The Museum of Flight Oral History Collection
The Museum of Flight
Seattle, Washington

Vince Capone

Interviewed by: Geoff Nunn

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Abstract:

Hydrographer and sonar search specialist Vincent "Vince" Capone, Jr. is interviewed about his career in ocean exploration and artifact recovery. The interview focuses in particular on Capone's involvement in spacecraft recovery efforts. He discusses his experiences with the 2013 search-and-recovery mission of the Apollo 11 F-1 engines, funded by Bezos Expeditions, and also touches on his involvement with the search for the Space Shuttle *Columbia*'s black box. Topics discussed include his personal and educational background, the logistics of sonar and ROV technology, details about the F-1 recovery mission, and the challenges of search-and-recovery operations.

Biography:

Vincent "Vince" Capone, Jr. is a hydrographer and sonar search specialist who has participated in the recovery of multiple artifacts, including air and spacecraft. He was born to Vincent J. Capone, Sr. and his wife in Camden, New Jersey in 1959. He first became interested in undersea exploration in grade school and learned to scuba dive in high school. In 1982, Capone graduated from Fairleigh Dickinson University with a bachelor's degree in marine biology. His studies included a semester of Coral Reef Ecology at the school's former West Indies Laboratory in the U.S. Virgin Islands. During college, he also worked for RCA, which further cultivated his interest in electronics. In 1986, Capone received a master's degree in marine science and experimental statistics from Louisiana State University.

An expert in side-scan sonar search operations and sonar image analysis, Capone has participated in several specialized underwater search-and-recovery operations around the world. In 1990, he participated in the discovery of an eighteenth-century warship in Lake George, New York. In 2003, he assisted with debris search operations for the Space Shuttle *Columbia*. In 2013, Capone served as the operations manager for the search-and-recovery mission of the Apollo F-1 engines, funded by Bezos Expeditions.

During his professional career, Capone has worked for Kaselaan & D'Angelo Associates (Haddon Heights, New Jersey), Oceaneering (Falls Church, Virginia), and Enviroscan, Inc. (Lancaster, Pennsylvania). He also founded Marine Search & Survey in 1990. Since 2008, Capone has worked for Black Laser Learning, a maritime technology training company in Hockessin, Delaware. His clients have included the U.S., Australian, and Singapore Navies, the U.S. Army Corps of Engineers, and the U.S. Environmental Protection Agency.

Biographical information derived from interview, the Black Laser Learning, Inc. webpage (https://blacklaserlearning.com/), and additional information provided by interviewee.

Black Laser Learning, Inc. "Black Laser Learning." Accessed September 9, 2019.

https://blacklaserlearning.com/.

Interviewer:

Geoff Nunn is the Adjunct Curator for Space History at The Museum of Flight and also serves as an Exhibit Developer in the Museum's Exhibits Department. He holds a Master's degree in Museology (Museum Studies) from the University of Washington and has extensive experience working as an educator and exhibit developer at science and technology museums. At The Museum of Flight, he serves as the resident historian and curator for spaceflight, leading the Museum's efforts to document the past, present, and future of aerospace.

Restrictions:

Videography:

Videography by Peder Nelson, TMOF Exhibits Developer.

Transcript:

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Index:

Vince Capone

[START OF INTERVIEW]

00:00:00

[*Introduction and interest in undersea exploration*]

GEOFF NUNN: All right. So my name is Geoff Nunn. I am the Adjunct Curator for Space History here at The Museum of Flight. My name is spelled G-E-O-F-F. Last name is spelled N-U-N-N. It is Friday, February 10, 2017. Could you— Vince, could you please tell us your name and spell it?

VINCE CAPONE: Vincent J. Capone. V-I-N-C-E-N-T, C-A-P-O-N-E.

GN: Thank you. So—and you prefer Vince?

VP: Vince, yeah.

GN: Okay. So, Vince, we're going to start with this—this oral history off kind of at the very beginning. Tell us when and where were you born?

VP: I was born in Camden, New Jersey, 1959.

GN: Okay. And did you grow up there or did you move around?

VP: I grew up mostly in southern New Jersey. But then once I got into college, I moved around and lived a number of places, down in the Islands [U.S. Virgin Islands], Virginia, Maryland, Delaware. So I traveled around a bit as I got older.

GN: Got you. And what were your parents' names and what did they do for a living?

VP: My father was Vincent J. Capone Senior. And he worked for the Radio Corporation of America, so he was kind of an electronics guy. And my mother was a nurse.

GN: And any brothers or sisters?

VP: A younger sister, Donna, who now works for ESPN.

GN: Oh, okay. And when did you first become interested in undersea exploration?

VP: Oh, I can remember it perfectly. Second grade, I had to give a presentation on what I wanted to be or do. And I gave a presentation on *The Underwater World of Jacques Cousteau*.

GN: And so you had encountered that on television?

VP: I had seen Jacques Cousteau on TV, Mike Nelson—there were a couple of shows back then—*Diver Dan*. And those all just sort of inspired me to want to explore. So—well, that was second grade. I didn't get my first opportunity to learn to scuba dive until I was in high school. And as soon as I did, I never looked back.

00:02:24

[*First dive*]

GN: Wonderful. And where did you dive when you—on that first dive?

VP: My first dive was in a quarry in Pennsylvania, but I started diving the shipwrecks off New Jersey. It was cold, dark, a lot of current, you know. It is not the gorgeous Caribbean water we see down in the Islands [U.S. Virgin Islands], but I absolutely loved it. And it got me interested in history and shipwrecks, and that kicked off my career in marine science.

GN: And were you diving wetsuit? Dry suit?

VP: Wetsuit. But later on, as we did more shipwreck diving, I finally bought a dry suit. And that was actually a result of—we discovered America's oldest intact warship, and it was in a lake—in Lake George. And the bottom water temperatures never got warmer than 40 degrees. So after one dive in a wetsuit, I said, "Got to get a dry suit."

00:03:46

[*Connection to aviation*]

GN: Okay. And how about—you know, some folks might find it interesting that there's an oral history with an underwater guy here at The Museum of Flight. How does aviation factor into your interests?

VP: I think that aviators and mariners are—travel similar paths. It's exploration. It's adventure. One of your Seattle authors, Richard Bach, always said that aviators have freedom in space, while mariners have freedom in time. And you know, the want—the sort of drive to challenge yourself, whether it's in the skies or on the water, those are very similar paths. They're both technology-oriented. They both require somebody who really has a sense for adventure. And I always looked at my interest in aviation as advocational [avocational], while my profession was in the marine realm.

00:04:59

[*Education*]

GN: Okay, wonderful. So let's talk about—a little bit about how you got to that profession in the marine realm. Where did you go to school?

