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Wikfors, Gary ~ Oral History Interview

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Voices from the Fisheries
166 Water Street
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Interview with Gary Wikfors by Fred Calabretta
Summary Sheet and Transcript

Interviewee
Gary Wikfors

Interviewer
Fred Calabretta

Date
July 13, 2016

Place
Milford, Connecticut

ID Number
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Use Restrictions

Biographical Note
Gary Wikfors was born in Weehawken, NJ. After receiving his B.S. in biology at the University of Maine, Wikfors became interested in phycology. He began working at the Milford Laboratory in 1976 while earning his Master's at the University of Bridgeport. He later earned his Ph.D. at the Universtiy of Connecticut while continuing to work at the lab. He is now the Branch Chief of the Aquaculture Sustainability Assessment Branch at the Milford Lab.

Scope and Content Note
Interview contains discussions of: phycology, 20/20 program, aquaculture sustainability, pollution, collaboration with other scientists, ecosystems, shellfish, biochemical nutrition, toxic algae, ocean acidifications, climate change

Gary Wikfors discusses how his interest in microscopic organisms in the water began in 6th grade when saw an article in National Geographic. He discusses the unique way he began his career at the Milford Lab, the changes he has seen during his career, his emphasis on a team approach with his staff, and his research in aquaculture and phycology.

Indexed Names
Rust, Mike
Patterson, Glenn
Semaine, Jean Francois

Trainor, Frank
Ukeles, Dr. Ravenna

Transcript

Fred Calabretta: This is an oral history interview being conducted as part of the Voices from the Science Centers project funded by the Northeast Fisheries Science Center. It is also a part of the Voices from the Fisheries project supported by the NMFS Office of Science and Technology. The narrator is Gary Wikfors. The interviewer is Fred Calabretta. We're located at NOAA's Milford Lab and the date is July 13th, 2016. Well, just to start, if you could just state where you were born. Well, your full name, where you were born, where you grew up.

Gary Wikfors: My full name is Gary Howard Wikfors. I was born in Weehawken, New Jersey, and spent a few years there. I started school in Zurich, Switzerland for one and a half years, and came back in elementary school and stayed in New Jersey until I graduated from high school.

FC: And what were your earliest interests in the ocean or marine science? How did you get interested in all that?

GW: Believe it or not, I remember some of these things. I think it was sixth grade. There was a class in biology or environmental something and I needed to do a project and I had seen in National Geographic magazine a photo display of microscopic organisms in the water. And I was absolutely fascinated and I wrote a sixth grade research report based on that article and ever since then I've been fascinated by the things that are too small to see in the water.

FC: And after that, if you could just summarize your education and then how you got into the field?

GW: I did an undergraduate degree, B.S. in biology, at the University of Maine in Orono and I took a program called the pre-marine option that assumed that you would go to graduate school and towards the end of my undergraduate work, I didn't actually, I hadn't discovered something that I really wanted to go forward with until my senior year, when I took a course in phycology, the study of algae, and mainly it was about seaweeds. But in the beginning, there was a short section on microscopic algae, and there were those tiny organisms that I remember from sixth grade, some functional education about how they worked, and that was it for me. And so I asked a professor at the end of the semester, at the very end of my undergraduate life, "If you were to suggest the best person, who's the best person on the East Coast of the United States with whom to study microalgae?" He told me that there was a woman working at a federal laboratory in Milford, Connecticut, who had written several very, very influential research and review articles recently, and he said "I don't know if she's involved with any university, or whatever, but she's the person that everybody is talking about". And that person turned out to be Dr. Ravenna Ukeles. And it was too late for me to apply to graduate school for that year, so I drove to Milford, with a road map, from New Jersey and drove around town asking where the fisheries lab was, came to the door, and said "I'm here to see Dr. Ukeles" and the receptionist said: "Do you have an appointment?". My heart sunk, but I said "No, but I have an introduction from my professor to meet with her." So I met Dr. Ukeles and told her that my professor had said she's the best, so I buttered her up a little bit, and

that I wanted to study with her and is there any way to do that. And she said that the University of Bridgeport nearby here had been kind of bugging her to get involved somehow. And she said: "If you can get accepted in there, you can do your master's research with me in the Milford Laboratory." So I gained admission at the University of Bridgeport and the intervening year and a half, I was a road musician actually, playing music in a band that travelled between New York and Boston, playing in bars and country fairs and what have you. So I started my Master's here at the Milford Lab in 1976, finished that in 1978 and graduated in 1979. And I got along really well with Dr. Ukeles. And so she found a way, she first hired me six months at a time on temporary appointments and then eventually had an opportunity to hire me as a permanent worker. So I worked with her for about 10 years with a Master's degree, and she and several colleagues said: "Gary, you really need to get a Ph.D." I was doing research. I was publishing in the peer review or literature. But just for a union card, more or less, people were telling me I needed to do that. So, I enrolled in a Ph.D. program at the University of Connecticut while I was working full time here. And it was a program, it was very generous program that the agency had and still has called the 20/20 program. And the idea is, you work 20 hours a week, and you go to school 20 hours a week. Of course, I discovered it was like a 40/60 program, where you work 40 hours a week and go to school 60 hours a week, so it was kind of tough few years, but I studied a UConn with Frank Trainor. I was his 19th Ph.D. student, so he knew how to do it, and I had a great relationship with him, learned a lot, but I finished my Ph.D. in three years. Just took all my classes, was doing research, I had written a proposal for Long Island Sound research that involved the University of Connecticut, State University of New York, did a field study, did some lab studies, wrote a dissertation, got that all done. And in the meantime, of course, I had still been working here, and since then, and kind of like a cafeteria tray, I raised up from one job to the next and now I'm Branch Chief, what's called a Branch Chief here, so, responsible for about half of the research and technical staff.

