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THE UNCIVILIZED ENGINE OF WAR  
INTO THE DEEP: THE EARLY PIONEERS  
REMOTE CONTROL EXPLORATION  
DEEP OCEAN ARCHEOLOGY  
A SCIENTIFIC REVOLUTION

THE UNCIVILIZED ENGINE OF WAR

ALAN ALDA (NARRATOR) In a quiet corner of Magnolia Cemetery eight men are buried. One of them is Horace Hunley - the man who gave his name, his energy, his enthusiasm, and finally his life to an extraordinary machine. All eight men drowned in a training accident in the submarine H.L. Hunley. This is the Hunley today - a priceless relic of the Civil War, but also a war grave. On February 17, 1864, four months after the training accident, a new crew took the Hunley to sea and carried out history's first successful submarine attack. They never returned. It's a hot August day, 136 years after the Hunley vanished. A few miles out from Charleston harbor, the sub is about to re-appear. Cradled in a specially built frame, the Hunley has been gently hoisted 30 feet from the floor of the Atlantic. She's coming to the old Charleston Navy Yard, and into the hands of a team of archaeologists. The Hunley is surprisingly well preserved - probably because soon after sinking she was covered by sediment. The hull has about half an inch of rust and marine growth, but the structure's sound. The interior is completely filled with sediment. That's what the archaeologists will go to work on.

WARREN LASCH This is all the controls for the tank area and here's the Hunley.

ALAN ALDA God, it's really...

WARREN LASCH Can you see how small it is?

ALAN ALDA It's really small.

WARREN LASCH Isn't that your first reaction? How could people get inside?

ALAN ALDA It's so tiny. How many people were in there?

WARREN LASCH Nine men.

ALAN ALDA Nine people?

WARREN LASCH Nine men.

ALAN ALDA The confederacy wasn't the only group of people working on submarines. At the same time, they were working on them in the North. What do you suppose the difference was? Why didn't they have the first successful submarine?

WARREN LASCH I think that's a great question, Alan. I think it's, desperate times call for desperate measures. The blockade was taking its toll, the South was in the process where it became evident that they were starting to lose the war. And they had to free the blockade, they had to restart the trade in and out of Charleston. They had to communicate with the outside world. They were forced to it.

ALAN ALDA (NARRATOR) War became inevitable when in 1860 South Carolina seceded from the Union, soon followed by the five other Confederate States. Attention focused on Fort Sumter, at the mouth of Charleston Harbor, to which all the Union forces in the area had withdrawn. For four months there was a stand-off. Finally Confederate batteries opened fire, and after 34 hours the Fort surrendered. With Sumter securely in Confederate hands, Charleston Harbor became the South's vital strategic link to Europe. The North set up a naval blockade - a dozen or more warships in a ring around the harbor entrance, far enough off shore to be out of range of shore batteries. Charleston Harbor was fought over for the rest of the war. Fast Confederate blockade runners attempted to race in and out of port. The new ironclads were used by both sides, with the Union mounting several attacks on Sumter and the other harbor forts, but to no avail. Then in August, 1863 the South brought into Charleston, from Mobile, Alabama, a secret weapon which they hoped would decisively tip the balance. It was called a "torpedo fish" or "torpedo boat." Now we call them submarines.

WARREN LASCH It's an emotional love story, too. It's got elements for everybody. It's just phenomenal.

ALAN ALDA (NARRATOR) Warren Lasch is the Charleston businessman who's pulled the Hunley recovery project together. In the process he's become a Civil War expert.

WARREN LASCH The lifeblood of Charleston was its trade -- its textiles, its cotton -- that would ship to Britain and other trading partners. The intent of the North was to choke Charleston with this blockade, not only from a commercial perspective, but that also was, running the blockade was its only way of communication with the outside world.

ALAN ALDA Is that Fort Sumter over there?

WARREN LASCH Yes, right here, this is Fort Sumter. To the left we have the opening to the harbor. And further to the left over here is a lighthouse. That's called the Sullivan's Island Light. Directly east out to sea is where the Hunley engaged the Housatonic and sunk her.

