALAN ALDA All the oceans in the world...they all go down...

BOB BALLARD Through this system.

ALAN ALDA Under the floor of the ocean.

BOB BALLARD Into the mountain range, and come up in the form of black smokers.

ALAN ALDA And it takes eight or ten million years...

BOB BALLARD For the whole ball game. That's a lot of water.

ALAN ALDA Well, of course.

BOB BALLARD And that's what's caused the chemistry of the world's oceans. And we didn't know that.

ALAN ALDA (NARRATOR) Ballard almost didn't live to tell the world about Black Smokers. It all began when they moved in to take a measurement.

BOB BALLARD The first time we saw one, we're coming up on one, we're inching up and it's high, so we had to come up high. So we're now neutrally buoyant and there's an updraft and it's pulling us towards it, OK? And we're trying to find out what the temperature is and so we take our mechanical arm out and we stick it in there. And we look at the, and it pegs off scale. And the pilot says, "That's hot." And then he removes the equipment- the temperature and it's melted. And then he says, "I just want to let you guys know that the probe's made out of the same material as the porthole." And we were like, three feet away.

ALAN ALDA And moving toward it.

BOB BALLARD And moving toward it.

ALAN ALDA So, what, everybody go like that?

BOB: Absolutely! Fortunately, the sub has a reverse. And we actually bumped by it, we bumped it and knocked it over and when we came up, the side of the submarine was melted. The syntactic foam, was melted.

ALAN ALDA When you came up this close to it, had anybody ever seen a black smoker before?

BOB BALLARD Never. Never.

ALAN ALDA So you almost discovered it and disappeared with your own discovery.

BOB BALLARD Yeah, yeah, no, it could have been a bad day.

ALAN ALDA Could have been a while before anybody knew that there was a black smoker down there.

BOB BALLARD Yeah, well what would have happened was if it hit your porthole at that high temperature, it would have shattered and imploded. Takes about a quarter of a second.

ALAN ALDA Because there's so much pressure.

BOB BALLARD To just go off like a bomb.

REMOTE CONTROL EXPLORATION

ALAN ALDA (NARRATOR) In spite of the spectacular scientific advances that have been made with the use of small manned submersibles like Alvin, Ballard says we don't need subs like this any more. He came to that conclusion right here on the Galapagos Rift.

BOB BALLARD The turning moment for me was in a submarine just like this one, when we found these unique life forms. And we were down on the bottom of the Galapagos Rift, it was 1979, OK. And biologists had never seen these life forms ever before, and we got them in the submarine and, a scientist by the name of Holger Jannish, who just couldn't wait to see these creatures. He knew he was going to be famous, just to be the first to see them biologically. And so we got down there and they were right outside the window. And I was sitting over here and I had brought down a new prototype camera system -- a digital camera system. And I was looking at the animals and I looked up from my porthole and I looked at Holger, and he had his back to the window. I said, "Holger, what are you doing?" And he said, "I'm looking at the monitor."

ALAN ALDA That's amazing.

BOB BALLARD And I said, " Wait a minute, let me see if I got this right...

ALAN ALDA We came all the way down here...

BOB BALLARD We came all the way down here, and you turn your back to the window -- and I went (snap)

ALAN ALDA (NARRATOR) The result of that insight is inside these blue shipping containers, on display at the Mystic Aquarium. It's the portable control room which Ballard developed to run subs remotely.

BOB BALLARD So this is where the pilot would sit, but see remember the pilot in the sub was dominating the view.

ALAN ALDA Yeah.

BOB BALLARD Now the pilot's sitting here and we get the view. So imagine these being multiple camera systems on the vehicle. Multiple windows. So all of a sudden a puny window that only one person could look out of, everyone gets to look out of many many panoramic view windows, OK? And talk about it together. And more importantly, it stays down 24 hours a day.

ALAN ALDA (NARRATOR) What's the point of taking people down if they can't go outside when they get there? says Ballard. Everything can be controlled from the surface - even collecting samples - so long as the communication link is good. Argo, a towed camera sled with a fiber optic link, was Ballard's first remote vehicle. After 9 days, 24 hours a day, Argo found the Titanic - thanks to an ingenious search strategy Ballard invented.

ALAN ALDA When a ship sinks, does it leave a trail of debris in the process of sinking?

