Frank Taylor: We are at the Woods Hole Oceanographic Institution for our second session with Dr. Donald Anderson regarding his life and his career. Don, during the first session, we started out with where you came, the numerous moves that you made through the course of your life, your formative years in Marin County, and how you happen to end up going to the college or a university that you went to. I was particularly, actually, really touched – having been a fraternity member myself – with the way the fraternity at MIT worked with you to make sure that you are not only a brother, but you were successful in your endeavors. That really intrigued me. That is what a fraternity is supposed to be about.

Donald Anderson: I agree and that's unfortunately not the image most fraternities have around the country, but certainly at MIT that was the case. That is the case. They are a different type of brotherhood than the ones that just there into partying and everything that's social.

FT: Well, when you said it, you almost had an apologetic look on your face that you had joined a fraternity.

DA: You're right. It's a bad word to most people. Most people say, "My god, there's nothing but just crazy activities and hazing and drinking and partying." But I will say it again and again that fraternity not only helped me figure out how to study at MIT and how to get through those very difficult early years, in particular, academically, but they also helped me socially. It's not that they didn't have parties and so forth, but it was all balanced. In my year, they taught a number of relatively socially inept young kids how to interact with others, as well as others, how to interact with women or girls. It was all an important part of life.

FT: Well, one of the things that frightened me a little bit as a teacher, looking back at years of the need to evaluate young folk, had they not given you that help? This will embarrass you, but we may have lost a world leader in a specific field and that is kind of scary, particularly for an ex-teacher.

DA: I've thought about that a lot. That everything swings on a decision here or there, and that one helped me developed had that not happened. I sort of jokingly said that there are people at MIT who can just travel through the tunnels of basement quarters all over the place and never sort of come out and see the light of day, and that's a terrible generalization. But it's sort of like you can get caught up in the world where the only thing you do is sort of your academics and you lose a lot of social development, and that could have been me.

FT: Now, you successfully completed MIT, actually, more than successfully. At a certain point, you ended up at the Woods Hole Oceanographic Institution on a postdoc. At the end of the postdoc, you applied for a position here at the institution that really did not fit your background. I was talking about Blue Water. Now, for someone who listens to this and does not know what we mean by a Blue Water Institution, we are talking about the ocean deeps. We are not talking about coastal kinds of things. You did not get that position to start with. But a little bit later on, a person who was very prescient in many ways said, "You are not Blue Water, but what you are working on is going to be really big and really important. So, why do you not reapply?" [laughter] Now, what that brings us up to is the idea that you have started to investigate what we generally call red tide. That is something we see in the newspapers. Sometime during the summer, I am going to see something in the newspaper where salt pond has a bloom or something like this. It is interesting, Don. One of the things I discovered in talking to general public, catch words like they do not even use the term climate change. They say global warming, red tide, things like this. There are a lot of misconceptions out there. My feeling is that one of the things that we should be doing in the scientific community is educating the public, so that they can make a good choice even in things like boats. So, I would like you to do is to really explain so that someone can understand in a kind of a basic level what the red tide is?

DA: There certainly are misconceptions there. The word comes from a number of events that have happened historically, and in places like Florida are probably the best example where, in fact, the water does turn red. There are a lot of negative impacts that occur. This is all caused by these microscopic algae, tiny cells, you can barely see them with the naked eye. If you hold a culture of seawater up to the light, you just barely see them. So, they're like the size of the sharpest point of a pin. But if you get enough of them, and when these cells grow – they're little plants so they photosynthesize. They grow, they become more numerous. As they become more numerous, then their pigments, the ones that they have to harvest sun's energy which are in the sort of brownish red in a lot of these cells, they become more numerous, they start to change the way that water color appears, so it actually starts to look brown and muddy or it can be reddish depending on the species. So, if you get enough of these cells, all of a sudden, you can look out there and see the water being a different color and, again, a very alarming color sometimes and that, by itself, is not necessarily bad. That's one of the problems with the term. There are many red tides that are harmless. In fact, most of them are harmless. So, when somebody sees the water and it's red, you don't immediately worry. You say, " This is perhaps cause for concern." But as I said, again, there are tens of thousands of species of algae in the ocean, and many of them can bloom and cause the water to be changed its color. But only a few, let's say, less than a hundred are going to be harmful or even a smaller number than that are toxic. So, you can have read water, it can be harmless. But then there are situations where the water can be red or brown, whatever, and dangerous because of the toxins that these little, microscopic algae produced. Now, those toxins can either kill fish right there in the vicinity of the bloom. Fish that either swim through the bloom or that the bloom encounters as it moves around with the currents. Those toxins can accumulate in shellfish. Shellfish filter feed. They filter large quantities of water and remove the algae as food.

FT: Did they become kind of like the canary in a mine for folks like you?

DA: Canary in one sense, but not in another. They are an early warning sign in a sense because – well, mussel is the best example. Mussels filter huge amounts of water and become toxic very quickly. So, they would be like the canary. In that way, they would warn you. If you test the mussels, that's where the analogy breaks down because they're really not affected by this toxin. So, it's not like the canary that dies as your early warning. The mussels will continue to look healthy, but they do contain the toxin. They have concentrated it so that you can find it, whereas it might be harder to test in the water itself, or it isn't any more. But used to be hard to test in the water to see if there's toxin present. You needed the shellfish to accumulate it for you. But in any case, the shellfish will take all this large amount of water, filter the algae, and the toxin then is retained in their tissues. As I said, with little or no effect on the shellfish themselves, they then become little poisonous pills, if you will, and an unsuspecting consumer comes along and will eat those shellfish and can get very sick or even die from those accumulated toxins.

FT: What might be the symptoms of poisoning from?

DA: That they're all quite different with some similarities. The one we have up here in New England, the easiest symptoms to remember are the fingertips start to tingle and your lips will start to tingle. Then you'll have difficulty breathing and you'll have a little bit of disorientation and so forth. If you're poisoned severely enough, you literally lose your ability to breathe and that's what can be fatal. The intervention would be then artificial respiration, someone breaths for you, or an iron lung or something like that. Because the toxin has literally stopped your nerve's ability to function and certain nerves drives the breathing of your diaphragm and so forth. In Florida, it would be a slightly different kind of manifestation because it's a different toxin, and there's different ones. There's some that we still call toxins, but they don't kill people. They will give you gastrointestinal problems, diarrhea, and so forth. There's a whole suite of these. But here, you've got algae of different types being eaten by shellfish that accumulate these toxins and are then passing those toxins along to consumers. You also have situations where, as I said, fish can die or other marine animals, seabirds, and so forth, can die from these outbreaks. But the part that's important to realize is that many is the time – and I'd say it's more often the case, that the water is not red or discolored and yet there are still these toxic algae present in concentrations that are not enough to change the color of the water, but more than enough to cause problems and a threat to health. Because the toxins they produced are so poisonous, so strong, that it doesn't take very much of it to become dangerous. So, that's where the word red tide is truly misleading. We have situations where the water looks very blue or green and looks safe, and yet the shellfish there would be lethal. You have a situation where the water can be discolored and caused fish kills or caused shellfish to be poisonous. But there are also many situations and, in fact, I think most often in certain parts of the world like this one, where the water can be very blue and look totally safe but it still can be very dangerous. Because there's sufficient concentrations of cells, these toxic cells in the water, and they produce such potent toxins, that it doesn't take very many for shellfish to become poisonous or to have some other impacts. That's why the terms are misleading because people will think that situation is safe. The red tide is there, but they don't see red water so I'll eat shellfish or I'll do this or I'll do that. We just had a situation last year where some people in Maine, they've been living with the red tide their whole lives. They know about it. They knew the area was closed, but they went out to the head of this harbor where the ocean was clean, and so forth. Their argument was, "Well, we thought the water was going to be much cleaner out there, and therefore, there wouldn't be a problem." They got very sick and nearly died. So, that's another misconception too. Some people think the red tide somehow is related to pollution as if it were sort of bacteria or something like that. It has nothing to do with that. If these are algae, pollution can sometimes stimulate them to grow more abundantly, but you don't need to have polluted waters to have a red tide. Some of the most dangerous situations in the world are in the cleanest waters in the world, in Alaska, or down in the Puerto Arenas in Chile. There are shellfish that are so poisonous that a single clam would kill a human being and their waters just as clear as it could be. So, it's just the term is misleading. So, scientists tend to say harmful algal bloom or H-A-B or HAB as one effort to have a term that encompasses all of the phenomena that we study. That would include situations where the harm is the mortality of fish or whale or sea lions or something like that. Where shellfish become toxic, where there are just blooms that are not toxic, but which are so dense that when they decay, when the cells die and decay, they fall to the bottom and use up oxygen. The lack of oxygen kills a lot of animals and plants on the bottom. Then you have situations where you might have – not even an actual mortality, but an ecosystem effect like from the shading of vegetation. The bloom is so dense that it blocks out sunlight that doesn't reach the bottom, so sea grasses in other areas, other habitats get destroyed. I could go on and on. There's many different types of impacts, and that's why this harmful algal bloom is an umbrella term that includes toxic ones and non-toxic ones that cause harm. But at least the central issue is that something has to cause harm. Because there are algal blooms and there are red water conditions, they don't cause harm. They're part of nature and they're natural and they're important parts of the way the oceans work.