ALAN ALDA (NARRATOR) Charleston was the Confederacy's only east coast port, yet it was being strangled by the Union's much more powerful navy. When the Hunley sank the USS Housatonic, Charleston itself was coming under increasing pressure. In the summer of 1863, Union forces had taken Morris Island, and set up batteries which threatened the entire harbor and the city. An enormous gun, the "Swamp Angel," lobbed 200-pound shells into the streets. Fort Sumter came under heavy bombardment from the new Union positions, which were only about a mile away. The siege of Charleston was gathering force. Several nights a week, the Hunley - stationed on Sullivan's Island - put to sea in an attempt to reach the blockading ships. It was dangerous work - 13 men had already died in her during training. And it was tough work - her propeller was hand-cranked, so getting a few miles offshore took hours of exhausting labor. On the night of February 14, 1864, 4 miles off Sullivan's Island, the Union sloop-of-war Housatonic came into view. But then the Housatonic saw the Hunley.

WARREN LASCH General Beauregard, who was in charge of the defense of Charleston, had said several times after the first two crews had perished, that the Hunley was more dangerous to its crew than it is to the enemy. So he basically ordered the Hunley to attack on the surface, which took away one of its big, big advantages -- its stealth.

ALAN ALDA (NARRATOR) Although she was capable of submerging completely, the Hunley attacked semi-submerged. For a vital few seconds, the lookout on the Housatonic was not quite sure what he'd seen .

WARREN LASCH By the time he realized it was something that was a threat to the Housatonic, he sounded general quarters, but the Hunley was too close. So they couldn't lower their cannons low enough to get an angle. So people came on deck and started firing upon the Hunley with small arms fire and rifles.

ALAN ALDA (NARRATOR) The Hunley jammed its torpedo, with a harpoon tip, into the Housatonic's wooden hull. The men backed away, then pulled a rope attached to a trigger on the torpedo. The Housatonic sank within 3 minutes, but with surprisingly few casualties. Five men were killed, with the rest of the crew picked up by other blockade ships. But what about the Hunley?

WARREN LASCH The system was that the Hunley would signal success by flashing a blue lantern.

ALAN ALDA But that doesn't mean that they were coming back on the surface of the water. They had some kind of periscope or something.

WARREN LASCH No, no, they were gonna come back on the surface.

ALAN ALDA Oh.

WARREN LASCH Oh, absolutely. They signaled shore with a blue lantern. They were on the surface, opened the conning tower and somebody signaled shore. And two different people saw the lantern. One of them was a sentry on Sullivan's Island that lit a campfire to guide the Hunley to come back.

ALAN ALDA (NARRATOR) But she didn't come back. She was lost. Until, that is, a team led by Clive Cussler, the author and shipwreck hunter, found the sub in 1995, after 14 years of searching. Cussler used a towed magnetometer to detect the Hunley's hull, which was completely covered by silt. The sub was further out to sea than where the Housatonic had sunk -- not where you'd expect her to be if she was already on the way back. It took five years for the plans to be completed - and the money raised - to recover the Hunley. The big concern was that the hull would break up while being lifted. Working in near zero visibility, divers placed a line of slings along the entire length, padded with plastic foam. The slings were attached to a massive steel frame placed over the sub. The whole assembly would then be raised in one piece. Everything went without a hitch. Today the Hunley lies suspended in the same slings inside a huge tank on the dock at the Charleston Navy Yard. When work's not underway, the tank is filled with chilled fresh water, to wash out the salt and minimize corrosion. Naval historians have been surprised at the Hunley's technical sophistication. Horace Hunley, who was a wealthy New Orleans lawyer, had pulled together a team of first rate engineers. The hull was based on a steam boiler, but much modified. Everything was streamlined. Rivets were finished flush, and tapered sections were added fore and aft. Buoyancy was regulated with two ballast tanks, with hand pumps to alter water levels. Dive planes, controlled by the captain, adjusted the sub's dive angle. There was a heavy ballast keel, which could be dropped from inside in an emergency. Although no crew ever managed to do that. And there were two snorkel tubes, with leather bellows, to bring in fresh air while submerged. A 20-

foot spar carried the torpedo - 135 pounds of black powder, with a rope trigger leading back to the sub. The spar was still attached when the sub was found, then removed before the recovery operation.

ALAN ALDA OK close the door?

PAUL MARDIKIAN Yep.