FC: So, when you first came here, you ended up, I mean it wasn't as though there was an internship or a specific opportunity that existed, I mean, you kind of created it, or talked your way into it, and it worked out?

GW: Yeah, and you know the lesson I learned, and one that I tell students now is, like, go for it. Don't be passive, be active. If there's something you want, something you want to learn, some place you want to go, something you want to do. Be active about it, find the person that can help you make it happen, and tell them, ask them if they can help you, it might work out.

FC: Yeah, it did in your case. So you mentioned your current title, could you maybe talk a little bit more about your current responsibilities and activities?

GW: Yes, so, as a Branch Chief, and the name of my branch changed very recently from Biotechnology, which was a bit of a misnomer, to Aquaculture Sustainability Assessment Branch, and that's a bit more descriptive of what we do. We are assessing aquaculture practices for their sustainability at every level, from production and ecological, to social carrying capacity for aquaculture. And in this role, I supervise 12 scientists and technical people. By supervising, I implement all the government requirements for employees to comply with various rules and regulations. I also, each year, prepare a contract with each of the employees and we plan the next

year, and a year later, we compare each employee's accomplishments with what we planned at the beginning of the year. And I grade them actually, and in that role, it sounds a bit bureaucratic, there is a bureaucratic component to it, but of course, it requires that I have a very complete understanding of what each person is doing and how it fits, and in fact, the way we've been working for at least the last decade, is to create teams of people, so people don't work in isolation very often in my program. They become parts of teams that do specific projects and the project may last 3 years or it may last a little longer, but it's not open ended. And each, when we create those teams, each person's role is defined in this contract, performance plan we call it. And so, the bureaucratic part of it kind of gives me the responsibility of also organizing teams and using the expertise in my branch and supplementing that expertise with outside collaborators, and so on, which we've been doing very actively again for a long time. So, I'm a scientist and a project manager, more or less. That's the short version.

FC: And the, you mentioned the word collaboration a couple of times. When you, in your early years here, were you doing your research more or less independently or were the projects very collaborative in nature?

GW: When I first came here, there were more um…. the structure of the laboratory was in small investigations, where there would be a chief investigator and one or two technicians, and it actually wasn't very collaborative in those days. And I discovered the power of collaboration by recognizing that there were capabilities, analytical chemistry, things like that, that I couldn't do myself, to answer the questions that I wanted to answer, I needed somebody else who knew something that I didn't, and I was actually very active in developing some of the first collaborations in the lab and have really recognized and used that incredibly actively over the years. There's nothing we do here that doesn't involve some people from someplace else, and I'm especially involved with France and Korea, internationally, and a few other countries with a little less intensity, but I travel to those places every year and we have visitors from those countries. We've had people from, I think, 20 different nations come, as post docs, on sabbaticals, as graduate students, so the collaboration isn't just between us and other people and the other program, and the lab, it's really international.

FC: And, could you talk a little bit more about the research focus of the branch when you joined at that time in the ‘70s?

GW: Yeah, when I came here, the mission of the lab was to understand the effects of pollutants on sea life. And there was expertise in heavy metals especially, and a little bit with PCBs and PAHs, and so my Masters project was about trophic transfer of heavy metals from algae to larval oysters. There was a very deliberate evaluation of that science, say in the mid ‘80s. And one of the leaders in the center had a phrase I will never forget was "How many times do we have to prove that poison is bad for living things? We've actually accomplished the main task, and there's recognition, and laws are being changed and so on, and what do we do next?" And, so the early history of the lab was in aquaculture development, but the federal government didn't think, and the agency didn't think that they had a role in aquaculture, and so we were tasked then with understanding early life history of living things, for about a decade, and that's something you can do if you have aquaculture capability. You spawn and grow the animals. You describe how they

develop and that went on again for about a decade. And then there was another change of administration in Washington, and a re-evaluation of that role, and that point we had an external review committee come in and give recommendations to the agency on what would be the best role for this laboratory and the decision at that time was to go back to the original mission which was aquaculture development. And so since mid '90s, I guess, we've been in an aquaculture role which is a little bit uncomfortable in the National Marine Fisheries Service, that is really focused on stock assessments. We don't do stock assessments here, we do something that actually doesn't really contribute that much to stock assessments, or how many cod are in the sea, or how many clams are on the bottom of the Atlantic Ocean, that's really what the agency is focused on doing, and we do very different things. So, I mentioned the new title of my branch has the word 'assessment' in it. Trying to bring ourselves in a bit closer coordination with , you could say, the biases or the focus of the agency.

FC: Now, when you first started especially in the earlier years, I have a couple of questions, but one is, were there certain paradigms or models that guided, the specific ones that guided the research at that time?

GW: Um, almost everyone here was doing some form of experimental biology and so as laboratory based design of experiments, with controls and variables, and measuring responses, and so the foundation of my approach to science is this experimental idea, and again that's a bit at odds with assessment, which is observational. You go out, you pull a net through the water, you can see what you caught, but you're not actually controlling variables and doing exposures. And it's been a bit of a challenge, actually, to break out of that mode, and again, it's something that we've had to do consciously to make sure that our work remains relevant to the constraints limiting development of aquaculture. I view our main mission now is removing barriers from the development of sustainable aquaculture for domestic seafood production, and that doesn't just involve playing in the sink, little beakers of oyster larvae, and so on. We do some of that still, there are some problems that can be solved that way. We need to be in the environment because many of these constraints have to do with precautionary principle and permitting processes that, if there's no knowledge concerning the possible environmental effects of an aquaculture practice, the default is to say no, to not allow it to happen, so we need to go in the environment and look at the interactions of aquaculture practices. They have to be good for the sustainable, for the animals that are being cultivated. They have to be sustainable financially for the aquacultures. They need to be sustainable in not causing ancillary effects in the environment that are undesirable and they need to be sustainable socially and people need to feel confident that what those people are being allowed to do out in my bay or out off my point is not harmful or not unfair in some way.

