RICHARD BACKUS ORAL HISTORY

October 21, 29 and November 12, 24, 2003 Interview by Frank Taylor

Tape 2 of 4 tapes

Woods Hole Oceanographic Institution

TAYLOR: [Tests equipment.] 4, 5, 6, 7. We're here at the Archives of the McLean Laboratory of the Woods Hole Oceanographic Institution for our second session on the oral history with Dr. Richard Backus. Before we started to record, Dick mentioned to me. He said, "You know, one of the things I should have said was how the hell I got into oceanography as such." So I think we'll go back to that and then . . . ."

BACKUS: OK, this is less how I got into oceanography, perhaps, than how I didn't get into something else. In any case, we were talking about my parents and about my upbringing the last time. So a year or so before I came to the Woods Hole Oceanographic Institution and was still in the graduate school, still studying ichthyology and related subjects at Cornell University, I came home to the place I grew up in one weekend, and one lunchtime I was sitting in the kitchen having lunch with my mother and father when, as a part of the conversation, but more or less suddenly, it seemed to me, my father said, "Well, it would have been nice if you'd been a lawyer and joined me in the law office and practice law with me." And I thought--I said, maybe--"What! You never, ever, in all the time that I lived with you, which was 18 years of growing up, never once suggested that I become a lawyer and come into the law firm with you." And I realized that that was a generous act on his part. He never twisted my arm to do something that he thought was a good idea. He let me have my head. So, if he'd twisted my arm perhaps I would have become a lawyer and gone into the law office with him, but instead I turned out to be a zoologist and came to work at the Woods Hole Oceanographic Institution.

TAYLOR: But, you know, you had . . . . Thinking back on this oral history myself, you had a number of things that happened to you that were kind of decisive in the direction that you were going to end up going. One of them was the fact that, as hard as it seems to say, in a certain way the Second World War was positive for you, because it allowed you to continue studying on the G.I. Bill, and your generation . . . . That was really important.

BACKUS: The G.I. Bill was a great thing and gave a lot of us a real break. I not only had tuition, living expenses paid towards in a big way by the G.I. Bill, but when I came to Woods Hole, and, after living here for a year or so wanted to buy a house, I got a G.I. mortgage--3 percent. My monthly mortgage bill, when I bought a house on what is now Cricket Lane for just under $15,000, my monthly mortgage bill was $93. [They laugh.]

TAYLOR: Yeah, because one of the things that you're not going to be as an oceanographer, you're not going to get fabulously wealthy, that's for sure.

BACKUS: That's true. Fortunately, I never cared too much about that.

TAYLOR: But you know the other thing that you had going for you, I think, was the fact that you had a very supportive but very active family.

BACKUS: Right.

TAYLOR: There's a lot of academic kinds of thinking that went on in your family background.

BACKUS: Yes, I suppose that's true. Yes, yup.

TAYLOR: So it kind of allowed you the freedom to develop and go in the direction you wanted to go in.

BACKUS: I had lots of freedom, and when I got out of the Army Air Corps at the end of World War II, I thought, "Boy, here you are. You're out of the Army. You're alive. You know you're lucky. You're smarter than you were before, and you can do anything you want to, and you got the whole wide world to do it in." That was a great feeling. [They laugh.]

TAYLOR: But you bring out a very, very interesting point. I'd like you to talk about it a little bit. As mentioned to you earlier, last Monday, the 27th of October, I talked with Bud Froelich, who was the designer of the *Sea Pup*, which became the *Alvin*, and he had similar experiences to yourself, in that he was in the Navy, and he was in the Guadalcanal scene, and all that, where you were in B-24s, and had your own series of adventures. Both of you had very strong families. Both of you . . . . In his case, college wasn't even on the drawing boards. He mentioned to me he worked at one point for 35 cents a day in a canning factory out in Iowa because that's all there was for money during the depression and all that kind of thing. But you generation has been called the "greatest" generation. And, boy, I know in terms of designing submersibles, putting down the foundations for what modern-day oceanography is all about, you guys did all that. Was it the times, do you think, that built you that way? I mean, you talk about this unbounded enthusiasm you had: "I'm out. I'm alive! The world's going to be my oyster."

BACKUS: Yeah, it was the times to a certain extent, sure. It was recovery from the depression. It was recovery from the war. And everybody took a very optimistic view of the future and was willing to work hard for personal rewards other than money, or sometimes money was the stimulus--not for an oceanographer, as you said. Yeah, I think it was the times in part. I don't think we were more special as people than any other generation.

TAYLOR: Well, everybody had to sacrifice during that time. You couldn't get certain products here. You couldn't get gasoline. Everybody was involved with what was going on. When it ended, and I can clearly remember exactly where I was when it ended, and when I started to hear all the whistles and sirens going off and all this kind of thing, people generally came out. They had this whole new void: now we can really go. And along with that, a lot of new organizations started. The ONR started.

BACKUS: It's true that, in American history, I think right from the start, after every war that we've had is closed there has been a great leap forward in new directions with new energy and new ideas. That was surely true of the aftermath of the Civil War and also World War I. I don't know about the Spanish-American War. That was kind of a minor fracas.

TAYLOR: So you came into this, a newly minted doctor. Oceanography was essentially just getting its feet wet. If we look at the history before that: Scripps started in the late 1800s, early 1900s, over in the boathouse in the old Coronado Hotel. Woods Hole Oceanographic came along in 1930. So we're only talking, roughly, 20 years after the start of this institution that you came here. So this was pretty basic stuff. You came in. You had mentioned that you applied for a job 'cause you thought this would be a great place to work. They asked you what it was you proposed to do, and then you got a subsequent letter asking you to go into the Hersey group. Now, we talked a little bit about that, but I'd really like to flesh that one out, because it just strikes me as being so unique to that particular period oceanographic research. You're a biologist with a doctorate, which you're going to work with a physical oceanographer here.