BOB BALLARD It can do that. The Titanic did that.

ALAN ALDA Why does that happen? What's going on there?

BOB BALLARD Okay, lets take the Titanic, because I looked for the debris trail. Everyone else looked for the Titanic. They didn't find it. Well, clearly it wasn't a good idea. Because the Titanic was in a very complicated, badlands of the Dakotas, canyons and valleys and you could hide a thousand Titanics in this rugged terrain, OK? So here's the Titanic up at the surface, OK? It goes vertical,

then it snaps in half. What's it now? Big salt shaker. What's coming out of it? Everything. Take this room, dump it. Okay, so lets take this room and throw it out the window OK? Well lets' say I took a heavy object, the stone. The stone's going to go... but lets' say my paper, I throw the paper. How long's it going to take the paper to sink? Longer than the stone? Yeah...it's going to take forever for the paper to sink. If it even sinks at all. So what happens is, there's a current running -- remember, there's rivers in the ocean. The Labrador current that brought the icebergs down, so that's a huge body of water. So an object will fall straight through it if its heavy. But a lighter object will be carried by it. It may take it hours and hours and hours. Well, it's traveling miles before it finally falls through the upper current layer. And then it falls down. So you get a debris trail. So ...look for the debris trail.

ALAN ALDA (NARRATOR) In late summer of 1985, Ballard managed to get 11 days of sea time on the Woods Hole research ship, Knorr. You can see Argo's portable control room on the stern here. Argo was towed back and forth through the area where Ballard figured Titanic's debris trail should be. For 9 tedious days, video of empty sea floor came back to the control room. Then... CREW We're over something... Oh look at that...you can see it on the I can see it too! What is it? I don't know, but it's man made! More stuff coming. That is big. Boiler! I got boilers. Yes, yes. Fantastic! Goddam.

ALAN ALDA (NARRATOR) With only 2 days' search time left, Argo's cameras had picked up Titanic's ghostly shape, 12,000 beneath the spot in the North Atlantic where she'd hit the iceberg that fatal night in 1912. Ballard's strategy had been exactly right.

BOB BALLARD I knew that current was north to south, because that's where the icebergs come from. So I ran east to west. And I knew, I said well where do you start? Well, what's the lightest of all the debris that came out of the Titanic?

ALAN ALDA Well, wouldn't it have been paper?

BOB BALLARD The lifeboats.

ALAN ALDA Oh, I see.

BOB BALLARD They didn't sink at all. So, if I know where they picked up the lifeboats -- the Carpathia -- it's gotta be north. So I started my search underneath where they picked up the lifeboats with the Carpathia, and then I ran my lines like that. And on the ninth line, picked up the debris trail, followed it home. It lead me right to the Titanic.

DEEP OCEAN ARCHEOLOGY

ALAN ALDA (NARRATOR) The following year, Ballard returned to the Titanic - but in the Alvin. He'd wanted to use a new remote, steerable vehicle called Jason, but it wasn't ready. So he approached the Titanic using what he now regarded as outmoded technology - although it surely must have been a thrilling experience to really be there.

BOB BALLARD OK, now that's the boat deck...

ALAN ALDA (NARRATOR) Landing on the deck of the ship, Ballard deployed from Alvin a brand new remote vehicle called Jason Junior. And it was Jason Junior that shot those haunting pictures that we all saw, some from deep inside the wreck. It was the last Alvin expedition Ballard would conduct. Although he did make some dives in US Navy deep-dive subs, from now on most of his efforts would be concentrated on remotely operated vehicles, or ROVs. That's probably just as well, since his interest was turning increasingly to wrecks, and wreck diving is dangerous.

BOB BALLARD When you go to wreck, it's a mess. Uh, the Lusitania was the scariest dive ever...

ALAN ALDA What, some of it can fall on you or what?

BOB BALLARD It was full of fishnets.

ALAN ALDA Oh, oh, so you can just...

BOB BALLARD Go right into them all and you can't see it.

ALAN ALDA You can get stuck.

BOB BALLARD We did!

ALAN ALDA You did? You got stuck?

BOB BALLARD Yeah, the submarine got stuck in it.

ALAN ALDA How did you get out of that?