FC: And one thing, backtracking a little bit, talking about you're establishing your career in the mid to late 1970s. And I'm thinking that in the late '60s and early '70s, you really, you have the environmental movement gaining traction and you have the EPA. Was there sort of a direct, I mean you mentioned pollution based studies and things like that, so was some of that sort of tied into that trend?

GW: Oh, absolutely. Yeah, and we all felt that we were helping to save the world, and that's a good feeling for a young person to say I'm part of the solution to the pollution and destruction and all the

bad things that people do. And, again, when you're in an aquaculture mode, it's actively doing something in the environment, so you have to get over this self-loathing. That whatever man does is going to be bad, and I think we're really in a good place as far as shellfish aquaculture is concerned because it's been shown to restore ecosystems by restoring the functions of oyster or mussels or something and it's good for the economy. It's a good thing people can do and actually we're in the forefront of describing and quantifying some of the ecosystem's services of shellfish aquaculture. We coined the term nutrient bio extraction as a way of managing nutrients actively using shellfish aquaculture to sop them up like sponges, and when you harvest oysters, all the protein in them has the nitrogen that came from the ecosystem, and nitrogen pollution is a big deal now. Not so much metals and toxins, but we're over fertilizing the sea, and cutting the grass and carrying away the clippings so to speak is one way to help manage that issue.

FC: So, different threats over time.

GW: And we still feel like we're helping to save the world, only instead of saying "we have to stop doing this, we have to stop doing everything that people do", this is something we can start doing. We do more of, that we think would be good for the environment. Again, we think it will be not because we want it to be, but because we go out and do measurements and do assessments of aquaculture practices, quantitative assessments.

FC: And would you talk a little bit about your specific research interests over the years. I know microalgae is a major aspect of that?

GW: Yeah, my first mentor, Ravenna Ukeles was known for microalgae culture and nutrition of shellfish and so once we got back into life history and that aquaculture mode. Actually, a big piece of my career was to develop biochemical based feeding standards for oysters and for scallops and for clams, and so we started doing serio box analysis of different algal species, how much carbohydrates, how much protein, how much fat. Then we started to recognize that that wasn't enough and we needed to know some things about fine lipids, about fatty acids, and one of my big discoveries was how important sterols are, in the nutritional bivalves and, with a collaborator at the University of Maryland, we more than doubled the literature on micro algal sterols. And once we could understand what sterols were in what algae, and we did some statistics to show we were pretty sure that some of those sterols were usable nutritionally by shellfish, and some of them weren't. Then all the mystery about why some algae were better foods for an oyster than others was gone, we actually figured that out. And, a little side note on that is, we discovered that at the same instant and presented at the same meeting as a colleague I had not met before in France, and that began my collaboration with French shellfish researchers. We presented one after the other, the session chair saw our titles and said "Oh, this is about the same thing", so you know he presented first, and then I got up and after I gave my talk that was pretty much the same results as Jean-Francois Semaine, instead of going back to my seat, I went and sat next to him, and I said, "That's really cool!" and he goes "yeah, yours was too", so anyway this biochemical nutrition was a big deal. The next thing that occupied another probably fifteen years of my career was recognizing that harmful algae that produce toxins that can make people sick, can affect the shellfish as well. And up until we started working on that, shellfish were considered to be symptomless vectors of paralytic shellfish toxin and diarrhetic shellfish toxin, and so on, to human

consumers, that they were immune to all these chemicals that were produced by harmful algae, by red tides and so on. And we, through some field work, recognized that that's not true at all. So then as another long period of experimental biology to demonstrate that these harmful effects occurred, to define what they are, and what's the risk to aquaculture. These are equivalent in a way, harmful algae, are equivalent to poisonous weed to Jimson weed in cattle grazing areas. It's part of the ecosystem, part of the environment, but you have to recognize that there's a risk and manage that risk somehow. And we published, I'm gonna say fifty or sixty papers about harmful effects of toxic algae on shellfish themselves, which again hadn't been recognized before. We reached an endpoint on that in a way, although I'm still working on that with some French colleagues, and proposing some things to do in Europe, more so than here, but my own agency is not that interested in it, so I'm sort of providing support to others to move that forward, but more recently we've moved to this, all aspects of carrying capacity and ecosystems services of shellfish, and one of those ecosystems services is this nutrient bio extraction where intensive mussel or oyster aquaculture clears the water of algae, first of all, it makes it clearer, that's a great thing. It's good for recreational fishing. There's all these social benefits all of a sudden to having an oyster farm in your bay, and then removing them takes the nutrients out, the habitat that's created by an oyster farm. We have a study going on right this summer, right off of Milford here comparing an oyster farm with a non-oyster farm. What kind of fish visit there? What kind of invertebrates find habitat and shelter in an oyster farm compared to a bare bottom? So that's, there's been very much an evolution, and what's amazing to me is like, no scientist ever reaches the end of the road on something, but the biochemical nutrition aspect of my career really came to a complete end in 2013, published a definitive paper on sterol metabolism with a colleague at University of New York, or State University of New York, and there's little bits of stuff that people are still gonna do, but we really have nailed down every aspect of nutrition of an oyster or scallop or clam and so on. And that doesn't mean we don't pay attention to that anymore, because although we've published the papers, a lot of what we know is not being used as thoroughly as it could be in the aquaculture industry, and so we do a lot of outreach on that topic now and I teach a class every year of 12 to 16 people who work in shellfish hatcheries. We teach them how to culture algae. We teach them which algae to culture for which stages for which bivalves. We take the science we published over the last 15 years and actively put it into practice over and over again, but there's no need to actually learn anything more, practically speaking, to feed shellfish in the hatcheries. So, again, there's really not a lot of models to look at, at scientists who have gotten to the end of something, and there's no more questions that really need to be answered, there's more you could ask, but you don't really need to bring that science forward anymore, you just need to get it into practice at this point.