BACKUS: Yeah. Brackett Hersey was a geophysicist, and there were other people in the group with various degrees of formal education. But there was Frank Dietz, a physicist who later became a professor at the University of Rhode Island. There were mechanical engineers such as Bud Mat[SP?], and electronics engineer Willie Dow, a number of people who were processing sound transmission data and other sorts of data collected at sea who were skilled, bright, smart people who caught on fast and were good at what they were doing. I was pretty much in the dark when I started out with this group. As we said the last time we talked, I had no formal physics course, which Brackett Hersey never found out about when he interviewed me for the job. I managed to coast through all of these first months and the first year or two, however. I spent a fair amount of time going to sea locally, mostly on the motor vessel *Bear*, and as a rolled around on her afterdeck, slacking and then pulling in hydrophone cables, I wondered if this was what I'd really gone to graduate school for. The first seagoing that I did was on the motor vessel *Bear*. It had been built in the . . . . It was called the box that the *Balanus* came in, because it was not regarded as a very handsome vessel. And it was shaped quite a bit like a smaller ship caused the *Balanus* that we operated for awhile, so the *Bear* was called the box that the *Balanus* came in, or sometimes it was called the "Plywood Palace" because the superstructure--lots of it was plywood. The hull itself actually was quite handsome. It had been built in the Herreshoff yard in Bristol, Rhode Island, during World War II, and served as an inter-island freighter in the Pacific. So she made her way all across the Pacific and back, or most of the way. I don't know who we got her from, but she served the Institution well for a number of years. We did a number of two-ship exercises, sometimes with submarines, but sometimes just the two WHOI vessels by themselves, doing seismic work, seismic-refraction runs and sound-transmission runs. On these exercises, the *Atlantis* often served as the "shooting ship" (so-called), because the sound source employed in these exercises was explosives, which we fired a lot of over the years, explosives of various kinds, but the commonest, I suppose, was the half-pound block of tetratol. That was fired by crimping a piece of black-powder fuse into a blasting cap, then inserting the blasting cap into the well of the half-pound block, and fastening it there with friction tape, then either lighting it with a match or a cigar or a fuse lighter, then throwing it overboard. We used to go through cases and cases of friction tape, and I remember one summer a guy said to me, "Wow," he said, "a roll of friction tape lasts my father four or five years. You guys [Laughingly] really use it up here. We had some amusing times during some of those two-ship exercises. In a seismic-refraction run, for instance, *Bear* would be listening ship--that is, there were hydrophones overboard and her tape recorders, and she would be hove-to in a certain spot, and *Atlantis* would start perhaps 10 miles away to the eastward, and on a rigid shot schedule steam towards *Bear* firing explosives every five minutes, perhaps, then maybe going on to a two-minute schedule as she got closer, and then coming right to *Bear* as close as seamanship would permit, then open the range by going ten miles to the westward. We had some interesting episodes when the two ships passed each other at close hand. We used to throw potatoes at each other as the work allowed, and then once Jan Hahn . . . . He was the Institution's PR guy in the early days, and the founding editor of the magazine *Oceanus*. He was even poorer than the rest of us, and he was a great scrounger of tobacco, so on one occasion he made a deal with somebody on *Atlantis* to throw him over some tobacco as the ships passed, and so the ships did pass, and the tobacco was thrown over, but somebody thought it was a missile, not tobacco, and caught it and threw it halfway back. [They laugh.] So poor Jan lost his tobacco.

TAYLOR: I'm surprised he didn't dive in to try and recover it.

BACKUS: Ah, gosh. Well, we did a lot of rolling around out there, because we couldn't wait to just go out there in the nice summer weather. We spent a lot of time rolling our guts out.

TAYLOR: You get seasick?

BACKUS: I got seasick off and on. Lots of people seem to be immune to it, but most people aren't, I guess.

TAYLOR: This was a really interesting group. I look at that whole Hersey group: names like Betty Bunce come out, and things like this. I think now: you went the gamut from people that were high-school dropout to people that had academic training in a totally different field. (Betty Bunce was a PE teacher--physical education.)

BACKUS: Right.

TAYLOR: Right up to someone like yourself or Hersey, who were Ph.D.s. Right. Betty Bunce was a graduate of Smith College, I think. And interestingly she was a hockey coach of my sister, who went to Smith College some years before I came here. Betty Bunce was a stalwart of the group and one of the first women to go to sea out of the Institution. We could get back to the subject of women going to sea sometime. She was a great part of the group. Another person who I remember with a special fondness because he was really bright, and I'm not sure he'd ever gone to college was a Finnish-American from Maine name of Henry Johnson, a really smart,

smart guy with little or no formal education but who was a wizard at interpreting sound-transmission data and working in the group in that way. Unfortunately, he was sick with alcoholism and eventually died of it, a great loss to the group.

TAYLOR: But see, that's what I'm trying to get a picture of. This is such a disparate group when you talk about educational backgrounds, family backgrounds, where they all came from; but yet it melded together in an incredibly productive whole that went on to set a certain kind of course for future oceanography. Betty Bunch, just to mention one, as I say, was a PE teacher, came down here, wanted to take a tour. Wouldn't let her take a tour unless she was applying for a job. Applied for a job and got it.

BACKUS: Then there was a brother group to the Hersey group which was . . . . I think maybe some people thought of it as all being one group, but it was actually divisible into two, and that was the group that Allyn Vine ran, which was more concerning with certain engineering aspects of underwater sound, particularly the matter of variable-depth sonar. This was a concept which would overcome certain problems that the near-surface temperature structure of the water caused to sonar sets. If you could lower your sonar to beneath such an embarrassing layer at the surface you would achieve greater range in submarine detection, and so the Vine group was concerned with that. One person in that group who became my especial friend was another biologist, a guy named Bill Schevill, who spent half of his week at the Museum of Comparative Zoology at Harvard, and the other half of the week here at the Woods Hole Oceanographic Institution. I don't remember why he was aligned with the Vine group instead of the Hersey group. Oh, yes, I do. He was one of the mentors to the submarine service during World War II. He and Dean Bumpus, for instance, went around teaching submariners about the bathythermograph and how they could use the bathythermograph to measure near-surface temperature structure to give them clues about sound-transmission conditions that suggestive evasive actions when they were being sought by enemy sonar, and so on. So Vine had been a part, during the War, of bathythermograph instrumentation development, and Schevill became a buddy of Vine's and remained a part of the Vine group after the War. But he, like I, was kind of a loner in the sense that he was a biologist amidst a group of non-biologists.

TAYLOR: But he kind of took from them what they were doing and applied it to his own later research with mammal sounds and things like this.

BACKUS: Yes, to be sure, he capitalized on the engineering abilities of both the Vine group and the Hersey group, maybe even especially the Hersey group so far as principally listening apparatus went. So over the years Schevill and I spent a lot of time at sea together on various problems. He was a really interesting man with a great sense of humor, a unique style of speech, very original in his speech. He was tall and lanky, kind of had a pointy goatee, was sort of a Don Quixote-looking character, a very bright man and a very talented one.

