**THE ENDLESS VOYAGE**

"Hands On" Episode 126

The deep sea is the largest living space on earth. It's home to the largest animal communities on earth—largest in terms of aerial extent, largest in terms of biomass, largest in terms of numbers of individuals. Any way you want to slice it, this is the biggest and probably most important living space on the planet.

The oceans control the air we breathe. They control the food we eat, and they control the water we drink. That's whether you live in New York City or California or the heartlands of Africa or Central China.

So the future's very exciting, I think, in terms of technology, opportunities…just the awareness of the general public and appreciation of the general public for what's out there. It's really an exciting time.

**NARRATOR:**
SOME WHO STUDY THE MARINE ENVIRONMENT ARE DRIVEN BY INSATIABLE CURIOSITY—A LOVE OF PURE SCIENCE—OTHERS PRIMARILY BY A DESIRE TO CONTRIBUTE TO THE BETTERMENT OF PLANET EARTH. IN NEARLY ALL CASES, THOSE WHO CHOOSE THIS FIELD OF STUDY DO SO WITH AN ENERGY AND DEDICATION THAT IS NEARLY BOUNDLESS. AND IN MANY INSTANCES, THOSE WHO FOLLOW THIS PATH HAVE FELT A SPECIAL BOND WITH THE OCEAN FOR A VERY LONG TIME.

**KATHERINE BARBEAU, Ph.D., Scripps Institution of Oceanography, UCSD:**
I grew up on the East Coast in Connecticut, and I used to go on a lot of fishing trips in Long Island Sound when I was a child with my father.

**ANNOUNCER**:
This is flight control. We have…

**SEAN CHAMBERLIN, Ph.D., Fullerton College:**
Actually, what really got me started was the space program. When I was a kid, I used to watch rockets go overhead—the moon launches and those type of things—and I always wanted to be an astronaut. Talking to my parents about that, they weren't so keen on the idea of me going to the moon for some reason.

**ROBERT GUZA, Ph.D., Scripps Institution of Oceanography, UCSD:**
As a boy growing up in Philadelphia, I was a saltwater fisherman with my dad, and we spent a lot of time surf fishing on the beach—Long Beach Island, New Jersey—and sleeping overnight and things like that. And the beach environment was one that I really, really enjoyed.

**ELLEN DRUFFEL, Ph.D., University of California, Irvine:**
I had a wonderful high school chemistry teacher Miss Spit at Immaculate Heart in Hollywood. She made chemistry so much fun that I knew I wanted to be a chemist.

**MILTON LOVE, Ph.D., University of California, Santa Barbara:**
I was taken fishing on the Malibu Pier—just north of Los Angeles—when I was five years old, by my father. And apparently shortly after that I announced that I wanted to be an ichthyologist—a fish biologist. And I had such limited imagination that I never changed my mind.

**STACY KIM, Ph.D., Moss Landing Marine Laboratories, CSU:**
I started out being interested in oceanography when I was about five and my mom would take us to the beach to explore in the tide pools. My brother found an octopus and he held it up and it squirted ink in my face. And I was just absolutely fascinated by this little creature that could squirt ink, and why it was doing that and what was going on.

**NARRATOR:**
FOR SOME, THE DEFINING MOMENT IS A WORD OF ENCOURAGEMENT FROM AN INSPIRING TEACHER. FOR OTHERS, A CHILDHOOD OUTING BRIMMING WITH THE SPIRIT OF EXPLORATION AND WONDER. THE ROAD THAT LEADS TO THE STUDY OF OCEANOGRAPHY IS AS VARIED AND DIVERSE AS THOSE WHO CHOOSE TO TAKE IT. AND IN SOME CASES, DISCOVERING THAT ROAD IS ALTOGETHER UNEXPECTED.

**WALTER MUNK, Ph.D., Scripps Institution of Oceanography, UCSD:**
I was an undergraduate at Cal Tech in geophysics. The decision to become an oceanographer was entirely accidental. I had a Texan girlfriend who was going to spend the summer here, and I wanted to date her and the only job you could possibly get in La Jolla at the time—City of Beach Cottages was at Scripps. And I applied and they gave me a summer student job and I'm still here.