VP: I did an undergraduate degree in marine biology at Fairleigh Dickinson University. And as part of that degree, I spent six months at the West Indies Laboratory in Saint Croix.

GN: And can you tell us a bit about the West Indies Laboratory and the kind of work that happened down there?

VP: That was generally tropical ecology work. It was, for a diver, paradise. We were diving every day and studying the ecology of the reefs around the island. I had yet to be introduced into marine technology, but that was coming.

GN: And it was run by Fairleigh Dickinson? What was the connection between—

VP: Fairleigh Dickinson ran the laboratory. It's sadly no longer in existence.

GN: Yeah, I was reading, it was—it got damaged in, I think, Hurricane Hugo. Is that correct?

VP: Yes.

00:06:04

[*Transition to sonar expert*]

GN: Okay. And so you mentioned that your bachelor degree is in marine biology. How did your focus transition to becoming a sonar expert?

VP: There was a—an additional degree in marine science at Louisiana State University, where I was first introduced by some of the graduate students to some marine technologies. But it really didn't take hold until I was working at an engineering firm called Kaselaan & D'Angelo, where the owner had decided to branch out into the marine field. And very quickly, we realized that the biological aspects of business were very limited. But because I had grown up with a father who worked for RCA and I worked for RCA with mobile radios and things of that nature, I knew electronics. I also knew the underwater world. And together, we decided to purchase one of the first remotely-operated vehicles and basically developed a business model of using that vehicle to do inspections. And so that was my first foray into the technology.

Using that vehicle, I was on a job where there was a sonar operator. And his job was to find things. My job was to put the robot down and look at them. And when I saw the sonar operate, I said, "I can see more bottom with that sonar and that resolution in a week than I could a full year of diving." So I said, "I have to learn to do this." And eventually, my expertise expanded from just ROVs into the sonar aspect and search and, eventually, have gone on to find aircraft and shipwrecks and rocket parts underwater.

GN: And so—you mentioned that the company that you were working for purchased an ROV. Do you know what model that was?

VP: It was serial number 007 of the Mini Rover Mark II, manufactured by a company, Deep Sea Systems, which was run by Chris Nicholson.

GN: Okay. And stepping back just a little bit, you mentioned that you worked for RKO or for—

VP: RCA.

GN: RCA, sorry. For RCA briefly.

VP: I did.

GN: Can you talk a little bit about about when that was and—

VP: So I put myself through college by, during the summers, installing mobile radios in police cars and public utility vehicles for RCA.

GN: Huh. Fascinating. And was that through connections from your father?

VP: Yes.

00:09:10

[*Plans after graduation*]

GN: Okay. And so when you graduated—and we've already talked a little bit about this—what was your ultimate, you know—what was your career focus? What were you hoping to do after you graduated with a marine sciences degree?

VP: The goal was to build a business in the marine field with a partner, this Kaselaan & D'Angelo company. That didn't work out. It was—even though we had one of the first ROVs, we were ahead of our time. So it was not being adopted by the underwater engineering community at that time. What I did was, I left them and then I went to work for Oceaneering. And Oceaneering was doing underwater search and salvage work for the U.S. government—the Supervisor of Salvage of the Navy. And as an employee for Oceaneering, we contracted to the Navy and went out and found lost aircraft and, once they were located, recovered those aircraft.

00:10:20

[*Undersea searches*]

GN: Okay. And you've been involved with a number of undersea searches for air and spacecraft. And are there any differences to the experience when searching for an aircraft or a spacecraft than when searching for something like a shipwreck?

VP: There are. Aircraft are either very, very easy—it looks like a plane on the bottom—or it's a debris field. And it takes a skilled operator to recognize the debris superimposed over what could be a cluttered bottom and pull out that debris field.

GN: And can you describe at all what's some of the things that you look for when you are trying to tease out aircraft debris from things like rocks and logs and the like?

VP: It is basically looking for what does not fit the environment. And you—as you start to survey an area, you get a feel for what the bottom looks like. And then there can be some very subtle differences that tell you, "I'm in the debris field."

For example, in the 2000s, I was tasked with finding an F-16, which crashed off a beach in New Jersey. It crashed Labor Day weekend, and it was witnessed by hundreds of people. And everybody said it just crashed right outside the breakers, just go out and find it. And I was subcontracted down. I said, "Does anybody have the radar data?" "Oh, we don't need the radar data. We have hundreds of witnesses." So we search for two days in that area and couldn't find it. And they finally went and looked at the radar data, and it was actually almost two miles off the beach. And we moved out there. And looking at the bottom, it was not a simple bottom. There were sand waves and different bottom types. There was an area where you would just see some small pieces of reflected material that didn't fit the natural bottom. And I said, "We're on the wreck." And they said, "No, you're not." And I said, "I'll bet you a case of scotch whiskey." And they sent the diver down, and he came up with a piece of the landing gear.

So it's very subtle in some of those debris fields. And there are people that are much better at it than us—much better at it than I am. Like Phoenix International, who worked on the MH370 search and has done many underwater aircraft searchers. Or Williamson Associates, who did the actual sonar work for the recovery of the F-1 rocket motor. It takes experienced operators to locate that debris, which is why MH370 is a very challenging search. It's a difficult bottom, and you need experience to be able to pick that signature of a broken-up aircraft out of that difficult bottom.

GN: And what depths—speaking of MH370, what depths are they working at on that search?

VP: If I remember correctly, somewhere on the order of 4,400 meters to 4,600 meters and maybe deeper.

GN: Yeah.

VP: Because you were right on the edge of the capabilities of some of the robots that they were using. So it—a difficult search.

00:14:13

[*Search for the Space Shuttle* Columbia]

GN: Absolutely. And let's talk a little bit about one specific search that you were involved with. In 2004, you assisted with the search operations for the Space Shuttle *Columbia*. Now, what was your role in that search?

VP: So the Space Shuttle *Columbia* spread a debris field from the State of California all the way to the border of Louisiana. And that debris field crossed two Texas reservoirs. And one of the most important pieces that NASA was looking for was essentially the black box of the Space Shuttle. It had the data from the last moments of her existence. So I was part of the team that was searching in these two reservoirs for that black box. And initially, I was part of the search team, where we would go out and tow sonars looking for the object. We would then come back to the base camp, hand that data over to analysts who would go through the data, and then pick out targets and hand that off to divers who would then go and dive those targets.

After the first couple of weeks, I was transferred from the search team to the analyst team and was part of the team—you know, we would work overnight so that the teams had targets to go for the next morning. And they would go out and look at the targets. And we went through just hours and hours of data. The black box was eventually found on land. But it was an extremely difficult search because the reservoir was 50 feet of water and 45 feet of trees. They had not cut all the trees down in the reservoir. So extremely difficult, black water, very difficult on the divers.