TAYLOR: What was he like on a personal level. You know, I've done Bill Watkins, who was with him for years, but of course Schevill had gone on.

BACKUS: Right.

TAYLOR: So, on a personal level. You know, you say, when you get friendly with someone, there's more to it than just a shared professional interest.

BACKUS: Yeah. Well, he was a charming man, a very literate man, a well-educated man. He did not have a Ph.D., but he had a Master's Degree from Harvard, and he had been at Harvard as an undergraduate. He grew up in St. Louis. His father was a portrait painter. But he was a charming person, a lot of fun, and whenever you went any place with him, you found out that he had friends everywhere, many of whom were biologists, and I remember within a couple of years of coming here, he and I went off on a trip to Florida, a Navy-related trip. One of the things we did, for instance, was go up in a helicopter that had dunking sonar. We went out of Key Wet on this helicopter, hovered over the ocean and lowered a sonar, so-called "dunking" sonar into the ocean, and pinged around, looking for things to get echoes from. But on that trip, for instance, he said, "Oh, we'll call on my old friend David Fairchild." David Fairchild then was about 90 years old, but he'd been a plant explorer for the U.S. Department of Agriculture and had been all over the world looking particularly for improvements to existing agriculture crops for the United States but also new ones, and he did a lot of improving grains and fruits in the United States by imports of propagation material from countries everywhere. The Fairchild Garden in Miami, or maybe it's Coconut Grove, which is one of the world's largest collection of palm trees, is named after him. Anyhow, David Fairchild was married to one of Alexander Graham Bell's daughters, and he lived in a charming house and garden in Coconut Grove (I think it was.), and it was a little cabin and a garden that Bill Schevill and I were invited to stay in for a couple of days. David Fairchild was a remarkable man, a charming man, so it was a treat to go traveling with

Bill Schevill, because, as I say, almost everywhere we went he'd say, "Oh, let's go over to the museum and look up so-and-so while we're here." [They laugh.]

TAYLOR: But you know, all of this, as you tell me this, all of this was continuing your own growth. I mean, you were learning techniques with Bracket Hersey and second-hand from the Vine group and whatnot, about a field that you hadn't been trained in.

BACKUS: Oh, right. I was on the steep part of the learning curve, and I was learning a lot of stuff. But for awhile, for a couple of years it didn't really look like I was going much of any place. But eventually that straightened out. One of the things that they wanted me to be interested in, and I was captured by right away, was the so-called problem of the deep scattering layers.

TAYLOR: For someone listening to this that might now know what the DSL was, would you define that for us?

BACKUS: Sure. It was called the "deep scattering layer," although it proved to be more than one layer, so after awhile we talked about deep scatter layers, but originally people talking about <u>the</u> deep scattering layer. This was a phenomenon that showed up on echosounder records. An echosounder, of course, is an instrument which emits short pulses of high-frequency sound which travel downward, principally, to the bottom, are reflected from the bottom and come back to the surface instrument, and the time that it takes for this pulse to go to the bottom and come back is measured and then time is translated into depth, so one measures the depth of the ocean and portrays an outline of the bottom by repeated, precisely-timed pulses followed by echoes. In the case of the deep-scattering layer, this was a band of echoes which showed up on the echosounder record in deep water off the continental shelves and out in the deep ocean, a band of echoes that showed up on the echosounder paper record between the surface and the bottom, so at first people thought, well, it's a reflection of sound from a change in density, perhaps. But almost immediately that was eliminated as a possibility because this layer moved up to the surface at sunset from a depth of a couple of hundred fathoms, maybe, 400 or 500 meters up to quite near the surface, where it was lost in the near-surface reverberation. Then in the morning, with sunrise, the layer formed again and was seen to move downward to its daytime depth, back around a couple of hundred fathoms or a few hundred meters. The fact that there was this diurnal vertical migration, this movement up to the surface at night and down away from the surface by day meant that whatever was responsible for these echoes was a collection of living things. And the question was, of course, what were these living things. So I got very interested in that.

TAYLOR: Let me ask you at that point. You spent a couple of years doing this work, hauling hydrophones, I think you said. How did it come about that you made the decision to say, "Hey, wait a minute, I'm not a physicist here. I'm not going to spend my career throwing hydrophones in and out." What was the mechanism that got you into "I'm going to start my own thing now"?

BACKUS: Well, that was easy. It just sort of naturally came about. I mean, Hersey was very generous to me and encouraged me right from the start to pick up on things for myself. There was no revolution involved or anything like that. It was all evolution. I naturally, as I learned more, I could become more helpful to the group by being less of a technician and more of a scientist, so it came about very easily for me because Hersey was so generous, for one thing. So there was no problem there. So as I learned more and was able to function more as a scientist, I did function more as a scientist and less as a deck hand and technician.

TAYLOR: But you wouldn't trade in that ability that you picked up as a deckhand and technician, I don't think.

BACKUS: No, no, no, everything I learned was useful. Maybe I already knew that I had a certain amount of organizational ability, and I didn't mind making decisions, and I got along well with ships' crews, so after awhile, if Hersey was on one ship, I would often be put in charge of the group on the other ship, become the so-called chief scientist. But the deep-scattering-layer problem was a very interesting one. And of course my immediate approach to the problem was to try to see what the possibilities were by trying to tow nets in these layers.

TAYLOR: Now, were you still with the Hersey group?

BACKUS: Still with the Hersey group, yup.

TAYLOR: Because, those were the early years of scuba diving, and if you were a knowledgeable scuba diver, there were two things that you could talk about: one was the thermocline, and one was the deep scattering layer. So they were kind of big deals at the time.

BACKUS: Right. Of course, the deep scattering layer was beyond the reach of scuba divers. Scuba divers are limited to 100 feet, maybe? in normal operations, or 50 feet?

TAYLOR: Well, in my case it was 15 feet, and I looked the other 85 down.

BACKUS: Yeah, right, so there were severe depth limits as far as scuba diving goes, and the deep scattering layer was well beyond the reach of scuba divers.

TAYLOR: But see this showed that you were on the scientific end of scuba diving. You had a term you could throw out.

BACKUS: [Laughingly] right.

TAYLOR: You actually started to do work on that.