FC: And, could you talk a little bit more about how that happens because as a result of your research, you generate valuable information, and how do you… What's the process for getting that out there or getting it into practice so that it is beneficial, is that one of the challenges of the work?

GW: It is, and we've been, I'd say, more than encouraged to do that by the National NOAA Fisheries Office of Aquaculture that's been providing funding to us, and one of the individuals in that organization, who's the science advisor, Mike Rust. I met him about 10 years ago and I had already been teaching the workshop, but it was more of, it still is hands on, but it was more just about the mechanics of how to grow algae, but not so much about the why, this algae for this

application and so on, and he and I have had, I enjoy arguing, that's why I get along with French people so well, he and I have had many arguments. We travel together to conferences and have spent a lot of time together and the conclusion we've come to, that we can both agree to, he was saying that nobody reads the scientific publications, there's no reason to do that. And my point is that, it's like the Good Housekeeping Seal of Approval. In the public outreach materials, the title may read “NOAA Research Revolutionizes Aquaculture", but the first sentence is going to be, "In research published in the journal Aquaculture, NOAA scientists have reported...", you need that validation, you need that peer review, you need to know that the science has been vetted in a professional way, but that's not the last step, and this is Mike's influence on me, that's just a first step. And as a government agency that's serving an industry and the public and so on, we're obliged to make sure to market that, and to make sure that it causes changes, it changes practices, it changes the minds and hearts of people involved in the thing we're trying to develop. And so that, I'm not sure I remember exactly how you asked the question..?, But that's been my evolution of thinking, to be sure that everything we do has an active outreach component to it, and we work a lot with Sea Grant, which is another completely different part of NOAA but in every state, coastal state, similar to land grant, there is a Sea Grant office, where there are extension agents that are the ones that actually go out to the oyster farms, that's their job, they don't do research. They go out to oyster farms and they say, "oh, there's a scientific study that we think would help you", and if the oyster farmers are not comfortable reading that verbiage exactly, you know, the extension people translate it to normal English, so we include, we collaborate with the extension agents from everywhere around the country honestly, to get some parts of what we do out there, but then we actually ourselves interact. If you're going to evaluate an aquaculture practice, you can either create a facsimile of it yourself or you can go to a real farm, where it's really being done the way they do it, and you don't have to guess, and so that's what we've been doing for the last 10 years, is collaborating with those people, and there's no stronger connection. I'm working on that guy's farm. I see him every day or see him once a week or whatever for three years, and then we really get to know each other. We get to know what they're doing, and all the conversation that happens includes transferring scientific knowledge. And also getting questions back, like "do we know enough about the effect of current speed in this range? This is higher than anybody else has reported on, so maybe we need to do a current speed study." So, it's very interactive at this point, it's actually interesting and nice.

FC: What about, we worked on a large project in the early '90, documenting the Stonington commercial fishing fleet, and we're talking about fin fish and lobster, and ... scallops too. And that's at a time when, greatly increased regulations on what they can catch, and a lot of resentment on the part of the commercial fishermen, but my point is, I heard a lot of, and again it's a totally different scenario, but I heard a lot "oh, those scientists, they don't know what they're talking about, I'm out here every day, and I've seen these cycles, and I've seen this and I've seen that and my father did it and my grandfather did it, and those guys don't know what they're talking about." Do you run into any of that?

GW: There are some shellfish farmers who think that the only thing worse than a scientist is a government scientist, you know? But we're breaking down a lot of those barriers, and I have to say that there's been a double digit increase in oyster farming, in the landings and in the value every

year for the last seven or eight years, that means a lot of new people coming in, and a lot of the new people coming in have science degrees, or they're coming from a culinary kind of background but with advanced education. And they're starting to recognize that there can be scientists who are just into their own thing and they can tell the difference, actually, pretty quickly between someone who is there to mobilize science on their behalf versus to feed their own egos and so on. The people that I find we're interacting with more are sophisticated, educated, and very smart. It's less the fifth generation, you know, baymen who are uncomfortably moving from wild harvest to aquaculture, and there are a lot of new people coming in, and it really is transforming the industry and it's growing like crazy, and it's growing based on new people entering the industry.

FC: So the aquaculture industry in Long Island Sound is healthy?

GW: It is, it's growing. You know, there are two big companies in Norwalk and their dominance is shrinking by the year, which is a good thing because diversity is great, and they use very traditional practices and the new people coming in are using very innovative kind of culture methods and so on, so there's a very much more, a bigger mix of things. You know, the old companies have been relying forever on catching wild spat. The seed comes from natural recruitment or natural reproduction and they put shell down in some areas and the oyster larvae like to set on shell, and then they pick the shell up and move it around and so on. And both of those big companies are building hatcheries right now so they're moving, also moving forward into more modern practices. We'd like to think we have a role in that, but they influence each other more than we do. So, if we influence a few people, and then those people influence their peers, I think that's more the dynamic that's happening. Again, it's happening very quickly, very actively right now. And oysters are trendy, and so with oysters being trendy, we pay attention to oysters and so on, but we're looking ahead to blue mussels as a crop for our region, and more off shore than near shore. So, we're continuing to serve the oyster aquaculture community, but we see that, that's like a snowball rolling down a hill at this point, it doesn't need a lot, a lot of push. Just a little bit, support, when it's asked for, but we're looking ahead to what's the next shellfish aquaculture opportunity, and we think it's blue mussels off shore.