FT: Now, what is interesting, you already cleared up one of my misconceptions. The first time I started to hear red tides was years ago. We are talking back in the fifties now in Florida. My initial assumption was there was a lot of phosphate being produced there and things like that that must be the cause of something like this. So, what you are saying then is that a bloom is a natural phenomenon?

DA: A bloom can be a natural phenomenon, and in many areas, it is. Florida is a good case study of sort of both sides of what I'm driving at here. The first is that the red tide in Florida has been there for a long time. The first explorers described situations in which the water turned red and fish were dying and so forth. So, it has been occurring long before there was pollution, long before humans ever got involved. But that doesn't mean that in present day situations, humans aren't making the matters worse. In Florida, there's a very significant controversy right now among scientists as to whether the phosphate mining industry, the sugar farming industry, or just development in general, the way they've changed the water flow in the Everglades, and so forth, whether all of that has made the red tide problem worse in Florida than it was long time ago. There's some ongoing studies trying to resolve that. But my point is more that there are places where it's very clear humans are involved or times when humans aren't involved, but there's also clear evidence that humans can make things worse.

FT: Just by saying that, I think you have cleared up another area where there might be some misconception. The fact that red tides now are being reported more in the newspapers also, I think, than they used to be. So, I think the average person will say, "There are more of them. Therefore, that is a result of more pollution taking place."

DA: Well, there are more of them. There are multiple reasons for that. This was at a meeting in 1987, I went to a meeting in Japan and was asked to give a plenary talk, a talk to the whole conference, about the global problem of red tides. It was up to me to decide what the topic was. I was thinking the same way you described a lot of people thinking this. I'm getting a lot more calls these days from people. There's a lot more going on. That year was an extraordinary year in this area because all these different things happened. We had a situation up in Canada where some people got very sick and a number of them died from eating shellfish. When they tested for toxins, they were very used to a certain kind of toxin that occurs up in that area of eastern Canada, and it didn't match. The symptoms weren't right. So, they put a team together and very quickly identified a new toxin. One called domoic acid, which was responsible for people getting sick and dying. In fact, a very nasty part of that, that toxin's actions are that some of the victims had permanent memory loss. That basically this toxin affected a part of the brain where short-term memory is stored and caused sort of lesions there that would result in permanent loss of memory. I remember that year vividly because that was happening. Then very much at the same time, people in the coast of North Carolina, who never really have problems with any sort of red tides or these blooms, all of a sudden, they started having trouble breathing on the beach with aerosol that was irritating and making them cough. There were other issues that started to suggest something was going on. When my colleagues were starting to work on it, they found that it was the Florida's red tide organism that was now in North Carolina. Turns out it had sort of taken a trip around the Florida Keys up along the east coast on the Gulf Stream and then an [unintelligible] spun off of the Gulf Stream and delivered these cells to North Carolina, the Outer Banks there and so forth, and it caused troubles. Now, the same time that's happening, we had nineteen whales that died here in Massachusetts Bay in a very short period of time. The vets were looking at this. What was the problem? Could it be the red tide? I didn't think so because this was like November. But we looked, investigated, and ultimately found in the stomachs of these whales, mackerel that contains quite a bit of toxin. So, these three things happened all at the same time that I'm being asked to give this talk at this conference about what is the global problem? So, I actually said, "Is the problem getting worse? What could we really say?" It's such a difficult topic to address because as I've just described, there are so many different manifestations of these types of events. How do you tabulate them? How do you compare one year to another? How do you compare this type of event to that type of event? Obviously, it's being compounded by the fact that there's different types of observation capabilities, different skills for measuring toxins around the world, and those are changing through time. But ultimately, I said that I felt the problem was getting worse. That the problem was larger than we thought before, but that there were a number of reasons. Some of them are the ones that everybody was suspicious of, pollution being one, pollution stimulating the cells. So, yes, that might be making things worse because of human activities. Other human activity would be ballast water discharges that could be sending these cells to different parts of the world where they would colonize and start to grow.

FT: Ballast where ship will take on water to help balance it and set it right in the ocean.

DA: A good example is that a ship that might start out in the Middle East and fill up with oil. It drops the oil off somewhere else. It has to travel back. It's going to be very unstable if it travels back empty, so they fill up these tanks with all this water at the place where they discharged the oil and they're bringing up water, they're bringing up sediment, and you get this perfect system. Especially with ships going faster these days than they ever did in the past, we have organisms that can survive the transit. Then when they're discharged, as they're filling up with oil again, that area has been an inoculum of organisms. That's another reason the problem can expand around the world. But then there are sort of other reasons. We've got many more scientists nowadays doing this kind of work. We communicate better with the internet and with just other scientific publications. The situation in Canada is a good example where they discovered domoic acid a few years later in the West Coast of the U.S. and a number of birds have died. Seabirds died. They were wondering what the story was there. They tested and they found that the symptoms of extracts from these birds, the stomachs of the birds was causing symptoms that they had read about in the Canadian publications. They brought the Canadian team in and verify that, in fact, domoic acid was now present on the West Coast of the U.S. None of us believe that was new, that it had been introduced, or that it was a pollution-related issue. It was just that now we knew what it was. We knew how to detect it. A lot of unexplained mortalities and unexplained illnesses could now be attributed to that toxin, which had always been there. It looks like an expansion, but it's really an increase in our awareness. I mean, there's other explanations for this expansion to the way I view it now is that we never fully knew the true size or nature or extent of the harmful algal bloom or red tide problem. We have now started to define that much better, and it is bigger and more extensive than we thought. With some of that expansion being because of pollution and other activities, but other parts of it are simply because we've learned more. Yes, there are more problems, but there's a lot of different reasons for that.

FT: The whole series of questions to ask here now revolved around it. First of all, I am really almost stunned to think that a whale could take in enough and the toxicity would be high enough that kill a mammal of the mass of a whale.