GN: So what does having, essentially, a forest across the bottom—what does that do to side-scan sonar or even trying to tow an array through that?

VP: Well, you can't tow through the trees—

GN: Right.

VP: …so you have to tow above the trees. And because your distance above the bottom is much higher, you don't get quite the resolution. But the real problem was there were a lot of trees and stumps and objects down there that were not related to the shuttle. So how do you pick out what is related to the shuttle and what is natural? And that was very, very difficult. We had very little success. And the divers were extremely frustrated.

GN: Yeah, I bet. And how long was the search—how long did the search of those reservoirs last?

VP: A good eight weeks.

GN: Wow.

VP: So we were there for a long time.

GN: And you mentioned that it was, you know—the black box was eventually found on land. Was there any debris from *Columbia* found in those reservoirs?

VP: We found a lot of tiles floating on the surface of the reservoir. That was kind of interesting, that the heatshield tiles were so light, they literally floated. And we found those on the surface. As to actual debris, those divers dove hundreds and hundreds of targets, and we may have found one piece or two. I—you know, but nothing of any significance was found.

00:18:03

[*Search and recovery of the Apollo F-1 engines*]

GN: Got you. So let's transition to one of the other big space-related projects that you've been involved with, which is of direct importance to the Museum here. You were involved with the search and recovery of the Apollo F-1 engines that were brought up by—from the Atlantic by Bezos Expeditions. What was your role in that project?

VP: Technically, I was the operations manager. So I basically saw—oversaw the physical operations that were going on. We had Williamson & Associates, who actually did the sonar work. They presented that data to us, and then I basically reanalyzed what they gave us, developed a search hypothesis based on the data that we collected, and then literally supervised the night shift of recovery operations with the ROVs.

GN: Okay. And when were you first approached about the project?

VP: I don't remember.

GN: Okay.

VP: So it was long before the search even started. So I was approached by David Concannon to sort of be a technical assistant to his legal knowledge. He had, you know, some knowledge of the underwater world. He had to find different technologies to locate this debris. And my first job was to assist him with, okay, what technology, how do we want to use it, who do we want to use, what kind of ship? And so I was part of that decision process.

GN: Okay. And so let's talk a little bit about that selection process. How did that proceed and—let's start with the search expedition. You know, how did you go about putting together the search expedition? What did you look for?

VP: The first thing we had to do was determine what is the basic search area. So we sifted through all the NASA data. And NASA did not track the first stage down to its impact on the water. So that first stage separates at about 40 miles up, and it keeps going up to over 60 miles. And then it falls back to the ocean. Well, they had estimated the impact sites, so we had to take those estimates and develop a search area around the estimates. And the total search area turned out to be about 180-square miles, which is fairly large. Not as large as MH370 but fairly large. So we—once we had the search area and we had an approximate depth, we went to contractors and said, "Okay, can you do this? Can you do it within our timeframe? And, you know, tell us about some of the projects you've completed." And from that, Williamson & Associates was selected to do the actual sonar work.

GN: And they're based here in Seattle, correct?

VP: They are based right here in Seattle.

GN: That's wonderful. And what was the stated purpose of this project?

VP: Mr. Bezos, Jeff Bezos had one goal in mind. He wanted to recover the F-1 engines from Apollo 11. The challenge was, there were eight other Apollo first-stage missions in the same general area. How do you figure out where Apollo 11 was?

GN: Absolutely. And so once you had figured out who was going to undertake this challenge, what tools and technology were required in order to locate—to actually locate those engines?

VP: So phase one was to determine the search parameters. We completed that. Phase two was to execute the search. That search needed deep water side-scan sonar. Side-scan sonar creates an acoustic image of the sea floor with enough resolution to be able to pick out the debris. Now, those sonars are only available through a few different companies. Williamson had two on—in their stable. One was a synthetic aperture sonar, which was yet untested but had fantastic resolution. And then they had their standard sonar, which—it was used typically for deep searches. Both of these systems would be towed behind a search vessel on about five miles of cable. So not a simple feat. We selected the *Ocean Stalwart*, which is—was also provided by a company here in Seattle. And that search was planned around using those sonar systems.

GN: And is this the type of search that—you went with a towed sonar, a tow fish. Is this a—could this have been done with a UAV—or an AUV, sorry—sent out to run a search pattern?

VP: So another option is an Autonomous Underwater Vehicle. Those vehicles are very expensive, especially that can operate down over 4,000 meters. So while we were looking at that as an option, there was really only one set of vehicles that were available and those were the ones used to find Air France, which had also crashed in deep water. But when we looked at the cost-effectiveness and the availability of those vehicles, the towed system was actually a better choice. And while AUVs, Autonomous Underwater Vehicles, are more common now, especially after MH370, the towed system was a little less risky and had better availability at a more economical price.

00:25:23

[*Differences in two sonars*]

GN: Got you. And can you talk about—you know, you had these two towed systems. Can you talk a little bit about the synthetic aperture sonar and how it differs and how it works from more standard side-scan sonar?

VP: The synthetic aperture sonar was really cutting edge. And it had never been used on a project at this point—up to this point. The synthetic aperture sonar is really cutting edge, and it had never—this particular synthetic aperture sonar had never been used on a commercial project before. So the first thing that we did was, we tested off of the coast of California. And the reason we wanted the synthetic aperture sonar is, at a range of 1,200 meters, which is very long for a sonar, it had ten-centimeter by ten-centimeter resolution. And we were able to locate a World War II aircraft and its propeller lying separate on the bottom at a 1,200-meter range. That is just phenomenal resolution.

So the synthetic aperture sonar has this incredible resolution that doesn’t degrade with range. Standard side-scan sonars, as you push out in range, the resolution decreases. So after testing the synthetic aperture sonar, we felt that it was ready for commercial operation, and that was our primary search tool. However, like anything else, if you’re going to do a large operation, you want to have the ability, if something goes wrong, to have a backup in place. Capone Rule of Three—always have three ways to accomplish any major part of a marine operation. So we had a backup sonar, in case something went wrong.

GN: And it’s my understanding that there was an issue with the synthetic aperture sonar on the operation. Can you talk a little bit about that?

VP: The synthetic aperture soar performed beautifully. The fiber optics in the cable broke, So the ability to transmit data from the system back to the surface was lost. Now, the secondary sonar did not utilize fiber optics. So we were able to put that sonar on the same cable and make it work.

GN: And what did the—what sort of a connection did the secondary sonar use?

VP: Standard copper wire.

GN: Okay.

VP: So you trans—through the cable, that five-mile cable that you're towing these sonars with, you transmit power and superimpose a data signal over the coax in the cable. So the older sonar, the tried and true, would be able to transmit a signal through that coax over five miles. The newer system, the synthetic aperture, had such a high volume of data—we're talking 30 gigabytes a minute—we needed fiber optics to be able to transmit that kind of data.