FC: And do you have concerns about the future in terms of threats to aquaculture, especially regionally, locally?

GW: Well, from my experience with harmful algae, I do know that toxic blooms that make shellfish unfit for human consumption, that make people sick when they eat them, are a constraint. It's an ecological constraint. It could be managed around and so on, but if there's ever a substantial outbreak of a shellfish poisoning, it's gonna put a big hit on the industry. And we're not responsible for monitoring. We're not responsible for human health. FDA either does that itself or delegates that to state agencies. In Connecticut, it's delegated to the Department of Agriculture-Aquaculture Division, which is right across the parking lot from us here. And we actually provide technical support to them, but again it's not our responsibility. I remain concerned that toxic algae could put the brakes on our industry. I'm less concerned about regulation, I think we're actively addressing the precautionary principal kind of issues and I think there will be some general permits. That if you're gonna follow these practices that are defined in this language, in this document and so on, it's much easier and cheaper to get a permit to build a farm of one size or another in a location.

We're always concerned about the emphasis of our own agency, because as I described through the history, we've been redirected fairly, almost at right angles several times to what we had been doing before. So we feel we're in a good trajectory now, to help this industry, to provide the science support and technical support and so on, but a change in administration could come with new leadership at whatever level in the agency. They can say, "no, we're not gonna do that anymore, we can do something else" and I guess we need to be prepared to do the best we can to follow whatever that emphasis is.

FC: So that's a, I don't know if it's a threat, but it's a concern and it depends on a higher level of administration, which is true of any organization, I guess. And in terms of future threats, what about concerns for, well related to climate change, like, sea level rise, ocean temperature change, are those things that...

GW: They are, yeah. Ocean acidification is mentioned very often as a threat, and I think it probably is. Another phrase that we invented, and got into the lexicon of ocean acidification, is winners and losers. There's gonna be winners and losers in the ecosystems. And shellfish, bivalve shellfish, have been characterized as big time potential losers and we're actually doing research right now to question that. Is that really true? And so far ,it looks like shellfish are more resilient than people are giving them credit for. And so, they're getting that message again to the industry, I've heard shellfish farmers my age say, "Well, I was gonna have my kids go into this business, but there's no future in it because of ocean acidification." And I go," wait a minute, you know what? Don't make that decision yet because we're still trying to figure out really what the threat is." Sea level rise, much more of a human concern, shellfish can move. The fecundity of those animals is amazing. Every adult female oyster makes four million eggs a year and so the reproductive potential is incredible so sea level rises, well, they'll just set in a different place next year. The temperature thing is kind of a big deal, and most of the shellfish that we've been working with exist from tropical to boreal ecosystems, oysters, hard clams, some of the scallops. Mussels are cold water species and they may be pushed north. In fact, you can't really grow mussels to adult size on Long Island Sound. It's just too warm for them. Lobsters have been excluded spectacularly by temperature, period. Despite what everybody else or what some people say about pesticides and so on, totally a temperature effect. The threats I'm more concerned about is not so much the physiological threat that the oyster or the clam won't be able to exist here any longer, but rather the spread of diseases. Parasites that are more prevalent in the south coming here, and worse yet, predators. There's an elasmobranch, the cow-nose ray in Chesapeake Bay and it's now in Delaware Bay, and that is a voracious predator on shellfish on the bottom. Our two large oyster companies do bottom culture. If the cow-nose ray comes in here, two years from now, their entire livestock is going to be eaten. There'll be nothing to harvest. Right now, it's still a little too cold for cow-nosed rays here. Blue crabs, once the lobster left, people are starting to see more blue crabs around and those are incredible predators on shellfish. And so the practices, bottom cultivation, I think, is not going to be practical very much longer here. And we'll have to look to the south and see how farmers have solved those issues there, with cage culture, with off bottom culture, you know withdifferent things, and so the temperature change thing, for certain, is going to change practices in each region, but again, the animals we're talking about as livestock, exist farther south than us

here, so physiologically, they're adapted or adaptable, and there are ways with dealing with parasites and predators.

FC: So, that's an interesting aspect, that you may in some cases be looking to the south for answers, as these species move north from where they've been, you can take a look at where they've been and maybe that will help deal with the issues here.

GW: Yeah, once again, certain things make an impression, you remember them a long time. When one discussion of climate change, it wasn't even a marine related one, but if you want to know what the climate is going to be like in Connecticut in 100 years, go to Savannah, Georgia in the summer. And so that tells me, so if I want to see what it's gonna be like here, I ought to be looking to the south and looking at how, what's different about cultivation practices and so on, and we have been doing that, and since you mention climate change, I think that's what's gonna happen, that conditions that exist now in places where shellfish cultivation is being done, those conditions are going to move northward and we're going to have to start changing what people have been doing here forever, to be more consistent with the environment that we're dealing with.

FC: And, another aspect of climate change is that we hear more about the potential for more severe storms. We've seen sort of a run of severe storms the past four or five years, now is that much of a threat or are the shellfish durable enough to handle that?

