RICHARD BACKUS ORAL HISTORY

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

Tape 3 of 4 tapes

Woods Hole Oceanographic Institution

TAYLOR: . . . ing 1, 2, 3, 4, 5, 6. It is November 12, '03. We're at the Archives at the Woods Hole Oceanographic Institution, down in the bowels of the McLean Laboratory. It's a typical miserable day outside for November, and we're getting set to do our third session with Dick Backus. As we finished the second session last time, he handed me a sheaf of papers that described a cruise that he made, and first of all, it was very, very entertaining reading. But secondly it brought out all kinds of questions, things that I'd like people to know about what it's like on a cruise, what it's like to be a scientist, what it's like to be a chief scientist. What are the responsibilities? What are the things you have to think about and worry about, and all that kind of thing? So, the cruise we were talking about here is the one that you made from Madeira to the Cape Verdes, back to Woods Hole again. That was a 50-day cruise. That seems to me to be longer than most scientists are out to sea today. And it seems most of the legs now are a couple of weeks, maybe three weeks maximum, something like that. Fifty days--pretty good portion of a year.

BACKUS: Yeah, right, it is. Yeah, it's--what is it?--it's a seventh of a year. I suppose there's sharper competition these days for expensive ship time, so that people have to claim lesser amounts or strive for lesser amounts, or are awarded lesser amounts these days than 30-40 years ago, when science was smaller and getting going, and there wasn't such lively competition for ship time. That may explain it in part.

TAYLOR: Let me ask you, then, right from the beginning on this. The preface to this cruise--getting yourself ready--what was it you wanted to find out, and how did you go about getting yourself funded for that?

BACKUS: The cruise that you talk about was one of a series of cruises that I participated in or was responsible for organizing over the period of a decade. The purpose of those cruises was to delineate the boundaries of a system of faunal regions and provinces for the Atlantic Ocean--North and South Atlantic both. We were doing that by towing midwater trawls and catching midwater fishes, mesopelagic fishes, the fishes of the upper thousand meters of the deep blue ocean. We were particularly interested in the fishes of one family, the family Myctophidae, the lantern fishes, which are fishes a few inches in length, called lantern fishes because they have a series of lights--luminous organs--along their sides, and often other luminous organs at the bases of their fins and even headlights--luminous organs--right at the front end, which can only be described as headlights, because illumination for seeing seems to be their purpose. Anyhow, this family of lantern fishes is quite a big family--about 80 species or so in the Atlantic Ocean. And we were fishing for these lantern fishes, taking them back to the lab, identifying them, and studying theirAtlantic-wide distribution. And on the basis of these distributions, the ranges of these animals, we were drawing a system of faunal regions, which were divisible into faunal provinces. We found a pattern of distribution for each species, some species being fairly narrowly distributed, some species being almost Atlantic-Ocean wide. So I suppose that's what one calls "zoogeography" or "biogeography," the science of how animals are distributed, and we were relating the distribution patterns of these fishes to the physical-chemical provinces of the ocean, if you can talk about them. We were relating distribution to the physical-chemical properties of the water.

TAYLOR: Let me ask you. I just want to interrupt for a minute and ask you this question. That's a big field. And you explain it in scientific terms. It's very clear. But when you actually have to go out and do it, any population species can be clumped, they can be random, then can be even. They can fluctuate vertically based on temperature or light, you know, all kinds of things like this. What kinds of things, as you're getting ready to go off on one of these expeditions, what kinds of things do you have to contemplate? Now I'm thinking of equipment, who you might be taking along with you or who you're going to work with--all of that sort of thing.

BACKUS: Right. The business of studying these little midwater fishes is difficult, and a lot of people that started out with it gave up on it for the very reason that you have put your finger on, that they are irregularly distributed both horizontally and vertically in the ocean, so that any one midwater trawl is kind of a rough sample, but if you make them over and over and over again, and you lay out your sampling pattern with respect to conspicuous physical-chemical boundaries in the ocean, it turned out we learned quite a bit. In getting ready to do this work, we of course had to have our gear well in hand. When we first started doing this, we had a pretty good net system, but we didn't have good information about what depth the net was at all the time. And we worked with Sam Raymond, who started the Benthos Corporation, and we were Sam's first customer. We told Sam what we wanted, and then we tested it for Sam. The first thing that we did was to get him to design and build for us a good depth recorder. This would be a device to be attached to the net that would tick away like a clock and continuously record the depth of the net throughout the length of the tow.

TAYLOR: Now is there some kind of formula you had to apply to that, because when the tow goes out, your cable is going to go out at an angle. Does that make any difference as to how the depth recorder worked, or . . . ?

BACKUS: It didn't affect how the depth recorder worked, but there were uncertainties about where the net was while you were fishing, and you might end up with the net not at quite the place you wanted it to be. That led to the development of a second instrument that we did along with Sam Raymond. That was a telemetering depth meter. During the course of the tow, that sent information from the net back to the ship about the depth of the net, so that we could adjust, during the course of the tow, the depth of the net, which has obvious advantages.

TAYLOR: You see, for us land-based people, the idea of not knowing exactly where you are every second doesn't occur to us. That's a common problem in oceanography. Where the heck am I, exactly?

BACKUS: Right, right. So gear was very important to us, and we had to provide spares of everything, of course, but with the passage of time, the gear got better and better, and we ended up knowing pretty much where the net was all the time, and that helped us.