GN: Got you.

VP: I'm going to interrupt you one second and check to make sure I got—I wrote that fact down that—[checks notes]—no, it's 30 gigabytes an hour. So I'll restate that. So the older sonar just depended purely on copper coax to transmit the signal and get its power for this tow fish. The synthetic aperture sonar just transmitted so much data that it needed that fiber optic connection. And we're talking about 30 gigabytes an hour of data, which is just huge. And so without the fiber optic connection, we had to switch to the tried and traditional sonar.

00:29:50

[Ocean Stalwart]

GN: Got you. And can you talk a little bit about the vessel that you were on for the search, the *Ocean Stalwart*?

VP: The *Ocean Stalwart* was an old T-AGOS-class Navy ship that was being—was converted to a scientific oceanographic vessel. So she was designed to do operations like this. And it was a good ship for the operation. So—but she needed some work before she could actually go out on this trip, and that work was done in the Baltimore Harbor in Baltimore.

GN: Was it just general maintenance or were there specific upgrades that needed to be made?

VP: Oh, there were specific upgrades. So we were the first operation for this—first—we were the first oceanographic operation for this ship. So there was a rebuilding of the deck, the installation of a big A-frame. So the cable, that five-mile cable goes from a huge winch out over a shive that's supported by an A-frame over the stern. And that A-frame had to be built and fabricated and added to the ship. So all these modifications were being done to the ship before we could go out.

GN: Got you. So not sure if you were—that ship, also built just 30 minutes south of here in Tacoma.

VP: Yes. That's—it all ties back to Seattle.

00:31:29

[*Identifying potential high-value targets*]

GN: Yeah, absolutely. So can you describe what sort of— you know, what you were seeing on the sonar when you were running the search of the target areas and how you identified those potential high-value targets?

VP: So a typical search operation, like the one for F-1, you have a team that is collecting the data. And their job is to make sure that you collect high-quality data and cover the area that you need to cover. That data, once it's recorded, is then passed onto a sonar analyst, who sits and then reviews that data. And basically, whether you're the collection team or the analyst, you're looking at sonar pictures of the bottom that are really no different than satellite imagery. The resolution may not be as good as some of our satellite imagery because we're using the backup system. But on that imagery, you would see bottom features, and there were swales in this area or big furrows. And when we ran across debris, you would see very reflect—patches of reflective material. And then we can measure those patches of material to get an approximate size. But it's—it was not the resolution where we could say, "That's definitely 1.2 meters long," because of the resolution of the older system was better suited to identifying debris—let me rephrase that. The older system was better suited to detecting the debris fields, but identification was more difficult.

What we ended up with was this map of debris fields. It was a huge debris field of nine Saturn first stages. And within that debris field, there were clusters of larger pieces. And so we took those clusters and analyzed those clusters for the relationship to the associated first-stage impact sites. And what we found was the downrange position didn't correlate very well at all, but the across range—or across track error was much smaller. So we thought, "Hmm." Different Apollo missions have slightly different azimuths. And by using the azimuth of the mission, we started to track where those azimuths crossed these bigger debris fields.

We also were able to identify the debris field of Apollo 12 because Apollo 12 burned longer than it should have and its debris field was way downrange further than anything else. And so we said, "Okay, this is where NASA predicted it would land. This is where it ended up. And we know this is 12 because it's so far away from all this other debris." Now, we take that overshoot distance and then come back to other NASA predictions and use the azimuth and the offset distance to come up with the highest probability locations for Apollo 11. And that's how we developed the recovery strategy from the sonar data.

GN: Got you. Fascinating. And you found that—did—ultimately, after you got down and actually started finding identifying marks, did they correspond fairly well with your predictions for azimuth?

VP: It was very difficult to tell because these engines had fallen through three miles of water and had impaled themselves in the bottom, for most cases. To be able to even see a serial number—what we were hoping to do is go to these debris fields, look at the serial number, make a determination of whether we were— you know, our theory was plausible, and then only excavate Apollo 11. Jeff Bezos was very clear. He wanted Apollo 11. When that wasn't feasible, we decided to do a recovery from the highest probability area. And the first engine we pulled up from that area was identified as being from Apollo 12. But we also knew Apollo 12 was supposed to be way out here. And once we were down identifying debris, we realized that these first stages—is that first stage?

GN: [affirmative] Hm-hmm.

VP: Yeah, okay. Once we recovered that first engine, we realized that the first stage broke up midair. So the debris could be a little widely—more widely scattered than we expected. And the first recovery made from the highest probability area was from Apollo 12, which sort of provided a conundrum to us because it shouldn't have been Apollo 12. And from there, we went to other locations and tried to identify engines and did other recoveries but came back to that area. And that's the area that we also recovered an Apollo 11 engine from. So were we correct? Was that first engine we recovered really on Apollo 11? That's a mystery.

GN: All right. So we've kind of shifted over to talking about the recovery operation now. The recovery mission was a separate mission, correct?

VP: Absolutely.

00:38:21

[*Next steps*]

GN: And so, between the search and recovery mission, once the search was complete and you had identified these potential targets, what were the next steps?

VP: Well, the next step was to identify a vessel and contractor which could do a recovery from three miles down. And there aren't that many assets available worldwide to do that kind of recovery. Sure, there are some robots that can pick up a small piece or a fragment or a black box from an aircraft. That's easy. These engines could weigh up to nine tons. We didn't know how intact or broken up they would be. And if they were intact, nine tons from three miles down is a difficult lift. So we had to find a vessel not only with a capability of maintaining position on station but also with a winch capable of lifting that weight, not from 100 feet or 200 feet, but three miles down. The only thing that made that possible was the synthetic cable on the lifting winch. If we had used wire, steel wire with enough tensile strength to make that lift, the winch wouldn't have the capability to lift that nine tons. So by using a synthetic lifting line, combined with this special winch, we found a capability that could lift those weights from that depth of water.

Now, that capability also included two 4,500-meter-capable ROVs. ROV is Remotely Operated Vehicle. Unlike an autonomous vehicle, these vehicles have a cable to the surface, and the pilots sit—and we call them "pilots"—sit in a chair and fly these vehicles across the bottom. I had experience with ROVs for—from my earlier days, both with small ones and larger ones with Oceaneering. And now I was supervising this recovery with these larger ROVs. So we had to position the ship over the debris field and then launch the ROV, and it would take about an hour and a half to an hour and 45 minutes to reach that bottom three miles below. Once on the bottom, there's a certain error to the positioning. We had to use a forward-looking sonar on the ROV to then locate specific debris and map that debris and decide which pieces we wanted to look at. And then later, which pieces do we want to recover.