GW: No, that is a threat and you know, in a couple of the storms that we've had, the spectacular one, Sandy, and a couple of the hurricanes, alot of bottom cultivated shellfish have simply been buried. Go with the dredge to the place that they used to be and dig down as far as the dredge will go and they're still getting new sand. Cage culture, the cages can be scattered for miles, and here you're leasing bottom, and if your cages go off your leased land, now you're in violation of your permit and so on. So for sure, the storm thing is going to have to be dealt with, and I think a lot of innovative growers are looking to less permanent, movable stuff that can be taken up with the threat of the storm, and put some place else. There's hundreds year old practices in the north, in Maine, of what's called pitting oysters. If they're intertidal, there's ice and snow, they freeze, they don't survive very well. For hundreds of years, people have been harvesting sub size oysters, small oysters, in the fall, and putting them in a hole in the ground and covering it with damp seaweed and leaves and pine needles and whatever they have there, and the oysters can survive all winter, out of water and kind of hibernating, and be dug back up in the spring and put back in the water and resume their lives. So, there's a lot of potential for working around and that's the way with aquaculture really. For every challenge that comes along, some innovative farmer or scientist comes up with a work around, and as far as storms are concerned, I think that mobile gear and moving stuff to a safe place for a few days, a week or whatever when there's a threat, is probably gonna be the response.

FC: Has the, not directly related, but has the historical record sort of been a factor at all in your research? In other words, is it useful to know that a hundred years ago this particular area was very productive for oysters, or this area wasn't or is historical research relevant to your work, or has it been?

GW: I have to say, there are individuals who are really into that. I'm not one of them actually, and so I kind of leave that to other people, that's their thing, but I mean in a way there's relevance, and in my view, like a lack of relevance to that, and again, it's recognizing that there has been change, there's been change in water sheds from human activity. Connecticut was mainly agricultural at one point in our development and now it's mainly forested again, and the human influences on the watershed have changed a lot. Now the urban and suburbanization rather than agricultural or forested, and to say that oysters or bay scallops let's say, flourished in Westport in some period of human history, that doesn't mean that we can go back to that, and it doesn't mean that the ecosystem is even able to support what used to exist there, because of human changes, because of climate change, because of ocean scale changes, the North Atlantic Oscillation, the El Niño, La Niña cycles and all that stuff, and people have memories, and there's written history that kind of describes the responses locally to environmental changes at every scale, and to look at that and try to evaluate it without all the rest of the data, I think can be very misleading, and I have arguments a lot with restoration people. It's like what are you restoring to? For most people, it is to when they were kids, and it's like when you get to people in our generation, when we were kids it was about the worst time in environmental history. Do we really want to go back there? No, heck no. So that's my "discomfort with the whole historical thing, just because something existed in a time and place before, that doesn't mean that we can restore that or that it's even desirable to go back to that time and place. I prefer to look forward and say alright what's the best thing we can do now and projecting forward", because there's nothing we can go back and fix.

FC: And there are so many variables. There could be this huge body of evidence that suggests that that happened, that oyster that died off in 1920 happened because of all this stuff, but there could be one critical detail that is not recorded that is the key to the whole thing. It's like archeology, you have all this evidence that suggest this was used as a tool to do something, but you could be missing a critical piece of information and it was really used for something else so.

GW: Yes, absolutely, that's the main point. You can't put that stuff back together, you know, from a practical standpoint, again there's academic scientists who do brilliant work reconstructing paleoclimates and so on, and it's a whole specialty and so on, but in a way, my question is, is that relevant to the future. It may be. There's the famous statement about reliving the past if you don't understand it and so on, and I mean somebody ought to be doing that in my view, but as far as very practical today sea food issues, we got huge problems to solve. We import 90% of our seafood, half of that is aquacultured somewhere else, and that's not food security in my view, so I tend to have a much more immediate and near term future, like we actually gotta do something actively to correct some of the imbalances that we have.

FC: Did, you mentioned earlier while you were talking about an aquaculture project, I guess oyster beds in Milford, and you worked with them to some degree, and I'm wondering, how do you collect your data for that project? What technology or devices?

GW: So, that actually is not my project, I have actually no role in it at all. I mentioned it because it's kind of an interesting one, but it's a good question because the initial vision for that project was to use very basic, simple technology of trapping fish. And part of the study is to put fish traps out every week and pull them up and count and identify the fish that are caught. What about the fish

you don't catch in little traps? So, the next idea was Go Pro cameras, deployed there that take x amount of footage every five minutes, every hour, something like that, around the clock and see the bigger things. So our division chief at some conference became aware of a technology called eDNA, and it seems that some scientists at Columbia University working on something completely different, recognized that every fish that swims through a piece of water, leaves behind some evidence that it was there. It leaves fecal material. It loses mucus from the outside. It'll drop a scale or something that'll start to decay and so on, and actually the water is full of little fragments of DNA that are specific to organisms. That's how you define in modern way a species, it has a certain sequence of DNA, and so we're not in huge scale, but we're doing a little investigative level testing of eDNA as a way to detect fish that have evaded our technologies that we've deployed otherwise, and that's super innovative and it's high risk, and my own view of it is, it's probably gonna give us this image of stuff that's not very easy to interpret. Maybe it's not a mature technology, but that's why we're not depending on it, we're doing a little bit of it, to see if we get anything back that's interpretable and so on.

FC: What about technology in general and how the impact of technology on your research, for example, whether it be computers or lab equipment, or whatever over the years?

