ORAL HISTORY 2 TRANSCRIPT

ROBERT E. STEVENSON
INTERVIEWED BY CAROL BUTLER
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BUTLER: Today is May 13, 1999. This oral history with Dr. Robert Stevenson is being conducted in the Signal Corporation offices in Houston, Texas, for the Johnson Space Center Oral History Project. Carol Butler is the interviewer, assisted by Sasha Tarrant and Summer Chick Bergen.

Thank you for joining us today.

STEVENSON: I'm happy to be here. I'm happy to be with all of you anytime.

BUTLER: Thank you. We appreciate that. We're happy to be with you, too.

STEVENSON: Good.

BUTLER: I thought today we'd talk about Shuttle.

STEVENSON: Okay.

BUTLER: I guess to start out, talk a little bit about your involvement in training the first class of Shuttle astronauts and how that came about, and what you talked with them about.

STEVENSON: All right. Sure. Well, okay. The first class came about in the middle of 1978, and shortly after they were announced, I got a phone call from Kathy Sullivan [Kathryn D. Sullivan] who I didn't know, but I knew that she was a member of the class. Kathy had just

gotten her Ph.D. in marine geophysics from University of what—Halifax in Nova Scotia, I think it was. She was in California schools before that, but then she went there to get her Ph.D. Her dissertation was on the structure of sea floor ridges and fracture zones in the ocean, North Atlantic Ocean off Nova Scotia.

Well, anyway, Kathy took it upon herself to organize earth—I think they called it earth resources in those days, training in the earth sciences. Since she had gone to sea and figured she was basically an oceanographer, although a marine geophysical oceanographer, she called me. She said, "Who's done the oceanography?" It was John Kaltenbach or Dick [Verl Richard] Wilmarth, who had been the head of the Skylab thing, told her me, or maybe George told her. I don't know.

So I get this call from her. I didn't know Kathy. She wanted to come out to Scripps [Institution of Oceanography at University of California at San Diego], and I said, "Well, fine." She could get a ride to Miramar on a T-38. I said, "Okay, fine. Let me know when you're coming." She said, "We really are not yet in the program," which was going to start in October, and this was like September or so, or maybe August. "So I don't have a lot of money. I'm doing this on my own." I said, "Okay, fine. So you don't have money to rent a room or anything. Yeah, yeah, okay, fine." Since Miramar Naval Air Station was Navy, I knew some guys out there, so I said, "Can you put this lady up in the BOQ [Bachelor Officer's Quarters]?" They said, "Oh, sure," visiting BOQ, they can do that.

So, anyway, Kathy came out. She had a nice suite in the BOQ, an admiral's suite. I went out and got her and brought her to Scripps. We sat down and we chatted, you know, and introduced her to a lot of people around. She's a very personable young lady and very eager, which, in her early days, was kind of part of her problem. She was eager to do science, and she wanted to do her science on the training, but, you know, the astronauts who go up on the training do what their job on the Shuttle is supposed to be. So it may not be doing marine geophysics, it may mean looking at some worms growing or something like that.

So, anyway, we had a good time, got to know Kathy. She came over to the house and got to know my wife, my late wife. She said, "Will you come and lecture to us? We're going to start our training in October." I said, "Sure, fine." Okay. She'd set it up.

So we did. She wanted the Earth science education and training to be fairly intensive. So I came in October and they set up over two weeks I did five weeks of lecturing on oceanography, three days one week and two days—I forget whether it was three and two, or two and three, but anyway, it was five days over ten days' period. They had it set up in the Lunar Planetary Institute. There's a big room there upstairs, where you could have a class. Thirty-five people in the class.

So it was a fairly intensive—well, you can say a lot of things if you're talking. We set it at six hours a day, so we'd have lunch off and that sort of thing, and that I didn't wear out too fast. But you can say a lot in that period of time, so it was a good class, and it was good for me because by the end of the two weeks, I knew most of them by name. Of course, they knew me. They were the people that you know. There was [Margaret] Rhea Seddon and Rick Hauck [Frederick H. Hauck] and Sally [K.] Ride and Judy [Judith A. Resnik] and Onizuka [Ellison S. Onizuka] and all the old guys. Crippen [Robert L. Crippen, class of 1969] was already there, of course. But these were all the people who have flown so much of the Shuttle in the eighties and one of them is still around today. Who's that? Who's the one left from '78? Female. [As of March 1997, Anna L. Fisher, Stephen A. Hawley, Jeffery A. Hoffman, and Shannon W. Lucid, remained active astronauts.]

BUTLER: Bonnie Dunbar?

STEVENSON: No, she came in '80.

BUTLER: Shannon.

STEVENSON: Shannon Lucid, yes. So, anyway, that started it. During those two weeks was when I first met George [W. S.] Abbey. George Abbey was then head of FOD [Flight Operations Directorate], as it's called, and he and Gene Kranz [Eugene F. Kranz] were the leaders of FOD, because in those days the missions operations was in the Flight Operation Division. Later on they split it up.

George was an image that you heard was kind of an enigma, you know. But anyway, during that time, turns out he and Steve [Steven A.] Hawley became very close friends, or very close at that time, and George was a big baseball fan, and Steve Hawley was, so they kind of, I guess—I don't know whether that broke the ice, but they were friendly. So we went out to dinner one night and Steve Hawley was setting up, and George wanted to go out to dinner, and he wanted to go out with some of the new kiddies, but he wanted to have this guy who was talking to him. Took me a while to understand how to deal with George. A lot of people never understand that.

But anyway, it was clear to me after that two-week session, and looking ahead to what at that time was proposed, because at that time the idea was that there were going to be Shuttle flights eventually probably twice a month, but at least once a month until they got enough Shuttles where they could do it more often. Even if they were going to do it once a month, you know, I was used to the idea, well, you had a flight now and a year later you had another flight. So I thought, "I can't handle all this briefing and all of the data that we get back. Somebody's got to help me."

Paul Scully-Power by this time had come to the U.S. …was a [U.S.] citizen, and working with the Navy lab in New London, and his family was there and everything. He had cooperated on the Apollo-Soyuz thing, where the Australians had ships out and airplanes out, and so [did] the New Zealand people. So he was very excited about the possibilities of what

could be done from space. So when I called him and asked if he could help me do this, he said, "When do I start? Tomorrow?" [Laughter]

So it was probably about 1980 when Paul and I began to go there, to come to the Space Center fairly routinely, and also the astronauts were coming to Scripps Institution fairly routinely. Of course, this was the early astronauts, you know, like Joe [H.] Engle and Dick [Richard H.] Truly and Gordon [Charles G.] Fullerton and Jack [R.] Lousma and those guys. The first four flights were two-man test flights, really.

Sally Ride was supporting Joe Engle and Dick Truly's flight, which was STS-2 [Space Transportation System, or Space Shuttle, flight number two]. Sally, she was a physicist, but she also was very interested in [Earth] sciences, so she wanted them to have the best possible Earth observation mission they could possibly have, because STS-2 was also going to carry a synthetic aperture radar. It was a modified radar from Seasat.

Seasat was an oceanographic satellite put up by NASA under the auspices of JPL [Jet Propulsion Laboratory, Pasadena, California] in 1978. Had everything on it. It had the radar, all the microwave stuff, had all the infrared stuff, had all the visual stuff, had radar altimeters, and it was the most completely instrumented satellite to look at the Earth, other than with photography, that had ever been built, or that's ever been built since then. This synthetic aperture radar, although it was an optical radar, when you got the stuff back, you had to digitize it to get good imagery, the imagery was so good that, man, it was really good stuff, you know.

Well, it suddenly had a great power surge internally after it had been up for 100 days, and that was the end of it. Still orbiting, as far as I know, but it's nothing; it's dead. There was a lot of speculation that the military was so concerned about what that radar was showing, that there was some mechanism—there had been a lot of consternation at first by the military, or at least a lot of chat, about the military, from the military, about having that synthetic aperture radar aboard. They didn't want it. They argued very strongly against it. So

the theory was that they had some mechanism. NASA had to agree to them that there was a button they could push to blow it up if it wasn't any good, if they didn't like it. Now, whether that happened or not, I don't know.

The big problem was that the first two months, two and a half months, it was in orbit and it was really a test period, and then they put it in a better orbit so it could cover areas more routinely. So most of the oceanographers didn't get around to beginning to do their work at sea, to take data while the thing went over before the damn thing blew up. Some did, and those who did got some unbelievable stuff. But anyway, so that was gone. They still had their backup synthetic aperture radar, so all they did was modify it a bit and they put it aboard STS-2. It was called SIR-A, Shuttle Imaging Radar-A. I think they've now had three of them up.

So, anyway, Sally was very eager for Joe Engle and Dick Truly to be well versed in Earth observations to back up that radar, but also because she and Kathy and some of the other people in that class were …eager to see this Earth observation program become a very solid program. At that time, in '78, it was the plan that the first Shuttle flight would be 1979. So since Sally was supporting them, she was out to Scripps almost as much as I was. She was out there all the time.

Joe Engle and Dick Truly would fly out to Edwards [Air Force Base in California] to fly the STA [Shuttle Training Aircraft - a modified Grumman *Gulfstream II* jet] Shuttle landing test bed, which was out at Edwards at the time, and that's where they were going to land, and then they'd give me a call and they'd say, "Okay, we're on our way back, but it's late and we're not going to get back all the way. How about if we come into Miramar. [We'll stay] overnight and we'll chat with you tomorrow morning, then we'll go on tomorrow afternoon?" I'd say, fine, you know. So they'd do that, and I'd pick them up at Miramar the next morning. They're down at Scripps in their flight suits with all their patches on, secretaries running around. [Laughter]

Jack Lousma. I don't know if you ever met Jack Lousma, but if there was ever a guy who was physically built to look like a real astronaut, that's Jack Lousma, big broad shoulders and tall and very classic features, a very nice guy. He'd walk down the hall and smile, and the women were swooning.

So, anyway, we began this kind of routine, then, in the early—when Shuttle was delayed until—first flight was in '81. We still continued this routine where Joe Engle and Dick Truly and Jack Lousma and Gordon Fullerton and T.K.—T.K. Mattingly [Thomas K. Mattingly II] didn't know why in the hell he was going to look at the ocean. He was Navy. He was a Navy captain, see. Paul and I would go in and argue with him at great length. But anyway, he was the fourth flight, so he said, "Well, I can wait anyway."

So, anyway, we were doing a lot of preparing. We were writing little manuals for them. Dick Truly thought in order for him to remember these things, because they were still engineering this Shuttle, that he couldn't remember all that, so could we make him a little book to take with him, about the size of their crew activity booklet [CAP], which they didn't have the computers aboard then, so they had these little CAP books, they'd turn the pages. You've seen pictures of them with these things stuck up against the front window, up on the dashboard.

So we were down, before STS-1 went off, we were down—let's see. They went in April of '81, so I guess it had to be in late February, Paul and I were down there, and we were walking down this old Building 4, third floor, and we're walking down the hall one day, and John [W.] Young was coming along. John Young was the big hero. I'd met him, but, you know, he doesn't say much a lot of the times. Once he starts talking, then you just sit and listen. So he was coming along in his flight suit, and he stopped and he says, "What are you guys doing this week?"