TAYLOR: Did you have to crate this thing up and ship it off to the vessel, or is that something that the Institution does for you?

BACKUS: Generally speaking, a ship might leave Woods Hole and not come back for a year, or nine or ten months. During the course of that period, several different cruises would take place. I mean, there were would be several chief scientists, several aims for the work--might be a geophysicist one day, a biologist the next, and a chemist a third--not one day but on successive cruises, so that when a ship left Woods Hole it had to plan not for one cruise but for a series of cruises or legs of cruises. I guess one cruise is from the time a ship leaves Woods Hole till it gets back, but that cruise is generally divided into several legs. Each leg would be the responsibility of a particular chief scientist doing a particular piece of work. But there's enough storage space aboard the ship so that one can put his gear aboard before the ship leaves Woods Hole. Even though that gear won't be used for several months, it can be aboard the ship and ready for him when he joins the ship. Of course, there are always last-minute items that have to be shipped to the ship--replacement gear, a piece of gear that was difficult to develop and only got successfully completed at the last minute and got sent to the ship. That was standard practice that the Institution did very well.

TAYLOR: But somewhere in here, don't you have to have time to <u>try</u> all this equipment so that it's not a mystery to you when you get onboard ship?

BACKUS: That's right, depending upon what it is. After awhile our gear was pretty much tried and true, so that we knew it was going to work when we got to the ship. And we always had spares, of course, and made allowance for breakage and other kinds of damage. Planning for a cruise, of course, had to begin months and months before the cruise took place, and of course one had to apply for ship time as a piece of the proposal that he wrote to one of the funding agencies. Much of my work in studying midwater fish distribution and scattering layers, for instance, was supported by National Science Foundation. A proposal would be written which, among other things, would describe the nature of the cruise that we wanted to make, how many days it would take to accomplish the proposed work, and if the proposal were successful then the Institution would allot on the calendar of the various ships time to do that work. So a 50-day cruise took lots and lots of planning, well in advance, many months in advance of the actual execution of the cruise.

TAYLOR: Is this an individual thing, or do you do it in kind of a teamwork sort of thing?

BACKUS: Large parts of it are individual. The principal investigator that writes the proposal to the funding agency--if the cruise is going to consist mainly of his work, and he's going to be the

chief scientist, then the burden is largely on him. And that includes the methodology, how you're going to go about it all?

BACKUS: Yes, my group--I and the people that worked with me, for me--was a fairly small group so that it would have been difficult for us to accomplish the work of the cruise without enlisting a few extra hands. Even more important was keeping a ship such as *Atlantis II*, which is the ship and the cruise that I described in writing to you . . . . Keeping a ship like that busy all the time is very important. One doesn't want to just lie in the ocean waiting for somebody to get out of bed. You have to keep the ship productively occupied all the time, either working or going on to the next work site, so that I generally combined my work with somebody else's work. For instance, Vaughan Bowen, the geochemist, often went or sent his people on cruises that I organized, and of course he organized his part of it, but we found that his program and my program dovetailed rather nicely, and we were good friends with the people in that group. So we often enlisted other projects around the Institution to share the ship with us, even though we were getting the lion's share of the time. That's important to do because the ship is an expensive facility, and one does not feel good about it if it's not being worked every minute that it can be worked, and learning something all the time.

TAYLOR: It's interesting, it's an enormous amont of work, really, to get funding, to get your ship time. Then you stand the situation where you've got to hop on a plane and you're going to fly all night, and you're going to land in some unusual place, and usually a long other trip beyond that, pretty mind-numbing kind of stuff. Does that ever get old for you? I mean 50 days at sea is a long time. Is that you looked forward to? Or you'd say, "Oh my goodness!"

BACKUS: I always looked forward to it. And you get tired, but you never get bored on a long cruise in which you have primary responsibility. There's no getting bored. It's hard work, but it's fun. You do get tired. I always looked forward to it and loved it. I used to get very excited in the opening stages of the cruise--flying to join the ship and so on. I used to get wound up tight so I had trouble sleeping for a few days, but after awhile sheer fatigue takes over, and you collapse for a few hours, but it was great fun. A distinction should be made, it seemed to be me, between being a scientist (with a small "s," a common noun, a "scientist") and what we call "Chief Scientist," which is sort of an administrative designation. A good scientist--that is a person who is intellectually successul, asks penetrating questions, can design work to answer those questions--a successful scientist isn't necessarily a good Chief Scientist. A good Chief

Scientist is an organizer and has to make sure that everybody knows what's going on, that everybody knows what their role is and when they're going to play it. So a good Chief Scientist is an executive, which is not the same thing as being a good scientist. And that distinction is often not made. And furthermore it seems to me that during my tenure at the Institution, which was 35 years or so, I don't ever remember that the Institution in any sense that you want to use the word, that the Institution ever spent any time helping anybody to learn how to be a Chief Scientist. The upper reaches of the administration of the Institution never said, "Well, we'd better instruct people as best we can how to be a Chief Scientist." In only the vaguest sorts of general terms were the responsibilities of the Chief Scientist ever laid out. The responsibilities might have been laid out a little, but how to fulfill those responsibilities was never taught, and maybe there was never anybody to teach it. I mean, maybe everybody had a different idea of how to go about it. Some people went about it very well. Some people went about it badly. So that people's energies were wasted. Ship time was wasted. And morale on the ships was lowered because of disorganization. I don't mean to imply that this was the rule that such could happen and did occasionally happen. I don't know how much it happened, but as I say there was never any school for Chief Scientists. You had to learn it by doing it, and some people, I think, never learned it. And of course some people weren't Chief Scientist too often. You had to do it over and over again, I think, to get really good at it. But it all boiled down to a matter of communicating. Like in most human affairs, I've decided, the weak place is always communication, and poor communication means trouble. Good communication means success. And that's the way it was on the ship. If there was good communication between the scientific party and the ship's crew, things went well. Poor communication--bad news.