DA: I love this story. Whenever I give a talk, I really just want to show a slide that says, "This can also kill whales." But I sort of invariably get hold off into telling some stories about it because it was such an interesting event, the one we had here, but it's true elsewhere. Let's just say, we find the toxin in the mackerel and we're saying the same as you. How much toxin did they take in, and how much does it take to kill a whale? The other question was, where they got the toxin from because it was not red tide season here? It turns out these whales had eaten mackerel, and the mackerel had been up in the Gulf of Saint Lawrence. You can track where they had been, what their migration patterns, where the Gulf of Saint Lawrence had a major red tide. The mackerel had eaten the algae and the zooplankton that eat the algae. Then it traveled down into Massachusetts where they got eaten by the whales. The whales were about to head south for their breeding, and when they do that, they eat four-percent of their body weight a day. They eat a huge amount, that's like a human being eating four, five pounds or eight, ten pounds of food on a day, it depends. So, you're eating all this food that is toxic. But even still, when we then calculated how much toxin the whales are getting and compared that to what we knew about the lethal dose for humans, it was low. It was too low. So, we're scratching our heads. We thought we had it figured out, but no this may not be it. But then we said, " Well, the lethal dose is calculated on the basis of body mass." It's how many micrograms of toxin per kilogram of body mass. Well, a whole lot of the whale is blubbered, so let's discount that as body mass. So, you subtract out thirty-percent of the mass of the whale. It still doesn't get you into the right ballpark, but then we realized a very important thing. Well, let's go back, you hear all the time when some young child falls through the ice in the wintertime and drowns. But they bring them out, sometimes thirty minutes underwater, and they can revive them and there's no damage, not necessarily brain damage and so forth. It's remarkable, how did that happen? Well, what's happening is something that they referred to as the mammalian diving reflex. Whereas the child is cold under the ice, the body's circulation stops and the blood no longer flows to the fingertips and the toes and so forth, and just goes between the brain and the heart. It's bringing oxygen from the lungs and so forth. It doesn't go through the kidneys and the liver and so forth. So, it just does a short circuit so oxygen can get to the brain. As long as it's cold enough, these children can be saved. I had heard about that, but then it never registered to me what this mammalian diving reflex is. But think about it, what it means is that these marine mammals, every time they dive, this is what their bodies do. They shut down the circulation to these peripheral tissues. So, it means that this blood that has toxin in it is not going to the kidneys or the livers to be detoxified or excreted. It's going on a short circuit to the brain to all the sensitive [organisms]. So, the lethal dose calculations go right out the window because now you've got a situation where you're focusing the toxin on a much smaller portion of the animal, especially in those sensitive organs. Then add to it the fact that these animals are in the water. That the humans who die are in bed or they're in a hospital or something like that. When they die, it's not like they're in a swimming pool where they're being asked to swim. In fact, in the case of a whale, to actually breathe, to coordinate muscles, to come up to the surface, we learned yet again that the air hole of whales, its natural state is actually open. So, if a nerve like the saxitoxin we're talking about, which affects that muscle, keeps it from closing, then they can't close their air hole when they die. So, all these reasons say that a whale can pick up enough toxin to die.

FT: [laughter] That is a stunner to me. It really is. I am wondering, is there also a problem that you run into with misreports and popular press and things like that. Just as an example, for years I had gone down at the Outer Banks, and you just mentioned the Carolinas, and I stayed at a place called Corolla. I think you might be familiar with it, just a little bit down from Duck where there is a research station. For years and years and years, that was an absolutely pristine place. The streets were sand. Then the developers got in there, and all kinds of golf courses went in. I noticed that in the Albemarle, Currituck Sound, that all of a sudden, these huge mats of vegetation were starting to grow out towards the middle. Then they had all this flooding in one year with heavy storms, much of which ran into the Sounds. Of course, they went through pig farms, they went through all kinds of things. The report I read in the newspaper was so sensationalized and [laughter] have so many possibilities and use terms like red tide, and other people lost their memory. They had to learn to talk again.

DA: That was the Pfiesteria.

FT: You mentioned Pfiesteria, and I have heard it described as "Cell from Hell."

DA: Yes, the "Cell from Hell." Yes, that was the Pfiesteria. Pfiesteria that just not only affected the press and the media, but the scientific community too. It was a chapter in the whole history of my field that it's sort of hard to describe, in retrospect, without taking a lot of time. But it resulted in some really fine research, but also a lot of polarization among scientists who were arguing about, is this right or is it wrong? Does this organism really do all the things that are being claimed that it does? Is there some overreaction by the press and so forth? So, the bottom line is now after all these years, that story's been smoothed out nicely. Science has answered a lot of the questions. There are some other organisms actually that are involved as well in this problem. I think the human health linkages are still very mysterious and unconfirmed really in terms of a mechanism. They still don't have the sort of purified toxins that people can experiment with and so forth. So, there's still much to be done there. But in that era, again, there was a strong linkage between all the pollution that was going on and that particular organism. So, it's one example of a part of the world where that linkage between pollution and red tides, or harmful algal blooms is very much worth exploring. But the point to be taken also, though, is that there's many other parts of the world where that's not the case.

FT: It is interesting. If you go down to a place like Florida, let us say, just as an example, Sanibel, Captiva, that area, when I have [unintelligible] people stay off the beach because everybody is coughing and hacking. This is kind of a different symptom than you are describing that we run into up here.

DA: We don't have that particular aerosol problem. In fact, there's only a few other places in the world that have it caused by a different organism. So, that's really unique feature of that organism and that bloom down there. Basically, the toxin gets liberated into the water. It gets taken up into bubbles, literally. Probably being more technical I need to be here, but it is a fat-soluble toxin, which means it doesn't like water. So, it will accumulate in these air bubbles that are formed when the waves break and so forth. As those bubbles come up to the surface and burst and make smaller bubbles, they can transport little packets of toxin that people then breathe as an aerosol, and that can be very irritating. That's the major manifestation of the problem down there, as well as these fish kills. The organism we have up here doesn't have the same sort of toxin. It doesn't become aerosolized. So, we just don't have that, but we have much more dangerous shellfish. Our shellfish can kill people and get more toxic than they do down in Florida, but it's not as severe a problem or as widespread a problem as it is up here. So, it's just a different organism, different kinds of toxins.

FT: Yet the newspapers will give it the general term red tide.

DA: That's right, and they'll say the red tides in Florida. They'll say the red tides in New England, the red tides in Seattle. They can be three different organisms, three different situations. The water may only be read in one or none of those situations. If you're a journalist, though, you understand that it gets people's attention. It's the same way, I often will give a talk and I'll put "red tide" in my title because it'll bring people to the talk that, otherwise, may not have picked up on a more scientific term that I would use, otherwise. You can fight against it, but it's a term that isn't going to go away.

FT: [laughter] This is true. Sometimes I even see what ultimately is ciguatera or something like this, and that gets confused into the whole.

DA: Again, the term harmful algal bloom, because it includes ciguatera, which is the furthest thing from a red tide. I mean, that's a situation where the same types of algae – these microscopic, little plants, they don't swim around and make the water red or they don't get eaten by shellfish. They live on seaweeds. They actually live attached to seaweeds and small fish come along and eat those seaweeds. Then the larger fish eat those small fish, and that toxin transfers to the food chain. It's another one of these fat-soluble toxins, sort of like the pollutant DDT that you remember hearing about, that would kill or caused problems to the eagles and the birds and the big predators at the top of the food chain. That's the same thing that happens with ciguatera. This toxin moves from the algae that are living on the seaweeds, to the herbivores, to the carnivores, to the bigger carnivores. So, it's the big fish, the barracudas and certain kinds of jacks and the moray eels and some grouper that are the ones that become very poisonous. So, you can't call it red tide, but it is a harmful algal bloom problem.

FT: [laughter] All of which leads to kind of general confusion as to what is going on. There are a lot of things that are involved with it. Now, in looking through publications on this, I know you are liable to pop up the salt pond or to the big marsh behind Nauset. I know you do not get in your car and cruise up and down Road 6, while looking for what seems to be going on out there. How do you get a word that there is a bloom in one place or another? How does that come down to you?

DA: It depends on the year. We will have research projects in various areas of this region in particular. This year is a good example of one where we are working out in, in fact, the Nauset Marsh system. So, just yesterday, people in that lab were out there sampling all over the Nauset Marsh system trying to figure out where these cells were and so forth. Now, we're there because we got funded. Because there's a recurrent problem year after year, we're trying to understand it. If we needed to know where there is toxicity at any given location or any given time, the state is doing monitoring of the shellfish. They go all along the coast. They've got certain locations, and there's three or four in the Nauset Marsh system. There's a number of others all along the coast of Massachusetts and New Hampshire and Maine. Every week, they go out, collect shellfish from these locations, bring them to a lab, extract them in a certain way, and then test for these toxins. So, you start to get this picture of where along the coast then. I get mailings every day or two from them on email of where, what kind of test results we've got. So, they will tell us then when the shellfish on shore are getting toxic. Now, if we have a research program, like we've had for the last about eight, nine years, out in the Gulf of Maine, where we have research vessels out there, we reciprocate. Because when we have boats out, we will get data on where the cells are, and we will tell the state agencies what we have seen. We also have these numerical models, these computer models we run that are very effective at providing a largescale view of what the bloom looks like at any point in time. Much like you'd see some of the weather maps where people are predicting what the weather is going to be, what we're predicting where these blooms are and where they're going to go. We release that information to the managers as well. So, it goes both ways. We tell them what we either know is happening or what we think might be happening, and they tell us what they're observing.

FT: So, in a sense, there is no one-to-one contact with shellfish wardens?