We said, "Oh, we're talking to Engle and Jack Lousma."

He says, "Why don't you ever come and brief me?"

Well, we'd love to brief him, but we just thought, gosh, the first flight, they've got so much going on and what they're supposed to be doing with that Shuttle, and there's still a lot of question whether the thing is going to stay together when you get it up there, that we thought, well, we didn't want to bother them. I said, "When do you want to be briefed?"

He said, "Come on down right now. Crip's [Robert L. Crippen] down in the office." They had that corner office there. "Let's go through some stuff." Okay. Of course, we couldn't show any slides in his office, which is all open, so we grabbed a bunch of pictures and came down and started going through this.

The big thing that we had at the time—this is 1981, and you may remember, or at least you've heard that in 1980 was the Tehran Hostage Crisis [Tehran, Iran], so they sent the Navy over there. Beginning in 1980, there were three aircraft carriers, each with a battle group, sitting around the mouth to the entrance of the Gulf of Oman, within carrier-aircraft flight of Tehran continuously. They'd sail over and they'd be there for four months, and then another bunch would come over and relieve them. So there were six-month tour of duties for three carrier groups. Of course, then we had more carriers than we do now.

The oceanography of that area was …poorly known by [the U.S.], and the first battle group hadn't been over there more than two months when I got a call from the oceanographer at Pearl Harbor [Hawaii], at Third Fleet, who I knew, and he said, "Do you have any information about the Arabian Sea in the academic community anywhere?"

So I finally found a guy who was a whale expert, who had a bunch of information on whales. [Laughter] But oceanographically and acoustically there was just very little. So I then went over to Hawaii. "What's the problem? What's the real problem?"

Well, the real problem was that there were six Soviet submarines in the Arabian Sea, and they'd see them transit in and transit out, but once they got to their port, which was at Aden, that was the port they were using, and they went active, they never saw them. They couldn't find them. They knew that there were two attack submarines and two cruise missile

submarines. The cruise missile ones were the ones they were worried about, because in those days they had 200-mile cruise missile, which is as long as they had then. But they could sit somewhere within 200 miles of the battle group, and they didn't know where they were.

So I said, well, the only answer to that is to learn something about the oceanography in detail, and the only thing we could do was the infrared satellite imagery from the NOAA [National Oceanographic and Atmospheric Administration] satellites which had a good infrared scanner so you got water temperatures, and you could scan the water temperatures and see the differences and where the cold water was and where the warm water was. And if there were any patterns to this, well, then you could probably tell where the submarines were operating or at least what the acoustics were in that area.

Unfortunately, at that time the Navy carriers didn't have capability of receiving data from the NOAA satellite, and so we therefore set up a system whereby the Air Force, which could get the information, would download it in Omaha at Offutt Air Force Base, and make a tape, and they'd fly that tape by jet out to Miramar, and we'd go up and get it. We had a satellite facility at Scripps. We'd process the tape. So it would take us about three days for all that to happen by the time we would get the images and be able to evaluate them and get the information by coded message to Hawaii, who would then send it out to the Fleet.

Actually, although we began to do that routinely and would get this information to the Fleet, the people on the carrier, even though there was an oceanographer on the carrier, they didn't know what to do with it. Well, so what? So there's a big cold water plume going here and there's warm water over there. So what does that mean? But anyway, we didn't know that at the time. So here we had a couple of these images. On the infrared image just inside the entrance to the Gulf of Oman was a large spiral eddy, or a large eddy that looked like a corkscrew. We'd never seen this before. We figured if we could see it on the infrared, what it must mean, that there's some surface slicks that show this spiraling motion, and they should reflect in the sun's glitter pattern.

So that's what we're briefing John and Crip to do. They had an orbit coming down there. As a matter of fact, a couple of their orbits came down there. So they were only up a couple of days, two and a half days, something like that. Well, of course, both of them were very excited about that, because they're both Navy guys, you know, so, okay, we're going to help the Navy.

So, anyway, when they did come down, it turned out that they're coming down, upside down, and the way the glitter was, in order to see this thing, John had to look over his shoulder back through his side window…but he did this, and he had a Hasselblad [camera], and he shot continuous string of shots down in the Gulf of Oman. Of course, we were getting imagery from the satellite at the same time.

Of course, indeed, in his photograph in the sun's glitter pattern there was that eddy sitting right on top of where it was from the infrared satellite, just rotating around like this. No, counterclockwise. We thought, well, it's an eddy, it's probably there all the time. There's a big headland coming out in the water. We know the water flows out of the Persian Gulf, out into the Arabian Sea, so the water flows down there and hits that headline and spirals around.

But it was of great interest because, of course, the Soviets had a navy over there, too, then. They didn't have a carrier, but they had a bunch of ships over there. So there was this big—not only was there concern about the Soviet submarines, here were all these Soviet ships. You could have gotten a real fight. Of course, the U.S. Navy had not been in a face-to-face fight since World War II, when they were banging away at the Japanese and the Germans. So here they were, you know. I think they were all excited about maybe they would be, but they still had, "What are we going do to?" because acoustically they weren't hearing anything.

Of course, we soon learned from the satellite imagery that where the battle group was located was in a huge eddy of cold water, and acoustically the colder the water, the slower the

sound transmission becomes, so if you're listening in here and there's somebody out there in the warmer water, you're not going to hear them. They couldn't have chosen a worse place to put the fleet.

Well, anyway, so John and Crip came back, and, you know, that was pretty good stuff. So we were then able to show Joe Engle and Dick Truly that, you know, we can really get some good stuff here… Also they had this imaging radar, SIR-A.

That was a JPL [project], so the JPL troops came in and they had a fairly sizable room in Mission Control, because they were going to… control, via radio on and off button, when that radar was on and when it was off. The crew wasn't going to be permitted to—which irritated me, because I figured, well, I'd get a lot of good stuff if Truly would turn it on when we wanted it on. They didn't. JPL didn't care much about the ocean, but they had agreed that they'd do a couple of legs off of Cape Hatteras [North Carolina] and another leg off in the Arabian Sea, because we had ships over there.

We had notified the Navy that there were going to be these two radar passes off Cape Hatteras and there was going to be a radar pass off the southeastern Arabian peninsula, where we still had a lot of ships. This was still in 1981, November... So the admirals in Washington sent out messages to the fleet to have ships along those flight lines taking data.

Well, the flight was delayed for a few days, two or three days, so that wiped out the ships. They couldn't hang around waiting for the flight. We ended up… with one ship off Arabia, and… one ship come out of Norfolk [Virginia], off Hatteras, both of which turned out to be good.

So, anyway, Paul and I were in this room with the people from JPL, who were not happy that we were there, because we didn't put any money into this and we didn't own any of that, you know, but anyway, we were there and we knew where all the tracks were, if any of the tracks were going to be anyplace where we had ships other than those that had now left. We brought in [CDR Bob Lawson] from the Navy who could communicate with Navy ship

control in Washington, D.C. He sat in an office over in Building 1, so he could call in an instant to determine where ships were.

Well, so then the five-day flight, after the first day they began to have problems. A CPU [central processing unit] problem? They had some problem and they were going to have to cut the flight to two and a half days. All of a sudden, all of these tracks at JPL had marked out were disappearing, and they wanted to get all of the imagery they could. They had eight hours'… of… an optical tape then. They had eight hours' worth of time on their tape, so immediately they turned to us and said, "We can do as much ocean as you want," you know. [Laughter] Well, that's fine. And they did. And we got some good stuff. We got some spiral eddies in places that we hadn't even expected to see. We got this one good leg off Arabia and there, sure enough, you could see our ship. It was a cruiser in there and it was tracking right along the track and taking water temperatures and other stuff. We had a ship that had come out of Norfolk, and it was just off the point of Cape Hatteras in the Gulf Stream.

So that turned out to be pretty useful, although the photography was not, because Dick and Joe were pretty busy with whatever problem they had, and they were going to have to land a lot earlier. It was a little touch and go, whether they were going to—they had to make it into Edwards. Didn't have anything at the Cape then. But anyway, that turned out to be a pretty good mission, and from the point of view that we got stuff that we didn't expect to get, and yet it also gave us the opportunity to show to our people higher up in the Navy, yes, we can get stuff that's interesting, and to the astronauts, that, yes, see what you can do.

So Jack Lousma and Gordon Fullerton went up, and it was T.K. and—I forget who flew with him. Well, anyway, the big thing that happened on STS-3, other than the fact that they had to land at White Sands, was that Jack and Gordo had clear skies over China. China was still an enigma. Still is an enigma. But I mean then it was even worse than it is now. So they just start shooting. One of their pictures was of a large lake, and there wasn't any

habitation, much habitation, but at one part of the lake there was some buildings and a couple of larger buildings. But it wasn't anything of any great moment as far as I could see. Paul and I weren't interested in China, anyway, so we didn't look at it, but it was interesting to see areas that we'd never seen from space, you know. Actually, they got some good shots out on the Gobi Desert, which, when kids, we'd always heard about these expeditions years and years ago, about these guys going across the Gobi Desert on camels or something.

But anyway, well, after STS-3, all of the crews did a lot of traveling and meeting people, you know, making presentations, because it was a big deal. Shuttle was really something else again. Nobody else had that kind of stuff going on. So, anyway, Jack and Gordo were invited to go to China to speak. They spoke in Beijing. I think they gave three talks—Beijing, Shanghai, and I don't know where else. But anyway, the talk in Beijing was to a huge audience, you know, some huge auditorium, probably 1,000 people in there, and a lot of big wheels up on the stage. I think whoever was the premier was there, too, at the time. So they were showing pictures. And the American ambassador was there. A scientist in the American Embassy, they had them all around in those days at the big embassy, was there. So there were people there from the U.S. who could speak both Chinese and English.

So, anyway, they were showing this picture, and they showed this picture of the lake. As a matter of fact, it was such a beautiful picture that they had it enlarged and matted and framed, with their flight patch down here and a flag over here, and then they signed it off to the premier of China. So they were going to give this to him, you know, after their talk.

Well, anyway, you know, everybody was "oohing" and "aahing," you know, as usual, and when they got to this picture, dead silence. Just dead silence. As Jack later said, they thought, "Well, okay, so they're not interested in that," and they kept on going. So when it was all over, of course, there was clapping and, I suppose, some questions. But it was rather subdued, and they didn't know what to think about this. So they turned to the ambassador and said, "We want to give the picture to the premier," and he grabs the picture and he looks

at it and he says, "Is this the same one that you showed on the screen?" I said, "Yes." He said, "I think let's hold this for a while. Do you have another picture for him?" Yes, they had about four pictures of different parts of China.

So when everything calmed down, you know, and they were leaving the stage, they said, "What's the problem here?" "Well, see that little built-up area? That's a secret nuclear facility in China that they didn't know that anybody ever knew about, and you've got a picture of it."

And Gordo said, right there he says—you know Gordon Fullerton, he doesn't have much hair. He said, "I turned so pale, I think." And Paul says, "Was your head pale, too?" He says, "I don't know, but, by God, I didn't know." And Jack Lousma said the same thing. He said, "I wasn't sure we were going to come home."