BOB BALLARD Well it was sort of humorous in reflection. We had a little submarine, and had three people in it and they went and you can't see the monofilament, it's like monofilament nets, its like a web. And the sub went into it, and it sucked it up into its stern prop. And it just ate up the net into the stern prop. So, now, it's tied to the ship. And it went around and around so fast it fused it. It

melted it and fused it by just spinning the prop trying to get out. And so now, then they -- I wasn't on that particular dive, I was up on the surface talking to them -- and then they dropped their weights. But what happened is they went like that, because they didn't know how they were trapped. Until they dropped their weights and instead of going up, they rotated. And now they're vertical. A submarine's not designed to be vertical. All the equipment and everything, all the people came, like a big tube came roaring down that tube. And then the guys called up and said, "You know, we got a problem. We're stuck." And then it turned out the pilot's father was another pilot-- his son. Very moving. I mean here's a father talking to his son, saying, "Well what's up, you know, what's going on?" They said "Well, we're trapped. Well clearly we're stuck on the nets or something or rope, I don't know. It appears to be in the prop." Well they had a procedure where they could uncouple the propeller shroud and drop it. So, we're all listening and we got the underwater sound and everyone's so tense, the tension -- oh, my god these people are gonna die. And they had a little rhyme that they'd memorized on how to turn the screw, and you hear this voice from the bottom of the ocean, "Righty tighty, lefty loosey," as he's turning it. Had a little jingle to teach him how to turn the screw, he'd memorized it. "Righty tighty," he didn't want to do that -- "Lefty Loosey." And he was turning it to the left and they dropped the prop and they came up.

ALAN ALDA (NARRATOR) Jason, Ballard's first fully-capable remotely operated vehicle, was launched in 1989 after 5 years of development at Woods Hole. There was skepticism about what ROVs could achieve. But over the next 10 years, using Jason, Argo and a series of other vehicles, Ballard opened up a new field of deep water archaeology, in the Mediterranean and Black Sea. As usual, Ballard's imagination was hard at work.

BOB BALLARD If you were on a Phoenician ship, and you were carrying 2000 amphorae of a fine wine for the pharaoh of Egypt, what would you do along the way?

ALAN ALDA You'd drink the wine and throw the jugs overboard.

BOB BALLARD You got it! Absolutely! And what if you did that for thousands and thousands and thousands of years? What would you find?

ALAN ALDA A lot of these jugs.

BOB BALLARD A trail. So what I do is I say, OK here's an ancient seaport, let's say it's Carthage. I'm gonna drive along here until I pick up the trail and I'm gonna follow it and that's exactly what I did.

ALAN ALDA Now how do you find it? Visually?

BOB BALLARD Yeah, just go along and look for empties. That's exactly what I did and there were the empties. And they weren't broken either! They didn't throw 'em over because they were broken, they threw em over because they drank em!

ALAN ALDA (NARRATOR) Finding shipwrecks, 2- or 3,000 years old, in deep water has forced a reappraisal of how ancient sailors behaved. It was commonly believed that they hugged the coastline, but these discoveries have shown they took direct routes, in open water. They were better sailors and navigators than we had supposed, but inevitably some ships were lost. There are many whole ships, whole cargoes, in these deep, cold waters. Ballard believes these discoveries are the first glimpse of a deep-sea archaeological treasure trove.

BOB BALLARD Shipwrecks are time capsules. They're pure moments in time. Everything on that shipwreck went down that moment. And particularly in the deep sea, it's preserved. It's in a high state of preservation. So imagine that probably everything humans have done has caused them to go out onto the sea with their commerce, with their technology and then they lose it. And they lose it in the deep sea which puts it in sort of a warehouse. I think there's more history in the deep sea than all the museums in the world combined. We think there's maybe one million time capsules.

ALAN ALDA A million ships that have sunk. And you can find them no matter how deep they are.

BOB BALLARD Absolutely. The deeper the better -the more preserved they are, the further they are from land to be buried. And just think what the historians are going to write when the generation of explorers that are in elementary school right now, find those time capsules.

BIOLOGIST ...and here we are in the Amazon trying out some cacao, chocolate...

ALAN ALDA (NARRATOR) Ballard has extended the idea of remote exploration to education. The Titanic discovery had prompted an enormous response. Suddenly thousands of kids wanted to be ocean explorers. Why not mount a whole series of remote explorations, he thought, and beam them live into museums and classrooms? "Telepresence," he calls it. So far, the Jason Project has conducted 13 expeditions -- to the ocean floor, to shipwrecks and to forests around the world -- involving thousands of students.