DA: We do that too. Right out again, the Nauset Marsh system, we're working directly with two of the shellfish wardens from Eastham in Orleans. They are helping us with boats and people and so forth because they really care about getting better information about the system and just how the red tide works there. So, we're dealing with them all the time. If they saw something unusual in a particular location, they would certainly let us know and vice versa.

FT: [laughter] It is an interesting thing in someone like yourself, in many ways, gets balanced kind of on a pinnacle kind of leaning one side than the other. Because if there is a huge HAB incident in a place like Cape Cod, and it is July and August, it is going to have a tremendous economic impact on the area. How do you deal with that kind of situation? Because you are going to have a politician that is going to fight and scream to keep you from saying something that might harm the tourists coming in, and yet you know that there is a clear and present danger here.

DA: Well, we've had to deal with this issue for a long time. I think I've gotten reasonably good at it. The year 2005 is a perfect example of what you're referring to. At least as far as

Massachusetts Bay in the area inside Cape Cod, Massachusetts Bay, we hadn't had any major toxicity in this region for over ten years. Really, people hadn't seen much of the red tide in the news. So, it was happening a little bit on North Shore, a little bit here and there in the Nauset Marsh system, but it wasn't a big deal. Well, in 2005, we had a cruise and we picked up some cells right at the entrance to Mass Bay , a large number of cells in very early May. Just at that point, the states, New Hampshire and Maine, started to pick up toxicity in that part of their coast. So, we thought this is something unusual because this time of the year, we're seeing that many cells there. So, we started to watch more closely. It turns out that 2005 was, we say, the biggest outbreak In at least thirty years. It may be the biggest outbreak in a hundred or more years, but we know we had one in 1972 that wasn't well monitored that was large. It was at least as big as that, and maybe larger. It ended up closing shellfish harvesting from the Bay of Fundy on the border with Canada, all the way through Maine, New Hampshire, and Massachusetts, all the way Massachusetts Bay, the Outer Cape, Monomoy Island, Nantucket, and Martha's Vineyard parts of those islands, and was actually threatening to make it down into Rhode Island and so forth before it finally ran out of steam. So, here's this massive outbreak. We were very much involved with the state managers the whole time in what I think is viewed as an extremely effective partnership. As I said before when we had observations, we'd give them the observations immediately. We would run the computer model and show them what we thought was happening. For example, we would release drifters from our cruisers. These little parachutes literally that are in the water that have a way to communicate with satellites, and they can be tracked. They show you where the water is moving, and we released those during our cruises. Some of them made that perfect track that went along Stellwagen Bank, around the tip of Cape Cod province town, down along the Outer Cape, right along Monomoy. That was tracking perfectly the areas that were becoming toxic, and they continued out towards Martha's Vineyard and Nantucket. So, we told the state that we thought that they really should be careful out there, even though there had never been toxicity out there before. In fact, we were able to get some shellfish from Martha's Vineyard Coastal Observatory. There's always mussels that grow on the tower out there. In fact, it was an interesting situation that just down the hall here, one of the folks who works in another lab, who goes out to the observatory all the time, always brings mussels back and eats them. He was about to, and we said, "Lexi, don't do this. This is a very dangerous situation." We said, "Let's take some of those shellfish and give them to the state to test." They tested them, they were very toxic, and they immediately closed down that part of Martha's Vineyard and Nantucket. So, that kind of communication with the managers was helping them to help make closures to sort of keep expanding where they're looking and so forth. They were very appreciative of that. Meanwhile, of course, the press is picking up all of this. What I have found over the years is that if you find the right journalists who are careful in their reporting, who aren't always looking for something sensational, who check back with you and say, "This is what I'm going to say. Is this scientifically correct?" Then I work with them. As busy as you might have ten phone calls and ten messages, it's the ones who treat you right and give the good stories that you, in a sense, reward them with what you know. Because that way, the flow of information is controlled and it's accurate. That's critical in an outbreak like the one that happened in 2005. Meanwhile, we're getting all these phone calls and messages, "Should I cancel my vacation to Cape Cod?" "Can I walk my dog along the water?" "Can my kids go swimming in the water?" "Can I eat fish?" "Can I lobster?" All of these questions that maybe some of the managers want to keep everything quiet, but you've got to get the correct information out. You have to tell them, "Yes, you can eat lobsters." "Yes, you can eat fish."

"Yes, you can swim in the water." "Yes, your dog can play along the beach." "Just don't eat the shellfish or don't do this." Those are the messages that we would just sort of pound into the journalists and make sure that they would get them into their stories. As a result, here, we have a situation where this well over a thousand miles of coastline is closed and with levels of toxin in shellfish that would easily be lethal to consumers of just a normal meal, and no one got sick, not one person got sick in that outbreak. It was a very special way where science and management communities worked together and prevented what could have been a much more serious public health disaster. The economic side of things, it was a huge disaster too, but that was mediated in some way, again, by the flow of correct information. There's not much we can do there. People can't eat shellfish and there's certain things that are going to cost money, but you can try to limit the damage.

FT: [laughter] It is an interesting phenomena because when I asked you that question, the idea was not to denigrate the task that a politician has. But they are always in a position of needing a relatively quick answer, and the scientist by nature has to be much more conservative and gather enough data before they can make a statement that they feel comfortable with. So, it is tough for the two to work together, particularly one that gets red tide as is bigger name as does climate change, so called global warming, all this sort of thing. It is something that is out there in the public.

DA: It is. I think we've got a good relationship now with the state agencies that are responsible for all this. They realized that they have to make sure the correct information is out there. At the local level, I think they've realized that too. Well, I mean, I'll give you an example. I was in Chile once where they had a big outbreak, and the local shellfish association was arguing that this was all a sham, that there really wasn't a real toxin problem, and some of the people running that association went on television and ate shellfish on television to try to prove that it was safe, right? Those guys got real sick.

FT: [laughter]

DA: It was like, "All right. They asked for it." They didn't believe it. But the public got the wrong message, and that's a rather extreme example of where some of the officials are trying to protect or argue to keep the information flow from being open and accurate. Around here, at least, that doesn't happen.

FT: Now, it is interesting, short time ago, within a few months, every evening I usually watched on channel two, *Where's Boston* with Emily Rooney. Lo and behold, [laughter] one evening, there was Dr. Donald Anderson talking about HABs, which as I recall, Emily Rooney called red tide. I had been considering going out to legal sea foods. [laughter] One of my favorite foods on the face of the earth is fried clams, followed closely with fried scallops, and so on. Is it safe for me to eat that kind of thing here?

DA: It absolutely is. In fact, on that same show with me, I don't remember his name, maybe it's Woodman. He owns Woodman's in Essex in North Shore. The idea was to have some scientific information. But then someone who owns a very popular seafood restaurant, and he was just pointing out that even though he could no longer buy the Ipswich clams that are so special and that have a special flavor for his fried clams, that he still had fried clams from Maryland or other places, and everything is fine. That's another important point for everybody to realize is that when in this country and in many other countries, there is a very good safety net out there now for these toxins in the various seafood products. I would have no hesitation eating fried clams during a time when the whole coast of New England is shut because of red tide because I know that product is safe. That there's adequate supervision by several different state agencies that dangerous product has not made it to the market and has been replaced by safe product, maybe from another state or other place. I won't say the same thing for other parts of the world. I'll go to some countries, and I'll be offered seafood. I won't eat that certain kind of seafood because I know what is not happening. I know that there is no appropriate testing; and therefore, it's a risk that I don't feel like taking. But in this country and in many other developed countries, the systems are developing. That's also something I can look back on in my career, and certainly not claim credit for it. But I have been very active, not just in the science part of this field, but in the policy side, trying to help develop the international cooperation or the national programs that keep people safe, where the information and the technologies needed to provide that umbrella of safety all over the world. That's been a very interesting and important part of my career, that sort of parallels all the scientific work we do. It's sort of the policy and sort of capacity building, and so forth side of things.

FT: Well, as I researched your career, I found that one of the things that really intrigued me about how you operate, and even though you do the science, and yet there is also this practical application of it in trying to steer people in the right direction. Just when you say you try to do these things, I can remember quite a long time ago in the *Currents* reading a little article. In there, you made the statement that you had no hesitation to eat seafood in the United States, but you would be very leery about it in other countries. I have adopted that as a mantra when I go to other countries. It kind of runs in mind, "Donnie Anderson said he would be a little leery about," and I will follow that.