BUTLER: What an experience.

STEVENSON: Well, this was not advertised at all. Paul and I just heard about it because we knew all the astronauts and we heard some of the rumors. So we picked up on that. Paul went back to New London and he had that picture blown up to the same scale as they had. He had it framed. There's a guy, a Chinese guy, at New London working with underwater acoustics, an American, but of Chinese birth. But he could speak Chinese. So he had him write on the front of it in Chinese and then sign it with some Chinese name in hieroglyphics or whatever, you know. On the back, then, we had translated, pasted on the back, what that said on the front, you know.

Those days, you know, the manner of daily activities and even space flight was a lot looser than it is now, and so if we happened to be in town on Monday morning, then we were welcome to sit in on pilots' meetings that take place every Monday morning, and sometimes we would and sometimes we wouldn't. But anyway, this time we wanted to sit in when we

asked John Young if we could make a presentation to Jack and Gordo, in congratulations, you know. He said, "Sure."

So, anyway, we got up in front after the meeting, and John said, "Everybody stay, because Bob and Paul are going to make a presentation," and he didn't say to whom. So we started in. Paul had this spiel about five minutes long, about the importance of being able to look at the Earth and being able to look at it with a very careful eye, and that we know that Jack and Gordo did such an outstanding job, and that we knew that especially in areas which people had never seen before, that we just simply had to put this together, and we have it autographed, signed by a very important person.

So they then came up, you know, in front of the bunch, and we held up this painting. I thought Gordon was going to faint. Jack says, "Where the hell did you get that?" [Laughter]

So then Paul said, "This is all in Chinese on the front, but on the back what it says is, 'If you damn Yankees ever come over China again—" [Laughter] And everybody just roared.

Gordo was a little concerned. He said, "That's supposed to be a secret."

I said, "Gordon, it's not a secret. You can't keep that a secret. Everybody in here knows about it."

"How did you know about it?"

I said, "How do you think we knew about it?"

So, anyway, it turned out that they then thought, well, that's a good idea. And until he left, this was hanging in Gordo's office, you know, up above his desk. Of course, Jack left earlier than Gordon did.

Well, anyway, that's how it was going along. From the point of view of looking at the ocean, we still were in a very early stage. A lot of things we didn't understand. But along came STS-5, and this was going to have a five-man crew. Bob Overmyer [Robert F.] was the commander, first non-Navy commander, although he's a Marine, so George said, well, he's

kind of Navy. [Laughter] I'm sorry, that's not true. Joe Engle wasn't Navy, but Joe Engle was a hero, you see. Joe flew more hours on the X-15 supersonic than anybody in history, and Joe was just the epitome of a hot fighter jockey, and a competent commander, you know. So he was an obvious person to command a flight.

And let's see. On STS-5, I forget all who was on it, but one of the guys on it was Bill Lenoir [William B.]. I'd known Bill Lenoir since SL-4 [Skylab 4], because he was part of the Earth observation ground team. Dick Wilmarth was in charge, and John Kaltenbach, and then Bill Lenoir was the astronaut representative on the ground team. We selected sites for them—or they did—each day. They'd look at… the infrared satellite imagery around the world, at nighttime, and determine where it was cloudy and where it wasn't cloudy, and where there their orbits would be and where the daylight would be, and all this sort of stuff. Then they'd choose sites. It was a great experiment.

STEVENSON: But anyway, Bill Lenoir had been on that team, so I knew him well. Bill Lenoir was a big Earth ops [Earth observation] guy, so we had a lot of experiments set up for that team. At the time, you see, STS was like in '84, I think, late '84. Is that right? The fourth flight was in—no, no, no. The fourth flight—no, no, it wasn't that late. The fourth flight was in July of '82. Yes, I remember that. Then along came—this had to be in probably late '82, as a matter of fact.

The Tehran thing had been basically resolved, but the Iranians were not happy, and so the Iranians had blown up the Karhg Island and an oil drilling platform in the north end of the Persian Gulf, and the whole Persian Gulf was covered with oil, and it was getting into the desalination plants on the Saudi Arabian side, down in the United Arab Emirates, and they were [all] hacked off about this. So there was still a lot of pressure and a lot of tension about activities in the Persian Gulf area, so one of the areas we were going to look at very actively

was the Persian Gulf, to determine if we could see the distribution of this oil pollution. Did it go out through the Strait of Hormuz in the Arabian Sea? All this sort of stuff.

But a bunch of other things, too. I mean, it was the first opportunity we had for somebody to be aboard where there wasn't much else—well, there wasn't a lot of other things for him to do, other than really do Earth observation, and a guy who had some experience or at least some background interest in it. Plus the crew was a good crew. I can't remember everybody on the crew, but [Vance Brand] was a very good commander and was very eager for all the scientific experiments to go.

So off they go. Bill Lenoir was a real happy chappy, and one of his great pleasures in life was, he grew jalapeño peppers in his back yard. When they were still green, he'd bring them to work and he'd nibble on these things. Yeah. And he thought it was funny as hell when he'd give it to some of the young astronauts who didn't much know what it was, and they'd bite into it the wrong way. So Bill Lenoir took a bag, a paper—see, again, it was a lot easier in those days. I mean, you still couldn't take things up and cancel postage stamps. That kind of went out. But everybody was permitted to take something personal. There wasn't any really close control on what that personal might be. So Bill Lenoir had this paper bag full of fresh jalapeño peppers, which I'm sure he thought he was going to pop them down every now and then, and when they'd have a TV broadcast, he'd be sitting there chewing on a jalapeño pepper.

Well, for most of the flight, Bill Lenoir was indisposed. I don't know whether we really want to say that, but, anyway, it just turned out that there was not the opportunity to visually observe and photograph. All the areas we had in mind almost disappeared. Had it not been for Bob Overmyer, who…[was] also interest in all this stuff, if it hadn't been for him looking out especially over the Persian Gulf and that area, we probably wouldn't have much at all. We got photographs, but it was easier to get them, you know, over land because over the ocean you had to have the sun glitter. It looks great when you look at a photograph. Yes,

yes, my God, how come you can't see that? Well, the point is, you're going over the Earth at 5 miles a second. That's some glitter pattern moving that fast. If there's something pops up in it and you're not ready with a camera, you've got to reach over and grab this camera that's Velcroed to the wall, it's gone. So you really have to be prepared to do that. So the guy aboard who was prepared was Bill Lenoir. Of course, by the time he got to really feeling good was near the end of the flight, and everybody else had eaten all his jalapeño peppers. [Laughter]

So where are we?

BUTLER: I think maybe we're at a good point to take a quick break. [Tape recorder turned off.]

Okay.

STEVENSON: Well, we're now, after five and a half hours of listening to me, we're probably about a third of the way through. But, anyway—no. [Laughter]

But just to reiterate this kind of camaraderie, I guess you'd say, when Dick Truly and those guys flew on STS-8, it was in 1983. It was going to be—although Sally and Rick Hauck and John [M.] Fabian, I think it was, and those guys on STS-7 did have some reasonable good sunlight to look at sun glitter in the Southern Hemisphere, they weren't going to have it as good as Dick Truly. You remember Truly launched at night, I think, and they were going to land—it was going to be the first night landing. One of their unofficial decals, or patches, was, you're looking right straight head on, on the Shuttle, and here's the cockpit windows looking at you, and here are five pairs of eyes wide open like that, looking straight ahead. [Laughter] No, there were four pair looking like that, and one pair of eyes that was over in the commander's side, and his cockpit just half open.

But anyway, those guys are going to have good light in the Southern Hemisphere, and in 1983, yes, that was an international assembly in Hamburg [Germany], and I was there. Paul couldn't get to the assembly, but after the assembly I was going to meet him in London because we were trying to set up some—what was the name of the new Shuttle? One of the new Shuttles was going to be—

BUTLER: *Atlantis* or *Discovery*?

STEVENSON: *Discovery*. Right. See, *Discovery* was a British ship, went to the Antarctic, was Shackleton's ship. The Brits, then, when they built one of their first big oceanographic research vessels after World War II, they named it *Discovery*. And there's now a *Discovery III*. They're beautiful ships. I don't know what they do with it now.

But anyway, so we wanted to get as many artifacts as we could from the ship *Discovery* for the launch, for the crew to carry something in space that had been on the HMS *Discovery*. So we did. We got a telescope that the captain had used…

But also Royal Dalton agreed to remake dishes—the ship *Discovery* had these beautiful Royal Dalton chinaware for the whole ship's company that was designed specifically for the ship, with the ship's crest on it and the British crown on it and all this sort of thing. It was beautiful stuff. There were about three pieces still around. The old *Discovery* is still in the Thames Estuary, in their area where they have a theme park, or whatever they call it. You can go there and look at it.

Paul was there, back in New London, and I was in Hamburg, and Dick Truly and those guys are up in space. Paul and I were going to meet in London and get that stuff going, and also we were doing some programs with the British ASW [antisubmarine warfare] people.

So I got back to the hotel one afternoon, and there was a phone message for me. This was back in '83, and it was a small hotel in Hamburg, and they weren't speaking a lot of English, and my German was about good enough to order a beer and that was it. No, it was better than that. But anyway, so there's a phone message, and the guy finally got it across to me that this phone message had come from Houston.

So I took the message, and it says, "Call," and the number was the number of Capcom [capsule communicator, an astronaut in mission control who spoke directly to the other astronauts during a mission]. I thought, "What is this?" So I called. Of course, by this time, of course, it's nighttime there, so the crew was asleep. Anyway, the Capcom was there. Capcom was Bill Fisher [William F]. Phone rang, he picked it up, and I said, "This is Bob Stevenson."

"Oh, Bob, hi. How are you? Where are you?"

I said, "I'm in Hamburg."

He said, "Oh."

I said, "Who's this?" Those days, didn't have satellite sort of stuff.

He says, "This is Bill Fisher."

I said, "Bill, what's happening?"

He said, "Well, you got a message from the commander."

I said, "You mean from Truly?"

He said, "Yeah."

I said, "What did he say?"

He said, "All right, I'll read it." He says, "Tell those damn oceanographers why aren't they here, that there are eddies, spiral eddies, as far as I can see either side of the flight path, from the western southern part of the Indian Ocean all the way past New Zealand." And he said, "On the first day there was nothing, and now for five days in a row we've seen this

stuff." And that was it. So I immediately called Paul. Of course, it was night-time over in New London.

We'd seen these isolated spirals. Sally and John Fabian had seen these down in the southern Indian Ocean. They were going the other way. So that was a big step, because we thought they were only going to be things that would go counterclockwise, because if they went the opposite way in the Southern Hemisphere, it meant that they were influenced by the Coriolis influence of the rotation of the Earth. In fluid dynamic theory, features that small were not influenced by Coriolis, so if they weren't influenced, therefore they did not conform to the linear theory of dynamics in the ocean. They were non-linear. Of course, then and even now, nobody can solve a non-linear equation. But anyway, so we were kind of excited about that.