BOB BALLARD You guys ready to go?

ALAN ALDA (NARRATOR) Here's Ballard's latest use of telepresence.

BOB BALLARD Alan, why don't you sit right down there in the co-pilot's seat. Alright, so here we are, the next step.

ALAN ALDA Now where are we? What is this?

BOB BALLARD This is a live shot, coming in from Monterey Bay.

ALAN ALDA This is like the ultimate webcam.

BOB BALLARD Absolutely! But even better. The aquarium's on our left. Cannery row is on our right. We're going to zoom in on these rocks, and we're going to look at some seals, looks like harbor seals, and a cormorant. See the cormorant sitting there? So, that's a live feed- oops! There's one right down there, and there's one up there. So. watch. We're gonna back up. Biiiiing. So that's the Aquarium, that's the Monterey Bay Aquarium right there, hello? Alright that's their observational platform. We'll pan back.

ALAN ALDA (NARRATOR) So far, it's maybe a bit better than a webcam -- but don't go away. The real point of the system is out in the bay, between these two white markers, underwater.

BOB BALLARD So we're now gonna jump underwater ...and there we are.

ALAN ALDA (NARRATOR) Now we're seeing live, high-quality pictures sent on a data link across the continent, from Monterey, California to Mystic, Connecticut. And we can control the camera, too.

BOB BALLARD Uh, hello guy!

ALAN ALDA Oh, look at that. What is that?

BOB BALLARD That's a fish!

ALAN ALDA I know it's a fish!

BOB BALLARD I know. Get the

BIOLOGIST! I'm a geologist. And I'll zoom back out because I'm gonna give it to you. Can I see your driver's license?

ALAN ALDA Just get out of the way.

ALAN ALDA (NARRATOR) Telepresence, I found, does have its limits.

BOB BALLARD Do it slowly, because there's a little time delay. Watch! You're at the end of the line! Stop!

ALAN ALDA Oh, I'm gonna crash!

BOB BALLARD You did!

ALAN ALDA I thought it was a fish!

BOB BALLARD No, that's the end of the line.

ALAN ALDA (NARRATOR) At the heart of the trans-continental telepresence system is - you guessed it - another remotely operated vehicle.

TECHNICIAN Thrust reverse...

ALAN ALDA (NARRATOR) It had been installed just the week before I tried it out, after a couple of years of work. Monterey Bay's a marine sanctuary, so it's hard to get permission to do anything here. But for Ballard, that's the attraction. This is the first of two remote vehicles to be installed in different parts of the Monterey sanctuary. Then the plan is for systems to go into marine sanctuaries in the Florida Keys and California's Channel Islands. Eventually, visitors to museums and aquariums across the country, and around the world, will be able to experience a wide variety of underwater environments by telepresence. It's the sort of crazy, ambitious idea that's typical of

BOB BALLARD's imagination. It was born of his lifelong obsession with ocean exploration, but grew out of that crucial insight he had, 8,000 feet down on the Galapagos Rift, when his

BIOLOGIST colleague chose the pictures on the monitor over the view out the window.

BOB BALLARD That's kelp... and come around again.

ALAN ALDA (NARRATOR) And it is extraordinary. You can feel you're there, as you steer the camera and vehicle through the kelp and rocks.

ALAN ALDA You know what's interesting about that surging -- I see this movement and it's out of my control, which makes it very different from a computer experience. Very different from a virtual experience.

ALAN ALDA (NARRATOR) We did have a little help from our underwater cameraman in shooting some of these scenes, but most of them could have been shot by remote control, and that's really the point. With telepresence the potential is there. It's up to you to do the rest. Ballard's not content with inspiring a couple of revolutions in marine science and archaeology, and then wiring up the country's marine sanctuaries. Now he's off and running with a new crazy idea. If 70% of the globe is covered in water, it's time we started living out there, he says. Here's a marine habitation you tow into place, then tip up and anchor.

BOB BALLARD There's no budget in America, zero, zip, for colonizing the world's oceans. Nothing. They're not even thinking about it.

ALAN ALDA You're actively at work on this? I mean, you've designed..

BOB BALLARD Yeah, we're designing it. See, also you can use heat exchangers, so that you can take advantage of the thermocline to have nice air conditioning. You can have this solar panels, where this thing...