DA: Well, it's still true. The number of countries where I might not have eaten seafood some years ago compared to now has changed. Because as more programs have developed, then the safety net is as expanded to more countries. But again, there are still many where there is not adequate safety, but that's the number is shrinking. Eventually, someday, we'll get to the point where you could safely eat shellfish anywhere, but the statement is still true. There are countries where you should very much think twice before eating shellfish, both from the sanitary standpoint, the bacteria, viruses, and so forth, but also from the marine toxin standpoint.

FT: So, it is a pretty complicated field. Let us take a look at that. As I mentioned earlier, a very prescient person decided that you should be at the Woods Hole Oceanographic Institution. Even though they did not have your specialty here, but they wanted you to develop it. Somehow, they knew this was, in fact, going to be big, and it certainly has become. So, let us go to that sophomore year, so to speak, at the Woods Hole Oceanographic Institution. When you got the job, what was it like? What were you going to be doing? Who are the people you are going to be working with?

DA: One of the things I remember from that time, you're naïve young PhD, you focused on a topic and it was one that you and your advisor worked out. At some point, you thought up and you're thinking, "My god, I'm going to be by myself. How many of these ideas am I going to have as a research topic that can carry me through a career, and will I really be able to follow this for a long time?" Well, it certainly has worked out that way. It started out just as a very much an extension of my thesis. I had started to come down to Woods Hole because there were these local salt ponds, where they had some toxicity and we had discovered this cyst of Alexandrium in the sediments. Then there were these experiments done to show when they germinated and how that could explain the timing of the blooms here. That was all part of my thesis.

FT: Does Alexandrium have that name then?

DA: No. It has had a number of name changes, but back then it was called Gonyaulax. The species hasn't changed, appreciably, at least. It's used to be called Gonyaulax tamarensis. Now, it's called Alexandrium tamarense, but it's the same general organism. The salt ponds were just a perfect place. Here I am, just myself. I ultimately got some money from the Sea Grant program, and that allowed me to hire a technician. I thought I was just hiring someone for six months, well, that stayed cool because he's right out here in the lab. He has been with me now for twenty-eight years or something like that. I got the funding to study these little salt ponds, which were perfect natural systems in which the water inflow was somewhat restricted. You could study the whole evolution of the bloom from beginning to end and look at the dormancy of the cells in the wintertime in somewhat in closed systems. So, I worked in those systems for a number of years, answered a lot of nice questions about the flushing and the way the cells stayed in there and so forth. It was a very nice program. But I can look back and while I'm focused there, it's like I have blinders on. I'm seeing what's going on. This is a Cape Cod salt pond, a system that starts and stops within that salt pond. Meanwhile, out in the Gulf of Maine, not far away and extending all the way up to Canada, is this much larger red tide problem. But it's so big, and I'm just myself and one other person, how can I study this? The money I was getting was small. It's enough to keep things going, but it was small. So, that's where, again, the strength of this institution came through. We have very good graduate students, very smart, just capable people. One of my students then was named Peter Franks. He's now a professor out of Scripps, has done very well for himself. I said, " Let's get our feet wet. Let's go out into the big deep waters of the Gulf of Maine and see what we can do." We got enough funding there to just run a simple little transect, it's called. The line of stations off of Portsmouth. We jumped on New Hampshire's research boat, a small little boat, run out, sample four or five stations, get the data on this line. What we would thought was the case was that the red tide cells that were there would be sort of coming in from offshore to onshore, and then we could follow their progression along that line. That ended up being his thesis, but what he found was very much, in a sense, perpendicular to that. That the transport really was coming along the coast, and that we were seeing it cross our line. Rather than moving through offshore to onshore, it was going past us.

FT: From north to south?

DA: North to south. We saw then that there was this coastal current that was moving down there carrying these cells. So, then the problem is, all of a sudden, getting more complicated. Now, they're going to source up to the north someplace. It's coming along the coast. At times, it'll get blown closer to the coast, but there is this coastal current we need to study. So, we then went from that to a field program. I was able to get more money and get more people involved.

That started right around Casco Bay and went down to Massachusetts Bay, and we had bigger boats. Now, we get larger vessels, not little fifty, sixty-foot boats, but now we're talking (Oceanus?) class and so forth. We're talking bigger projects, but we've set the stage for it with this research. Then we start to document this coastal current, the nature of the cells in it, and the fact that certain winds would bring these cells. These winds out of the northeast would bring the cells to shore and accelerate them down the coast. We started to develop our first computer models, and you can see the program sort of expanding. But again, it stopped at Casco Bay. We kept seeing cells come across the boundary of our study areas, like we still need to go further north to figure out what's happening.

FT: During the period you are talking about and during that period of your reputation at that particular point, money is not easy to come by. I would suspect it is better now. I do not know how, but I am going to have you describe your funding over the years because we live in a state that a hundred towns are right on the water. I recall something like one out of every four people make their living from something to do with the sea, whether it is a gift shop, a restaurant, a marine insurance, or actually fishermen or things like this, for a problem that is roughly going to be a big deal in a place like this. So, you did not really have an awful lot of money then, did you?

DA: No. In fact, the misconception there is that even though the state has all of these cities and towns that are affected and these industries that are affected, we've gotten virtually no money from the state of Massachusetts or these other states in all these years. We're about to get some this year, but it's a very rare situation. It's been the federal government that has had to step in and do this. The states spend their money on making sure they test the shellfish and so forth, but they don't have the research money that we would want. They would be very supportive by providing what's called matching money for things like the cigarette project. Cigarette needs to have something that shows that others are contributing. The matching money doesn't have to be dollars that they hand you. It can be, "We will collect shellfish and give you toxin data. Then will do this and it costs us this much to do this work, and it will complement what you are going to collect." So, the state was very good that way, but they didn't have real money. So, we had to go out and get federal money. Let me first go through the progression of the research. Because right at the point where we've been able to get some money that covers this region from Casco Bay, let's say the Massachusetts Bay, and it's fairly substantial research projects. I'm only involving two or three other scientists. It's some cruises and so forth, but they're limited in the scale. So, in that interval, which was actually around [19]92, [19]93, we were studying this region from Casco Bay downward. We pretty much tapped out the big funding sources, whether it's Sea Grant – and we have something called the Regional Marine Research Program, and so forth. Yet, the problem was bigger than that. What I needed to do – and what my field needed, was to somehow get more recognition of the scale of the problem and of the funds that are needed to study it.

FT: When you say field, was there a field then?