00:41:29

[*Challenges*]

GN: So you're well out of sight of land. You're way out in the middle of the Atlantic Ocean. You mentioned that the station keeping was a challenge. How did the ship manage to maintain its position over these targets while you were doing these operations?

VP: This ship had been specially designed for deep-water salvage. We had to bring it from Norway. It could keep its position within two meters, three meters at the most, in eight knots of current. It had a series of thrusters and special propulsion units that would hold that ship in position. It was totally computerized. The satellites—the GPS satellites would give us the ship's position within a meter, and then the ship's computer translated that required position into thrusts on all these thrusters. So it was basically holding its position far out of sight of land, with wind and current pushing this 290-foot ship within two or three meters. And then dangling from that ship on a three-mile cable was an ROV that you're trying to get over top of a target.

GN: And what sort of wave heights were you dealing with during the recovery operation? Like, what was a comp—you mentioned eight knots. It could handle eight knots in terms of current? But—

VP: Yes. We weren't seeing current that strong. That was its capability. The wave heights—normally, we could operate in, you know, easily five- to six-foot waves, sometimes up to ten. Sometimes we'd push it up to 12. So the ROV on the cable, if you have 12-foot seas on the surface, would be yanked up and down. So these huge winches with the ROV cable are what we call motion compensated. So this drum, 14, 16 feet in diameter, with the ROV—miles of ROV cable on it, as the ship rose, would spool out cable. And as the ship dropped down, it would spool in cable. And it was just this amazing scream of—[makes sound effect]— just to stand next to that winch while it was doing this. So that allowed us to operate in that, you know, marginal condition of 8- to 12-foot seas.

But it didn't stop there. The seas picked up, and we ended up with some of the worst weather this crew has ever seen. And we had to suspend operations for at least six days, which—everybody was frustrated because we couldn't work. There was nothing we could do. Some of the people were seasick. And until that weather calmed down, we had a lot of unanswered questions.

GN: When in the process did that recovery hold—did that hold happen?

VP: It happened right after we pulled up the Apollo 12 engine from what we thought was going to be the debris field from Apollo 11.

GN: Yeah. I can imagine how that would be incredibly frustrating, given the prime objective of the mission.

VP: You know, without having a definitive plan—we had actually moved to another site. We were looking at different things as the weather had picked up. But we didn't have a solid feel for which engines were where. And that weather delay, you know, allowed us to take a step back and think, "Okay, let's reevaluate our plan. Let's figure out what the best, you know, option was." And I can't tell you why, but I never lost faith that we wouldn't come home with an Apollo 11 motor.

GN: Nice. So with these—you know, you've got this—the *Seabed Worker* that's designed for deep-sea salvage and these ROVs. Like, what are the sort of projects that they're normally on? I mean, they're not spending every mission going out and recovering rocket engines. What—

VP: So they are known for salvaging deep shipwrecks.

GN: Okay.

VP: They have pulled silver bars off of a wreck in 4,500 meters of water off Ireland. It was lost during World War II, loaded with silver. It was torpedoed and sunk. They have recovered other base metals from wrecks. You know, zinc—and I don't know if they did any gold or not. But on the oil and gas side, there was an oil rig collapse, and they were one of the few ships that could go into this debris field and clean up the debris field. Very specialized.

GN: Yeah. And does that go for the—because the ROVs were built in Sacramento. And are these ROVs specific for this sort of salvage work or do they do—or are they designed to do other stuff?

VP: The ROVs are used all through the oil patch.

GN: Okay.

VP: So the ROVs are fairly common. But to combine the ROVs and the ship together is—was unique. These—where it's only five or six years later, but back then, you chartered a ship and the ROVs separately and you put these things together.

GN: Okay.

VP: Swire Seabed was offering a combination. And what that did was it really put all the responsibility onto one company and made for a more unified effort.

GN: Got you.

VP: And it was difficult. I mean, we had ROV breakdowns. We had some winch breakdowns. The environment was challenging.

GN: Yeah.

VP: Think about—[coughing]—excuse me. Fighting a cold here. Two ROVs from the same ship. Separated by maybe 20 meters.

GN: Right.

VP: Do you want me to go meters or feet?

GN: Either way is fine. Typically in our exhibitory, we do feet first, since that's what most of the audience understands. And then, in parentheses, we include meters. So for video stuff, whatever you want to do, so…

VP: Okay. All right. Both launching that close together and then three miles of wire. Not tank—you've got to make sure the ship doesn't spin—

GN: Right, yeah.

VP: The ROVs don't cross.

GN: Yeah.

VP: And then there's a third line, the lifting line over here. So it's a very delicate ballet.

GN: Yeah.

VP: All working in concert.

GN: Yeah.

VP: And when the ship and the ROVs are used to working together, it's a much more successful operation.

GN: Okay. All right. This might be a good way to introduce discussing the challenge. Because that's a fascinating challenge, just—yeah, trying to—

VP: Sure.

GN: …to precisely maneuver stuff down there. And yeah, some of the questions I have coming up are on kind of that specific recovery process, so…

VP: Yeah. And this was challenging for the ROV operators. Because they were more used to working on a single object, not searching large debris fields.

GN: Right.

VP: And I found it—my ROV background was extremely helpful in being able to relate to what they were doing and kind of help move the process along.

GN: Yeah.

VP: So, you know, basically a manager just stays out of the way. But sometimes you have to do a little coaching.

GN: [laughter] Yep.

VP: Because these are very automated ROVs. They—you know, you tell the ROV, "I want to move 20 meters bearing 273 degrees magnetic," and they punch it in and it does it. All the ROV stuff I did was old school—

GN: Yeah.

VP: …hand flew. You had to keep yourself oriented. So when—you know, trying to track the position of an ROV three miles down through different water layers is very difficult. And this is one of the challenges I think is important to bring up. And so when they would lose tracking on an ROV, you have to be old school, in that, by using your forward-looking sonar and where you are in the debris field, remember how to get back to—

GN: Yeah.

VP: …the other spot to pick this up and bring it over to the basket.

GN: Yeah.

VP: So—and there's a whole choreograph of what we do with the basket, so I think that—I didn't look at your questions. But what's really fascinating is, how do you actually get one of those engines out of the sediment—

GN: That's—yeah.

VP: Is it in there?

GN: It's in there, yeah, so—

VP: You know? And into the basket.

GN: Yeah.

VP: And then how do you get the basket to the surface?

GN: Yeah. Did the sediment, like—does it create suction trying to pull those things out of there?

VP: Oh, yeah. It was like extracting a tooth.

GN: Right [laughter].