BACKUS: Right, right. So as a biologist and a person who was used to collecting things and pickling them in formalin in quart jars, my right-away inclination was to tow nets in these layers. The fact that you could tow a net and catch something in one of these layers didn't of course mean that that was the source of the sound scattering. Not sufficient to say that, "Well, there's a good strong correlation between what we caught at this depth and the fact that the layer is at this depth." You've got to catch the animal, we decided, in the process of sound scattering. So one of the things that we worked on quite a bit and was ultimately only moderately successful was an echosounding camera. That is, we combined a 12-kilohertz echosounder with one of Harold Edgerton's deep-sea cameras--Harold Edgerton of MIT fame, "Papa Flash," as he was known by Cousteau and others. So we built and tested and used an apparatus that we called Suspedo which was for the suspended EDO, the name of the 12-kilohertz echosounding system that was in use at the time, built by Noel McLean's company, the EDO Corporation, Noel McLean of the McLean Laboratory that we're sitting in. So the idea of this apparatus was to photograph well enough so that the we could identify the sound-scattering object at the same time that we were recording echoes from it. As I say, we only had modest success with that apparatus, which was difficult to design well. There were technological limitations that we never quite solved.

TAYLOR: Now, were you actively involved in the design of this yourself?

BACKUS: Yeah, conceptually. I didn't have much to do with the actual . . . .

TAYLOR: . . . manufacture?

BACKUS: . . . building of it.

TAYLOR: Yeah, but you know it's interesting. First of all, you didn't know what was down there.

BACKUS: Right.

TAYLOR: So you had to come up with an idea to find out what was down there. And then you had to come up with the concept of what it was going to be. Now since Galileo's time I don't know of many people that have build their own microscope so to speak.

BACKUS: [Laughs.]

TAYLOR: But that's what you fellows had to do.

BACKUS: Right, yeah. Now, there was another approach to the problem that I undertook with Hersey, and he gets most of the credit for this. As I said earlier, we spent a lot of time in this group firing explosives and using the sound that an explosion is as a sound source for seismic studies, sound-transmission studies, echo studies, so Hersey had the idea that we would look at these layers using explosions as sound sources. Now the echosounder that we ordinarily looked at the deep scattering layer with was operated at a single frequency, emitted pulses rapidly on a precisely timed schedule. Explosion as a sound source and a way of studying the layer was something entirely different. Instead of being a single-frequency source, an explosion is a multi-frequency source. There are sound frequencies in an explosion from quite low, below the limit of human hearing, to quite high, beyond the limit of human hearing. So as a multi-frequency source the explosion is a great thing. The limitation of an explosion as a sound source is that you can't fire them rapidly, and it's impossible to put them on a really precise schedule. Nevertheless, Brackett decided that we should fire explosives, record the scattered sound as the layers were coming up toward the surface at night. And when we did this and analyzed the scattered sound . . . . Well, first of all, it sounds like this: we got "BANG!" and then you've got "SHHHH! BOOM!" Now the "SHHHH!" is the scattered sound from the layer. The "boom" is the echo from the bottom. In any case, we would fire explosives on a, say, two-minute schedule for a couple of hours while a layer was coming up from several hundred meters up until the surface. Then tape recordings of the scattered sound is received by a hydrophone, run through a spectrum analyzer, and this plots a rectangular sheet of paper which is blackened in proportion to the intensity of the sound scattering, so that as you go from the left-hand margin of the paper to the right-hand margin of the paper, time increases, and as you go from the top margin of the paper to the bottom margin of the paper, frequency decreases, so that the depth of a layer is translatable into time, or time is translatable into depth, so that a layer, for instance, might show up in the middle of this paper record as a black blob. If it was in the middle of the piece of paper, it was mid-frequency. If it was well toward the right margin of the paper, it was deep. And then we found that this black blob, as we expected, migrated in depth as the sunset vertical migration went on, moved from right to left on the paper. But what we didn't expect was that the band of frequencies at which this layer best scattered sound also migrated or changed so that as the scattering layer got closer and closer to the surface at night it scattered sound at a lower and lower frequency. And this was a really exciting discovery. Actually, the layer was changing its sound-scattering properties the way a bubble would change its sound-scattering properties, and what did it mean that it was bubbles? A bubble could be related to the swim bladders of fishes, so that here was a strong clue that the layer was composed of small fishes whose swim bladders were gas-filled, were bubbles, were the principal sound reflectors, and then the characteristics of the sound scatter changed as the layer moved up in accordance with physical laws that said bubbles of gas were indicated. I'm sorry that I've made that a little awkward. It's complicated, and I haven't said those words for a long time. In short, when we studied the migration of the layers either up or down, the sound frequencies best scattered by the layers changed as the layers changed depth. They changed in such a way that meant bubbles of gas were involved. And bubbles of gas could only be, we thought, the swim bladders of fishes. So that was a big discovery, and moved us well along in our thinking about deep scattering layers.

TAYLOR: OK, a couple of questions immediately come to mind, because you said it any youngster could understand when you kind of restated it. But there are two things I'd like to talk about: one, first of all, there's a huge reliance now on physical properties to go with your biology, and of course that's what you've been doing for a couple of years. You and Brackett Hersey, how did you come up with the methodology that you were going to use? Two scientists, now, two eminent scientists: how do you get together and come up with this methodology?

BACKUS: Well, it was principally Brackett that had done that. And the methodology was not a great departure from methods that were in common use by the group; that is, the whole business of using explosives as sound sources. That was straightforward. The business of recording echoes generated by explosives and recording them: that was straightforward. Although, the group often looked horizontally at things in the water, looked at . . . . For instance, the group studied the spectral characteristics of the echoes off of submarines when you fired an explosion and looked at the sound that the submarine scattered back to you.

TAYLOR: Which, of course, now has been refined to an art that you wouldn't even believe back in that period.

BACKUS: Right. So it didn't require too much of an alteration of methods and equipment already in hand to decided, "Hey, we'll look down at the layer as it moves up, and we'll fire explosives one after the other and record the scattered sound, and then we'll do a frequency analysis of the scattered sound and see what we see."

TAYLOR: So that, in that particular period of oceanography, an energy release answered a multitude of different kinds of questions. It was kind of a standard tool of the day?