DA: No, and that's exactly right. At that time, certainly early in the [19]80s and so forth, there were only a few scientists in the academic community getting funding from Sea Grant or NSF, other agencies. Maybe just one federal lab that was doing research in the ocean, at least. There were others doing toxicology research and so forth. But it was a very small community. I don't actually remember who heard it and who made a statement that registered with me. But you're a young scientist, you're worrying about whether you're going to get tenure and so forth. One of the things they're saying is that you should be showing leadership. One of the ways you show leadership is to help build programs. What's the program? I didn't even know what that meant. But the message was that if you're trying to work with government agencies, with Congress, with international programs, to start building a bigger field. You're not doing it for Woods Hole. You're not doing it for yourself. What you're supposed to do is make this effort and be a leader, be a martyr, whatever you want to call it. Spend your time to try to put this together, and then if funding develops, you compete for it with everyone else, but the ideas of which people will compete very well for it. We will get money from it, but we're not going to get all of it. In fact, at the time, it was always said that other universities were getting pork barrel or earmark money from the government, and we would not do that. That we would take the high road, and we would, in fact, even take our names off of legislation that had been written, "This money should go to Woods Hole." No, we're not going to do that. We are going to help to put money into a field, which you then compete with everyone else. Now, that field didn't exist. I remember vividly, it's one of these evenings that I've had swings on both for me in my field. I was having dinner at my house with someone from MIT, one of my lab mates and her husband. He works in the astrophysics field. We're just sitting there, having dinner, and he's talking about all the next mission. Three years, hence, it's going to go out to Neptune and it's going to have this many sensors on it, and the one after that was going to go out to Pluto or whatever it was. I'm just listening to him saying, "My god, you've got so much money coming into these programs, and you're going out into outer space. I've got deadly toxins, people are getting sick or can get sick, and I can't get significant money for this at all. What's the difference? What's the story?" He says, "Well, we, as a community, hold workshops. We get together. We decide what it is that needs to be done. What are the priority research areas? What new equipment? What new missions are needed? We all get behind a consensus, and then we go down to Washington. We tried to build support for that program, both with Congress and with the funding agencies." I remember after that thinking, "Well, I can do that. I should be able to do that." At that same time, it was a fortunate sort of coincidence that there was a government lab down in Charleston that the National Marine Fisheries Service then operate it. Now, it's National Ocean Service. They knew that there was some money coming into NOAA for seafood safety. As I said, there were very few government labs doing this work, and they wanted to get involved in it. So, they came to me and they said, "Can you help us?" What I remember is sitting in my office, and they were saying, "We want to do this. What we think we need to do is hold a big international conference in South Carolina where we bring all these red tide people all over the world, and we all try to figure out what's happening and so forth." I remember thinking, "No, this was not what you need to do. We need to get a U.S. program. We need to get U.S. scientists and managers together and figure out what it is that stopping our progress, and what are the priority areas to go forward." They agreed. We then ran a workshop down in Charleston, South Carolina. This must have been 1992 or so. The same time, as I told you, we're hitting a wall on my research in terms of being able to get money. We basically created what is now what we call a *National Plan for Marine Biotoxins and Harmful Algal Blooms*. I have the report right over there. It was published in 1993. It goes through and very clearly takes this attitude of what are the things that are stopping us, not just not enough money, but we don't have toxin standards. We don't have good enough analytical equipment. We don't have cultures of the right organisms. We don't have understanding of the physics and the circulation of the ocean. All these things, and then what do we need to do to remedy that impediment? And so, we had this great report, we published it, and then I thought, "Well, the money will come in. The agencies will see this, will recognize the logic and the science," but nothing happened. Then I talked to my colleagues at this lab in Charleston, and we said, "Well, why don't we take this further?" And I said, " Now, we need to be proactive. We need to get agencies, and ultimately, Congress involved. Well, they can't get Congress involved, but I could." So, we then created what we called an ad hoc interagency task force. Ad hoc meant it was totally unofficial. But we literally called up NSF and Sea Grant and the FDA and the EPA and USDA and everyone and said, "These are all people that have some relevance to these red tide or harmful algal blooms." We held meetings down in Washington where we'd spend two or three hours and talk about what was happening in blooms, outbreaks, what was needed. It was sort of during those first few meetings, I remember sitting there with a guy from NSF on one side, a guy from NOAA on another. This is Phil Taylor, program manager in biological oceanography. He says, "I can get behind a program on the ecology and the oceanography of these blooms. I can't deal with all the public health issues and toxicology and epidemiology and so forth, but I can do this." Don Scavia, from NOAA, on the other side says, "I can do that too. Why don't we partner, okay?" Bingo, and then they said, "All right. We'll host a workshop." So, I then was asked to run a workshop out in Winter Park, Colorado, now focused on a subset of all those questions we had done on the College in Oceanography. That workshop ended up with another report that is called *ECOHAB*, that we named *Ecology and Oceanography of Harmful Algal Blooms*, which was, again, a set of research questions and strategies for how we move forward. The agencies then took that and formed a partnership. It was NOAA, it was NSF, it was the Navy as well, the Office of Naval Research, and NASA at that point, and they then issued a call for proposals. They all pitched in a little bit of money because they then had documents that really defined what needed to be done. They could take that language, put it into the wording for a program, and program solicitation and then people started to write proposals. Well, what we had done in that workshop was we said, "We want all these individual research projects where this lab can do this, and this lab can do that." I was seeing it in my own world, we need the big regional research program where I can go all the way to Canada with chips and I can have a model that covers the whole Gulf of Maine. That's a whole new realm of funding that is not just something that just comes to me. It comes to a group of ten investigators, and we need to get that kind of program going. So, we wrote that in to the *ECOHAB* report that we needed these regional projects. They had to be built around computer models of the circulations, that was so critical. So, in the very first call for proposals, there was the statement that they will support one or two regional programs. So, just as I said earlier, this was in no way earmarked money, right? We created a program, the beginnings of a program, helped to get it going. They issue a national competition into which we competed. We ended up winning a five-year award for a program called ECOHAB, Gulf of Maine. That gave us a lot of this money for cruises and modeling and so forth, at the same time, Florida got one as well. So, they were two regionals funded at the same time. The same time that's going on, many other investigators are getting funded for their individual laboratory studies or small-scale field studies. The reason we could get that big funding was not because we had some inside track or it was an old-boy network or anything like that. It was because we had built from the salt ponds, to the little transect off of Portsmouth, to the Casco Bay, to Massachusetts Bay segment. We already had some modeling. We knew where these cells came from. We knew that there was stuff going on up to the north that we didn't understand, and we could make a very good case for the next stage of research. So, I ran into the wall on the funding, but then found a way to get down in Washington to fill that gap with a big funding program that continues to this day. I mean, that was 1994 or so. So, here we are, fourteen, fifteen years later, and ECOHAB is still running. It is funded by so many programs all over the country, multiple regional studies, dozens and dozens and probably maybe over a hundred, I'm sure now, individual targeted studies from various labs. It's viewed by many as a model program around the world for other countries for how they then are starting to spin up their programs.

FT: [laughter] My head is absolutely buzzing here. The first question I would like to ask, when you started this, when you started into the salt ponds, when you had one person working with you, and then you amped up to doing a transect through the Gulf of Maine, about how old were you about that time?

DA: Let's see, I would have been thirty when I came here as a postdoc and an assistant scientist, so from then, until, let's say, the next ten years, thirty, thirty-five. I had work for three years or so after I got my undergraduate degree, so I was a little bit older as a graduate student.

FT: A veritable baby still –

DA: Still.

FT: – age-wise. Now, the program had started, you started to look at a specific thing. A couple of things I would like you to comment on, because this really is fascinating to listen to. Because when I did want to be director of Oral History, either two or three years ago, he talked at length about disappointment in some instances of being able to build a program in certain areas. We discussed the idea of in an institution like the Woods Hole Oceanographic Institution, sometimes there are programs you have to start to phase out because their usefulness is no longer there. Then there are programs that you try to support because they are working with things that are critical. Then there are other areas where you have to kind of use your crystal ball and see where things should be going and then maybe talk about bringing in the right kind of people. I have a program for something like that. Now, here you are in early to mid-thirties [inaudible] need some money for this program? [laughter] That day had gone by, so you had this whole empire to build, so to speak. I don't mean that as a bad term. How did you put all that together?

DA: Well, I can look back and see [inaudible] this is concept of building a national program that you then compete in.

FT: How did you come up with that?