ALAN ALDA (NARRATOR) One advantage of the Hunley sitting on the bottom for 136 years, is that advanced analytical tools are now available. This is a state of the art digital x-ray system.

PAUL MARDIKIAN Look at that.

ALAN ALDA Yeah, amazing.

PAUL MARDIKIAN And you're looking at something which is maybe completely gone. The iron has left the object and gone into the encrustation around it.

ALAN ALDA So what that means, it seems to me, is that if you chipped away the encrustation, you would never see the threads.

PAUL MARDIKIAN It's very possible...

ALAN ALDA Because you don't get down to the threads. The threads no longer exist.

PAUL MARDIKIAN Exactly.

ALAN ALDA They're now in the encrustation.

PAUL MARDIKIAN Exactly.

ALAN ALDA (NARRATOR) It's taken the archaeologists more than a year to excavate the Hunley's interior - tons of silt removed a spoonful at a time. Skeletons of all eight crew members -- with their clothing, their shoes, their personal possessions -- have been recovered. The human remains will eventually be buried with Horace Hunley and the other crew in Magnolia Cemetery. There's a high level of preservation because the fine silt shut out oxygen.

ARCHEOLOGIST Oh look at that. Unbelievable.

ALAN ALDA (NARRATOR) It's believed that the crew were all Confederate soldiers. Here's one man's pipe. Did they smoke down there? A lead pencil. A thimble - soldiers did their own sewing. Many different kinds of buttons, including one from a US Navy uniform, where one crewman must have served before the war. And here's a Union soldier's I.D. tag - probably a battlefield trophy. A match stick... And the candle it was used to light - perhaps just for a moment, to read the compass. Maria Jacobsen, the project's Danish head archaeologist, learned her trade excavating Viking long boats - a trade which mainly seems to involve unpleasant working conditions.

ALAN ALDA What's all this stuff here?

MARIA JACOBSEN What you're looking at is the forward end of the crew compartment. And this is the forward pump that controlled the water level in the forward ballast tank. This is probably the handle to operate the pump. And the crew members would sit on this wooden bench. There was only three and a half feet between the edge of the bench to the starboard side.

ALAN ALDA But look at how little room there is between the seat, between the bench and the top of this. They must have been bent over like this, if they sat here...

MARIA JACOBSEN One of the things we wondered about, because all the men sat on one side, how did they balance the sub? Did they have a counterbalance over here? But I think we're learning now that the sub was so cramped, in fact, that when they were sitting at their stations, the heavy upper torso and head was directly above the center line of the sub.

ALAN ALDA So they balanced it automatically.

MARIA JACOBSEN Exactly.

ALAN ALDA Okay, now you know what I see now that I didn't get before, is these handles were what they turned to move the ship. They sat there and turned the handles.

ALAN ALDA (NARRATOR) It's this hand-cranking that's the sub's most astonishing aspect. Horace Hunley's engineers had tried electric motors, but couldn't get enough power. Others tried steam, but that meant never submerging. Seven Hunley crew men were there as human engines. The eighth was the captain. For the attack on the Housatonic, the captain was a young lieutenant, George Dixon, who'd been wounded at the Battle of Shiloh. Maria Jacobsen will never forget that connection.

ALAN ALDA Dixon's body was identified?

MARIA JACOBSEN Yes, he had a very significant artifact on him. The golden coin that was given to him by his sweetheart, Queenie Bennett.

ALAN ALDA (NARRATOR) The gold coin that Queenie Bennett gave Dixon had saved his life at Shiloh - it had stopped a bullet.

MARIA JACOBSEN I got it.

WOMAN Really?

MAN Say the words.

MARIA JACOBSEN I have the golden coin right here.

MAN You feel it in your fingers?

MARIA JACOBSEN Oh, I feel it in my fingers, oh I do.

WOMAN Oh my God! Oh my God! Oh my God! I have the chills!

MAN Oh my God!

MAN There it is. Is that fantastic or what? Maria, why are you shaking?

MARIA JACOBSEN Why do you think I'm shaking?

MARIA JACOBSEN Not only was it very clearly a gold piece that had been hit by a projectile, but he had actually had it inscribed. As a memento of...

ALAN ALDA What did it say on it?

MARIA JACOBSEN It said "Shiloh, April 6, 1862. My Life Preserver".