BACKUS: Yeah, it was [laughs]. Yes, there were attempts by Harold Sawyer when the Vine group, for instance, was working on a device--I forget what it was called, whether it was called the "thumper," or whether the thumper was something else. But there were various attempts to make mechanical devices that would generate multi-frequency sounds, complex sounds to be used as sound sources in various studies. Explosives as a sound source have several shortcomings. They're dangerous, for one thing. They're not too reliable. That is, sometimes they don't go off, and you can't schedule them very well. You can't schedule them to repeat themselves rapidly. You can't schedule them to be on a precise schedule. So there were a number of attempts to devise mechanical systems that generated complex sound signals. So the explosion--firing tetratol--was a standard way of generating a complex sound source in those days. It was maybe a year or so after a came, I was walking down to work one morning. I lived up on what was Stewart[SP?] Lane, now Cricket Lane, and I walked down to work, and at about the drugstore I bumped into Vine. He lived out on Juniper Point. He was coming to work, and we walked on down Water Street to Bigelow, which was the only building then. I said to Vine, "I could see it would be handy if I was checked out as an explosives handler, because I can see that's going to be a part of my work and would make me a handier guy in the group anyhow. So, will you check me out sometime?" And Vine said, "Sure. What are you doing this morning?" I said, "I don't know." "Let's go see if Bosworth will take us out on the *Asterias*." So Bosworth didn't have anything to do with the *Asterias* that morning, so we go over to Sheep Pen Cove on Nonamesset and get some explosives out of the magazine over there, and Vine took me out and checked me out. It was a very elaborate checkout. A few minutes of instruction, which mostly had to do with how not to blow yourself up.

TAYLOR: You know, all the guys that do that always seem to greet each other with, "You still got all your fingers." [They laugh.]

BACKUS: Well, the thing is you don't lose a finger. That's the trouble. You're more apt to lose your head or . . . . There've been some nasty accidents over the years, but none here that ever killed anybody, as far as I know. Lamont had an unhappy accident in which a guy was killed on the *Vema*, but we never had any bad accidents. Once a half-pound block, I think, got tangled in *Atlantis*'s main boom, and everybody ran below, and it went off and didn't do too much damage.

TAYLOR: Of course one of the things of being an oceanographer during that period--it was a lot of fun.

BACKUS: Sure was.

TAYLOR: I mean, where else could you get firecrackers that size?

BACKUS: Right. That's exactly right. And later, well, that account of that cruise there talks about explosives use studying sound deep scattering layers, and at the start of that cruise, there were only . . . . *AII* cruise 59, I think it was. We were firing explosives every day at 1 o'clock in the afternoon, and there were only two of us that were checked out, so that meant every other day, whatever else you had to go up there and fire half-pound blocks. As I say there, it's always easy to come up with a couple of guys, who, the idea of making a loud sound appeals to. So we checked out a couple of guys, and they took over most of the explosives work on *AII* 59.

TAYLOR: About two months ago I took a group of tourists through the REMUS laboratory, and of course there were three or four guys all working on the new deep-sea REMUS, and this woman said to me, she says, "This place looks like a bunch of boys playing with their toys." I said, "Good Lord, she's discovered the secret of the Woods Hole Oceanographic."

BACKUS: That's right, she's . . . .

TAYLOR: That's absolutely true.

BACKUS: . . . right on. That's right.

TAYLOR: And another thing that intrigued me this description you had of the beginnings of your work with the deep scattering layer. I had asked you how you went about coming up with a methodology. In all of the natural sciences, it's not like the textbook illustrations an eighth-grade kid is going to see: a little x-y axis, and there'll be a nice, neat, single line. You've got stuff coming in from all over the place. How do you work your way through all that, particularly with a new procedure like that.

BACKUS: There are lots of sloppinesses. Well, lots of scientific work is surrounded with sloppinesses, I suppose, and you just have to work your way through them. The secret is shutting out a lot of the slop and eliminating as much noise as you can and hoping that there's some signal or outstanding feature left that you can make some sense out of and learn something new from. But science mostly is a sloppy process, although I suppose strict, white-coat laboratory science, I suppose, is perhaps tidier, but it doubt it very much.

TAYLOR: Well, your field didn't really lend itself to laboratory experimentation.

BACKUS: No. There's a lot sloppiness in oceanography. In any case, at the same time that we were trying to photograph sound scatterers, and were studying the frequency-dependent properties of these deep-scattering layers, I also started towing nets in the deep scattering layers, and . . . .

[END OF SIDE 1]

BACKUS: . . . Isaacs and Louis[SP?] Kidd. Yeah. It was called the Isaacs-Kidd midwater trawl. And that was a trawl net that had a big steel, sort of open V-shaped depressor at the mouth of the net and a spreader bar and a bridle, and the point of this depressor or paravane was that it took the belly out of the cable of the net and made the net go deep so that you could get relatively deep with relatively short amounts of wire, and also that let you do little simple trigonometry to figure out, however crudely, the depth of the net, because the wire that towed the net was straighter than it would have been had the depressor not been there. So I got the depressor and allied stuff built over in Fairhaven at one of the yards that does work for the fishing industry, and I forget where the net came from. Somebody over there probably knitted that up too. Anyhow, the net was about 10 feet across at the mouth and several feet high, stretched out 25 feet or so behind the mouth. The net was 25 feet long is what I'm trying to say. I began towing that net in the deep scattering layers and other places and had good luck at catching . . . . This was in deep water off the continental shelf south of New England, and had good luck catching really interesting fishes, the kinds of fishes that people then had associated with William Beebe and his ventures in . . .

TAYLOR: . . . the bathyscaphe?

BACKUS: . . . the bathyscaphe, and you know, big-eyed, big-mouthed, toothy [??] fishes, and . . .

TAYLOR: [Talking over Backus] Scorpion fish, yeah.

BACKUS: So, the captures that we made with that net told us what some of the possibilities were for inhabitants for these deep scattering layers. As I said earlier, we couldn't be sure what we caught was what was actually doing the sound scattering, but at least it told us some of the possibilities of animals that were living in these layers, and indeed we caught a certain number of fishes who had gas-filled swim bladders of a size that seemed to fulfill the bill and fit what Hersey and I had seen by firing explosives and looking at the sound-scattering changes as the layers moved up from deep up to near the surface. So we definitely were making progress in deciding what these layers were likely to be composed of. And as deep-scattering-layer study went on and on, and as echosounding equipment became more and more refined, and the Hersey group made big contributions in the design and testing and application of high-resolution, high-speed echosounder systems. As we used that equipment more and more, we found that there were lots of different layers to be seen under different sets of circumstances, and the final conclusion I suppose was that mostly these layers were composed of fishes with gas-filled swim bladders.