TAYLOR: Some ship's captains have told me in these oral-history interviews that they welcome with open arms some Chief Scientists and they welcome with sheer dread some of the others that were coming on, because some of them would almost run them over their own cables with their instructions, you know. Could you differentiate, for anyone who might be listening to this, what the difference is between a Chief Scientist and a principal investigator?

BACKUS: A Principal Investigator is the author of a proposal and is the number one guy on a proposal that goes off to one of the funding agencies. There is a Principal Investigator, and there may be associate investigators, but that Principal Investigator is a paper-pushing term. He's the guy that writes the proposal, sends it off to the funding agencies, communicates with the funding

agency about the proposal, is awarded the funds, including perhaps ship time, and he is responsible for fulfilling the obligations that are inherent in the proposal--the report writing, ultimately seeing that scientific papers result from an investigation undertaken. So he's Principal Investigator. "Chief Scientist" is an at-sea term--the person responsible for organizing the scientific party, giving such orders are as necessary for carrying out the work. So the Principal Investigator and the Chief Scientist are often one and the same man, but they're different designations for different parts of his role as a scientist.

TAYLOR: First of all, I would say being a Chief Scientist basically is an honor. Someone has said that you, Dick Backus, are capable of running the whole scientific show at sea, making sure that everybody gets what they're out there to get, and being a good liaison with the captain and the crew. Because once you're out there you're an island. There's no other little things you can pull in to make your day easier.

BACKUS: That's right. Well, I always thought of it as kind of an honor. On the other hand, sometimes the role just gets dumped on somebody for various reasons, and it may be kind of hard to look at it as an honor, but when you're let be a Chief Scientist, it's an expression of faith in your ability to manage things reasonably well and to see that that ship is well used. So, yeah, it's an honor.

TAYLOR: But you not only have to make sure that the ship is well used, but you also have your own program that you're working on. You're the Principal Investigator for your own program, as well as being Chief Scientist.

BACKUS: Right, right. Right, well you certainly look out for your own interest, that's for sure. But when the whole thing is well done, everybody's interests are protected, and everybody's given their chance. People do organize things in different ways. I always organized things so that the whole scientific party, in spite of the fact that individual members of that scientific party were attached to different projets, that while we were at sea together we worked as a unit--that is, we worked to help each other accomplish each other's work. So that, I always felt, was important for getting all the work done, but also it's friendlier and more companionable for everybody to help everybody else.

TAYLOR: It's somewhat like being a head coach, isn't it, in a football team? You got to make sure the team operates well. If you do, you win. If you don't, you lose.

BACKUS: Yeah, I don't know much about football, but that sounds right to me, yeah. Yeah, yeah.

TAYLOR: Generally speaking, then, being a Principal Investigator and a Chief Scientist must give you the equivalent of a 28-hour day and an 8-day week, or something like that.

BACKUS: Yeah, the thing about working at sea is if you're going to keep the ship occupied and working you work around the clock, so there's always something going on. Things may be a little easier when the ship is going to steam for a number of hours to get on to the next place where work is to be done, but even then I always maintained around-the-clock scientific watches so that the echosounder, which gave us so much information about the ocean--about scattering layers and the water column, and of course ocean depth. We ran the echosounder 24 hours a day, and that meant a watch to keep an eye on that gear and to mark the records, and so on. But there was always something going on, so it's easy to find yourself short of sleep if you're interested in a lot of different aspects of the work, or if you are responsible for keeping it on track. It's easy to get short of sleep. But you can sleep any time you've got a couple of hours to do it. It's not an 8-5 job. It's from midnight to midnight, and you don't make too much distinction between noon and midnight and 4 o'clock in the morning and 4 o'clock in the afternoon in terms of work ongoing. There's always something happening.

TAYLOR: Did you ever feel that you just wanted to go into your cabin, bolt the door, put a big "Do Not Disturb" sign on the outside, and just kind of sit there and vegetate for awhile?

BACKUS: If you were Chief Scientist you couldn't put up a sign saying "Do Not Disturb," because at any time somebody might need your ear. And it didn't matter when. The Chief Scientist often gets his telephong rung, which is right next to his head in his bunk, gets his telephone rung, or somebody pounds on the door to tell you that thus-and-such unforeseen event has taken place which requires some rescheduling or decisions made of some kind. So you can't put a sign on your door saying "Do Not Disturb." That's one thing a Chief Scientist can't do. And generally, although I was often tired, I was always interested in what was happening, so I really didn't ever want to put up a sign saying "Do Not Disturb." It's too exciting, what's going on.

TAYLOR: But the few moments you do have that are going to be yours, what kind of things do you bring onboard, for your private time? Looking at what your responsibilities were, I might have brought a gallon of Jim Beam.