**William Hamner, Ph.D., University of California, Los Angeles:**
I was an ornithologist and got my Ph.D. working on birds. And after about six or eight years of working on birds and teaching at the University of California on the Davis Campus, I became allergic to feathers…and I couldn't work on birds anymore. So I thought since I was also a covert surfer, I would look at birds in the ocean. But they don't want you to watch them very easily, so I ended up looking at jellyfish more often, 'cause they're a lot slower and not so clever as birds.

**TIMOTHY SPANGLER, Ph.D., National Center for Atmospheric Research, (NCAR):**
I worked the summer for the Forest Service in Idaho as a lookout and a forest fire fighter. I'm on my lookout on top of Gardner Peak in the middle of Idaho, and a big thunderstorm's coming. And it was really fun to watch it coming, but I began to get really nervous, and it was going to come right over the top of my lookout. I'm standing on a glass-legged stool so I'm insulated, and all of a sudden things began glowing blue,

and kaboom, and the lightning struck right next to the lookout and blew up my outhouse. And since then, I found I was really interested in weather.

**GEORGE MATSUMOTO, Ph.D., Monterey Bay Aquarium Research Institute:**
I got started off in I guess fifth grade, when my parents signed me up for a snorkeling class on a weekend. And that's the sort of thing you never want to do on a weekend, especially in fifth grade, 'cause you want to play with your friends and other things.

**DAVID GALLO, Ph.D., Woods Hole Oceanographic Institution:**
I grew up in central New York State, and we had the Finger Lakes. I didn't think much about the ocean from there. I knew that the ocean had fish in it. I saw Jacques Cousteau on TV a couple of time, maybe. I read "Kon-Tiki" in Elementary School.

**GEORGE MATSUMOTO:**
They put a mask and snorkel on me, to actually look underwater and see what was down there was just stunning. And that was pretty much when I first started to get my interest in the marine environment. All the way through college I managed to convince my parents that I was considering being a medical doctor, 'cause that's one of the things they wanted me to be.

I was bored with some of the things we were learning in school. So at the end of it all, I got out of high school and I did what they thought I could do best, which was sell shoes, and I did do that. I did it for seven years. I sold shoes.

**GEORGE MATSUMOTO:**
I majored in Marine Biology, where my mentor at U.C. Berkeley spent four years trying to convince me that Marine Biology was not what I wanted to do, because there's no money in it. He was unsuccessful.

In 1976, I was in my mid 20s. I remember in the shoe department I opened up a "National Geographic" magazine, and in there there was an article by Bob Ballard—who was later to discover Titanic, but it was 10 years later—and in that article, he talked about exploring the oceans. And in that article, he talked about exploring the oceans.

I went ahead and applied for medical schools, but I also applied for graduate schools. And at the end of that year, I broke the sad news to my parents that I was going to graduate school. And I don't think I've ever regretted my decision.

**GALLO:**
And I remember it vividly—flipping through that article that night—because it showed a hand drawn mountain under the sea—done by an artist and on that mountain there was a little speck. And in that little speck, on that underwater mountain was Bob Ballard and two other people exploring this underwater mountain world in the dark in this little tiny submarine called "Alvin." It just changed my life. One picture changed my life.

**NARRATOR:**
OCEANOGRAPHY HAS A WAY OF CHANGING THE LIVES OF NEARLY ALL WHO CHOOSE TO STUDY IT, WHICH MAY EXPLAIN THE PASSION WITH WHICH THEY GENERALLY DO SO. IT IS A RELATIVELY YOUNG SCIENCE, AND YET, TREMENDOUS PROGRESS HAS BEEN MADE IN A SHORT TIME—SOMETHING ALL THE MORE REMARKABLE GIVEN THAT THE MARINE ENVIRONMENT PRESENTS CHALLENGES UNLIKE ANY OTHERS NO PLANET EARTH.

**DEBORAH KELLY, Ph.D., University of Washington:**
It is difficult to explore because there's so much water. It's difficult to find things that see through several kilometers of water. And so, for instance, Mars is much better mapped than any of most areas in our oceans. Also it's costly. I think up until now there hasn't been such a big driver to get out there as often. And to be honest, right now we're just getting the technology to really look at it in detail.