TAYLOR: You kind of shot right by it, but you talked about coming up with a net, a trawl, to put over the side. Now you're talking to a guy that never mastered casting without getting a big wuzzle and all the backlash and things. You weren't a commercial fisherman. How did you go about learning to use a device like that? This is not a small piece of equipment.

BACKUS: No, it's not a small piece, and we were clumsy at the start, but the first fishing that I did was of course from old *Atlantis*, who had a pretty good deep-sea winch with lots of heavy wire. It had a gallus frame that held a wheel that wire could pay out over. It had handling gear that could pick up this depressor and put it out over the side. So getting the net off the deck and into the water and not getting tangled here and there, and keeping it out of the ship's screw was always a problem. Paying out the wire and towing it was always straightforward, although sometimes there were screwups, with the net not streaming out properly and getting open. But getting it back over the side of the ship and on deck without banging things up was not quite as difficult as getting it out. But later, as we went to bigger ships, it became easier and easier. When we went to *Chain*, for instance. *Chain* cruise one was in 1958, yeah. That was a big change in the Institution's life. I'm getting off the subject of nets for the moment, but a big change in the Institution's life, and a big change in my life, and a big change in the life of the Hersey group was when we went from little ships--the *Bear*, the motor vessel *Bear* that I've spoken of (the box the *Balanus* came in, was about a hundred feet long. *Atlantis* was about 140, maybe, as I remember . . .

TAYLOR: 144, yeah.

BACKUS: . . . 140 feet long. We had some experience with the *Yamacraw*, a retired coast-guard cable layer in 1957 and 1958, which was a bigger ship, a couple of hundred feet plus, I guess. The , a retired coast-guard cable layer in 1957 and 1958, which was a bigger ship, a couple of hundred feet plus, I guess, the *Yamacraw* was. But in the fall of 1958, I think November of 1958 we got *Chain*, and that revolutionized seagoing life at the Institution--life at the Institution. *Chain* was a Navy rescue and salvage tug, ARS-20, I think. In any case, she was turned over to us for use, and at the first operation by the Military Sea Transportation Service (MSTS), I lucked out. The Hersey group was going to bring the ship from the shipyard in Savannah to Woods Hole, and the Hersey group was expected to be a big user of the *Chain*, as they were. In any case, the ship was refitted to a certain extent in a shipyard in Savannah, Georgia, and Earl Hays, a Ph.D. physicist, had joined the Hersey group by this time. Earl Hays was going to go to Savannah and be chief scientist on *Chain* cruise one. For some reason or other, he had to bow out, couldn't. So Hersey said to me, "You're going to be chief scientist on *Chain* cruise one. You're going to go to Savannah and bring the ship back to Woods Hole." And of course I was delighted. And wow! Was that a big time. Dr. Redfield and Dr. Fye and I went down in a sleeper from Boston to Savannah. There were others that made up the scientific party on that first cruise, but we were in Savannah for two or three days as the final touches were being put on the ship. Later the Oceanographic Institution operated the ship with its own crew, but for the first couple of years--I'm not sure how many months--the MSTS operated the ship. The skipper of the ship was a wonderful man named Warren Allovie[SP?]. I really came to be very fond of him. He was a great guy. The afternoon that we sailed from Savannah, the head of the shipyard was down on the deck of the ship, giving Allovie[SP?] a hard time about something. I was nearby, and I heard Olivie[SP?] say, "Mr. So-and-So, I'm the skipper of this ship. Kindly take your ass in your hand and carry it ashore." [They laugh.] So that was Warren Olivie[SP?]. He was a great guy, very competent seaman, charming, handsome man that we got along with fine. I remember there was a lot of ceremony in Savannah at the time, and there was a big luncheon at one of the downtown hotels and a commissioning ceremony, and I remember at one point some Navy commander said to me, "Oh, I'm really concerned that you guys are going to get along with the MSTS, because it's very important if the MSTS is going to operate this ship that there be good relations between the MSTS and you people at Woods Hole Oceanographic Institution." I said, "Go worry about something worthwhile. I'm sure you've got something that you ought to be worrying about. Don't worry about that one." And of course everybody got along fine. They were great people, the MSTS people. And after a couple of years, why Emerson Hiller became the Institution's first skipper of *Chain*.

TAYLOR: Another wonderful individual.

BACKUS: Oh, right. Terrific individual. And as far as I'm concerned, *Chain* was the best . . . . I know nothing about the present day *Atlantis*, but I made many cruises on *Atlantis II*. I was lucky enough to be chief scientist on *Knorr* cruise one, and I made a number of cruises on her. I made many cruises on *Chain*. In my estimation, the *Chain* was the best ship the Institution ever had. It was too bad that she was retired, I think and turned into razor blades. I think, for political reasons, she had to be the ship that was retired. She was old, of course, but she was very comfortable in a sea way, and very handy, a great ship.

TAYLOR: But see, you're bringing out a whole host of different things here.

BACKUS: I'm wandering. [Laughs.]

TAYLOR: No, not really. 'Cause we're going through your development here, and your growth as an oceanographer, and I mean it's gone from hauling hydrophones in and out up to chief scientist, change of ships, new kinds of instrumentation, need to learn how to get that instrument, back up, all that kind of thing, and it's a whole growth process. That's what gives you the title "oceanographer," not just biologist, if you will.

BACKUS: Right, yes, yes indeed.

TAYLOR: When you were on the *Bear*, not as comfortable a ship, not as good in a sea way. Bob Dinsmore told me once, 'cause he'd had a lot to do with ship design. He said, "Hey, number one thing is to make the ship comfortable for the scientists, because if it isn't they're not going to go to sea enough." And he said that's a real important factor. So your mentioning that was important.

BACKUS: That's right.

TAYLOR: I had to ask you, when we got on this, about learning to deploy nets and things like that. That net that you first started to use with the deep scattering layer, what size mesh was that? Do you recall?

BACKUS: Oh, it was about . . . . Well we used . . . . The main shell of the net was about inch stretched mesh. If you grab a couple of knots and pull 'em apart like that [GESTURES?], they stretch out to about an inch or a little bit more.

TAYLOR: Because a lot of the things you were going to haul up from that deep scattering layer were really small.