VP: Because the excavation was very slow. So at some point, you just had to say, "That's enough digging. Let's yank on it and see." [laughter]

GN: And so for tracking the ROVs, is it just an acoustic signal? Is it pinging down from the ship or up from the ROV? What's the—

VP: Yeah, so—

[production talk 00:52:04]

VP: So the ship has a transponder pole, and there is a transducer pinger receiver on the pole. And then a responder on the ROV. And so this will ask it, "Give me your position," and the pinger on the ROV will respond, and it calculates a range and bearing to the ROV.

GN: Okay.

VP: Now, it also—that pinger has also got depth information from the ROV itself, which is fed into the navigation and helps create a better solution as to where you are. So it’s pretty sophisticated. But when you have thermoclines and different water layers—

GN: Yeah.

VP: …that acoustic pulse is bent. And if you’re not directly under the ship, tracking was a little difficult.

GN: Yeah. And going down to 14,000 feet, how many thermoclines are you dealing with? Because like I—you know, I’m familiar with, you know—you’ve got the top layer of water that kind of gets heated a little bit. And you can get one—you can get some of that and sort of—you can get a single one in scuba diving range. But going through these layers of the ocean, how many—

VP: I don’t recall exactly. But it—you know, two or three.

GN: Okay.

VP: So the deep ocean is pretty uniform.

GN: Yeah, right.

VP: Once you get, you know, over 1,000 meters. Or, you know, a couple of thousand feet. So I’ll try and use the feet instead of the meters. And sonar guys, we usually talk in meters.

00:54:06

[Seabed Worker *and recovery process*]

GN: So let’s—we’ve talked a bit about the recovery and are starting to talk a bit about the—or we talked a bit about the search, and we’re starting to talk a bit about the recovery operation. So you are out on this vessel called the *Seabed Worker*. And you’re over the site, and now you have to deploy these ROVs. Can you talk a little bit about the ROVs and how you actually got them down to the target?

VP: So the *Seabed Worker* was designed to handle large ROVs. These ROVs are the size of cars, basically. And the vessel had two of these ROVs that were capable of that deep-water operation. One was deployed through a hole through the center of the ship. We call that a moon pool. And the other was deployed off the side. So that ROV would be lowered through the ship down three miles to the bottom of the ocean. That cable is attached to, first, what we call a tether management system. It’s like a big spool, and it’s weighted. And then the ROV itself breaks way and has a flexible tether to go off and explore the bottom.

We have three miles of cable down to the tether management system for ROV 1. ROV 2 is launched not 50 feet away and has another three miles of cable down and is working off its tether management system. And not 150 feet away is another three-mile-long cable that we use for lifting the baskets and lifting the rocket parts. So this ballet with these long cables in the water had to be choreographed in such a way that you didn't tangle those cables up because it would be very difficult to get them untangled. So there was a very close coordination between the ship's navigation, the ROV navigation, and where these cables were in the water column.

To track the ROVs and the recovery baskets, we had an acoustic beacon on each one of those. So the ship had a transponder, and the transponder would ping the acoustic beacon, and that acoustic beacon would respond. That response would tell us a range and a bearing to that beacon. We also incorporated depth and, by using depth, range, and bearing, derived a position of those underwater assets. All that navigation information was displayed on a navigation station in the operations room. That same display was then also given to the ship's captain. And the ship's captain was told how to orient the ship and where to move the ship when we needed to make an adjustment. So it was a very dynamic situation with these long cables, the ship, and moving ROVs to make sure that they didn't interfere with each other or get tangled.

One of the things that people ask is, "Well, why do you have recovery baskets?" So we didn't know what condition the engines would be in. You can put a sling around large engine parts and maybe lift them up. But to lift them for three miles, the odds of something happening increase exponentially. Maybe it'll slip out of the sling, it could be damaged, pieces can fall off. So we devised a plan where we had—we would lower a recovery basket to the bottom, and then the ROVs would excavate the engine parts. Think about the engines falling through three miles of water. They impale themselves into the soft bottom. We then had to take a dredge mounted on the ROV and excavate around the engine before we could pull it out. And that excavation was extremely tedious. And this is where the environment posed a challenge. If you have too much current, it's hard to hold the ROV in position. If you have no current, as you excavate, clouds of sediment build up and you can't see. So you hope that you've got a little bit of current. And then you worked the up-current side first, so that any sediment was blown down current, and you kept your visibility.

Once we got most of an engine excavated, we had to rig the engine for lift, which required slings. The slings were kept on the recovery basket. We had all sizes and different weight capacity slings wire-tied to the recovery basket. So the ROV would then go over to the recovery basket, pick which sling it wanted, pull it off, bring it back to the engine. The operators, using the manipulator arms would then work the sling around a secure point on the engine and get it so that there was a loop exposed. The other ROV would go back to the recovery basket, release the lifting line, bring it over, snap it into the lift, both ROVs would back off, and then we would take a strain and pop that engine out of the sediment. And it wasn't always easy. There was suction of that sediment. Even our excavations couldn't release everything every time. And so it was kind of like extracting a tooth.

Once the engine was up, we would give the ship directions to maneuver over the basket and then lower the engine parts into the recovery basket. Then the ROV would come over, unhook the sling, and hook it back to the basket, and we would raise those parts up. So it was an extremely delicate ballet, all on three-mile wires, without getting them tangled.

GN: And of course, three miles down, even without the sediment, like, you've got absolutely no light. What was the visibility with the lights from the ROVs?

VP: So we had put special lights on those ROVs for filming purposes. In addition to doing the recovery, we also wanted to capture the effort on film. And we literally installed these high-intensity lights on one of the ROVs that had a special 4K camera mounted on it. The other ROV was primarily the workhorse that did the excavations and such. But these ROVs are used to working in deep water, so the lights are a common—it's called a common fixture on these deep water ROVs. We have multiple cameras, multiple sets of lights, and low-light cameras, so we're used to working in the deep, dark ocean.

GN: And so with those lights, you know, what sort of range would you get, in terms of the area that you could see around?

VP: Maybe ten feet, 15 feet.

GN: Wow.

VP: Sometimes the water clarity, you know, you might push out to 18 or 16, but very short distances. So each ROV was also equipped with a forward-looking sonar. So with that sonar, we could look out a couple of hundred feet and say, "Okay, there's an object over there. We're going to swim to that object and identify it." Once we say, "Well, that is something that is small enough for us to pick up with the ROV," we'd use the manipulators, pick it up, and then turn around and have a position of the basket—but also the scanning sonar looking—and find the basket, drop the smaller pieces in the basket by hand. The engines and the larger pieces, we had to use the lifting winch to pick them up and put them in the baskets.

GN: And those baskets were built specifically for this mission, correct?