BACKUS: The rules have changed. I guess alcohol is not allowed on the ships at the present day, if I understand it correctly, but during my seagoing days alcohol was OK. It was rarely, rarely abused. That's a dangerous substance, there's no doubt about it, but I always brought along a little booze, and of course we went to a lot of places where there was good booze to be had. On *AII* cruise 59, that started for us in Madeira, why we took aboard some madeira, of course. Most people think of madeira as a sweet fortified wine, but there is a very dry madeira, Cercial, which is drinkable at any time, nice and dry. Often the scientific party or parts of it would gather for a drink just before dinner, and sometimes those were planning sessions or information-exchanging sessions. So they were productive as well as enjoyable.

TAYLOR: You know, it's hard. When you're out at sea like that, there has to be something that gives you--for lack of a better term--that taste of home, that taste of civility, of a gathering, if you will.

BACKUS: Right. Alcohol is a dangerous substance, and I wouldn't argue with the Institution's rules that make that wrong now, but there was the plus side of a little alcohol.

TAYLOR: Also, good food is important, isn't it?

BACKUS: Good food's important. Another great amenity aboard ships was the library, which really gets hard, hard use. A library can't be big enough or good enough, in my estimation. Food is an interesting thing. Food on the Institution ships, with a few, short-term, minor exceptions, was always good. It was sort of unvarying. Different stewards did it different ways, I guess, but it was common for the menus to be kind of on a week's cycle so you could tell it was Thursday noon by what you had to eat. I have no complaints about that. The food was terrific, and there was always more than you could eat. Most people thought, I think.

TAYLOR: You write very well about doing this mind-numbing trip and then taking a 600-mile ride to get to Madeira to pick up all these duties that we've been talking about, and yet you comment on the flowers, and you comment on the scenes you see, so that's an important part of it too, isn't it, being in different locations of the world, and seeing different ways of life.

BACKUS: Yeah, oceanographers really do tend to get around. Of course, intercontinental travel is a common thing now in a way that it wasn't 50 years ago, and lots of people travel on their vacations to another continent, but 50 years ago people were impressed when oceanographers just kind of offhandedly said, "Well, when I was in Capetown last month such and such."

Oceanographers didn't think anything about it, people that heard them tended to be impressed by the urbanity of oceanographers so far as travel went

TAYLOR: See, we came from that generation, if you wanted a safari jacket you had to go to Kenya or South Africa. You couldn't get it at Banana Republic, or you couldn't get it at the Gap or something like that.

BACKUS: Right.

TAYLOR: So there was something really unique, and that had to be part of the appeal of the whole job.

BACKUS: It certainly was. The travel attached to it all was fun. I never liked the feeling that I would get when I'm a tourist, particularly, but when you were going some place in connection with your work, your feeling about it was quite different. You didn't feel like a tourist when you flew to Belfast to join a ship and come back across the Atlantic. You didn't feel like a tourist. You felt like--what did you feel like?--and international traveler and worker.

TAYLOR: But you saw something that was an extension of home. I mean, the vessel was there, and you'd seen it at the dock here at Woods Hole, and now you're seeing it over in Belfast or Madeira or wherever it happened to be. And that's a little sense of something familiar. I'm going to my work place.

BACKUS: Yes, that's right. Yeah, I also had kind of a weird feeling when I joined the ship in a foreign port when I first laid eyes on her, lying there at a strange dock in a strange place where I'd never been before. Here was this familiar object that was going to be my home away from home, and here she ways, in completely foreign surroundings. It always was a . . . . Couldn't quite believe it. It was a strange feeling for a few minutes.

TAYLOR: But kind of a warming feeling.

BACKUS: Oh, yeah, you liked it. It was great being in a foreign place instead of having to live in some weird hotel that you know nothing about. It's great to be living in a foreign place in a ship that's wholly familiar to you, or a hotel that's wholly familiar to you.

TAYLOR: You went out with John Teal, didn't you?

BACKUS: On this memorandum that I gave you a copy of, I wrote this piece called "Living and Working at Sea" as kind of representative of what it was like to go off for a few weeks on one of our ships and do this particular work that I was interested in, this zoogeographic work in connection with mesopelagic fishes. I wrote this memorandum as . . . . I always thought it

would be part of a book sometime, maybe, about life as an oceanographer. That particular cruise, which was one of a series over a decade, involved flying to Lisbon and then going on to Madeira to pick up the ship. And yeah, it's kind of accidental how not everybody ends up on the same airplane on the same flight, getting to the ship at the same time. I don't know why it works out the way it does, but on that particular flight it was John Teal and I and a guy named Sam Simkins, who worked as an electronics technician, who worked for a guy named Paul MacElroy[SP?]. We ended up on the same flight to Lisbon, and then we killed a few hours at a restaurant in Lisbon, and then flew on to Madeira. Teal is somebody that you should talk to, if you haven't already.

TAYLOR: And his wife.

BACKUS: Susan Peterson, yes. But Teal is a great friend of mine and often went on cruises with me and made various physiological observations on midwater animals that he took out of the nets that we were towing.

TAYLOR: Ok, this crew got to Madeira. You mention meeting someone named Jerry MalL[SP?] and Pedro Dafranca[SP?].

BACKUS: Yeah. Jerry Mall[SP?]--I think his name was Gunter Mall[SP?]--he was an expatriate German who ran the museum, the Museo do Funchal, the museum in Funchal . . .

TAYLOR: Another good wine, incidentally.