BACKUS: Right. But we had a liner in the net. Sometimes we lined the net. The liner started at the head of the net and went all the way back to the end. And that liner was of a small mesh, say about a mesh that a pencil would just kind of slip through. And then, at the cod end of the net, we had a cod-end piece that was a truncated canvas cone that increased in size towards the end of the net until a meter hoop fitted it, and then to that meter hoop we had what was basically a coarse plankton net. So the cod end of the net was quite different from the head end of the net so far as the material out of which it was made. So it retained a lot of small stuff. We had to tow it at very low speeds because just couldn't get it to go through the water and strain the water if you went very fast with it.

TAYLOR: Well, a lot of those things, if you go too fast they tend to porpoise. They go up and down.

BACKUS: Yeah. All kinds of things happen. But in any case, when *Chain* came along, we had a greatly increased ability to handle gear of all kinds on and off the deck of the ship. We had a big fantail aft, a big, flat, open working space, although when *Chain* first came she had quite a bit of gear on her afterdeck which ultimately was taken off so that we had a flat, smooth expanse of working space. *Bear* and *Atlantis*, for instance, had very little open, working deck space. Then we had big, hydraulically operated A-frames, over which one ran the wire. And these A-frames could be brought in or tipped out, which facilitated gear handling quite a bit. And then we had cranes. Cranes came along. I think the first person to take a little crane to sea was Cousteau on *Calypso*. I think he was the guy that saw the utility of cranes. So oceanographic ships have had cranes ever since. But to go from 140-foot *Atlantis* to however big *Chain* was--I forget what *Chain* was, how many--300 feet or 275? I don't know. But we just moved from one class of ships to another, and almost overnight--there was a transition time with things like *Yamacraw*--but almost overnight we went from a little-ship outfit to a big-ship outfit. And that was revolutionary, I think, in the affairs of the Institution.

TAYLOR: Well, little things that most people would never think of--the ability to keep yourself clean.

BACKUS: Right.

TAYLOR: Things like that that people don't realize how dirty you get going to sea.

BACKUS: Right, right, right.

TAYLOR: And to have a few creature comforts. Maybe have a little library onboard, or something like that.

BACKUS: Oh, yes, yes. Yes, it was huge.

TAYLOR: And it also made for a more stable platform, didn't it?

BACKUS: Oh, yes. Yes, indeed, and *Chain* was very good in that respect. No, what winds that limited operations in *Bear* and *Atlantis* were nothing for *Chain*. She too could ultimately be limited by wind, but it really had to be blowing pretty hard before she had to stop work. So 1958 was a big year, the year that *Chain* came.

TAYLOR: But you know, that's another factor that you're talking about here. Let me refer back to a big hit movie from a couple of years ago, which I really chuckled when I saw the beginning. When the movie *Titanic*, and when they were showing going down on the *Titanic*. Here was this oceanographic vessel. There wasn't a whitecap in sight. The water was pond-smooth. The ship was pristine in its cleanliness, and anyone that's been down here immediately had a huge grin on their face. Because, with the smaller ships, even more than with the bigger ones, people have this kind of textbook view of a vessel sitting in perfectly calm waters while people are running around in shorts and cut-off shirt, easily lowering things into the sea. That's practically never the case.

BACKUS: Practically never, right, yes, yes.

TAYLOR: So you're always faced with trying to do these things--well, like putting a net over the side with cables. Man, that stern goes up and down. You can put an enormous amount of strain on one of those cables. That gets to be pretty dangerous.

BACKUS: Right, right, it does. So working off of *Chain* was not to be compared seriously with working off of *Bear* and *Atlantis*. So I think of that as one of the big steps in the evolution of the Institution, the year that *Chain* came along, which was November of 1958. Then of course we had plenty of use for *Chain*, and *Chain* was worked hard. The Institution managed to run *Chain* and keep *Chain* occupied. Over the years, the number of days that the Institution has managed to keep ships at sea is outstanding.

TAYLOR: How much of your year were you spending at sea during that period?

BACKUS: Well, uh . . .

TAYLOR: Realizing that it varied.

BACKUS: . . . it varied quite a bit, but I suppose I was spending five or six or seven or eight weeks a year at sea.

TAYLOR: Did you like going to sea?

BACKUS: Yeah, I liked it a lot. Yeah, I liked everything about it except too rough weather.

[They laugh.]

TAYLOR: When you first started--I'm going to keep referring to this, because I see a real development here. You were hauling hydrophones, then you got to the point where you were working your own project. Certainly if you're going to stay here you're going to publish sooner or later, or you're not going to be around for long.

BACKUS: Right.

TAYLOR: So you became competent at that. Then you made the switch from a smaller vessel to a larger vessel, and, although that's a good thing, it also brings in a new set of problems, a new way of needing to do things. But then you also started to get the experience of being a chief scientist. Now, could you talk a bit about being a chief scientist, what your role was? You had two big camps you had to keep happy. You had to keep the scientific crew happy, and you had to keep the captain happy. And while you're thinking about that, I asked Emerson Hiller about this: "Oh, I always got along wonderfully with all of the chief scientists." And then one day he brought in his scrapbook with all the testimonials when he retired, and I'm reading all these big name scientists who said, "I stood in fear before Emerson Hiller," you know, and so on. And he said his secret, because I told him, "You know, you really have to know how everything on this vessel operates, don't you?" And he looked at me, and he said, "No."

BACKUS: [Laughs.]

TAYLOR: "You have to be perceived as knowing how everything on this vessel operates." So that's kind of a unique situation for a chief scientist to step into.

BACKUS: Right. Right. Well Emerson and I got along very well. I consider Emerson a great friend. I also consider him to have been the best skipper that we ever had. I mean, I'm talking about the period during which I went to sea and got to know skippers, and we had lots of good ones, but Emerson was outstanding. I always enjoyed going to sea with him. I suppose the problem for the chief scientist is to make sure that the ship is worked as hard as he can work it during the time that he's responsible for it. When the ship is costing several thousand bucks a day you can't take that lightly. So keeping the ship busy, keeping the ship always at work or moving on to the next place is important. Now that thing that I gave you to read talks a lot about being a chief scientist and a lot about using the ship to the utmost. That doesn't put it on the tape, unfortunately, but . . . .

TAYLOR: Believe me, we'll get to this.