VP: We had two types of baskets, some that were built specifically and others that they had used on other recoveries. The hard part is those baskets then had to be recovered onto the ship, right? You think, "Oh, the hard part is done." But the lifting winch only brought the baskets up to about 50 feet or 100 feet. We then had a crane onboard. The crane would drop a hook, and they'd transfer the basket load from the lifting winch to the crane. And then the crane would pick the basket up and try and drop it on deck, which in flat, calm world works great. But sometimes we were working in six-, eight-, ten-foot seas. And the basket would come up out of the water, and the ship would be moving, and the basket would be swinging. And it just amazed me at the skill of these crane operators to be able to delicately drop that recovery basket on the deck of a moving ship. I mean, it was phenomenal to watch. These guys were hugely talented.

GN: And so making that transfer from the lifting winch to the crane, was all that done from the ship or did you have to have divers in the water to do that?

VP: ROVs.

GN: Okay.

VP: Robots did everything. So they did that transfer underwater. They would unhook one and hook it on the other.

GN: And how long would a typical dive, to go down, excavate, recover, and bring a part back up, take?

VP: It would take an hour and 45 minutes to get to the bottom. We would be on the bottom 10, 12, 14, 16, 18 hours, as long as the ROV was functional and we were ready to pull it up. I mean, some pieces—there were a few engine parts that were just sitting on the bottom that required very little effort, so we could throw a sling through it and haul it up. You know, it might take six, eight hours. Nothing happens fast in deep water. But the more impaled engines that were sometimes more intact could take, you know, 24, 36 hours to do a complete recovery, assuming everything went well. You know, occasionally we would have an electrical or mechanical fault on an ROV, and we'd have to bring it back up to the surface. Takes two hours to come back up, repair the vehicle, and then get it back down again. So—and that's not uncommon. When you mix electronics and the deep ocean, things are bound to go wrong. So we had, you know, a full set of spares and capabilities to repair anything on those vehicles onboard the ship.

There was a lot of planning that went into the mission. And you know, I think you have to credit the Bezos Foundation. They're very meticulous, and they made sure that, you know, we had looked at these contingencies. And even with all the contingencies in place, still unexpected things happened. But that's exploration. You can never plan for everything when you're exploring and going into new worlds and pushing the boundaries. So the talent on the ship played a huge role. Not us, but the ROV operators and the crane operators and the ship handlers. It was an orchestra of people, and to try and conduct that orchestra to have it come to a full symphony was a challenge. But you know, in the end, we pulled it off.

GN: And how many people were involved—how many did you have on the recovery ship? What was the total size of the crew?

VP: I think we were somewhere on the order of 50 to 60 people.

GN: And you were mentioning that some of these recovery operations would take 24, 36 hours. And what was the shift structure during the mission?

VP: So typical survey operation is you run a 12-hour shift. So your ROV operators, your—we had a special navigator who manned the navigation station. And, oh, one of our team were always up and operational at all times of the day. I ran primarily the night shift. While I have responsibility for overall operations, you have to wear a lot of hats. There's just not enough—there's not the luxury of having, you know, enough people onboard. So my job was to oversee the operations and recovery but also to run basically the night shift and supervise the night shift. So my day would start after dinner at 6:00, and I would run all night to 6:00 a.m. And then I would have breakfast and then we would have meetings. And then I would catch three to five hours of sleep in the afternoon, and do it all over again. It was probably the most demanding project I had ever been on. And we did this for almost 30 days.

GN: Wow, 30 days onsite, over the targets?

VP: Just about.

GN: Wow. So—

VP: With six days of storm there, too.

01:10:11

[*Recovery of first engine*]

GN: Right, right. So let's step back to that first dive down. What was—when the ROVs first hit bottom, what was the experience going from getting down to the seafloor and then seeing that first engine in person?

VP: Oh, it was phenomenal. I mean, the cheer that went up through the crew—so we have a main operation center with huge plasma TVs that are displaying what the ROVs are seeing. And beside that is the navigation station and a station for the archaeologists and pilots for one of the ROVs. That video is also broadcast throughout the ship. So when that first engine came up, there was just like this cheer that went through the entire ship. Everybody was extremely excited.

But it wasn't quite that simple. It teased us. So we got down to the bottom. The first thing we saw was this little bit of bent metal. Well, we need something a little bigger than that. Where's the engine target? And we were—the ROV was down in one of those deep furrows so its sonar couldn't see out. So we had to come up on top and then scan. And there were pieces hidden in these swales or furrows. So we had to keep going until we finally tracked down our first engine. It was—we had to work for everything that we recovered. You know, you just never give up. Until you have to leave station, we were pushing and always trying to do better, trying to do more.

GN: Fascinating. And so the engines were obviously the target of the recovery. Did you—were there—you know, they were—at least, last NASA saw them, attached to these first stages. What other debris did you see down there? Were there—were they attached still to the stage structure? What was the—you know, the overall impression of what had happened to the engines and the impact of the first stages?

VP: So these F-1 engines generate 1.5 million pounds of thrust each. They lift a 3,000-ton spacecraft, the Saturn V spacecraft, to supersonic speed in about a minute. So that first stage, when it separates, is 40 miles high. It keeps going to over 60 miles high and then falls back to the sea surface. And that transition from 60 miles high down to the sea surface, that first stage is tumbling and coming apart. We didn't fully understand how much it was coming apart until we saw the debris field. And there was very little of large structure left. The engines had all separated from the thrust plate and were scattered. There was one or two large pieces of the first stage in one or two locations, and we did film some of that, but that wasn't our primary goal. It was the engines. But they were broken up and scattered into these clusters of debris. And that cluster of debris turned out to be an engine, the—I'm trying to think of the terms. This is something I didn't—

GN: Heat exchanger or the turbine?

VP: Turned out to be the engine, the heat exchanger, the turbine, and associated pieces in sort of the pile. So it looks like those engines broke off, hit, and then, you know, were scattered as they fell to the bottom. The actual nozzle was gone on most of the engines. We did find two nozzles, one that was relatively intact and—fantastic recovery of that nozzle. Because the nozzle was very delicate. It had come basically apart. So it—a nozzle is made up of these channels of metal—basically square tubing that fuel would flow through to cool the nozzle and then ignite as it exited the nozzle, kind of like an afterburner. Those nozzles were very delicate, and we did find one that was relatively intact.

And there was one ROV operator named Hans, he—[coughing]—Hans was extremely ingenious. He was inventing tools for the robots' hands to recover—make the recovery of some of these pieces. When I said—we got with Hans—"How are we going to recover this delicate nozzle?" And he came up with a method of whereby one of the baskets—we attached a rolled-up net to the side of the basket, and we lowered the basket next to the nozzle debris and unrolled the net next to it and then sort of rolled the remains of the nozzle into the net and brought it—brought the end of the net up. And we were able to recover this very delicate nozzle, which you couldn't have done any other way. So the ingenuity of the operators and crew aboard the vessel was phenomenal.