BACKUS: . . . the museum in Funchal, which is the principal city of the island of Madeira. I'd known about Mall[SP?], had correspondence with Mall[SP?] for some time before I actually met him on this particular occasion in Madeira. Teal and I went to the museum on the morning after we got to Madeira, went to the museum and met Gerry Mall[SP?], and there was a guy there named Pedro da Franca[SP?], who was introduced as a Portuguese fisheries biologist, a guy I didn't know anything about or had never

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BACKUS: Gerry Mall[SP?] and Pedro da Franca[SP?] and Teal and I went out to lunch together in Funchal and during the course of the lunch it came about that Pedro da Franca[SP?] was going on the cruise with us, which I didn't have a clue about, but when Institution authorities had made application to the Portuguese government so that we could do work in Portuguese territorial waters, the Institution invited the Portuguese government to send along a Portuguese observer, and that was this guy Pedro da Franca[SP?], but nobody had ever told me that he was going, and

I felt like a fool when I asked him. He didn't have much English, and I didn't have much Portuguese, but anyhow I asked him how long he was going to be in Madeira, and Gerry Mall[SP?] said, "He's going on the ship with you!" Oh well, no harm done. We did have a bunk. But the poor guy was on the ship for several weeks, from Madeira to the Cape Verdes, and there was only one other Portuguese speaker, as it happened, on the ship at that time, and that was Joe Ribero[SP?], the steward.

TAYLOR: Ol' "Ribroast."

BACKUS: Joe Ribroast. I have no idea how Joe Ribroast might have explained various things to Pedro da Franca[SP?] asked Joe Ribroast what was going on in terms of science at hand. But anyhow, Pedro da Franca[SP?] seemed to have a good time and so that was OK.

TAYLOR: That's interesting, because it's one of the little curve balls that a Chief Scientist gets thrown every now and then. Most people probably don't know this, but you can't just sail into someone else's territorial waters and set up shop, and sometimes there are little tradeoffs that you have to make in order to get that kind of permission.

BACKUS: Exactly so, and the tradeoffs are generally pleasant enough, as they were in this case. Even though we couldn't talk to each other very much, I enjoyed having Pedro da Franca[SP?] on the ship. As I say, he seemed to have a good time.

TAYLOR: Did he have any specific purpose at all?

BACKUS: Nope. Just wanted to see a modern oceanographic vessel at work, I guess. Yup. And of course he was interested in seeing what came up in our nets. Yeah.

TAYLOR: When you're going off--the whole thing was this geographic distribution of pelagic animals. Was there going to be some kind--you're probably going to hit me on this--a practical application of this as opposed to pure knowledge? Because I think back to your initial work with deep scattering layer, that had some very strong military applications . . .

BACKUS: Yeah.

TAYLOR: . . . and importance.

BACKUS: Well, interestingly enough, yeah, there were practical applications, and I never succeeded (mostly, I suppose from usual lack--lack of time, lack of patience, lack of cash, lack of energy) . . . . I never pushed it to its logical conclusion, but I think I helped it on its way, and I think it's been picked up on by others. But in connection with sound scattering and submarine detection and ambient-noise studies and so on, it happened that there was a Canadian who was

studying the geographic distribution of reverberation intensity or sound-scattering intensity around the ocean, and he compared his sound-scattering strengths with my conclusions about faunal regions and provinces for a limited part of the ocean, but found that there was a pretty close linkage between my zoogeography and acoustic properties of the ocean which relate to military operations.

TAYLOR: Communications, I mean there's all kinds of ramifications for that.

BACKUS: At the time I retired I was still kind of making noise about . . . . I said that these faunal regions and provinces that we had sketched out on the map, based on the distribution of these fishes were also what I called "operating regions and provinces" that, when a naval vessel crossed a boundary between one of my faunal regions and another, he could expect a change in reverberation conditions. But, as I say, ...

TAYLOR: That must be incredibly important now, to submarines.

BACKUS: Well, yeah I think it's important, but I just don't know whether the linkage was ever sufficiently strongly made so that the charts that we drew based on lantern-fish distribution were really taken and run with in terms of translating them into what I could call "operating areas," that is, functionally useful to a skipper of a destroyer or submarine or whatnot, in anticipating a change in sound conditions in the ocean, principally sound conditions based on the scattering of sound or reflection of sound by animals in the water. So there was that connection which was recognized in the Office of Naval Research and other places.

TAYLOR: And I would think, you know, as distribution of food sources for certain kinds of animal life in the sea and things like this, particularly now, with all the problems with fisheries depletion and all that. I guess the point I'm getting at here is that when this cruise took place in 1970, the Institution was only 40 years old at that point, and we had gone from the point of a biologist putting a dip net in to see what he came up with, to someone like you, who, in the early '50s, started to think about bouncing sound waves off biological critters to try to make an identification of what they were. So they were kind of steps on the way to doing different things.

BACKUS: Yeah. One of the things that everybody was interested in was refining echosounding equipment for the purposes of locating aggregations of commercially important fish, and we never did too much work directly related to commercial-fish finding, but we certainly worked on a lot of sort peripheral aspects of that problem. And of course, after awhile fish-locating

equipment got so good that it was one of the reasons that we've caught all the fish in the ocean--was because acoustically-based apparatus for locating fish got so good, so good.