**NARRATOR:**
TECHNOLOGY IS NEARLY ALWAYS AN IMPORTANT TOOL IN SCIENTIFIC DISCOVERY. IN THE FIELD OF OCEANOGRAPHY, IT'S PLAYED AN ESPECIALLY CRITICAL ROLE.

**BRUCE ROBISON, Ph.D., Monterey Bay Aquarium Research Institute:**
From my perspective as a deep-sea biologist, the greatest technological breakthrough in more than a century has been the technology that put the scientist in the habitat directly. Most of the first hundred years of deep-sea biology was done indirectly, was done by scientists standing on the deck of a ship dragging a net down at depth, hauling that up to the surface, dumping out the bucket, and trying to understand what was going on down there based on what they caught and brought to the surface. They did a marvelous job with what they had to work with, but it was a very limited and very biased view of the deep-sea realm. The technology that allows the scientist to go into the habitat directly, or indirectly through a remotely operated vehicle, revolutionized our understanding of these deep-sea communities.

**PAUL JOHNSON, Ph.D., University of Washington:**
You can go down and instead of being on the bottom for four hours, you're now on the bottom for four days. And you can do experiments in a much different and much more efficient way. When we started out, we could hardly see where the mid-ocean ridge was. Now we can see individual boulders.

**GALLO:**
The cornerstone of science is observation, and when you're dealing with the ocean, observation has to be done through technology. The average depth of the ocean is about two and a half miles. It's a dark world. It's a world where the pressure could crush the Titanic like you could crush an empty paper cup in your hand. It's a world that's very hostile to us. And we can't go there and observe as scientists without technology.

The use of technology to go down there and see for ourselves using the eyes of the remote vehicles, or our own eyes in manned submersibles, has really opened up a whole new realm of information for us. We're now finding things down there that we thought were there, but now we have some evidence.

**NARRATOR:**
ONE OF THE LEADERS IN THE EFFORT TO PUSH THE ENVELOPE OF OCEANIC OBSERVATION IS NOAA—THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION.

**ED HARRISON, Ph.D., National Oceanic and Atmospheric Administration:**
NOAA's been involved in the tropical Pacific and in the study and the forecasting of El Niño. And NOAA's developed technology, moored instrument systems—buoys, we tend to just call them—that make it possible for us to sustain observations both at the ocean surface and down into the ocean water column. We now have an array of buoys that extend from the Western Pacific all the way to the coast of South America. It's jointly operated by NOAA and Japan. It's called the Tao-Triton Array. There's a mooring at the surface which is buoyant, which contains sensors that let us measure surface temperature, surface wind, surface humidity, the things that meteorologists are concerned about who want to understand how the ocean and atmosphere interact. It also is moored down on the bottom of the ocean with wire and rope, and along that wire, in the upper part of the ocean, we have sensor systems like these, which measure temperature conductivity, and other sensors that measure pressure. So we know the depths from which these measurements come. And they're coupled inductively through this system here, so the information makes its way back up to the buoy at the surface. The buoy talks to satellites, which send the data back.

One of the great advances we've had in the last 10 or 20 years is the advances in satellite technology—looking down on the earth from space. And what a great thing that is, what a great perspective to see the whole planet.

**ERIC TERRILL, Ph.D., Scripps Institution of Oceanography, UCSD:**
Satellite remote sensing has seen a tremendous growth where we're, in fact, applying satellite information that regularly passes over say, the coastal area, and using that information to learn about the coastal environment.

**LEE-LEUNG FU, Ph.D., Jet Propulsion Laboratory:**
There's no way we can sample the ocean—you know, put enough instruments to really get the entire picture of the ocean. So the vantage point from space is the only way to really get a good look at the ocean to understand the variation on all different scales.