GN: Was there a machine shop on the ship for coming up with some of these solutions?

VP: So the ship itself is a fully working facility. We had machine shops, electrical shops, hydraulic shops. We had a galley. We had a gym. We had a full photo-editing room, okay. And the ship is eight stories tall. So the photo-editing room was at the lowest level. And if you went from the photo room to the bridge, you went up—[makes sound effect]—eight stories of stairs to talk to the captain about something. And then down three to the ROVs, down two more to the galley, back up to the ROV station and the operation station. I came back in really good shape.

GN: [laughter] Awesome. Okay, so I think we've hit on most of the questions—

[production talk 01:17:51]

GN: Oh, here's one more. How many of the—you identified multiple high-value target areas. How many of those target areas did you ultimately end up visiting with the ROVs?

VP: I don't remember. So I can't answer that.

GN: All right.

01:18:23

[*Final words*]

VP: So let's just try two little statements. Let's see if I could get these out. One for kids and one just about the F-1 project. [checks notes] So here's one for kind of the kids, if there's value—

GN: Yeah, no, absolutely. This kind of falls into the—is there anything else that you would like to say about this project and—

VP: So for younger generations who are looking at this project and others, exploration is a great metaphor for life. Have a vision, have a goal, and go after that goal. But you are going to be faced with some daunting challenges. You must persevere. Nothing comes easy. It's only through hard work and, most importantly, perseverance that you'll find success. Find your passion, find your dream, and go for it.

So then one about the project itself—[clears throat]. The F-1 recovery project embodies the essence of exploration. It's got this sense of history and this just daunting challenge of how do I recover—find and recover this material from three miles in the deep ocean. And it's only through a lot of hard work and perseverance that we were able to succeed. And I'm going to do that one again because I—[coughing]. And I've got to teach on camera next week, too—

GN: Yeah.

VP: …and I'm trying to get rid of this thing. It just won't go away. All right, we'll try that again. So the F-1 search and recovery product—the F-1 search and recovery project embodies the essence of exploration. It's got this sense of history and this unbelievable challenge of how do I find and recover these F-1 engines from three miles in the deep ocean. And it's only through hard work and perseverance that you really can succeed at exploration. And that's what brought us through to actually recover an Apollo 11 rocket motor.

GN: It was good. Good, yeah. I think it's good, yeah.

VP: Let's see if there's any other points that—[checks notes]. Oh, just about the challenges.

GN: Oh, yeah. Were there any particular challenges that we didn't get a chance to touch on in terms of—

VP: Yeah.

GN: If you want me to feed you a question, I can also do that.

01:21:57

[*Re-cap of challenges*]

VP: Nah, I'm good. So working in the deep ocean is really challenging. We talked about the difficulty of maneuvering these robots on three-mile cables. But we—the weather played such a role. We can't operate in really bad weather. But that wasn't the only challenge. You had this challenge of the environment. Tracking those ROVs three miles down through different water layers can sometimes be challenging. So we had—sometimes had difficulty of tracking the ROV. We also had the challenge of visibility. So as you're excavating the engine from the seabed, you would kick up sediment and lose visibility. And in the deep ocean, there's not always a current. That visibility would obscure our ability to work on the engine. Sometimes we'd have to wait for an hour, an hour and a half for the sediment to settle before we could start working again. Now, we mitigated those challenges by trying to work when we had a current, up-current, and allowing that sediment to flow away from us. So there were many challenges.

Anytime that you have electronics in the deep ocean, there's going to be issues. Sometimes we had an electronic or a hydraulic failure in one of the vehicles. It's not uncommon working in the deep ocean and under the pressures and strains that these vehicles go under. But we had the capability onboard to repair those vehicles. And I could tell you that there were several times that the crew worked straight through a double shift to make sure we could get those vehicles back in the water as soon as possible. It's only through that perseverance that we were able to succeed. Not just by us, but every person, every person played a role in overcoming those challenges. And it was a very satisfying success when we learned we had actually succeeded and recovered one of those Apollo 11 rocket motors.

GN: Very cool. Thank you. All right.

01:24:24

[*Favorite aircraft*]

PEDER NELSON: I guess one question that we like doing with the oral history—

GN: Oh, yeah.

PN: …is what is your favorite aircraft and why?

VP: The De Havilland Beaver. I absolutely love that aircraft. The way it sounds, its ruggedness. So I was fortunate enough to do a project looking for an antique Sikorsky plane in a frozen lake of Alaska. And we flew a De Havilland Beaver on skis through the mountain passes and landed on the frozen lake. And that was absolutely one of the highlights of my career. You say, "Why a frozen lake?" Well, these remote lakes—you can't get a boat up there, so how do you conduct a recovery? You use the ice as a platform and cut a hole in the ice and work through the ice. But that De Havilland Beaver was just—that was my favorite aircraft ride.

GN: Nice. Thank you.

01:25:30

[*Apollo 12*]

GN: Apollo 12 is one of the major themes for our exhibit. We've got a lot of material from astronaut Pete Conrad and his widow. And the thrust chamber we received was identified as the number three engine from Apollo 12, so…

VP: Apollo 12 played a critical role in our understanding of the distribution of the debris. Because the first stage of Apollo 12 went further downrange than all these clustered debris fields, we were pretty confident that that was definitely Apollo 12, in terms of a position. So NASA didn't give us splashdown points. They had only calculated where the debris should be. Apollo 12 was separated from the rest of the debris. So we took NASA's estimated splashdown position and the debris field from Apollo 12, which we later confirmed by recovering some material there, and said, "Okay, it is downrange four nautical miles from where NASA thought it was at—but the azimuth was very close to what it should be." Every Apollo mission had a slightly different azimuth. So by combining that information from Apollo 12, we were able to back-calculate where we thought Apollo 11 would be. It verified our azimuth theory, and it told us that these other shots would—were more likely to be further downrange than expected.

So while NASA said Apollo 12 should've landed here, it was actually four miles further on. So every other calculation we estimated was probably, again, further downrange. And that proved to be true. So it sort of fit the debris fields. Although they were still scattered, it gave us some way to analyze the data. It wasn't till we were actually on the bottom recovering pieces that we realized how much these first stages had broken up in scattered pieces. But it gave us a way to look at the clusters and try and figure out, how do we prioritize the recovery? Which debris field do we go to? So without Apollo 12, it would've been very difficult for us to prioritize the other debris fields. So it was critical to how we approached the recovery.

GN: Very cool. All right. I think that's the last question. All right.

PN: Awesome.

GN: All right.

01:28:41

[END OF INTERVIEW]