TAYLOR: See, what's so important about this is the average person that's going to listen in to something like this still thinks of a thermometer as a physical thing that you actually, through conduction find out. They don't know that electronics plays roles in this now, that fish identification through sound, and things like that. They see these nice beautiful little charts in schoolbooks, and things like that. Like, if we were going to study the mesopelagic fish with you. In a schoolbook, I would see a beautiful little illustration, 14-5, "Mesopelagic Fish," and boy it's going to be confined in that thousand-meter area. It's going to be beautiful, and there's going to be no vertical change in where the little critters are, and there's going to be no clumping or random or even distribution, or anything like that. So, when you go off on an expedition like this, you have to deal with all these things in the natural world. You don't always get--in fact you never get--beautifully pure, just textbook kinds of things. You've got all kinds that come in together.

BACKUS: Right, right.

TAYLOR: So what are some of the frustrations of this, of trying to collect your stuff and make your identifications and all that?

BACKUS: Well, the deep ocean varies a lot from one part of it to another so far as how much life there is in it. Some places like the Sargasso Sea are famously impoverished as far as any life goes, with the exception of the stuff that one finds in Sargasso week at the very surface. But there are places in the deep blue ocean where there is scarcely any life at all, and other places in the deep blue ocean where there's a whole lot of life. It's a lot easier to study a place and learn something about it when you catch a whole lot than when you catch practically nothing, so one of the frustrations in our work was in the poor parts of the ocean. We knew there were parts of the ocean that were equally poor but still different from each other, so that studying those differences between different but poor parts was difficult, because you couldn't catch enough stuff to help you learn about what was characteristic of that part of the ocean. So by and large, of course, the net that we towed was quite a small net. Let's say the area of the mouth was 60 or 70 square feet. I don't quite remember--not a big net--but say it had a mouth of 60 or 70 square feet. We would tow it at 2 to 3 knots, and we would tow it for a couple of hours. And the stuff that we ended up, except in the very richest parts of the ocean, in an average part of the ocean,

what we caught from towing such a net for a couple of hours would be held in a kitchen-sink washbasin, not very much stuff. Most collections that we made we pickled them in two-gallon jugs. Most of that would be preserving fluid.

TAYLOR: 'Cause not only were the critters subject to temperature, light conditions and things, but they move too. I mean, I understand some of 'em can move up to speeds like 16 feet a minute or something like that.

BACKUS: Sure. For the most part, in this little net that I've crudely described, we caught mostly small stuff. I mean, something six inches long would be on the big side. Occasionally we caught big things, but they always came as great surprises. They were rarities. So any fish that could move rapidly and see what was going on could get out of the way of our net pretty readily. But this family of fishes we based our zoogeographic studies on were . . . . I'd say there were about 80 species Atlantic-Ocean wide in the family. They were small fishes, and we caught them rather well with the gear that we learned, so we could learn about the ocean from them.

TAYLOR: One of the things that I wondered about: when you pull up a net, you're going to get a very wide variety of critters in there. How do you decide which ones you're going to put your energies into? How do you decide, "This is the one that's going to give me the answers to what I want to do here?

BACKUS: Right, well we did catch a great variety of things, and ultimately all the fishes were saved and went to the Museum of Comparative Zoology at Harvard for permanent keeping. We ourselves spent most of our energy on this one family. The first thing we would do would be to pick out all of these Myctophids, as they're known as. (The family is Myctophidae, the lantern fishes.) We would pick out the lantern fishes and sort them into the various species. And there might be 12 or 15 lantern fish species in any given net haul. So sorting them out and counting them, measuring them and identifying them to species was the primary data upon which we based our conclusions about how things were distributed in the Atlantic pelagial. Other people ultimately looked at the other fish species. Of course there was a big invertebrate-animal remainder of shrimps and copepods and jellyfishes and salps and other invertebrates. Some of those were utilized by others, but much of those invertebrate remainders still sit in the original preservative, in the original jar which they were pickled in, unfortunately. The Atlantic-Ocean wide collecting that we did stretched from Iceland and Newfoundland and the Norwegian Sea south throughout the Atlantic all the way to a line between Buenos Aires and Capetown. We

didn't go to the southern Ocean. Then we went also into the Mediterranean and into the Gulf of Mexico and Caribbean sea, so we did that over the course of about a decade. Each cruise that we made was designed in a way to study a particular piece of the total puzzle. We sampled widely, but of course quite thinly. But were able to plainly see patterns of distribution, so that sense we were successful.

TAYLOR: Did you ever have things come up on those nets that you looked at and said, "What in the heck is that?"

BACKUS: Oh, all the time. Of course, generally there would be somebody some place on the face of the earth who was a specialist in that particular kind of organism, that particular family of fishes, perhaps. But we often found things that were new species, meaning species that zoologists had not described and given names to before. One particularly interesting fish . . . . Well, one night somewhere north, I can't remember where. Maybe it was off Norway or . . . . We came up with a huge jellyfish in the net. And this posed a real problem. We could hardly get the . . . . This thing was so big that we could hardly get the net out of the water. I suppose the jellyfish was probably five feet in diameter, maybe, and it weighed several hundred pounds. We had a terrible time getting the net on deck without destroying the net. There was no way to get this jellyfish out of the net before we pulled the net on deck. But anyhow we finally got the net and jellyfish on desk. We found a weird fish, about eight or ten inches long in the net that we hadn't seen before, and then someone said, "Ohhhhh, this is the same thing we got the last time we had a humongous jellyfish in the net, and that was down here off New England, towing an experimental midwater trawl that we were fishing with, off *Captain Bill III*, a local fishing vessel. And this is a fish of a family that lives on the bottom of the ocean, and this was a weird fish, apparently, as near as we could reconstruct it, looking at subsequent records of this fish, was always found in association with this jellyfish, and it's a bottom living fish that finds the jellyfish bottom enough to live on. It lives somewhere inside the jellyfish, somewhere inside the skirt of the jellyfish, or . . . . So we did get weird and wonderful things fairly often.