ALAN ALDA You're just moving cold air up, or you're creating electricity or what?

BOB BALLARD Yeah, no. It's cold! It's freezing down there! Circulating air. You've got vanes that you can control so your solar panel follows the sun throughout the day. You can help out to it. I want to put it in a marine sanctuary, and have rangers living on it.

ALAN ALDA (NARRATOR) I have to admit I was skeptical about the ocean colonization idea, but when I said so,

BOB BALLARD answered with the confidence of experience.

BOB BALLARD All my life, I've had these ideas, and people say, "you're nuts." 'Til I do them. Then you know what they say? "You know, actually, that wasn't a bad idea, but it's the new one you have that's nuts." And then I go on with the new one and I do it, and then they go, "Well, actually it wasn't such a bad idea but it's the next one." This is the one they think I'm nuts on right now.

ALAN ALDA (NARRATOR) Ballard's one of the most celebrated explorers of his generation. With his list of achievements, you could forgive him for indulging in a little self-congratulation. But 30 years of underwater surprises have taught him not to be so sure.

BOB BALLARD I just think we have this great arrogance, you know, that we know everything. And every generation laughs at the next one. Well, get ready to

be laughed at by your grandchildren. I mean, I have no idea what's ahead of us, but I know it'll be very surprising and very fascinating.

CREATURES OF THE MIDOCEAN

ALAN ALDA (NARRATOR) Early morning fog shrouds the harbor of Moss Landing, on Monterey Bay, California. We're taking a ride on the Point Lobos, a research vessel run by the Monterey Bay Aquarium Research Institute. Bob Ballard's remotely operated telepresence vehicle is out here, in the shallow inshore waters. But just 10 miles offshore, the ocean plunges down into a deep canyon - larger than the Grand Canyon, and deeper than the Galapagos Rift, where Bob Ballard first discovered life at the hot water vents. For the last 10 years, the research team has been cruising the Monterey Canyon, investigating what's called the Mid-Ocean - below the top few hundred feet, and above the bottom waters. That's 90% of the earth's living space, and it's less known even than the deep ocean floor. The team uses a remotely operated vehicle, called the Ventana, controlled from the ship.

ALAN ALDA What is all this stuff here?

BRUCE ROBISON Well, we've got a variety of tools that we use at depth. These are samplers that we use to collect the more fragile and delicate animals. Down here is the big eye. Up here along this middle bar are four metal halogen lights. The depths we'll be working at today are very dark. Less than a hundredth of a percent of the sunlight which reaches the surface penetrates as deep as we'll be working today.

ALAN ALDA If we were down there without a light, what would it be like? Would it be like being in a room that just has a tiny crack somewhere under a door?

BRUCE ROBISON Even less than that. About the only thing you can see is that looking up towards the surface is less dark than looking down.

ALAN ALDA (NARRATOR) The Ventana was not made by Ballard's group. In fact it's much-modified oil industry technology. But it does embody Ballard's basic idea, that you can do good ocean research remotely. Actually, around about now I wouldn't mind switching to full remote telepresence - maybe somewhere in my living room. The ocean swell is making life distinctly uncomfortable. Going below to the control room only makes matters worse. The room is small, dark, hot and constantly pitching. As I munch saltines in an attempt to settle my stomach, the pilot takes the Ventana on a 3,000 foot dive. The spectacular views from Ventana's camera come back to us through an immense fiber optic cable, like Jason and Argo.

ALAN ALDA So we're just traveling through space here, it looks like we're, oh what went by? Something good went by. What was that?

BRUCE ROBISON Oh, Peralia. Peralia.

ALAN ALDA What's that?

BRUCE ROBISON These are great big, brown colored medusi.

ALAN ALDA Oh, that's gorgeous.

ALAN ALDA (NARRATOR) In his dives off Bermuda in the 30s, William Beebe reported seeing many unknown species. This is called a siphonophore.

BRUCE ROBISON This is the propulsive end. There are two swimming bells, one on either side, that allow the animal to pull itself through the water.

ALAN ALDA (NARRATOR) The siphonophore may not be a single animal at all but an assembly of many. Until it was remotely studied here in its habitat, no-one knew much about it.

ALAN ALDA You couldn't have ever brought this up in a net, could you?