ALAN ALDA (NARRATOR) Why could Dixon not bring the Hunley back that night? The sub is clearly damaged. There's a gash in the stern... And there's a hole in the forward conning tower. It's plugged here with white foam. Was the damage perhaps caused by a collision with one of the other blockade ships, racing to the aid of the Housatonic? The silt deposits seem to say no. There's a tell-tale band of coarse material half way up the inside. For Maria that's significant.

ALAN ALDA So does that indicate to you that that coarse material came in through a larger opening than the fine silt?

MARIA JACOBSEN Exactly. Exactly. Because it's a later deposit. And it's scouring into the existing sediment. It tells me it occurred afterwards.

ALAN ALDA (NARRATOR) If coarser sediment could only get in after half the fine material entered, that means the large holes in the hull happened after the sub sank - probably caused by a ship's anchor or fishing gear. The project's high tech equipment may be pointing in a different direction.

PAUL MARDIKIAN This is the cover of the forward hatch here, okay? And this is the hatch itself. Now, if you measure this. At the front of the conning tower, there's a gap. If you play on the density, you see it is black. It means that there's no density. That's rubber. This is a rubber seal that sealed the submarine closed.

ALAN ALDA Now why is the rubber thicker here than it is over here?

PAUL MARDIKIAN You are going to draw the conclusion yourself.

ALAN ALDA I am guessing there was some kind of a leak here or some kind of a separation.

PAUL MARDIKIAN Or it's open.

ALAN ALDA It's open? You think it's definitely open?

PAUL MARDIKIAN My theory is that this is unlocked. The closing mechanism is unlocked.

ALAN ALDA The hinge is over here. So it's compressing this part of the rubber, but it's not compressing this because it's not tied down.

PAUL MARDIKIAN And the rubber itself has a tendency to pop up

ALAN ALDA ...pushes back if you're not locking it in place.

PAUL MARDIKIAN Exactly. You've got it.

ALAN ALDA (NARRATOR) If the crew really did signal their success on the surface after the attack - which means they'd survived their own explosion - then something subsequently made them dive the boat. Maybe in a hurry, rushing to avoid an approaching ship, they didn't fully lock the hatch, it sprang open...we'll



probably never know. Somehow this "engine of war not recognized by civilized nations" -- as a Union admiral described it -- went to the bottom.

INTO THE DEEP...

ALAN ALDA How long do you think it will be...

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.

BOB BALLARD ...within five years I'll have everything...

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.

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-person 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. PILOT I.D. light on, request permission to dive. TECHNICIAN Roger you're clear to dive. Depth is 25-20. PILOT Roger Alvin diving.

ALAN ALDA (NARRATOR) With two 500-pound ballast weights, the Alvin sinks at a steady 80 feet a minute. PILOT Gary can you give me a vector to the target please?

ALAN ALDA (NARRATOR) Sub and mother ship communicate with an acoustic phone that echoes as it broadcasts sound directly into the water. TECHNICIAN Ninety meters away. Eight zero degrees. PILOT 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 that 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 Oh, you mean personally.

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 (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. It would be another 50 years before he was proved right. 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, it's 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 air 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.

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. 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. The water's saturated with hydrogen sulfide gas -- toxic to most life forms we know, but down here there were bacteria that were new to science. They can extract energy from the hydrogen sulfide in the vent water. Many scientists believe life on Earth began in places like this. All the vent life depends on the sulfide-eating bacteria. 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 its now full of chemicals that it didn't have before. And its 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. ALA 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.

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. Now the sub's windows have become underwater cameras. 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 - and that was 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. Break out the champagne.

ALAN ALDA (NARRATOR) With only 2 days' search time left, Argo's cameras had picked up Titanic's ghostly shape, 12,000 feet 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.

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. 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 would 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, and much of his attention would be devoted to shipwrecks -- and a new kind of archeology. 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, lets say its 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 navigated. 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. You guys ready to go?

ALAN ALDA (NARRATOR) Here's Ballard's latest use of remote underwater vehicles. He calls it telepresence.

BOB BALLARD 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.

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.

BOB BALLARD That's up and back.

ALAN ALDA Right. OK. Wait...

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 another remotely operated vehicle. It had been installed just the week before I tried it out. 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.

BOB BALLARD OK 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. 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.

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