**NARRATOR:**
SATELLITE TECHNOLOGY IS A CORNERSTONE OF OCEANOGRAPHIC RESEARCH DOEN AT THE JET PROPULSION LABORATORY.

**FU:**
There are many different instruments measuring different parameters of the ocean. Ocean topography from radar altimetry is one. Another important instrument we call the scatterometer allows us to measure the speed and direction of winds that drive the big ocean currents. And we can also derive the height of waves from radar. We can suddenly see sea surface temperature from visible infrared sensors. We can also measure the color, which reflects the chlorophyll content of the ocean—it relates to biological production—from a satellite. And currently, we're also planning a new satellite that can measure the salt content, we call it the salinity, of the ocean surface, that will allow us to study the exchange of fresh water between the ocean and atmosphere, which is also very important for circulation. So this oceanography viewed from space really revolutionized the way oceanographers study the ocean and the understanding of weather and climate. So it is a big leap forward.

**NARRATOR:**
BUT EVEN WITH THE LATEST TECHNOLOGICAL BREAKTHROUGHS PAVING THE WAY, ULTIMATELY THE DRIVING FORCE BEHIND SCIENTIFIC DISCOVERY IS THE SCIENTISTS THEMSELVES.

**DEBORAH DAY, Scripps Institution of Oceanography, UCSD:**
Oceanographers tend to work intensively on the biggest questions, the biggest controversies in the science. Right now, that's climate change. In the past it's been global warming or hot vents in the ocean—all sorts of things like that, controversies which people surround and try to attack, and try to solve important scientific problems.

**LIHINI ALUWIHARE, Ph. D., Scripps Institution of Oceanography, UCSD:**
And I am primarily interested in sort of photosynthesis and respiration, and how carbon and nitrogen and phosphorous—those elements that are critical to life in the ocean—how those different elements are cycled. And the ocean plays a huge role in the cycling of these elements, particularly in terms of sequestering them in sediments on long timescales.

**NARRATOR:**
LIKE MANY OCEANOGRAPHERS, LIHINI ALUWIHARE AT THE SCRIPPS INSTITUTION OF OCEANOGRAPHY IS INTERESTED IN THE LINK BETWEEN THE MARINE ENVIRONMENT AND GLOBAL CLIMATE. BUT REGARDLESS OF THE SPECIFIC SCIENTIFIC WORK BEING DONE, PATIENCE, PERSEVERANCE AND UNLIMITED ENERGY ARE CONSTANT REQUIREMENTS.

**ALUWIHARE:**
In order to do the kinds of analytical techniques that I do, I need large volumes of seawater, and I filter out these compounds and just isolate the organic compounds. So I do have to go out to sea, and often I go out to sea—nobody likes to go with me because I need to sit on station for a fairly long time to get the kinds of volumes of seawater I need to do the kinds of work that I do.

**NARRATOR:**
WHILE THE WORK MAY BE HARD AND THE HOURS LONG, MOST SCIENTISTS, FIND THE PROCESS TO BE INVIGORATING AND THE RESULTS TO BE IMMENSELY REWARDING.

**J. WILLIAM SCHOPF, Ph.D., UCLA:**
Science is really good stuff. You camp out and you get all dirty, and there have been two or three times that I've come close to getting killed. You get in some dangerous places sometimes. But it's fun to discover new things and it is fun to do the work. I'm just one of these fortunate people that they actually pay me money to do what I think is just really fun. Over the years, I've traveled all over the place, to Africa, to India, to China, to the Old Soviet Union, various places in Russia, in Siberia, in South Africa, Australia—collecting rocks that looked to me, and my colleagues, to be places where we might find evidence of microscopic life.

**NARRATOR:**
WHILE THERE IS ALWAYS THE CHANCE OF SUSTAINING AN INJURY WHILE CONDUCTING FIELD WORK, MOST SCIENTISTS ARE UNPHASED BY THE PHYSICAL CHALLENGES THEIR CAREERS SOMETIMES PRESENT. OF COURSE, THAT DOESN'T MEAN THEY ABANDON CAUTION ALTOGETHER.

**HAMNER:**
Collecting jellyfish is not much different than collecting other live animals in the ocean. Most of the jellyfish in the ocean aren't very large. And so you can chase them into a jar and bag them up. And most of them are so little that it doesn't matter if you touch them—you're not going to be hurt. The bigger animals are trickier, because if you have an animal like a sea wasp or a box jellyfish that's the size of the chair you're sitting on and it has tentacles that are 30 feet long and there's 60 tentacles, you're going to get stung. So you don't collect an animal that big. That's just not real smart.