GW: Well, I mean computers have been transformative, that's amazing. I remember doing analysis of variance with a giant piece of paper on the table 'cause you have a big data set and a calculator . You sum the square, you square each value in a box, and then you sum those across, and with a calculator and you write the number down and everything and those all have to be put on a slide rule in the end kind of thing, and now you just push a button and it happens. It's easier to misuse it now, of course, because you have access to statistics and what have you, but I mean that's made a huge difference actually in what's possible. And the other thing I haven't mentioned yet when talking about the history of my career, in the last 15 years I've been hugely involved in immunology of shellfish, which is not algae, but it's a single celled thing. Oysters and clams and mussels have white blood cells that function just like human neutrophils, and the technology that I signed on very early for microalgae was something called flow cytometry and that's a blood analyzer that was developed as a consequence of the AIDS epidemic. Because patients would need very rapid, daily assessments of the immune status, their white blood cell status. And so this technology passes blood cells in single file in front of a laser and measures a bunch of optical properties at the rate of five to ten thousand cells a second, so it's amazing technology. We bought the very first desktop flow cytometer that was offered for sale, in this laboratory, the year it was released, to do phytoplankton counting and evaluations and so on, and about 15 years ago, I started with French colleagues to apply flow cytometry to the immune cells of shellfish and we wrote two papers together. The first demonstration that you can use flow cytometry to analyze the immune function of white blood cells in shellfish in 2003, and I had to check for another reason, but those papers have been cited 185 times, no 285 times, so a really big influence, and so flow cytometry has been, sort of, my second career out of algae into shellfish physiology and immunology and how they defend themselves, hugely useful at the harmful algal work, because there are protective immune responses that shellfish use to protect themselves, and that's one of the first ways we knew that they were affected, by the fact that they were trying to protect themselves from that stuff, and so flow cytometry for me that's been the technology that again, a bit later in my career, I've

recognized another whole aspect and potential for that I didn't anticipate when we first got into it for phytoplankton work, and that's kind of my passion at this point, actually, to apply that technology and questions in marine science, and relevant to the practical business of shellfish health, and how to deal with climate change, by modifying culture practices. When is disease pressure, every disease is opportunistic, a disease is a failure of the immune system, and if you understand the immune system, you can really understand disease dynamics, you can understand. Many, many people study oyster diseases but they study it after the immune system has failed, and I want to define that period upfront. What have we done to that oyster in terms of its' exposure to the environment or to what we do to it. How we contain it? Are they too crowded? All these questions, and again it's an experimental approach, you can do experiments where you control the treatments and analyze the response. And, you know, flow cytometry in the immune cells is, in my view, a hugely unexploited potential for understanding shellfish health, that's my current thing that I'm really into.

FC: I mean it sounds like a tool that's just a gateway to all this data that you couldn't access before.

GW: Yeah. Well, you know recognizing that these immune cells are so equivalent to human neutrophils, that's our innate immune system, that all of the biomedical tools that have been developed, people have a lot of money to study human health. I mean those guys have all the money, all the toys, and so on. All the stuff that those guys have developed can be applied, and there's catalogues online of pages and pages… if you want to measure the rate of alkaline phosphatase activity in a cell, you use this probe and here's a protocol that's written, and the stuff is cheap. So, I mean, I go to that website and it's, like, the other people I work with flow cytometry are all like "Gary's looking at the catalogue again, we're gonna be running another set of probes or something" but, I mean, to be able to take advantage of this kind of cross field technological development that's been accomplished with a human health aspect and applying that to shellfish. It saves us the 50 years it's taken biomedical science to get to this point. I mean it's really exciting I think.

FC: Why not use it?

GW: Yeah.

FC: What have been some of the greatest challenges you've faced in your career, I think we've probably touched on some, but..?

GW: Really, it's organizational stuff. A lot of my colleagues and professional friends are at universities and they're free to follow whatever they'd like to, and if they can convince someone to give them money or write a proposal, and their challenge is a lot of professors are proposal factories. They sit there, that's all they do is write proposals to keep their students and tjeor technicians and everything funded. My challenge, on the other hand, is, like, having great ideas and not getting buy in from the agency, and the worst thing in my view, the worst thing I've had to do in my career is to have a junior person that I supervise come to me with, like, a brilliant, fantastic idea and have to tell them two weeks later or two months later, "I tried as hard as I could to sell it, but it's getting no traction, so no, you're not gonna do it." I mean, I hate that more than anything, and so when I can actually make something like that happen for somebody or an idea I

have or whatever, it's a great victory and a miracle [chuckles] in a lot of cases. And you know, the regrets are the ones I wasn't able to get buy in by the agency to make an investment to give us the time, to give us the stuff to follow up on some ideas that a number of us have had, that really should have been done, and it especially hurts when somebody else does it, and gets a lot of credit for it and it's like ahh..

FC: We could have done that.

GW: That's right, we could have done that.

FC: What's been the most, or what are the most rewarding aspects of your career to date? What are you most proud of?

GW: There's two things, and it may sound strange, in that it's not been technical stuff I've been working on. Developing this team based idea of working, of cultivating a human dynamic that allows people to bring their expertise, their ideas together collaboratively, instead of being like, the boss told me to do it, so I'm doing it even though it's stupid kind of thing, but creating that environment, hugely rewarding, because I see the benefits of it. I see the people with whom I'm working are happy. I see people from countries all around the world, wanting to come here, to be part of the teams that we've put together to do things. That's huge. And the other thing is, at my age now, the young people I've influenced. I have a very strong recollection of Ukeles and Trainor, Glenn Patterson and a number of other people that early in my career were really supportive and considerate and recognized that I had something to bring and I wasn't just someone to be told what to do and so on. And to be giving that back to the young people, with graduate students, I've been on more than 20 graduate student committees at this point, and many of them come here to this lab for a year or a summer or whatever to do a big chunk of their dissertation or thesis research. And I look at a list of those names, I feel really good, because I see people who are out there doing great stuff, and I know that. I'm in touch with most of them still. They don't go away and forget. So I have this extended family, enormous extended family of young people, who have part of their development and part of their growing up that happened here and I influenced it, and they're happy about it. [laughter] There are so many students who come out of a Ph.D. with bitterness, and I have not a single instance of that, so I feel really good about that. And I think it's because I care about these people. I make an effort, I put the time in, I listen to them, I don't just tell them, I listen to them. So those two things, the team business and my, all my children.