But then along comes Truly, and he sees these things for five days in a row, covering 6,000 miles of ocean, and he says, "As far as I can see from either side," and, of course, he had photographs. It was unbelievable when we got them. It was just staggering. So that was a big step. We didn't really know what to do with it, because, well, of course, most of the oceanographers, nearly all the oceanographers who looked at it said, well, it's the wind. The wind is blowing across the sea, and that's turbulence in the lower layers of the atmosphere and it's making those things.

At that time we didn't have any photography or observations that showed anything but the spirals, and we didn't have any that showed any ship wakes going through them. So we had no way of telling them, no, it ain't that, except that both of us being physical oceanographers, we felt that it was ocean dynamics, not the atmosphere.

In those days, people were trying to model the ocean just as they still are trying to model the ocean, and so anything like that wasn't possibly going to fit in their model, because in those days the points in the ocean that they could handle in the model were 1,000 kilometers apart, and then later they could get them down to maybe 500. Now they can get

them down to maybe 10, but, even so, they're not going to handle that kind of stuff. But in those days, to think of that sort of thing, "Forget it, you know. I don't want to hear about it." So, anyway, that was a big step forward, major step forward, in what we then began to think about, well, we'd better do this on a more systematic way. But it was strictly an observation, because Dick Truly was interested, you see.

When he got back, that's when he said, "Look, I don't care what you guys say. You guys have got to fly." George had said earlier that he wanted to fly [us] back in '82, but then the space sickness thing came up and headquarters said, "No, you've got to put some doctors up there." So Norm [Norman E.] Thagard went on 7 and Bill Thornton [William E.] went on 8, and so on. But then Truly said, "No, no, there's too much going on in the ocean, and, sure, we can see it, but we don't really know what to look for. We don't know how." So, anyway, that's kind of how it all started.

Well, of course, I'm not going to stop at every one, but STS-9 was John Young and Brewster [H.] Shaw [Jr.]. They were in a high inclination orbit and they had aboard a European Space Agency [ESA] earth resource package, but their flight was delayed, supposed to go off in August, I think it was, and it finally went off in December. So that earth resource package was useless because it was dark over Europe then, so the Europeans didn't get what they wanted to get. But they came over Russia, and so Captain Young thought—and they'd been told, "No, don't photograph Russia." But John wasn't going to miss that opportunity, so we got not a lot, but we got some photos of Russia, especially in Siberia; weird things, we didn't know what they were at first. Of course, a photograph of Petropavlovsk, which was the big Russian submarine port on the Pacific. That got the Navy pretty interested. Then some interesting stuff in China, too. A picture of an interesting embayment there, Nimrod Bay; a very strange place.

Well, so, okay. What's the next big thing here? Maybe we should stop for a minute and let me—long as I'm saying nice things. But, you know, John is probably can and does

have the greatest sense of humor of any person I've ever met, almost. You weren't around, but when Deke [Donald K.] Slayton retired, after Apollo-Soyuz, and went upstairs somewhere, but retired from the Astronaut Office, they had a giant retirement bash for him out in the Gilruth Center. I mean, that place was packed to the rafters. John Young was the master of ceremonies, and they did this slide show of the history of Deke Slayton's time in NASA. God, it was funny. Even Deke was sitting there laughing, tears were rolling down his eyes, he was laughing so hard.

Well, anyway, when John launched the first time in an STS-1, John and Crip went up. Of course, in those days they had medical monitors on them, because, you know, what's going to happen with this big—? Nobody had ever launched on top of this roman candle. So they had heartbeats and all that sort of stuff coming back. Well, Crip's heart rate went up to about 145, something like that. John's went up to 78, from a norm of about 72…

So when they got back, at their big press conference one of the questions that somebody asked, they asked John, "Were you excited on the launch?"

He said, "Oh, yeah, it was pretty good, you know. Really shook around a bit."

This guy said, "Well, your heart rate didn't go up very high."

He says, "Well, you know, I tried to make it go up, but it just won't go any faster than that." [Laughter] Well, anyway, so John's a cool cat, you know, he really is. He's a great guy.

So they're flying up there in STS-9. They were up for, what, about ten days, eleven days. They're getting ready to come back, and they've got four basic computers for flight computers. They had four of them in those days. I don't know how many they've got now. And they were new. I mean, this was big new stuff, to have flight computers aboard a manned spacecraft, you know, but the fact is that Shuttle was complicated and you weren't going to manhandle that thing down, turn it around, and fire the rockets like the Mercury

guys or the Gemini guys did, or even the Apollo guys. Everything was computerized. So you had four computers and each one was a backup to the main. They're all the same kind.

The flight configuration was that if you lost two computers, you're in trouble, because if you lost another one as you were literally in the reentry pattern, then that one computer might not be sufficient to get you into the landing pattern. I mean, you'd get back down all right, but then you were going to have to fly that thing down from 100,000 feet down to the ground, and you're still doing better than mach 5 when you hit that level.

So they're just about getting ready to go through reentry, and they start punching the number-one computer and it ain't there. So John says, "Well, that's all right. Just go to the next one. It'll be all right." Well, it was gone, too.

Brewster later related that he turned to John and said, "This is not very good. What do we do now?"

And John says, "Well, that's why they pay all the big money." [Laughter] Brewster said he was laughing so damn hard, he forgot to be scared of what was going to happen, you know. So, fortunately, the next two computers both worked and they got back. That was so typical of John.

All right. So where do we go? Okay. We go to—well, I don't know. The next one of any great moment—well, they're all good stuff.

BUTLER: I'm sure there are stories for every one.

STEVENSON: For everybody, yes. But anyway, probably the next one, you know, that was really significant to me was 41G.

My wife had breast cancer. She knew she had breast cancer back in 1977, and she did have the surgery, but after that she just didn't want radiation or chemotherapy. She was going to do it the natural alternative medicine way. So from there through late 1983, it was very

good. She worked very hard at it. You totally change your diet, no meat. She was allergic to wheat. She found out she's allergic to milk and any milk products. No meat of any kind other than seafood. Not shrimp, because that's shellfish. So to get into that mode was very difficult. I did everything she did. I didn't want her to feel that she was imposing on me, and I wanted to be able to help her.

So for all that time it was very good. She worked very hard, and our whole personal lifestyle of how we lived had changed a lot, and yet we had a house, a new house we'd built. She came to several launches. Of course, a lot of the people had been to our house. She knew Sally well, and Kathy, and a lot of the guys who had come to the house. We'd take them out to dinner, and we went to quite a few of the launches. She was a good friend of Bonnie's and so forth and so on.

To her, it was just natural that Paul and I were going to fly sometime, and it was no big problem with her, except she wanted to be damn sure she was there. But when we came back from that meeting in Hamburg in '83, she spent two weeks at a clinic in Germany, a world-renowned cancer clinic, and lots of people have gone, people whose names you'd know. Yul Brenner went there, but he went there too late. She came out of there thinking—and the guy there—I forget his name. Hans Neiper was quite convinced that it was under control, although he did notice a little spot on one of her ribs, but that was easily controlled.

But when she came back, she hurt—her legs, her hips, and all that sort of thing. But we still went to the launch that year, but when she got back, her hips were hurting so badly, she couldn't walk very well. So finally, in January, I said, "Look. You're feeling really lousy. The doctors really didn't know. Why don't you just go to Scripps Clinic and have a complete checkup, let them do the whole bit, CAT [Computerized Axial Tomography] scans and everything, and find out what the hell's going on." And that's when she learned that it had spread first into her neck, bones, and all that stuff, and that didn't look too good.

But anyway, she was pretty well confined to bed. She could get up and still get up and go to the bathroom, but she could no longer climb up the stairs in our house, so we set up a bedroom down in the family room, which was convenient for her. I did all the cooking. I like to cook, anyway.

So we were going through this, and the medicals, they told her if they could just give her a little bit of radiation, they could knock out this stuff in her neck and then she could go back on her non-alternative diet or alternative methods, in which she still had a lot of confidence. So she said, "Okay, fine." That was a horrible time, that radiation. And once they did the radiation, they still found a couple of spots in her ribs. Then they convinced us that, "We just want to give you a little bit of chemotherapy, not the big heavy stuff, but it will just knock that out now that this stuff is gone. Then you'll be all right." And I didn't think she'd do it, but, anyway, we talked about it. It was her decision. She said, "Yes, I think it will be all right." I said, "Okay, fine." It was all downhill from there.

So, anyway, it was in March of '84, and I get a call from Paul, and he said, "George Abbey just called me. He was trying to call you, but he knew that maybe you were off to the hospital," which we had been, and he says, "They're going to make space in 41G. So what he needs to know now, to set up the training, is do you want to go? You're first. George just wanted me to call you and let you know. Why don't you think about it and then let us know."

I said, "I don't have to think about it. I can't go."

And he said, "Really? I'd better tell George. I don't think George likes that. Crippen has not been told which of us is going to go yet, but George says Crip is willing to take either one of us." See, they already had another payload specialist. [Joseph Jean-Pierre] Marc Garneau was already assigned from the Canadian agency.

So I said, "Hey, Paul, I can't leave my wife. I can't do that. And even if she does get better," and I thought—she didn't. "Even so, I can't leave her alone. If you're going to go training, you're going to go training." So I just said, "No, you go. Why not?"

So he called George back, and the next day I got a call from George. He said, "Are you sure?"

I said, "George, I just can't do it."

He said, "I understand that."

I said, "If Paul falls in a hole a week before launch, give me a call. Probably my wife will be better by then and I can go."

So, anyway, it didn't happen that way. It's just as well. She died about a week before launch. The funeral was the day of the launch. The whole crew called me from crew quarters that morning. I think it was the day before. They were going to launch the next morning. The Admiral [Rear Adm. J. B. Mooney, Oceanographer of the Navy] was there with them, and George was there, and everybody was there. It was kind of a difficult time then. The crew sent a beautiful arrangement, all orchids. My God. Kathy chose those.

But, anyway, so off they went. One of my wife's best friends… from San Antonio, was there with me, and another of her friends who lives in Honolulu was there, so we kind of cleaned up the house and they organized her clothes and that sort of thing. We still left them there because another of her friends was going to come over and take care of it. So after a couple of days and I felt like I could get away, well, off I flew then with old friend to San Antonio, where she lived, and then I flew on to Houston.

I guess I was here about the third day into the flight, and I was over in the Astronaut Office. We then had an oceanographer assigned to the office by the Oceanographer of the Navy. His name was Don Mautner [LCDR], was there then. No, it was Ty Aldinger (LCDR) was there, but he was about to leave. Yes, Ty Aldinger was there. I had one of the desks that was empty in the Astronaut Office. There was always an empty desk there. So that's where I'd go. So Ty came down to grab me, and Steve Nagle came to grab me, and they said they're going to talk—they’re going to dump some stuff over in real time at Mission Control, "So let's go over there and see what they've got to say." Okay, fine.

Anyhow, again, those were different days, see. Of course, in those days we had classified and unclassified badges. Maybe they still have them, I don't know. So I had a classified badge and I had a badge that would let me into any building, on the base. So we go over and it's just above Mission Control. Dick Covey was Capcom. The loudspeaker was on. I heard him say, "Yeah, okay, Crip, he's here." I didn't know what that meant. So then they said, "Okay, we're ready to download the TV," or down—or radio transmit. So the TV came on the big screen and there was Paul there with his beard, saying, "I just thought I'd tell you what I'm seeing up here, you know." [Laughter] It was tremendous.