BRUCE ROBISON No. We would have had only bits and pieces. We wouldn't have known how many siphonophores were there, whether there was 1 or 100. These animals get to be extraordinarily large. We have measured them up to 120 feet long. That is a very big surprise.

ALAN ALDA (NARRATOR) Siphonophores may be the longest creatures on earth. The crew in the control room can collect specimens by remote control, as effectively as they could if they were actually down here.

ALAN ALDA You gonna put him up the vacuum cleaner there?

BRUCE ROBISON That's right. We're gonna draw this siphonophore into the suction sampler. So that we can look at it's stomach contents.

ALAN ALDA You can get a big guy like that into one of your containers?

BRUCE ROBISON Sure.

ALAN ALDA And he wont break?

BRUCE ROBISON It will be, what's the polite term, "wadded up".

ALAN ALDA This is why I don't believe in flying saucers coming down and taking samples of humanity. I don't want to be "wadded up" by one of those things.

ALAN ALDA (NARRATOR) The siphonophore is gently sucked aboard in one piece -- accompanied by some of the particles that are everywhere down here.

ALAN ALDA What's all this snow-like stuff we are seeing around the animals?

BRUCE ROBISON You called it by the right name. We refer to it as marine snow. It's sort of all of the junk and detritus and dust of the upper layer of the ocean.

ALAN ALDA So, that's stuff falling off of animals up above. And it passes through this region and continues on it's way all the way down to the bottom?

BRUCE ROBISON That's right.

ALAN ALDA And animals are feeding on it all the time?

BRUCE ROBISON Yes, certainly bacteria feed on it while it descends. But there are other animals, filter feeders, that occur in mid-water, and they process these particles. But eventually, they all reach the sea floor.

ALAN ALDA (NARRATOR) Since

BRUCE ROBISON and his colleagues began their mid-water explorations, they've identified dozens of new species. Creatures down here range from the gruesome fangtooth... To the angelic-looking ribbonfish. 2000 feet down, the Ventana passes through a layer where oxygen levels are very low. Among the creatures adapted to hanging out here is the wonderful Vampyroteuthis infernalis, a distant cousin to octopus and squid. It glares at us through a huge blue eye, specially adapted to pick up the trace of light here.

BRUCE ROBISON Oh boy, time out. This is a paralepidid. A very, very beautiful little fish that we don't see all that often. It's nose is up, it's keeping itself almost vertically in the water column. It's looking up trying to see it's prey silhouetted against the surface. Very soon, it's going to take off and it will be gone just like it vaporized. There he goes. He's history.

ALAN ALDA (NARRATOR) To evade shadow stalkers like the Paralepidid, potential prey are often transparent. Or, like this little fish, they generate their own internal light. When viewed from below, this makes them less visible against the lighter surface. Bioluminescence, as it's called, is used a lot at these depths. The

otherwise-black angler fish has a luminous beard to fool prey into thinking it's just the size of the beard.

BRUCE ROBISON This is a red-bellied tomachtarid. It's a type of polechite worm that lives down here. This animal has bioluminescent organs at the ends of all its legs.

ALAN ALDA What a good shot that is.

BRUCE ROBISON It's like having glowing toes.

ALAN ALDA (NARRATOR) There are still many questions in the mid-ocean. This catcher's mitt-shaped creature seems to propel itself with shimmering hairs along its edge, but otherwise it's utterly mysterious.

ALAN ALDA How does this animal reproduce?

BRUCE ROBISON Good question, I don't know.

ALAN ALDA Ha, Ha. Well, you know what's wonderful is how much there is to learn down here.

BRUCE ROBISON Oh sure.

ALAN ALDA It's a whole other universe.

BRUCE ROBISON That's part of what makes it so exciting. Each dive can, and often does, bring us something new, something unexpected.

ALAN ALDA (NARRATOR) Unfortunately, my own curiosity had begun to lose its battle for attention with my stomach.

ALAN ALDA I think I have to go up and get some air.

BRUCE ROBISON Okay.

ALAN ALDA It's not that this isn't fascinating. But I think staying in one piece will be more fascinating.

BRUCE ROBISON Certainly more enjoyable.

ALAN ALDA (NARRATOR) That's it for our voyages Beneath the Sea. Next time, I'm happy to say, it's mostly on dry land.

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