BACKUS: There are good chief scientists and poor chief scientists, and I've heard a lot of complaints from people on the ships about, "Jesus, no, So-and-So was not a good chief scientist. He was disorganized, and he . . . ." Anyhow, the main problem, like in practically every aspect of human endeavor, is communicating. And I finally worked out a system of communicating that I thought was fairly efficient and effective, and that was to type up a calendar, a schedule for the next 24 hours as well as you could see it, and I would make such a schedule in four copies. I would post a copy of the schedule in the main lab. I would post a copy of the schedule in the bridge, and I would post a copy of the schedule in the engine room. And sometimes we would have to tear up that schedule within a few hours of having made it and type up another one and repost it, but you did that as much as you needed to so that everybody knew what was going to happen: when, what for the next 24 hours. So communication I felt was the heart of the whole thing, so that there were no ugly surprises as far as the engine room went, and as far as the bridge went, and as far as your colleagues in the scientific party went. I had the problem when I first started going to sea on protracted cruises that my project, based on a proposal made to the National Science Foundation or whatever, was allotted a certain amount of ship time. I had a relatively few people working for me. We had to mount this expedition and keep the ship busy. Obviously we couldn't do that, just a few of us, so I began, for one thing, taking extra people to sea, schoolteachers. I took a dentist once. I took colleagues from institutions from colleges and universities around the country that had a few weeks that they could be away. They started going to sea to do their own thing, or sometimes just for the hell of it, but they went and helped me out. And also I began collaborating with other projects so that they would send people and things to do. For instance, my group, after I became independent from the Hersey group, would often collaborate with Vaughan Bowen's group in the Chemistry Department. We found that his activities and my activities fit together rather well, so that . . . . In other words, you had to assemble a critical mass of scientists and projects so that you could keep that ship at work all the time, either working or moving on to the next site of work. And that was the main trick of being a chief scientist, was organization, scheduling, no nasty surprises, no shocking inefficiency, where you suddenly find yourself . . . . You're just lying in the water having to kill a few hours because you can't move because you need to be there at that spot but the time of day is wrong for doing what you want to do. You have to eliminate that sort of waste, and that was the main challenge of being a chief scientist on a large ship. And I loved it. I thought it was just great sport.

TAYLOR: Well, you know, it's an interesting thing in that when you go away to sea you might just as well be going out to a space station. I mean, you are a little universe all unto yourself, and, in a sense, when you're chief scientist you're the CEO of this particular island that's floating around out there. And you talked about communication, but there also has to be a degree of cooperation. I have met very few people in this field that weren't terrific guys, but there are some, and they could be difficult to deal with for a chief scientist.

BACKUS: Right. Right, right.

TAYLOR: You know, want more time on station or . . .

BACKUS: Right.

TAYLOR: . . . "it's more important that we get my work done than we get his work done."

BACKUS: Right, right. Well . . . .

TAYLOR: That's hard to handle.

BACKUS: Yup. The only way you can do is be straight about everything and be tough and not get pushed around. But Emerson, he was great, and I always had a good time with him. For instance, the first thing after breakfast I always went up to the bridge, and I would read the numbers as Emerson plotted the weather map, so I always enjoyed . . . . That was a companionable sort of thing to do, and he and I got along real well.

TAYLOR: Well, when he told me some of the tricks his crew played on him from time to time, it was really a wonderful recitation, because there wasn't a mean bone in any of these tricks. They were funny.

BACKUS: Yeah, yeah.

TAYLOR: And to me they showed a certain amount of real affection.

BACKUS: Right. Yeah, well, not everybody loved him, but mostly they did, and as I say, I think he was tough. He didn't put up with any nonsense, but he knew what we were out there for, and that was to get the work done, and he saw to it that as far as he was concerned it was not going to be the ship's fault or the crew's fault that the work didn't get done. So he never did anything that threatened the safety of the ship or its crew or its scientific party, but he always had an eye to getting the work done.

TAYLOR: So when you started as a chief scientist, was that kind of a nervous time for you, when you were first into that?

BACKUS: Well, not . . . . I don't know. It's hard to think back now, but I always got along with sailors pretty well, so that made it easy. So I was always conscious of the responsibility of using that ship. But I always found it highly enjoyable, and I always got along well with the ship's crew and ship's officers and crew. And that's important, and that made it easy.

BACKUS: Well, is one of the factors then, necessary to be a good oceanographer and a good chief scientist is you've got to be one of the guys?

BACKUS: That helps.

TAYLOR: And I mean not, you know . . .

BACKUS: That helps.

TAYLOR: . . . "I'm a Ph.D.," you know what I mean?

BACKUS: That doesn't get you anywhere. [They laugh.] That doesn't get you anywhere. No, that doesn't get you anywhere. But I think going to sea in our ships was a great adventure, and a wonderful line of work. The mix of intellectual and physical adventure was great, and the business was filled with interesting people--filled with interesting people. One of the things I learned before long at the Institution, and I already had some idea that it was so, but it was really reinforced here at the Woods Hole Oceanographic Institution in the first couple of years that I was here, that not all the smart, clever people go off to graduate school and get PhD. Degrees. There are lots of smart, clever people that are mechanics. There are smart, clever people that are technicians. But the guys that worked in the so-called "garage," which was . . . . I don't know whether that word is still used in connection with the big building, big shop out on the dock, but for years and years and years the carpenters, shipwrights, mechanics, electronickers[SP?], whatnot, were known as the Garage Gang, and worked in what was known as The Garage, because the original building that held all those functions was the Penzance Garage that the Institution took over at some time just before I came here. But there were a bunch of outstanding people there--Bill Gallagher, Bob Weeks, the Garage Gang supervisor Stanley Fisher, carpenter Stanley Aldrich[SP?], shipwright Scotty Morrison, machine shop boss Chuck Bodman[SP?]--all those people were wonderful, wonderful, productive, smart, competent people. I mentioned

Bodman[SP?]--actually the machine shop was in the basement of Bigelow when I first came here. It was not out in the Garage. Warren Bowman, Fred Gaskell--they were wonderful, wonderful people, and I learned that a Ph.D. didn't mean "smart." Smart meant "smart."

TAYLOR: So the Institution kept educating you, for years and years and years.

BACKUS: Oh, years and years. Never stopped.

TAYLOR: You know, when you said that, you really put oceanography into a generic term, and a kind of an interesting context. You know, you made me think it's almost like coming up with a great stew. You throw one bad ingredient in there, it curdles the whole thing.

BACKUS: [Laughs.]

TAYLOR: And that's really important here. Everybody had to be part of the stew, so to speak and get along and work together.

BACKUS: That's true.

TAYLOR: Let me stop this one.

[END OF SIDE 2]