The thing is that he had seen these whole fields of spiral eddies that Truly had seen in 8, and it was one of the things we want to know. Do they really exist other places or was it just a strange event down in the Indian Ocean? He said, "The whole Eastern Mediterranean is full of them, see them off the Gulf Stream," and blah, blah, blah, blah, blah. They only had five minutes in the past. He was going on and on.

So then Kathy came floating by and said, “Hi Bob!” you know. [Laughter] Sally came up feet first, like this. "Wish you were here!" They all dumped and that sort of thing.

So, you know, then they came back and landed. I remember they landed, flying in the STA back to Ellington [Air Force Base, Houston, Texas], and we went out. It was raining to beat hell. The water was about this deep on the ramp. Of course, they had to climb down on the ladder of the STA and walk across the ramp. The families were running out, and I just walked out, you know. Paul's wife was there, of course, and his kids, and all the families were there. So that was a big event. For me that was a major event.

Then, of course, for the next week, the whole crew was debriefing, but so was Paul. So he and I just sat there and he just dumped. He'd taken a tape recorder with him. He'd recorded everything he saw. Plenty of photographs. But then he just sat there and dumped to a tape recorder and to me. You have to do it quickly, because it's amazing how quickly the

people who go in space really forget the feeling and forget things that they saw and did in sequences. The feeling goes in probably about twenty-four hours.

I remember Rick Hauk coming back from whatever mission it was, I think it was the mission they flew with Sally Ride. It was the next day, and usually, even though they're tired and everything, they usually come out to the photo lab the next day to look at their pictures. It's one of the things they all get excited about. Their excuse is that they've got to give a media debriefing and they want to get the best pictures ready for the debriefs. So Rick was there, and I said, "How are you?"

He said, "I'm madder than hell."

I said, "What happened?"

He says, "Well, I don't like it."

I said, "What do you mean, you don't like it?"

"Well," he says, "I woke up in the middle of the night last night in bed, at home, and I had to go to the bathroom, and I tried to push out of that bed, and I kept pushing and I wasn't moving. I couldn't figure out what the hell had happened." Well, you know, up there, you know, if they've got to go anywhere, they just go like that and they go sailing away. "It took me about five minutes to [get] up and figure out that I was at home in bed, and it was so damn hard to get out of bed." [Laughter]

But after a day or so, you see, they lose that feeling. So this is why it was so important that Paul sat and just dump to me. His wife, the next day, flew home with the kids, because they'd been down to the Cape a little before and during the flight. So she was with him for one night, I guess, and the kids, and then he—we had a hotel room. We just sat there half the night, talking.

So that was a big deal, and it was a big deal for oceanography because he had confirmed, or he had determined that some of the things that we thought were just maybe sports of an occasion or just happened occasionally and were not really real things, or didn't

last for any, or there were not many places, were indeed true. They were there. And, of course, he also showed that there were these huge waves coming through the Strait of Gibraltar that we knew were internal waves, but we didn't know they were that big. There were ten kilometers between crest to crest. Well, that means they were not regular internal waves, they were not waves like all other ocean waves and sound waves like this; they had peaks and then they had this long flat bottom, then another peak. The wave heights were under water, but they were about 150 meters. Then you go for ten kilometers and get another one.

Well, that's non-linear. We'd kind of known that. I have a photograph that Vance [D.] Brand took on Apollo-Soyuz, but we'd never seen it again, but here it was in the Strait of Gibraltar. Everybody knew there were internal waves coming in. See, the water in the Strait of Gibraltar, the Mediterranean water is highly saline, more saline than the Atlantic Ocean water, so it's heavier and it goes out through the bottom, on the bottom of the Strait of Gibraltar, and the Atlantic water comes in. So there's a very sharp density break between the top water and the bottom water. When the top water's coming in, it impacts on that bottom water and it makes waves down here on that surface.

BUTLER: The waves.

STEVENSON: Okay, the internal waves coming in through the Strait of Gibraltar. The fact that they were solitons, that is, they were internal waves that had a peak, and there was a long trough in between the peak, was not known. We did not know that before 41G and we got the photos. Since that was one of the prime sites that we were going to look at during Paul's flight, or during that flight, we did have a Navy team over there working on the waters of the Strait of Gibraltar, a team from the Navy Ocean—NORDA, Navy Ocean Research and

Development Activity, or whatever it was. They had ships over there. They had a couple of aircraft helicopters.

They were particularly interested in internal waves, and they even had an old war-weary B-17 over there for photography, that was owned by the French Geodetic Survey when the French were down there to get pictures. So it was a well-covered experiment, but it was not expected that those waves were solitons; non-linear.

The thing is that back in the pre-World War II days, the U.S. oceanographers did not know there were internal waves in the ocean. Of course, physical oceanography in pre-World War II in the U.S. was not nonexistent, but it was very usually done very near shore because we didn't have research vessels, big research vessels. But the Germans had a big research vessel called a *Meteor*. They're probably up to *Meteor IV* by now, I don't know. I don't even know whether they have one now. But I know I sailed on the *Meteor II* once. But they had the *Meteor*, and they had some of these early German oceanographers. They were famous.

After the war, we were able to get some of the papers written by these guys that were published in the late thirties and the forties, that were not available to us before the conflict. So this guy [Albert Defant] had been on the *Meteor* and he'd been making stations off Northwest Africa, off the bulge of Africa in waters off of the continental shelf in waters maybe 1,000 meters deep. They just sat there for about a week at that one station, and they made temperature and salinity and depth casts into the water every hour.

When he put all that data together when he got back, the temperatures showed that there were waves beneath the surface for these longer wave lengths, lengths of maybe one to two kilometers on the surface of that boundary layer between the warm water and the cold water here. So they knew there were internal waves, but we didn't know that. But even if we had, I doubt if anybody would have worried about it.

Then on that particular cruise, it was Albert Defant who was on the cruise, they went on up to the Strait of Gibraltar and made a similar set of stations just inside the Strait, a little

to the east of the port of Gibraltar, which was British. This was in 1938, so there wasn't any conflict going on yet, and the Brits thought they had it under control. But they made this station in there.

Again, we didn't learn until later that they had indeed determined that there were internal waves there. They did not, in their paper, … consider that the waves were indeed solitons. They said they were long wave-length, but they just didn't have enough data to be able to determine that they had such long troughs relative to the crest or that they were really created routinely every day.

See, there's two high tides in the eastern Atlantic every day, and going north and south across the middle of the Strait of Gibraltar, between Gibraltar, which is in towards the Mediterranean, and Algiers, which is out on the Atlantic coast, there's a ridge that goes across the Strait and comes up to about 150 meters from the bottom, whereas on either side it's much deeper. So when the highest of the two high tides, which is once a day there's one high tide higher than the other, punches that water into the Strait, it finally gets enough water there so it breaks over the top of that ridge, and that's when the waves are created that flood like somebody bangs on a piece of water and that wave floods into the Mediterranean. Now, we didn't know that until later, but the Germans knew that.

The British, of course, they had Gibraltar during World War II and wasn't anybody going to get past them and Gibraltar. They didn't want any German submarines coming in there. The Germans didn't have a port, you see, in the Mediterranean. The Russians didn't have any submarines, didn't have to worry about that. So all the British shipping and our fleet in the Mediterranean, which was running around, felt fairly secure until early in 1941, when the first event happened, when a British ship was blown out of the water and they didn't know what had happened. They figured it was a mine, because the Germans were very active flying their long-range patrol aircraft and dropping mines. So they just attributed it to a mine that they hadn't picked up on their sonar or something.

Then later in early '43, a couple more Brit ships got blown up, and by that time the U.S… was in North Africa, so we had some ships in the Mediterranean, too. The Americans got really pretty twitchy about all this. The British had a Corvette, kind of like a destroyer, but a little shorter than a destroyer—Brits were big on Corvettes—that they had stationed off Gibraltar in deep water, that had hydrophones down on some cables beneath the water, so that they figured that if any submarine came through or even tried to come through, they'd hear it.

They weren't hearing any, but, nonetheless, they began to realize that there were some submarines in there. How did they get in there? The British had submarines in there. Well, it wasn't till after the war that we learned what they did. The German oceanographers were brought into the German Navy. A pretty longtime good friend of mine now was an oceanographer and was in the German Navy, beginning in 1938, I think, eventually was shot out of the water from his ship and went in the POW camp.

But anyway, they went to the submarine people and said, "Well, look, when we tell you what's down there, there's this strong density difference. The water up here is much less dense than the water down here, and there are these waves along there. If you could get your submarine down to 100 meters—." And 300 feet, that was pretty deep for a World War II submarine. "If you can then make it neutrally buoyant, just kind of let it sit there, you can then surf in on those waves. Shut off your engines and just cruise on in." They didn't know how far the waves would go in, but the waves may take you by this British hydrophone station and you're home free. So they did that. That's how they got in. We didn't know that. But anyway, we heard that story. There were a lot of American oceanographers who will never believe that story, but it's documented in German literature.

But anyway, so it was a big deal for us to look at that. Number one, we learned that they were solitons. Number two, what Paul was able to document was the fact that when you see the group of waves that have come through today, you also could see the waves that were

farther into the Alborn Sea and the Mediterranean, that were made yesterday. As a matter of fact, with some of the photography he got, you were able to document that you could see at least three days' worth of waves going through that sea.

This is important because that means that those waves, being long and very active, because the water, even though there are not waves going around like this, the water, as the wave goes by, is down here at 150 meters, but when the wave comes, that water's got to go up to the surface. The wave is coming by. Then the water is going back down. Furthermore, if it's a soliton, it's not a regular ocean wave, a regular ocean wave is just a wave that goes up and down. The water just goes up and down around with the wave, but when you get a soliton, it is literally moving through the water, so this whole mass of water is moving at reasonable speeds, 10 knots or something like that in the ocean. That's pretty fast.

So what it meant, therefore, was that whole area of the Alborn Sea was going, past Spain and Morocco down on the south side, was moving, and therefore that was the main dynamic factor. So anything that was happening in that water didn't have anything to do with eddies, didn't have anything to do with the difference in water temperature, was created by those waves going through.

Of course, even back in '83, that was a big deal to both the Russian and U.S. navies, because we both had stuff going through there. So the Navy was very excited about that. Worse than excited. Panicked, some of them. Well, that was a big deal. Plus the fact that Paul had seen spiral eddies in fields.

Then, of course, for the next year, Paul was in such demand by the Navy to brief people. I did a lot of briefing, too, and we finally decided—I briefed the Pacific Fleet and he'd do Washington, D.C., and the Atlantic. But he was Australian, so he had to go down there and shake the hands and drink the beer and all that sort of stuff, which he loved. Paul's a great entrepreneur. He's a great buddy, and he loves to be friendly with people, which some of the lady astronauts didn't like … too much. But anyway, you know, he had a beard. The

only guy to fly with a beard. They told him, "You have to cut the beard off because you can't wear it under your helmet." And he said, "I ain't gonna cut it off and I'll wear it under my helmet." And he did.