**NARRATOR:**
AN INTEREST IN THE ENVIRONMENT, AS WELL AS A DESIRE TO SPEND LARGE AMOUNTS OF TIME WORKING OUTDOORS, IS CHARACTERISTIC OF NEARLY ALL OCEANOGRAPHERS. FOR THOSE WHO DO MOST OF THEIR RESEARCH IN THE OCEAN ITSELF, THE EXPERIENCE CAN BE ALMOST MYSTICAL.

**RICK GRIGG, Ph.D., University of Hawaii at Manoa:**
As you enter the ocean, it's like a new world begins to open up. You feel very private suddenly. It's truly a silent world. Of course, you can hear things, but very subtle sounds. It's a magnificent place. It's very pristine. As you look up at the sun, it makes you feel like you're in God's cathedral in a world that's magical.

**NARRATOR:**
FOR DAVID GALLO OF THE WOODS HOLE OCEANOGRAPHIC INSTITUTION, EXPLORING THE VERY DEEPEST REGIONS OF THE OCEAN IN A SUBMERSIBLE IS AN EXPERIENCE UNLIKE ANY OTHER.

**DAVID GALLO, Ph.D., Woods Hole Oceanographic Institution:**
Takes two and a half hours to get to the bottom, but after about a half an hour, that lovely color blue on the outside goes to deep blue, darker blue, and then black. It's too faint to take a photo of, or video of, so it only lives in our memory, but it's an incredible world out there. And then you show up on the seafloor, and that's a whole nother world. Now you're looking at places—mountains, valleys—things that people have never seen before in their life, and there you are exploring and the sub moves across that bottom at about a half a mile an hour—real slow. The lights go out ahead about 30 feet. You never know what's going to come out of that darkness or what you're going to stumble across.

**NARRATOR:**
WHETHER THEY USE A DEEP-SEA SUBMERSIBLE OR A MORE CONVENTIONAL RESEARCH VESSEL, MOST OCEANOGRAPHERS DO A GOOD DEAL OF THEIR WORK AT SEA. FOR WILLIAM FENICAL OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY, THIS IS A CRITICAL PART OF THE ONGOING EFFORT TO EXTRACT PHARMACEUTICAL RESOURCES FROM THE MARINE ENVIRONMENT.

**WILLIAM FENICAL, Ph.D., Scripps Institution of Oceanography, UCSD:**
I'm an ocean scientist because I love the ocean, and so I spend time there. And that includes every form of our research activity, whether it's diving in relatively shallow water to collect sand samples, or to collect small pieces of marine life. We bring those back to the laboratory, we work on ships at sea, we have aggressive programs using research vessels that go out to effective study sites, whether it's deep ocean sites to sample sediments, or whether it's shallow waters for diving and collecting.

**NARRATOR:**
WHEN UNIVERSITY OF SOUTHERN CALIFORNIA PROFESSOR DONAL MANAHAN GOES TO SEA, HIS DESTINATION IS OFTEN ONE OF THE MOST CHALLENGING REGIONS ANYWHERE ON EARTH.

**DONAL MANAHAN, Ph.D., University of Southern California:**
I have two lives. One is here at the University in my research lab, where we bring samples back and analyze them, but probably—certainly the more adventuring side of being interested in the oceans is going out onto the oceans. So for instance, we were out recently using ships out on the Pacific Ocean, and using submarines to dive on hydrothermal vents. So the whole process of how we get out there and how we study these things involves an enormous understanding and the interaction with big logistical operations—big ship operations, submarine crews. For instance, when we were diving to the bottom of the Pacific, and in October, I'll be going to Antarctica to study life forms in extreme cold. And there we interact with an enormous infrastructure of airplanes and

helicopters and support teams to get a science team down to Antarctica to be able to study life forms in extreme cold, and we'll be there for three or four months doing that.

**NARRATOR:**
FOR GEORGE MATSUMOTO OF THE MONTEREY BAY AQUARIUM RESEARCH INSTITUTE, DEEP SEA EXPLORATION OFTEN TURNS INTO OCEANIC DETECTIVE WORK.