DA: Well, it was just this dinner conversation with my astrophysicist friends. That's how they sent missions off, is to get their community together, work together, and go down to Washington. If you just sit in your lab or in your office and say, "I've got an important problem. You should give me money for it." That's not the way the world works down there. You have to go and get not only the program managers at these agencies, these funding agencies, to believe your field or your ideas or this one area needs funding, but then you need to start getting Congress to deliver the money to them. That was another part of the education I had, which you started to say, "I'm not just going down to visit NSF and NOAA. I'm going over to Capitol Hill." How does that work? This institution, in general, was naive about that. I think, at that point, we had someone whose office was supposed to facilitate interactions with Congress, but we're still nowhere near as sophisticated with it as we are today. So, a lot of it was learning pretty much by the seat of our pants. One of the things that became important was to realize that certain congressmen or senators sat on committees that had very strong oversight over some of these agencies, and one of them was NOAA. So, by finding the committees and so forth, and talking to people, then you realize that you talk some to the actual congressmen and senators, but it's the staffers. It's the lower-level people that have been hired in, who are the keys in this, the way that system works. So, they are the ones being charged to write the legislation or to find topics that are interesting or to decide, should we go this way or that way? So, once you have some of their attention, then they're very anxious to have people who are competent. I think it especially helped that I was coming down to them, and not saying I want money from Woods Hole. I was not just going to our congressmen or our senators. In fact, I didn't go to them very much at all because they weren't on the right committees. There was other committees, and then I'd be arguing for the country, "We need this. We need that." Again, I'm not arguing give the money to Woods Hole. I'm saying give it to NOAA for the ECOHAB program that will be this peer-reviewed, competitive national competition. So, that, meanwhile, is going on. Sort of, concurrently, I was doing this internationally. So, you said you hear red tide everywhere? Well, part of that has been an effort to communicate with the media to get photographs out there. If there's a red tide, you help them so that people do see it, and that means congressman and others see it as well. You do the same thing internationally. So, it was sort of one of these branch points that I can look back to again. Another, you say, "How do you build this program and keep it going?" Again, as much as I was doing well, getting oceanographic studies and being part of the modeling world and so forth, I was seeing that I was going to have a hard time keeping my lab funded. I needed some more skills. I think I was able to do with what I was doing at that stage because my background was quantitative enough at MIT that I could talk to physical oceanographers, to modelers, and so forth. I knew some I could learn my biology. It was relatively simple biology, that's what I'll get to in a second. It was something that I could handle there too. But again, I was running up against the wall of some techniques that I needed that I didn't know anything about. What I do now is the molecular biology era, and that was just beginning to make its way into oceanography. Molecular biology is the study of the genes and just all of the various machinery of the cell that produces whether that's the toxins that we worry about or that makes cells grow and so forth. There's a whole way of studying it using DNA technologies, for example. Back then, and this is like the late [19]80s, you could sort of read. A few people were starting to apply technologies from medicine in oceanography. I realized this was a good area that I needed to learn something about. So, again, it was just a matter of this is where I sort of view the training I had of just always sort of taking care of myself and being persistent in my mother's training of just never let up on something. I wanted to go away and learn how to do molecular biology. But Woods Hole doesn't have sabbaticals like other universities do. My colleagues are so lucky. Every six or seven years, they get to go off. They get paid for six months or a year to go someplace and rejuvenate, learn something new, and it's a part of their job. It's something that they look forward to every seven years, Woods Hole doesn't have that. So, I, at that point, had been here ten years or something, I wanted to do this. I was told, "Well, if you want to do it, you need to find your own funding for it." To make the old long story short, I dug around and found money here and there. I had a colleague over in France who did this kind of work, who agreed to host me for nine months. So, I left the lab, brought my family over to the southern part of France, right near the Spanish border, the town called *Banyuls-sur-Mer*. Then basically worked in the lab and tried to learn molecular biology. I remember another part of that was interesting, which was the very earliest part of the internet time. There was a science-based email system called OMNeT that I was part of, but they didn't know anything about in France. I was the only one using it in this entire laboratory. I figured out a way then to be able to contact back to people in the U.S. It was way before real email was so common. So, I was able to actually still sort of run my lab with a little bit of this OMNeT capability from afar. But learned and trained, and at the end of nine months of this really wonderful time there, I came back and had a new set of skills that I could start writing proposals. Now, I can start to look for this or that. I can start doing some molecular biology. I could keep the other work going. But then again, because of the wonderful student pool we can draw on here, I would then have students that either had some skills in this area already, or would quickly learn them, who could help carry that program forward. So, then we could start getting funding from some different agencies, from the National Institute of Health or from just other agencies, that would fund this more physiological work and so forth. There then comes another part of the program development story at the national level. Here, you saw we had this national plan, all these grand visions of what the country needs in general. We take a little piece of it for ecology and oceanography, get NSF and NOAA to host a workshop, to write a report, the science plan, and then we could fund it. But then there's other parts of that national plan that needed support, and especially the ones that provide molecular biology funding, right? The things that are ecology and oceanography. So, that's what we've done. Then the next stage is to put together another module or two. The next one was what we'd call Oceans and Human Health. We got, again, working with program managers, working with Washington, design science plans, finding out program structures that would work to help to get the funding into those. Now, we have this Oceans and Human Health Program funded by the National Institutes of Environmental Health Sciences and NSF. They're co-sponsoring that. NOAA also has an Oceans and Human Health Program as well. So, that is addressing topics that are much more related to health. That's where you could get funded for studies of pharmacology of toxin effects, for example, whereas you could never get that funded under ECOHAB because it's not ecology and oceanography. So, then you put in module number two. We're still to this day we're working with just now gotten module number three, more efficiently going, which is prevention, control, and mitigation. It was yet another subset of this national plan, which will have different agencies, still some are the same but some different agencies, different priorities. It's going to have its own sort of funding program as well. Then you can see that you've taken the field, gotten it to have a substantial source of money in these different areas, each one which is continuing and each one makes sense, each one with a supporting Congress, supporting agencies, and then we just compete in these different programs. So, looking back, it all fits together nicely and dovetails well with the development of my program. At the same time though, I can feel very good. Because nationally, I think a lot of my scientist colleagues are very – I won't say envious necessarily, but they sort of admire the way we've built a program that is diverse and strong and sustained. See that's part of, I think, what sets a lot of Woods Hole scientists apart, and I don't want to sound elitist anyway. But either because they're encouraged to do it or because it comes naturally, a lot of people here are leaders. They step into that, and you have to give up a lot of time. I used the word martyr earlier. You do things that are going to help a lot of other people. It has happened for sure that it can engender a lot of resentment, a lot of jealousy. I've taken a lot of heat. You said about building an empire. I sort of cringe when you said it because I've been accused of empire building. All I can say is that I've built my program to answer the questions and to keep this whole issue going in this region in what I do. There's a huge number of beneficiaries in the rest of the country and the world. Because if we had a five or six hundred million dollars going into red tide research back in those early days, I'd be surprised. If you will see grant projects, maybe one NSF, we've got tens of millions of dollars now going into it. That's obviously not all going to me. So, I have no compunction, but you do catch when you're at the front of a lot of these things. You do catch some resentment and flak, but I've gotten an awful lot of support from my colleagues who were very happy for that kind of effort. But it is one little known downside of trying to help build programs and be a leader, is that there's a negative spin sometimes.

FT: I am sitting here with my hand on my face because my jar has dropped out above the middle of my chest at this point. This is really pretty amazing. Let me explain on tape, maybe I misused the word empire. I was simply thinking of some big, larger thing. Unfortunately, I guess we use that term in kind of a negative sense, and I did not mean it that way at all. The development of a field may be a better way to have said it.

DA: I know you didn't mean it, but it has been used in a negative sense towards me by one of my colleagues, in particular that I just think it's misguided or misinformed. If people look at this as being a big lab in a very well-funded lab over the years, but what is missed there is that in order to do that, it has come by developing a national program into which we fit.

FT: Let us see. I see it even a little bit bigger. I want to go back to something that you said though. You said you were sitting with a friend, a colleague from your MIT days, and talking over dinner. I can recall very clearly asking graduate students here in the joint program what they consider to be the most valuable part of the program? It was interesting to me that more than once, fairly commonly, I would hear this comment, "Just being able to sit on the porch with a mentor and a few beers and talk," as being a very important part of how they see themselves and how this developed. Essentially, you are saying the same kind of thing here. When I look at that whole thing morphing out into this whole program, and it was very specific to the study of red tide, now let me ask you to comment on it. In 1930, when the Woods Hole Oceanographic Institution was founded, it was basically a Physical Oceanography Institution. For years and years and years, biology basically played a rather minor role here. But now, all of a sudden, health and the oceans – I see John Stegeman down the hall. He is working on those. All of a sudden, the Biology Department – and I look at Larry Madin, and the kind of things he is doing. A lot of it is because of the building of that particular field that you are talking about here.

DA: Well, the evolution of this institution reflects in many ways, the Navy, and its needs and so forth. But then in time, the realization that there's so much else that needs to be done in the oceans. For the longest time, I think biology was sort of one of the harder to get funding and so forth. We used to envy our physical oceanography colleagues because they could get one or two grants and support all of their salary and so forth. There seemed to be a lot of money and big money there. In biology, we'd have to put together lots of small projects to get enough money to keep the lab going. That's changed some. It's still very much the case, though, that we have a lot of different projects to keep things going. But because of the end of the Cold War and other things, some of the other areas that were there at the beginning of this institution are less emphasized now. So, there's been a shift, and it's a shift towards some biology, some instrumentation, observatories, that kind of thing. Some of the other topics, there's just less support there. That's just sort of the nature of the field of oceanography. Fortunately, I've been here during the time that biology has had a resurgence, and people are recognizing how important it is. It's just still amazing for me to think that here I am talking about myself as a biologist, when again, my background, you'd never ever have guessed that. I would never have predicted it that long ago, but that's I guess what I am.