BUTLER: Quite a significant mission.

STEVENSON: Yes, it was. It was a big breakthrough from the point of view of Earth observation. I think it was a breakthrough from the point of payload specialists, because they'd had these guys like [Senator Edwin] Jake Garn and the Prince of Saudi Arabia [Al-Saud, Sultan bin Salman bin` Abdulaziz], and later on they had—I guess those guys were after that, actually. I think that was maybe early—he and Mark were maybe the first payload specialists. I think that's right. Then they had a bunch after that, guys who were paid to fly by their companies and then Jake Garn and the Prince. Oh, my. And then finally the [Clarence William] Willie Nelson [Jr.] congressman who was on the Science Committee or Space Committee from Florida. As John Young says, "The one who doesn't sing." Yes, those were—I don't know why they did that. I don't even know why they do that. They did that just a few months ago with this senile senator.

Jake Garn was up with [Margaret] Rhea Sedden, and they had a problem with one of their satellites. They were sitting there, trying to put things together with tongue depressors. Jake Garn was sick, was pretty sick. I don't know whether we should tell stories like that. But anyway, Jake Garn, he has made a mark in the Astronaut Corps because he represents the maximum level of space sickness that anyone can ever attain, and so the mark of being totally sick and totally incompetent is one Garn. Most guys will get maybe to a tenth Garn, if that high. And within the Astronaut Corps, he forever will be remembered by that… The young kids don't know… the origin of a "Garn."

BUTLER: I'm sure somebody explains it to them.

STEVENSON: Yes, I always do. The Prince flew with [Daniel C.] Dan Brandenstein. I forget who else was on that flight. That was a good crew. The main thing, other than the fact that his daddy wanted somebody from Saudi Arabia to fly, what he was going to do was, when they came over Arabia, he'd take pictures. But during the flight, at the appropriate times he demanded that he be permitted to pray to Mecca. So it was the responsibility of the flight deck crew to make sure that he knew at the right times what direction Mecca was from the mid deck down below, so he could point himself in that direction.

When I heard that, before they were going to fly—I forget what mission that was, it was in '85, anyway—I was talking to the crew one day and I said, "You know we can all become millionaires out of this flight, and it would be very simple, won't cost us anything. This guy is going to pray. I don't know how, four times a day, whatever it is. He's going to get on his knees and get his head down on the floor on the mid-deck. Everybody's going to leave him alone for that time, right?" Right.

Now, it's the Prince. He didn't want to get his knee on the metal decking of the mid deck or the grill deck down there. I said, "He's probably got a towel or something like that to kneel on. What we want to do, we want to go down here to Houston to a furniture store, and we want to get one of these imitation Persian rugs, about yea long, long enough so he can kneel on it and pray, with fringes on the end. And we let him kneel on that.

"Now, when he kneels, you know, he's going to be in zero G, so he's probably going to—he can't hold himself down because he couldn't pray properly that way, but he may do it quickly, but, nonetheless, he's going to be up like this. So what you want to do is get that rug, get him on that rug, and take some pictures, enough so that you can see that here he is kneeling on this carpet and he's up away from the surface. Now, when he gets back, we'll take that picture and we'll fix it up so that the background is desert and the trees of Arabia,

but here's the Prince up above on his flying carpet. Real Prince, see." And I said, "Can you imagine how many millions of those things you'd sell?" He thought about it for a while, but Brandenstein finally chickened out. He wouldn't do it.

So, let's see. What else came along? Those were little things that went on. I'm sure that Dan, who's now a vice president of Lockheed, will probably say, "I don't remember that." But Shannon Lucid remembers it and [Steven R.] Steve Nagle remembers it. I don't know about the Frenchman [Patrick Baudry].

BUTLER: How did your role change over time? Did you continue to come in with each new class and do training?

STEVENSON: In those days, there was a class of '78, and then the classes through '85 would just be a few people come in, half a dozen or so, so it wasn't really a class. So what would happen would be, sometime during a month or so after they'd get in, John would tell them, "Paul Scully-Power and Bob are going to talk to you today or tomorrow," or whatever, and it would depend on what we thought we might talk to them, get them for a day and we'd do it in the Gilruth Center, and get them away from the Astronaut Office.

We'd talk to them usually for a day, six hours. We'd get rather detailed with them, technical, because in those days it was important that we be concerned with acoustics. Paul would give them at least an hour of underwater acoustics. It was fairly simple to do. There wasn't any organization that controlled the training of the astronaut class then as there is now.

I can remember whenever it was, when Mike—I think the last class that he and I did that way was when [C. Michael] Mike Foale came in. I forget when that was, in the late eighties, I think it was, when he came in. That was the last class. After that, things began to get under the hands of the bureaucrats. They schedule these classes. The classes, instead of

kind of training by osmosis, they had regular training periods of class. They were training for a year and they were astronaut candidates for a year. Now it's two years. Stuff like that.

So, again, in those days it was still kind of the same. The only difference was that there would be some time during the year when John Young would say, "Hey, you'd better take care of those guys," and so we'd do that. And even after, when reflight was a long one—let's see. Who was head? Dan Brandenstein was head of the office. It still was that way for a while. But then I think what changed really was when George Abbey, of course, was deposed for a while after the Challenger.

I forget the guy's name who was FCOD then, some guy that came from Washington. That was when the bureaucratic stuff began to really start. Even when he was there, there were enough guys like—I think [David C.] Dave Leestma was his deputy, and stuff like that, so there were enough people from the time before that things really didn't change a lot, and the director of NASA-Houston was still hanging on from before. I think it really wasn't until a lot of things changed. [Dr.] Carolyn [Huntoon] came down to be the director, and George came down to back [her] up, and [Daniel S.] Dan Goldin became the administrator. That's when the big changes began. Dan Goldin insisted on control.

BUTLER: Did you work with each crew?

STEVENSON: Oh, yes. Oh, yes. Oh, yes. Oh, yes. After the Soviet Union disappeared [in 1991], it became less intensive because for a while it was difficult to prepare them in a way for observations that had some meaning that they could understand, because there wasn't any big demand by the Navy any longer. So why do you want to look at these things in the ocean? Don't you have enough of them? Well, you know, no. We're still finding things we hadn't seen before. Not a lot, but—

The big thing after—I guess it was after midway in '85, I was first going to fly with Joe Engle and those guys, and then when that satellite broke down and they had to change that flight to go up and get that satellite and [James D. A.] "Ox" van Hoften got out there and held the big satellite, if you remember seeing that. They got it all fixed and he says, "Okay, you bad boy. Go," and pushed it away. [Laughter]

So, you know, about that time, in that period leading up to that, Paul was busy running around doing other things, but I'd see him every now and then and talk to him frequently. We came to the great conclusion that spiral eddies were everywhere, that they simply were not confined to certain areas of the ocean where there were strong currents or where they were spun off from the shoreline, but they were everywhere. The reason we didn't see them everywhere was that there were not enough organic oils, refractants, these monomolecular oils on the sea surface, to permit the streamlines to be reflected back by the sunlight into the camera or into the crew's eyes.

So I began to try to get the crews to look for spiral eddies in areas where in no way would we ever expect to see them. There were no major ocean currents, there were no bumps in the bottom of the ocean, there was no shoreline, no anything. Out here in the middle of the Pacific Ocean away from everything, there aren't any spiral eddies, but what is there? Well, they began to see them, isolated, maybe, but very difficult to see because, as I say, there's not enough biological oils on the surface there. It's pretty biologically barren in a lot of the seas, but, nonetheless, we began to see them.

It became very clear that they're everywhere. They're ephemeral. We began to see areas where there would be spiral eddies, and then the Shuttle would come back on that orbit two or three days later, whatever the orbit was, and there would be spiral eddies there, but not the same spiral eddies. You could never see the same ones. So that meant the field was still there, but these things were moving and changing. Like smoke from a cigarette, you can't follow any puff as you blow it in the air, or pipe or whatever it is, or any kind of motion like

that. You can't continuously follow that for very long, because they keep changing. That doesn't mean that they're not dynamic. They're still there. There are still eddies there.

We then learned that they go down to 100 to 200 or 300 meters. They're rotating. They're rotating at good speeds. They're only rotating cyclonically. That is, they go counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. There have been oceanographers say that can't happen, but, you know, nobody's ever been able to explain why that does happen. This one guy, I was giving a talk somewhere, a guy I'd known for years and years and years, a physical oceanographer from England, he said, "Bob, that's against the law of conservation of vorticity."

I said, "Who the hell ever made that law?" [Laughter]

He said, "I did. It can't happen."

I said, "Yeah, but it does," you know. So we became convinced that they were indeed everywhere, and the forces that were creating them, therefore, had to be everywhere. It wasn't just here along that current boundary or that shoreline, but there had to be something else. So we finally began to realize there had been a lot of Russian research also on these subsurface eddies of a little larger scale, but, nonetheless, subsurface eddies.

So then we decided then it had to be that at the thermocline where the sea temperature in the upper layers it's so well mixed by waves that the temperature is the same going down to a given depth, and then finally that surface turbulence disappears, it can't go any deeper, and so then the temperature begins to decline. So there's, again, a surface there where this density of the water is less than this density down here. That's called the thermocline, or the place where the temperature gradient changes. People have known that for years. This surface layer was where all the navies like to have an acoustic channel, so when nuclear submarines came along and they could below that, that was a big—oh, God. Horrible.

So, anyway, the thing, then, we began to feel what's going on here is that that subsurface layer is probably not flat, because there are these eddies the Soviets had found

down below the surface. So they're going to be rotating, and they rotate one way, the water's going to go down, and the other way it's going to go up. So that subsurface layer is probably like a bunch of hills and valleys. So on top of the hill, the water subsurface is going to flow off the top of the hill, and in the Northern Hemisphere it's going to turn, because of Coriolis, it's going to turn to the right, and if you've got a valley, then that water's going to flood down the valley. So what you're going to have is those subsurface hills and valleys, creating a motion in the upper layer, which is going to spin into eddies. But we couldn't really prove that.

So it wasn't until—actually, it wasn't until the late eighties and early nineties when the French and the Italians and the Germans and the U.S. had a big experiment called physical oceanography of the Eastern Mediterranean, POEM. You know you always have to have a good acronym. They went over and they did, for several years, very detailed examinations of this variation in the depth of the thermocline and what the difference of water, because in the Mediterranean it's a big deal. A lot of evaporation and Jacques Cousteau running around saying the Mediterranean's dead, and yet all the fishermen who live around are catching fish just like they always did. They don't listen to him, anyway, you know.

So it was a big deal to figure out what is really going on in the exchange of water between the eastern Mediterranean and the west, because there's water coming out of the Black Sea, you know, through the Bosporus, and all that stuff. And then there's always these people who say there's so much water coming out of the Nile River that it's creating all this. Of course, the Russians are going to build a dam and there isn't so much water.

So it was really a big deal to find out what is the structure in the eastern Mediterranean, and therefore can you translate that to other ocean areas, like the South China Sea, which is kind of closed, or the Caribbean Sea or the Gulf of Mexico or any sea that's kind of inclined, maybe you can translate what's in the Mediterranean to those seas. As a matter of fact, maybe you can do it to the open ocean. Nobody knew that.