**GEORGE MATSUMOTO, Ph.D., Monterey Bay Aquarium Research Institute:**
One of the things we really want to do, besides trying to find out as much as we can about the ocean environment is learning what's in the ocean. And we can't really understand or even begin to comprehend the ecosystem unless we know who the players are. And as we go down into the deep sea, what we're finding is that almost everywhere we turn we're finding organisms that nobody's seen before. And part of the problem in the scientific community right now is we're facing a huge shortage of people skilled in the art of taxonomy—the ability to name new species, the ability to know what a new species is or how to figure out how to name a new species. And again until we can name a new species, we can't really study them.

**NARRATOR:**
WHETHER TO ADVANCE THE PROGRESS OF TAXONOMY OR FOR OTHER REASONS, OCEANOGRAPHY'S RAPID GROWTH REQUIRES THAT SIZEABLE NUMBERS OF NEW, YOUNG SCIENTISTS JOIN THE RANKS OF ESTABLISHED VETERANS. FOR SOME BUDDING OCEANOGRAPHERS AT THE UNIVERSITY OF SOUTHERN CALIFORNIA, THE CATALINE SEMESTER CAN BE AN IMPORTANT FIRST STEP.

**ANTHONY MICHAELS, Ph.D., Wrigley Institute of Environmental Studies University of Southern California:**
We have a marine lab on Catalina Island. And a group of students will go out there for an entire semester. And what it lets them do is to get fully immersed in the project, fully immersed in the subject, and to really understand science as a creative process. They don't just do the normal lessons, follow the directions through a book. They do experiments on things that have never been done before. They look at the physiology of an organism that isn't known. And by doing that, they see science as exploration—science as creating new knowledge.

**NARRATOR:**
FOR OCEANOGRAPHERS AT ANY STAGE, AS WELL AS FOR THE ENTIRE GLOBAL POPULATION, THE NEED TO LEARN AS MUCH AS POSSIBLE ABOUT THE MARINE ENVIRONMENT CAN'T BE OVERSTATED.

**MICHAEL LATZ, Ph.D., Scripps Institution of Oceanography, UCSD:**
Study of the ocean is important not only for learning about the processes occurring in the ocean, the currents and other aspects of the physics, the chemistry, the biology—but it's

also important for global processes. It's important for everything on our planet. This is a growing realization that the ocean and the planet as a whole are very tightly meshed.

**KENNETH COALE, Ph.D., Moss Landing Marine Laboratories, CSU:**
As much as we think we know about the oceans, there's still a lot more we don't know about the ocean. It's up to us to teach our students to have an imagination so that they can push back the frontiers of marine science everywhere. That's the nice thing about science, is it's always evolving. And it's always evolving because we're always wrong about something.

**MATSUMOTO:**
Most students are taught that the oceans cover 70% of the earth's surface, but that's really just in terms of area—flat surface area. Biologists really like to think about the oceans in terms of living space—available living space. If you think about the oceans in terms of a three-dimensional living habitat that ranges down to 11,000 meters deep in the deepest portion, the oceans represent almost 99% of the available living space on earth. So to think about the fact that we spend so little time exploring or trying to find out about the ocean, is just unimaginable.

The truth is, we have explored a few percent of the ocean floor and even less of the ocean water above that floor. So we really don't know exactly, it's very much a work in progress, our exploration of the oceans.

**NARRATOR:**
IN ALL LIKELIHOOD, IT WILL PROBABLY FOREVER BE A WORK IN PROGRESS—AN ODYSSEY OF DISCOVERY IN WHICH THERE IS ALWAYS SOMETHING MORE TO LEARN, ANOTHER OBSTACLE TO OVERCOME, ANOTHER FRONTIER TO CROSS. AND WHILE THE JOURNEY MAY AT TIMES BE FRAUGHT WITH FRUSTRATION, ULTIMATELY THE BURNING NEED TO UNDERSTAND OUR WORLD WILL NO DOUBT PROVIDE ALL NECESSARY INSPIRATION AS WE CONTINUE ON THE ENDLESS VOYAGE.