TAYLOR: Did it ever make you say to yourself, "Oh, I wish I had the time to research that?"

BACKUS: Oh, yeah. Yeah, there were lots of wonderful things that we couldn't follow up on because they were too peripheral to the main part of our work.

TAYLOR: But you know, as I read the things you have written, it really impressed me that, besides very specific in what it is you were looking for, oceanographers have always been

generalists. You commented on birds. You commented on different kinds of fish that you weren't particularly studying, flying fish, for example, and so forth. So you're very aware of everything that goes on in the whole environment.

BACKUS: Right, yeah. I think it's all such good stuff to look at. You can't ignore it. It's too handsome and too lively. And of course on the ocean there's a lot of just water, so when something comes along you're apt to look at it and enjoy it.

TAYLOR: Well, some of it you even kept, didn't you? You kept kind of an aquarium onboard.

BACKUS: Yeah, well on the particular cruise that that memorandum describes, we had a particularly good aquarium set up that time, better than we had before or since, I suppose, in which we managed to keep some fishes that were collected in shallow water quite early in the cruise. We kept them for the duration of the cruise, and some of them were turned over to the New England Aquarium at the end of the cruise. But that's hobby stuff. That's [laughingly as Taylor laughs] . . . .

TAYLOR: It's beginning to sound like the whole oceanographic field is your hobby, besides paying you a salary.

BACKUS: Right, as Dr. Bigelow, the founder of the Institution, said, "I went out there and had fun and got paid for it."

TAYLOR: While you're collecting all this there are so many ramifications. How did you know in this aquarium you weren't putting in some fish that would cannibalize all the other fish that you had in there?

BACKUS: Well, that's a chance you take. But generally speaking you can identify the bad actors either beforehand or on the basis of a very little experience in the aquarium. But aquarium-keeping is a lot of fun, as people who do it know. And we did see some interesting things in that shipboard aquarium. The aquarium that we kept going was a cube about 30 inches on an edge, maybe. So it was a nice spacious aquarium, with viewing ports around the sides, and of course you could look in from the top, but looking through the plate-glass ports on the sides gave you the best looks at the animals that were inside. And we were running fresh seawater through it all the time, and even when it got . . . . I don't remember whether we had any provision for warming any of this water. These were subtropical fishes that we mostly had in the aquarium on that occasion, and we got back to Woods Hole in December on that cruise, and the water was getting pretty cool back here. I forget how we kept the fish alive. I guess we shut

down the exchange of water pretty much, and aerated the aquarium some other way than just by circulating fresh water through. Anyhow, aquariums are great fun.

TAYLOR: And you had one right onboard ship.

[TAPE STOPS AND STARTS]

TAYLOR: We were talking about the aquarium onboard ship. In reading your notes I was just so impressed with the fact that you have a specific thing that you're interested in, but you're all basically really environmentalists. I mean, you're so into the whole environment. Now, we've talked quite a bit about what your duties were as the Chief Scientist, and we just spent quite a little bit of time on what your duties were as a Principal Investigator, essentially, in looking for your mesopelagic fish. There's another factor that you have to take into consideration here. You've got a vessel that you're working on, and those vessels were not designed specifically to be biological stations. They don't sit in a nice flat millpond all the time. So could you comment some on the importance of people like bos'ns and things like that, and the need for a Chief Scientist to be able to work well with someone who's a bos'n or other crew members on a ship?

BACKUS: Yeah. Of course there were lots of things that the ship's crew is much much better at than the scientific party, and these, largely, I guess, have to do with gear handling, getting perhaps heavy objects, or delicate objects off the deck of a heaving ship and into the water, and then back out again without destroying the gear. So one counts on the ship's crew for help in things like that, and I always got great help from the ship's bos'n and crew members. It's important to have a good relationship with them. That's always easy, 'cause they for the most part are interesting people and good guys. It's true that a ship's laboratory is a special kind of laboratory, because it's not holding still, so you've got to make sure that your gear is well secured against the motion of the vessel. And that's what the design of an oceanographic . . . . Let me back up. We started out with ships that were not designed to be oceanographic ships, with the important exception of *Atlantis*, which was designed in 1930 for oceanographic work of that day. And of course, over the period of a couple or three decades it got behind, so far as being a good platform for oceanography. But one of the interesting demands on a ship specifically designed for oceanography . . . . Let me back up again. We used a variety of ships that weren't designed for oceanographic vessels, and we learned a lot from what those ships lacked as to how modern oceanographic vessels ought to be designed. So that when the day came to design another ship from the bottom up for oceanographic work, we'd learned a lot. A