Well, anyway, they did such a great job in determining the surface topography of that thermocline layer, they made beautiful maps, charts, and so they had one that was of the Aegean Sea. Aegean Sea is between Turkey and Greece, north of Crete, you know, and it's up where Rhodes is and all those famous old islands we all want to go see but most of us haven't. I haven't, anyway.

So we had some good photographs from that area. [James F.] Jim Buchli, on 61-A, had taken some fantastic photos of spiral eddies in the Aegean Sea, so I just took that thing and I got the chart from those guys that year, in the fall and winter of 1985, and I just laid the photo over, changed the photo so it was vertical, and laid it over, and that's where they are.

BUTLER: Fascinating.

STEVENSON: Just perfect. Now the thing is, you see, that so therefore it turned out that spiral eddies represent a major dynamic feature in the ocean. Kinetic energy, which is the energy which makes the water rotate, before anybody knew there were many eddies in the ocean, they thought that kinetic energy was all created by the major ocean currents, the Gulf Stream flowing over to Europe and coming back, and the equatorial currents, and over in the Pacific the Kuroshio [Japan] current, and so forth and so on. But when you start putting eddies into that scene, they rotate, too, and if you have enough eddies, then they have got to be accounted for in the budget of kinetic energy.

By 1976, the oceanographers determined that these great huge eddies, which are 100 to 200 kilometers in diameter and go down to about 1,000 meters, there were enough of those in the ocean that they represent the major part of kinetic energy in the world ocean. That turned the whole physical oceanography world upside down. But they didn't know about spiral eddies, so then along come spiral eddies and, you know, first of all, they're nothing, they don't mean anything.

But the more we saw and the more we realized that they were indeed integral parts of the dynamics of the upper ocean, therefore when I saw one of the key oceanographers, I said, "You know, you really have to understand that they represent a significant percentage of the kinetic energy of the “oceans;” spiral eddies. You can't have more than 100 percent. But they're part of this 80 percent or whatever it is of the eddies. So the big eddies are not 80 percent, they're less than that, and these are whatever." Probably [20] or [30] percent.

We finally got to the point where spiral eddies were everywhere. They're ubiquitous. We saw them in the Caspian Sea, saw them in the Salton Sea in California. They're in Bay of South China. You name the sea, they're in it. Not the Aral Sea, it's too small now and too shallow. But if they are, as we had realized, influenced by a coriolis, by the rotation of the Earth, then there's going to be a place in the ocean where there are no spiral eddies because the coriolis influence effect isn't there. That's at the equator.

So the big challenge to the astronauts was, therefore, beginning in the middle of 1985, how close to the equator are spiral eddies? Gary [E.] Payton on 51-C had photographed one about 9 degrees south in the Arabian Sea, and that's the closest we'd seen one.

Well, nobody got any very close, much closer than that, but finally on 61-C, [Robert L.] Hoot Gibson and [Charles F.] Charlie Bolden [Jr.] and [Steven A.] Steve Hawley—who else was on that? Hoot Gibson, Charlie Bolden, Franklin [Chang-Diaz], Steve Hawley, and [George D.] Pinky Nelson, along with Willie Nelson, the one who doesn't sing. [Laughter]

So, anyway, this was Charlie's first flight. He's a nice guy. He's now a three-star general, Marine Corps. Good guy, though. So Charlie—I forget, it was Hoot's third or fourth flight, second or third, anyway, and they told Charlie, "Look. You're not going to get space sick, but when we get to zero G, just don't start moving very quickly very soon."

So they get up there, and they're in zero G. All the crew are there getting their gear off, and Charlie's just sitting there, got his helmet on, just looking straight ahead, you know. Finally he says, "Can I take my helmet off?"

"Yeah, sure. Go ahead, Charlie."

So he takes his helmet off, unscrews it, gets his helmet off. I think Steve Hawley grabbed it from him. But he's still looking straight ahead. He said, "Is it okay if I look out?"

Hoot says, "Oh, yeah, sure. You can look out now."

By this time they're upside down and they've got their cargo bay doors open, all that sort of thing. So Charlie looks out and, as he later told me, he says, "You know, the first damn thing I saw, that whole damn ocean was full of spiral eddies, and I said, 'That goddamn Stevenson, he's right! He's right!'" [Laughter]

But anyway, the deal on that flight was, they were going to find the eddies closest to the equator, but the sun angle wasn't all that great, so it wasn't until near the end of their flight that they had the opportunity to do that. That flight, they couldn't come back [on schedule]. They had some weather problems, so they had an extra day in orbit, but by that time they'd shot all their film. They didn't have anything to do, so they decided, "Okay, we're going to find those eddies, but we don't have anything to photograph, so everybody's just going to draw a chart."

So Charlie and Hoot and Steve and Pinky were going to do this, and they, therefore, had a pool of who found the one closest to the equator, except, as Steve says, "How are we going to prove it?" But, see, by that time they had the Spoc computer aboard, and they could just hit that computer and give them immediate latitude and longitude of their nadir point. But even so, how were they going to document it?

Well, anyway, they came back, and three of them had hand-drawn eddy... They're all trying to convince me that they saw the ones closest to the equator. But the bottom line is that nobody—as far as we know, they do not exist within 6 degrees of the equator. That's the closest we've ever got it. And even ships, Navy ships and research vessels going through equatorial waters, you know, had become interested in this sort of phenomenon, and they have not seen it either. So that's a fairly clear area.

On STS-26, the reflight, [Richard O.] Dick Covey was the pilot. Dick Covey was a classmate of my number-one son at the Air Force Academy, so he was a pretty eager sort. Rick Hauk was the commander, and he was good. He was very eager to do these sort of things. But anyway, Dick Covey was—they were going to have a lot of time over the equator in the Pacific, where the sun angle was perfect, there would be sun glitter, and, by God, he was going to do it. So part of his flight task was to be at the window with a camera in his hand.

STEVENSON: By this time, people got the brainy idea that if they put some Velcro stuff all around, that they could hang cameras all around their windows anyway. So he did that… when he got back, I saw him the next day.

I should break here and stop this tale for a bit and say that I wasn't very comfortable [briefing "reflight" crews]. See, I used to brief the crews down in crew quarters, before they launched, maybe one or two days before they launched. I'd go to the launch and I'd come back here. On 51-L, I was down there, and I knew the crew well, other than Chris [Christa S. McAuliffe] and Gary [Gregory A. Jarvis]. That mission kept slipping day after day after day. So every time I'd be ready to brief them, well, [Michael J.] Mike Smith would come out and say, "We're changing all of our crew activity plan for this," blah, blah, blah. I'd say, "I'll come back tomorrow."

Finally, on Saturday, before they launched on Monday, on Saturday I said, "Are you going to go tomorrow?"

"No, no, no, we're not going to go tomorrow."

I said, "Look. I can't stay around anymore. I've got briefings all next week back at JSC [Lyndon B. Johnson Space Center], so I'm going. You guys know what I want anyway. I've talked to you enough times. It's no problem." So I left, flew back here. It was Super Bowl Sunday. I watched the Super Bowl game on TV.

Next morning I was watching NASA Select. I was over at the Camino Village Apartments... I see all the ice hanging from the tower, and I say, "Well, they ain't going today." So I went in [to the office]. When I got in, I heard that Mike Smith had called his wife, who was down there with the kids, and said, "We're not going today, so don't even bother to come out, because it's cold." It was cold.

So I don't know what time it was, about 9:30 or so, Steve Nagle came by and he says, "Let's go watch."

I said, "Watch what?"

He says, "They're going."

I said, "They're not going."

He said, "Yes, they are. Come on down."

So we went down to the then library of the Astronaut Office, back in the old building. That all bothered me. I mean, you know, over and above the fact that we lost so many good people, good friends.

But the fact that—see, the day before [Virgil I.] Gus Grissom and those guys [Edward H. White II and Roger B. Chaffee] burned up, I had briefed them the day before, you know. They didn't want me to come down for the launch in those days, but they were going to go in to do this sim [simulation] in the capsule, so they said, "Why don't you come down and do a briefing then." So I did. The next day, they were gone. I never briefed another Apollo crew. Didn't want to do that. So it was tough to—I did not go down to the Cape for the STS-26 launch. I just wasn't going to do that. As a matter of fact, I didn't go down for a while.

So when they got back [STS-26]—but I was waiting for them when they got back. Dick Covey's walking down the hall and said, "Come on. Let's go over and look at the film." He says, "I'm really sorry, Bob. That damn tropical ocean was just flat as a board. There was nothing there, not anything. Clouds around, but no eddies, no nothing, no waves, no nothing."

So we go in the photo lab, and Hauk was there and others, and we were looking at film. I'm cranking some film over. We had three viewing tables. I'm looking along, and I'm looking at the equatorial area, and here are these long lines going through the ocean, and there we saw solitons. We later learned that there are suloys. Suloys are chaotic wave lines where two masses of water will come together and the waves are being blown, but the water on one side is going this way and the other side is going that way, and the waves come here at that point. The waves just crash together. You can see little ones out here in Galveston Bay or even in Clear Lake. But in the ocean, they can get pretty big. They can get so big that in the old days sailing vessels couldn't get through them.

We had known that they existed, and we knew they existed in bays where tides would come in and there would be this thing in front. The Soviets call them a suloy. We call them chaotic wave lines. But we called them suloys after we learned what they were doing. So I looked at those things and I said, "What is that?" So I got the list of the nadir points and I saw that that line was right along where the boundary between the equatorial current was going west and the countercurrent was going east. So it was clearly a converging boundary, so that had to be a suloy. So I yelled at Dick, "Come over here and look at this. Here's the tropical Pacific and you were taking these photos."

He said, "Yeah, look at how flat that is. There's just the wind streaks."

I said, "Yeah, but what's that?"

He said, "God, I never saw that." Well, they were all over. It was the first evidence that we had that there were these long converging wave lines showing a convergence in the ocean, that there were these long things in the open ocean.

So then Paul and I began to go back through oceanographic data to see if we could ever find any subsurface information about them, because they're not very wide. You look at the photograph and it looks like some guy had a hoe and dug a trench in the ocean. Well, they're really wider than that. They're maybe 100 meters wide or something like that. But

from space they don't look that wide. So Paul finally found—he said, "I remember this research crew I was on down in the Coral Sea, and we found something like that, but it was at nighttime, and I was not on deck, but the guys took a lot of data, so let me see if I can find the data."

Well, sure enough, what's happened is when those things come together, they actually form a bunch of very tight internal waves that go down to as deep as 500 meters. Well, what a hell of an acoustic discontinuity that's got to be. Then we dredged out some papers from Japan. They call them—what do they call them? Siomes. And they determined that they gave off a hissing sound. Under water, listening to them, it gave off a very high-frequency sound that sounds like bacon frying, hissing.

So when we checked into the frequency, it was exactly the frequency [of] the new, fancy Mark 45 torpedo, that will go 40 or 50 miles, and has its search sonar on its nose, so when it gets going and its fire-by-wire thing, it gets out far enough and you kind of head it towards where you think the other guy is, then it can pick up the noise from the ship or the other submarine and home in on it. But if you're firing through a suloy, it ain't gonna make it, because there's the sound and it's going to explode on contact.