FT: [laughter] As I told you in our pre-interview, what intrigued me about you so much was the background did not seem to lend to what it was you were doing. I see mechanical engineering, civil engineering. How does this get into this field?

DA: That's actually one of the things that I can really thank my university for, MIT. When we came in there as freshmen, they sort of told us that they like to teach you how to learn and how to think. It's not going to be memorization and learning this and learning that and then just sort of spitting it back. They were going to get us to think about the process. That's one of the things that when I was struggling in my first exams. Now, what they were teaching us was how to think. What I missed in the early times when I was flopping all my early exams was I was just trying to do the problem, and I would write down a certain amount of information. But what the instructors wanted was, what are you thinking? How are you thinking? So, you basically should write down, "I think this is the situation." You'd actually think out loud as you wrote the answer down. I would do this and this, and you show the equation. Then therefore, I'll cross out this term because it's negligible. Then I do this or that, and down you go. You may end up with the wrong answer because of something you did back. Even though you made a bad assumption early on, and your thought process from then on was still valid, you'd get more credit. So, that was something that took a while to learn. But I think it's done me very well because then you're used to learning things new, you're not intimidated. You can say, "Well, I can learn this new area," or you recognized what you know and what you don't know, and you then go and try to fill that gap. That's worked very well for me. But the other part of it, without a doubt, is that, again, just like we have wonderful graduate students here, we've got wonderful colleagues who are just the best in what they do. They're just right down the hall or right down the street. So, you can form these partnerships here. In time you've developed enough perception, whatever, to form partnerships outside of Woods Hole that bring in the other capabilities you don't have, then you start putting together the best team there is for doing certain work and you make this great progress. It's not because you know how to do it all, but it's so that you're enough conversant in some of these topics that you can recognize good capabilities in someone else or recognize even what's needed. So, all of that, I think comes from the background I had, which trained me in sort of a logical way of thinking, a quantitative way of thinking, and where numbers came relatively easily. I wasn't intimidated by physics or other things. So, it was that background, which described as being a lot of serendipity, as I can see the benefits from it to this day.

FT: It is interesting when I was teaching – and of course you give labs to the young folk, I was never so concerned with the answer they got as the procedure they used to come up with that answer. We used to do a lot of talking about the idea. You can come up with correct answers. But in some cases, when we look at procedures, there are more efficient ways of arriving at that answer, perhaps in some other ways. I can remember telling a parent one time, who was complaining about their child's coach at the high school level, and say, "Well, the good coaches for a field sport– there are a lot of things in common in all those sports. If a person learns what those common things are, they may not be an expert in that particular sport. But they can start to put things together and move forward." That kind of sounds like what you were doing here with this massive amount of stuff that you had to bring together. I mean, how does this little plant get from here to there? How come it is here rather than down here? How come it comes up here at a certain point in the year, which leads me to ask a couple of more things that I would like to enlarge on what we are talking about here? First of all, one thing I meant to ask you earlier, is there a season perhaps?

DA: Again, it depends on where you are. There absolutely is a season around here. It's just beginning right now here in April. Out on Cape Cod is where the things are going to happen. First, there's already detectable toxicity out in some of the ponds and salt ponds on Cape Cod, not at closure levels, but you said you're going to hear it's in paper. I would not be surprised, in the next week or two, you'll hear that they've closed down parts of Nauset. We've been there ahead of time because we know these are like other plants. They're germinating in this time of the year. March, April, they're starting to grow, but it's still cold and the days are short. As it warms up a little bit, they'll start to grow better. They bloom, cause toxicity, and then they drop back down to the sediments, and then we won't hear about them again until next year. Out in the Gulf of Maine, it's a much more protracted season, but it has that same sort of timing. Spring, May, April, May, ending sometime June, July, August, sometimes a little bit later and then gone during the winter. So, there definitely is a seasonality here. Other parts of the world, yes and no. Florida has some seasonality to theirs, but they've had red tides that have lasted thirteen to fourteen months that have never gone away. So, it really does depend.

FT: Another thing that going back to what would you just finished discussing, one of the things you gave a wonderful example of, I think, particularly for some young person that might listen to this is what investment in your field is all about? This is not nine-to-five. This is something that is a way of life [laughter] kind of thing.

DA: That's truly the way I view it. This is a job, but it's really not a job because it is a way of life. It is your life. I do a lot of things on the outside, but also as part of being a WHOI scientist, you travel a great deal. You go to meetings. If you're involved in a lot of workshops, you are a representative to this or that committee. You lose a lot of weekends. You lose a lot of weeks here and there. It's just something that you work into your life, just like other things. It certainly isn't tiresome, or I mean, we keep doing it because it's fascinating and it's a wonderful way of life, actually,

FT: I am wondering, as your reputation grows and continues to grow, and as your lab gets bigger, and as more and more funding becomes available, you still have to go through the process of going out and going after that money. It is not like they stand over your roof and shower it in on your head. How has your job changed from those early years in terms of how much time you have to spend on what? It is only twenty-four hours in a day.

DA: Well, several answers to that. The first one is that we spend much more time writing proposals than we used to. This lab wrote at least a dozen proposals last year. Of course, that varies year to year, but each one of those is often ten to fifteen pages of single-spaced text with figures and so forth. It's a big effort and you don't just do those in just a few days. They take a lot of time.

FT: Can I interrupt you right at that point? Because there are some, I am curious about, and I have heard polar opposites on this question I am going to ask. There are those people that absolutely hate the whole business of grant writing and say, "Gee, I wish after a certain point that they would just give us the money once we have proven ourselves." But then I have heard others say, "Actually, I like to do grant writing because it is a chance for me to crystallize my ideas and to kind of put everything together and think it through again." How do you feel about that?

DA: I'm afraid I come down in the middle. I think we write too many proposals, and I don't like that. But I do agree that it's important to keep yourself sharp by having to compete for money. If they just gave money to us, I think everybody would be dead wood in no time at all, because you need to be sharp. You need to be right on the edge of your field. You need to be thinking about what's new, how do I advance things? How do I sell this idea to my colleagues? We're going to be reviewing this proposal. I can't do that without being sharp and doing a lot of thinking. But on the other hand, times have changed, where it's a combination of things. As we have gotten older and our salaries are higher, and that's not just me but it's everyone who works for me, the money that's out there has not kept pace in the sense that I used to be able to write a proposal and put three months or four months of my time on an NSF proposal. So, if you did that, it wasn't that hard to then come up with nine or ten, or twelve months of my salary as Woods Hole needs. But again, the important point for some people that may not notice is that Woods Hole is the "soft money" institution where we have to raise all of our salaries on grants and contracts. You get a little bit of money for advising students or for other activities, but by and large, you're raising not just your salary, but the salaries of all the people who work for you. So, early on, when your salaries are relatively low, and the agencies have more money and less competition, you can actually get grants where you could meet your quota, if you will, with just a few grants. Nowadays, it takes much more. It takes much more because our salaries are higher, and so, the same money doesn't go as far. Therefore, you might get a month of time on a grant, or even some of them where it's only a few weeks for someone as a senior scientist. It takes a lot of those then to start adding up to get you the total. So, that's why you write proposals. Of course, not all your proposals get funded, so then you write more. So, that process then as over time has gotten to the point where I think we are fragmented a little too much that we're doing a few too many things, keeping a few too many balls in the air, and unfortunately, having to write too many proposals to get there. It's not just what's whole. It's like that. It's science in general. My colleagues all over the world will say the same thing, that they're too busy. They're having to do too many things. But we, by being "soft money," by not having money coming in from the state or something like that, for nine months of teaching position or something like that, like most universities, we have that much more to raise. So, there's a little bit additional pressure here, but it's true everywhere and times have changed. That being said, why are we still here? It's doable. We can still do good research and get the funding without giving up too much of our own personal lives and so forth. You get more efficient. You get better at knowing which of the opportunities you should compete for, you're better at competing for them, but it does take time. Like I said, if this were nine-to-five job, you could never do it. You could never do it.

FT: [laughter]

DA: This is something that you do some nights, some weekends. It's just something you do. You do the work when it has to be done.

FT: It always strikes me when I talk to biologists that we hear in the thirties, forties, and even up into the fifties. They had no idea where the money came from. Well, where did your money come from? "Well, I asked Columbus for it." [laughter] It is simple as that.

DA: They had it very good back then. They really did.

FT: We are running out of time slot –