principal demand of an oceanographic vessel is that it has to handle a great variety of work, from a coring apparatus that a geologist wants to lower into the bottom to a delicate plankton net that a biologist uses, to large-volume water bottles that chemists want to use for studying trace elements. A great variety of activities have to take place, so that the mission of a vessel changes considerably from cruise to cruise to cruise to cruise, so that there's little in the way of permanent equipment aboard ships beyond basic gear like computers and echosounds and navigational instrumentation, so that at least in my time--and I've been retired for a fair while now, 15 years--an oceanographic ship's laboratory was basically a big empty space with elaborate provisions for fastening things down so that instrument racks, benches, all kinds of furniture could be moved into the laboratory and bolted to the deck and bolted to the overhead, and bolted to the sides of the space. I forget exactly what the spacings were, but for instance on the deck of *Atlantis II* I think there was a 3/4-inch bolthole every two or three feet all over the deck of the laboratory, so that no matter where you were and you wanted to fasten something down you could back the bolt out of its bolthole and then, using that bolt or whatever suitable fastener, you could bolt to the deck rigidly whatever sort of furniture you wanted to bolt down. And the same with the overhead. There were boltholes in the overhead. I call them boltholes because that's what they were more than bolts. They were boltholes, always with a bolt in them so that they didn't get filled up with dirt and made unusable. I haven't been much on oceanographic vessels of the present day, but I suppose there's still that way with respect to being able to fasten down anything any place on the ship, 'cause ships do move, and just because you're working on some (to you) important problem does not mean God will spare you so far as not rolling your gear off the bench top onto the deck and smashing it.

TAYLOR: And that's in decent weather.

BACKUS: [Laughingly] that's in decent weather, right. That's right.

TAYLOR: Now this is going to sound very trite, and I don't mean it to be that way, because in any corporation now there's a whole hierarchical structure, and almost all of the CEOs say, "Call me Sam" now. You know how it is, but on a ship, Chief Scientists, Captains are big deals on the ship, but it really has to be a very democratic kind of situation. You've got to be able to get along beautifully and not lord it over anyone.

BACKUS: Sure. It's true of human relations. It's the same as human relations every place. Some people are better at getting along than others. I suppose it's not much different at sea, with

the exception that you're thrown together more, perhaps, at sea, because there are a lot of you, and the spaces are not large, and you see each other morning, noon and night, eat with each other. Some, at least, share sleeping spaces, and so on. So a very intimate contact with people when you're at sea, more so I guess than ashore. So it does sometimes put on a strain. But basically it's still people dealing with people. 'Course for many years, it was men dealing with men, not people dealing with people, but men dealing with men, because for a long time women didn't go to sea on oceanographic ships.

TAYLOR: OK, we're going to get into that, because I've heard some interesting things on that. But let's finish up with this cruise first. When you're onboard with someone like John Teal, who's noted in his field. It's not the same as yours, but it's related to yours. Did you guys ever sit down and discuss similarities, things you saw, idea that he had that you might not have thought of, or vice versa? When you've got a couple of biologists on board, how do you interact with each other? Maybe that's a simpler way of asking it.

BACKUS: Well, you certainly talk with each other. And the animals that you see certainly stimulate talk, and your sort of common admiration for a particularly handsome fish or a jellyfish or a bird or what-have-you stimulates talk, and that leads to what to one person may be a novel observation, and it leads to ideas and sure. So biologists, whatever their slant, and chemists too, on the cruise, on that *AII* 59 that I've given you the description of, the principal other work was chemistry, and biologists and chemists can share a lot and talk to each other a lot and have quite different ideas about certain aspects of the work. On that particular cruise we were looking at certain pollutants in ocean animals, so that necessitated as well as stimulated exchanges between chemists and biologists.

TAYLOR: Now that might have an effect on your geographic distribution. If some area near where I live becomes polluted, I stay away from that area. Is the same thing true with your critters?

BACKUS: Sure, but the ocean is such a big place that except for certain coastal . . . . What I'm about to say, I suppose, gets less and less true, and I'm not up to date on these things, but the ocean is such a big place that it's hard to pollute, but it has been polluted particularly at the surface, where one sees remnants of floating oil, tarry remnants of oil. But the pelagial, the high seas, the deep blue ocean is relatively unpolluted. The point has been made that it's slow to pollute something so big, but once polluted it would be very difficult to clean it up again,

because it's so big. But ocean pollution has mainly been a question of shoreside, coastal water pollution and didn't affect my work, with the one exception of . . . . We towed surface-skimming nets. At the same time that we towed our midwater trawl, we towed nets that rode at the very surface and skimmed off whatever was in the very top three or four or five inches of the ocean. There are some animals that characteristically live there. The net that we used for that purpose got fouled after awhile with tar, which is the result of tankers washing their tanks and discharging a bit of oil onto the surface of the ocean. But the chemists were looking for subtle forms of pollution that were not . . . . Well, I'm getting into grounds that I don't know much about. They were looking for some subtle forms of pollution that most people wouldn't notice and could only be detected by elaborate chemical means. Those didn't affect my work, but they were important for seeing what was there in the way of midocean pollution that might not have been noticed.

TAYLOR: It's interesting that when Thor Heyerdahl made his first *Kontiki* trip, and then a couple of decades later made the *Ra* trip. One of the things that people asked him was had he noticed any difference, and he said the biggest difference he noticed was that in the second trip not a day went by where there wasn't oil tar flowing through the water. And he said that just was not the case during the *Kontiki* expedition.

BACKUS: Um-hmm.

TAYLOR: So even though the ocean is awfully big, your point is well taken. It would take a long time to take and pollute it.

[END OF SIDE 2, TAPE 3]