So, you know, suddenly this opened up a whole new can of worms, because these torpedoes were highly classified, you know. I didn't know much about them. Paul did, but I didn't. He said, "By God, that's it," then he went back home to his lab and told these guys all about it, and then this accounted for a lot of premature firings that nobody could explain.

So then the question was, where are they? Where are they in the ocean? Well, you know, once the astronauts saw these things that Dick Covey had photographed, then other guys say, "You know, I saw something like that out in Hawaii," and so we began to get more and more information about suloys. Well, they're not only created in the open ocean, as we knew, but they're in tidal areas, sounds where the tide moves in, and they're between islands. There's a constant suloy between Maui and Lanai in Hawaii. It gets so great, if you've ever

been to Maui, there's the Kaanapali coast, Lanai is down here, you know, you know the famous old song, "I'm going to Maui tomorrow, to marry—" Oh, well, okay. Different generation. [Laughter]

Anyway, Lahaina is here. I don't know if you've ever been there. It's a neat town, a little old sailing village. Then you come up along the coast where all of the hotels are. And then right across is the island of Lanai, which has now become a nice, very expensive sort of resort.

So there's this suloy. I'd seen that thing the few times I had stayed there. I then went back to learn about it, and it turns out that each day it's a tidal thing, and it gets so high that if you're in a sailing vessel, sailboats—a lot of sailboats over there—and you're heading north and that thing's there, you're not going to get through it. So there are certain times every day when the people who live over there, the Hawaiians and, of course, the Haoles [white folk] have gone over there and live, don't sail their boats up there. I mean, they wait until the tide changes, because if they get caught in it, they can't get through, and they've got to either come back or go around Lanai or go around Molokai or something like that.

So, anyway, those kinds of things then begin to pop up all around the ocean. Of course, once the threat of the Soviet Union went away, they still became important, because they then permitted us to be able to determine boundaries of water motion. We knew water motion from the spiral eddies, we knew that kind of motion, but how do we detect where the actual boundary is between equatorial and countercurrents? Or are there boundaries along the edge of the Gulf Stream? Yes, there are, but we didn't know that until we began to see this. So, yes, it was a serendipity sort of thing, because Dick Covey never saw them, but after that, you know, the boys and girls, astronauts, would see them. So, anyway, that was a pretty big deal.

BUTLER: Looking back over your time at NASA, you've brought up so many important points where there was a new discovery or new findings, but as you were going through, what was your biggest challenge throughout the whole time, whether it was scientific oriented or people oriented?

STEVENSON: Our biggest challenge, without question, was to convince the scientific community and, in the case of the Navy, the naval community, that these things that we were seeing were real and should be addressed in a scientific way. The physical oceanographers better find out what the action is that creates these things and so forth and so on, and the Navy better damn well look at them. That was the biggest problem in the early days.

After Paul flew and we briefed a lot of high-level Navy guys in England and we got to know people like [Admiral Sir John] Sandy Woodward, who was the big admiral, went down to Falkland Islands and all that sort of stuff, and the admirals here, and a lot of people who were operational submarine people and aircraft people. Aircraft people were kind of easy to do because they had seen crazy things, but they didn't know what they were. That was the biggest challenge, to convince people that what the astronauts were seeing with their eyeball and what they were photographing with a camera were indeed real, important features in the ocean, and were features that represented dynamics in the ocean that you had to address if you're trying to consider the origin and the changes in the ocean.

Spiral eddies, you know, now that the threat is gone, spiral eddies are really a key to all this stuff that they're trying to do about climate change. See, one of the biggest things in the models that they're doing on changing climates is the influence of the ocean, or the interchange between the ocean and the atmosphere. It's very difficult to model the ocean, and so what they do is that they model a mean ocean temperature and then they forget it, and they may change it as they're running their model year by year by year by year. They have enough capability to change the ocean temperature twice a year, summer and winter, but that's it.

Now here are these spiral eddies, you see. They're at the surface. They're spiraling cyclonically, which means there's cold water in the center. They're not turning because there's cold water there; they're turning because there's some force that's created them. So they're bringing the cold water to the surface. So if you're out there measuring ocean temperature, then if you happen to measure in the middle of a spiral eddy, which you're not going to see from a ship or whatever, then that water is that temperature, but over here it ain't, 15 miles away.

But when you get so many of these things, people say, "They're just 15 kilometers in diameter, or 30. What difference does it make?" Well, you get these whole fields of them covering a major portion of the ocean, and therefore they're a major difference in the temperature of the sea surface and you must account for that. But you can't do it, because, number one, they're ephemeral. The whole field may be there all the time, but they are not there. So what is there for the difference in temperature that they create? And there's no way that these models can possibly address that.

Furthermore, those eddies are bringing water up from 100 meters or 150 meters, whatever it is. That water is much different than it was at the surface, because there are a lot of beasties down there, as John Young—well, I don't say that. But there are a lot of beasties down there which eat up the carbon dioxide, right? So this water in the center of the spiral eddy is lower in carbon dioxide than surface water would normally be, and therefore if there's a field of spiral eddies, which there are all the time, they represent a carbon dioxide sink—that is, carbon dioxide going into the ocean—which has not been, and in their models is not addressed.

So all this mystery about—see, there's a big mystery. They cannot account for the CO_2 that's produced by man—or by women, too, but I mean, you know—they cannot account for where 50 percent of it is. They measure CO_2 in the atmosphere, it's only half. If they take this CO_2 that's up there and man's producing this much, which is going up there,

that amount cannot be found in the atmosphere, so it's got to go somewhere. So this is a big deal, looking for sinks. Recently somebody said, "Oh, the forests in the Northern Hemisphere, [are] grabbing it all up, and people growing orchids in Hawaii," all this. They don't know where it is. Since they've measured the ocean on a broad basis, they say, well, the ocean temperatures, that determines how much CO_2 can be drawn in. But that ain't it, see.

But the spiral eddies are creating a circumstance or a situation which is very difficult to determine, because the eddy that you measure right now is not there probably four hours from now. There's another one there. This whole field is moving around just like smoke in the breeze, smoke rings and all that sort of thing. They exist. There's probably roughly—we figured there are probably 5 million spiral eddies rotating in the world ocean continuously, somewhere, so they represent a major part of the ocean.

So from the point of view, from the Navy, that's bad news. From the guys who are worrying about climate models, it's impossible. Forget it. "I don't even want to talk about it." But the models aren't any good anyway, are not very good anyway, but they cannot ever be anywhere close to being precise until they can account for that continuous change in temperature. It's either going to have thermal energy going up or it's going to have thermal energy going down, and you can't do anything unless you know that.

It's the same with all these gigantic cumulus clouds that are roaring up in the Tropics. There are thousands of them. They're like chimneys. They're like air and water and everything is going up at 40 miles an hour, up into the stratosphere, every day, and then at nighttime, there isn't enough energy and they all collapse. Well, that stuff is going up and down and up and down. How do you account for it? You have to, but they don't.

Everybody's worrying about CFCs [Chlorofluorocarbons] are going up, all this air-conditioning stuff, and you can't have that anymore, that's bad stuff, because it's going up and eating up all the ozone, because the chlorine disassociates from the CFC and it becomes chlorine monoxide. All this sort of stuff. Probably not true. [Besides], they say there's not

enough chlorine going up there from the ocean, because chlorine is hydroscopic, you see. It will grab water, and when it gets up there, the moisture in the cloud or the moisture in the atmosphere will get together and it rains down. It doesn't get to the stratosphere.

But if you look at these towering cumulus in the photographs that these guys take many, many times, you can see there in the stratosphere, the rising air currents are 40 to 50 miles an hour, and that stuff, chlorine, is not going to rain out of those things. More than once, aircraft have been at that altitude, or balloons, to measure what's going on, and even when they're worried about ash from volcanoes in the stratosphere, they get up there with airplanes and they scrape around in the stratosphere, in the lower stratosphere. You can't get up too high. Don't have airplanes to get that high.

They take a lot of stuff, and there's a lot of chlorine up there. There's a lot of dust up there and, interestingly enough, on some flights in the Caribbean, after Mt. Pinatubo [Luzon, Philippine Islands] erupted, they were up there and they were trying to determine how much ash might be up in the lower stratosphere, because Pinatubo created kind of a change in temperature for a while. So they had all these little things in the front of the airplane that were collecting air samples and little screens to filter out the ash. They could get pieces out to a few microns in size.

These meteorologists got back and they looked at this stuff. Gee, what's that in there? There's something in there that they didn't recognize that looked like silica. Well, it was pieces of marine microscopic phytoplankton that had been carried into the stratosphere. So the point is that there's a tremendous amount of energy that's carrying stuff in to the stratosphere that we haven't been accounting for. Then, of course, these things collapse and go down.

So you get the spiral eddies that are creating havoc. Suloys don't create a lot of havoc. Internal waves do in the sense that they are so numerous now, we know internal waves now are in many, many open areas of the ocean, as well as near shore, and, of course, what they're

doing is carrying water up. They come up to the surface, 50 meters or 100 meters high, and they come up and they bring that stuff up. Well, it's kind of like a spiral eddy, except it's in the waves and this stuff is going through the water. Then on top of that you got all this stuff coming out of the ocean, into the huge cumulus clouds, and even some of the climate guys doing models say, "Man, we're never able to take care of clouds."

So a lot of this stuff that looks kind of—well, it's kind of fun stuff. There's spirals down there, and, oh, boy, there's a suloy. On STS-88 up at 240 miles, Jerry [L.] Ross and [James H.] Jim Newman. Jerry Ross claims they wouldn't let Jim have the camera, but I don't think that's right. But anyway, they got pictures of south Australia and the southwest Pacific Ocean that we never had before because it was clear there. They just put the long focal length lens on, and they got a fantastic picture of this tidal suloy going up Prince Consort Sound next to Adelaide. We'd never in the world seen that sort of stuff.

So you keep going on, and the more you understand or the more you feel is that this ocean and the atmosphere is so mixed up and so turbulent and so dynamic, that when you start playing around with a computer model, even though you may run that damn model for what computer-wise is a couple hundred years, you know, it's kind of like fun and games. It's a "what if." The modelers hate to hear that. They don't like to hear me. But it's a "what if" thing. You say, "What if the CO_2 in the atmosphere was twice what it is?" Which it ain't yet, but what if. What's going to happen? So they run it, and it's going to be that much warmer, and [Vice President Albert] Al Gore claps his hands and all that sort of stuff. But the point is, you see, the model does not really take into account what the dynamic ocean and the atmosphere really is. And they can't. I mean, even the big computers are not big enough.

So, what was the biggest challenge? It was getting people to be convinced that this kind of turbulence in the ocean really did exist, does exist.

BUTLER: Quite a challenge, and I think you've really shown how—

STEVENSON: We did it.

BUTLER: —how intricate it all is.

STEVENSON: We did it.

BUTLER: You did it. I think it's a good point to stop here.

STEVENSON: Yes.

[End of Interview]