FC: I was going to ask you about your teaching, and that's a great description...

GW: I hate the dynamic of standing in front of a room and blabbing, and having a room full of passive people sitting there. I don't do that, and that's one of the reasons that I didn't think ever of going to a university job. I've had offers, I've been head hunted at a number of places and so on. I said, no. I hated that when I was on the receiving end of it. I mean I tolerated it to the very end, as much as you can, but I don't want to be on the other side of that dynamic at all. But working with a team of people or one person, I mean when somebody comes here and they're part of a big team and so on, you still have to have that one on one interaction so that you really understand that

person. And that's the kind of teaching I really, really like and appreciate, and I think is effective compared to just transmitting, broadcasting words and hoping they fall somewhere.

FC: Yeah, it's like watching a prerecorded speech on YouTube or something.

GW: Right!

FC: We've covered a lot here, I should let you get back to work, but have there been any, and you've mentioned some, I think. I was gonna ask you about major surprises in your research, and you did address a few things. Are there other surprises that we haven't talked about or unexpected results, or over the years?

GW: There's always little ones. This is a really specific one. But, I remember it so fondly, that I'll mention it. While working with harmful algae with some French colleagues, we had an unexpected opportunity to have a population of clams. This was Manila clams that had extremely variable parasite burdens in them, and we experimentally exposed, before we do, clams to harmful algae and clams to non-harmful algae side by side, and then did a whole bunch of evaluation, including parasite burden. And in the clams that had been exposed to one toxic algae, they were cured of their parasitic disease. And me and my Ph.D. student at the time, who were doing this, looked at each other, and we both smiled at the same instant. It's like there was one light bulb in between us in the room. The parasite is more susceptible to the toxin than the clam is! And all of a sudden, now she's in France, has a great job with their national fisheries agency, patterns in disease and harmful algal bloom started to make sense. If the parasite is more susceptible to the algal toxin, a harmful algal bloom may stress the clam a little bit, but it cures its' disease. I mean, who would have anticipated that, right? I mean, you couldn't, but I mean you could do an experiment and find it out, and it's like my Ph.D. advisor. I asked him, he discovered some really fundamentally important stuff. And I said, "How do you do that?", and he said, "Well, first thing, be doing something, ‘cause you can't trip on anything if you're not walking, but then be smart enough to recognize when you trip on something that there's something there. Like, pay attention to the things that you see, that you're like what the heck? That's where you discover the big things. If you're expecting something and you confirm it, that's 90% of what you do. But once in a while you trip on something that you don't understand. That's your biggest opportunity." And he was right, 'cause 20 years later, there we were looking at this data going, holy smokes like who would have thought?

FC: Yeah, just totally unanticipated. Well, is there anything else that we should have covered, but didn't, or anything you'd like to add, or...?

GW: [chuckles] Well, I feel like I've talked myself out pretty thoroughly.

FC: Well, that's the idea, no, that's great, very helpful.

GW: I guess the one other thing, you know, and we began before you were recording with me, talking about my second career with music and so on. I know a lot of technical people who are also into music in different ways, and I think everyone is starting to recognize the quantitative, the numeric nature of music and scientific data. And I think those two things, it's not unexpected that scientists should have an aptitude in music or have an intuition about it, because it's about numbers. It's about quantities. It's about relationships that are quantified by numbers and intervals

and things like that, but the other aspect of music that I have been doing, performing and composing, and you know every aspect of that, I think the, and I'm not a solo player. There are two kinds of musicians, the ones that struggle with their limitations alone in a room, and there are people like me who go to a party with a mandolin and a guitar and spend six hours making stuff up and singing with people and everything. But I think that communal kind of sharing of a nonverbal, quantitative kind of thought process is so much like the science environment I've tried to create. That team approach and so on I think comes from playing music together with other people, playing different instruments. You have to somehow make it harmonize, you have to somehow make it coordinated, you have to make it the meter, everyone has to observe the same meter or at least in one dimension, you have to be together kind of thing. And I really think that those things come together so much, and I never thought about it explicitly until the last few years, I became a little bit more aware, or analytical about how I spend my time and how I interact with people and so on. So I mean I think those two things reinforce each other so well that other aspects helped me to also understand the other people I work with, like, what are their hobbies, what are their interests, how do they relate to things. People are entire beings, not just your work life, and I think that's been very, I'm very aware of that now, and I wasn't until fairly recently.

FC: So, do you think, in your case, there's a, you have these two passions, one is science, one is music, other interests I'm sure, but those two are very important to you, so you've seen this connection between the two, do you think that's true of others? That there are other people on staff here who may have interests, other than music, that also kind of correlate to their scientific work?

GW: Yeah, yeah there's a student with us this summer who is an aerialist, has worked in circus. And when you think about how she analyzes a situation, it's more about balance, you know. If we're going to put emphasis on this, we're gonna get less emphasis on that, and so her thought process is very different than mine. Rather than coordinating tones and harmonizing and having everyone on the same meter, she's thinking always about the balance of things, and it helps you appreciate where people are coming from, 'cause sometimes someone will say something, or contribute a thought or evaluation or something, you are like what the heck? But that's because their whole person has a different aspect that what they bring to the science and to the team is going to be something that's different than mine, and I should pay attention to that, I shouldn't dismiss, you know.

FC: Yeah, that's very interesting. Well, I think that's great, I'll let you..