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Griffis, Roger ~ Oral History Interview

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Voices from the Fisheries
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Interview with Roger Griffis by Ruth Sando

Interviewee
Griffis, Roger

Interviewer
Sando, Ruth

Date
June 29, 2016

Place
NOAA Headquarters
Silver Spring, Maryland

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Use Restrictions

Biographical Note
Roger Griffis is a climate change coordinator for NOAA's National Marine Fisheries Service. He has a B.S. in Biology from Carleton College and a Master's in Ecology and Evolutionary Biology from UC Irvine. Griffis grew up in Minnesota with a fascination for lakes and streams, and was particularly inspired by the complexity of ecosystems. Wanting to play a role in protecting the environment, he was led to conservation work through the Knauss Sea Grant Fellowship in Washington D.C in 1994. He spent a year in the NOAA Office of Policy and Planning where he helped advise policy makers on issues relating to the conservation of marine biodiversity and was subsequently hired for a full-time position in 1996. He started in his current position in 2010.

Scope and Content Note
Interview contains discussions of: NOAA, NMFS, climate change, climate-related change, global warming, marine ecosystems, coral reefs, conservation, acidification, fishery biology, trust resources, Climate Science Strategy, Magnuson Stevens Act, Endangered Species Act, Marine Mammal Protection Act, Sea Grant Fellowship

In this interview, Roger Griffis discusses his path to his current position as Climate Change Coordinator for NMFS, projects he has worked on during his career, and what's in store for the future of climate science within NOAA. In his position, he helps assess the impact of climate-related change on the oceans and what the agency should be doing to prepare and respond to those changes.

Griffis describes the growing collaboration with scientists from other countries as well as other federal agencies. He names Australia as a pioneer in tracking and documenting climate-related changes, particularly regarding coral reef conservation—an area of research in which Griffis worked both domestically and internationally and considers to be one of his proudest accomplishments. He has also helped to identify the seven core areas of NMFS's Climate Science Strategy and worked on a project to conduct vulnerability assessments for marine species be in response to changing temperatures in order to prioritize preparation for climate impacts.

He states the current challenge for NMFS is to begin looking at the climate implications for fishery management and determining how to successfully manage fisheries in a changing ocean environment. He emphasizes the need for cross-disciplinary of information across fields ranging from biology, to physics, to economics, to social science, and the need to be able to construct multiple possibilities of future scenarios. He also talks about the importance of learning about changing fisheries from the local fishermen themselves. He ends by highlighting the important role those in leadership positions have in paving the way for future success, and the value of vision, determination, and continued efforts over time.

Indexed Names
Baker, James
Clinton, President Bill
Fruchter, Susan
Inouye, Senator Daniel
Merrick, Richard
Obama, President Barack

Transcript

Ruth Sando: Alright, so it's recording. So, I have an opening statement that I need to make for the record. This interview is being conducted as part of the Voices from the Science Centers project funded by the Northeast Fisheries Science Center. It's also part of the Voices from the Fisheries project that's supported by NMFS Office of Science and Technology. I'm Ruth Sando and today I'm meeting with Roger Griffis at the NOAA Headquarters in Silver Spring, Maryland. We're meeting on June 29th, 2016 at 1:00 in his office. Let me put this right here. Mr. Griffis is Climate Change Coordinator for NOAA's National Marine Fisheries Service. He has a B.S. in Biology from Carleton College and a Master's in Ecology and Evolutionary Biology from UC Irvine. So, that was my research.

Roger Griffis: Good job.

RS: So, let's start with today and your current role. How would you describe your current role in NOAA?

RG: So, as you said my title is Climate Change Coordinator for NOAA Fisheries Service, and my role has been—I've been in the job since 2010, so going on six years. My role has been to

work at a headquarters level in helping lead, really an assessment of how climate change is impacting our mission and also what we should be doing to prepare and respond to that. Much of that work has been focused on what kind of science enterprise do we need to track changes in marine ecosystems, assess the impacts on our trust resources - the fisheries and other species that we are by law mandated to manage and conserve - and then identify the key information tools, science products, that we need to do that and how we're going to get there over the next five to ten years. All of that culminated in the development of the first NOAA Fisheries Climate Science Strategy, which articulates—it was actually the strongest, boldest, clearest statement that this agency has ever made—that our climate is changing, that those changes have significant implications and effects on our marine resources and our trust resources and on our ability to do our mission, that we're not currently prepared to respond to those impacts, and that we have tremendous science needs to be able to advise the decision-makers so that they can make climate-informed decisions. So in short, my job has been to help the agency think through the implications of a changing climate and changing oceans on our mission, and really what science and tools are we going to need to fulfill our mission in a changing world.

RS: When you say trust resources, what does that mean?

RG: Sure, that's kind of NOAA Fisheries speak for—trust resources really is a legal term that refers to the species that we are mandated by law to steward. And so, for example, the Magnuson Act is the legislation that gives us the authority to manage fisheries in the nation's Exclusive Economic Zone out 200 miles. Under that piece of legislation, that law, it identifies what are "fisheries", what are "fish stocks," and so by trust resources, I mean the species and habitats that we're mandated to conserve and be stewards of. And that really includes, as I said, fish stocks, species that are commercially or recreationally fished, the habitats that they depend on, and then under our other two major mandates—the Endangered Species Act and the Marine Mammal Protection Act—a whole other group of species that have been designated either because they're threatened or endangered or because they're marine mammals.

RS: So, you started in this role in 2010 and prior to that, did the issue of climate change have a focus, have a person guiding it? How was it being handled in the organization?

RG: Yeah, within NMFS the issue of climate-related change and its' impact on fisheries and our species we're responsible for—there was someone in this role before me, and it was focused primarily on what science do we need to understand it better. And it's been certainly an issue that's been flagged going back into the '80s, 1980s even, with some of the even early—both the growing science and information that both the climate was changing but also ocean was changing and some of the early Congressional hearings held on this thing called coral bleaching that was beginning to be observed. Obviously, some early warnings and growing science communities saying, you know, things are changing and we've got to pay attention. So, it goes back all the way back to, particularly with marine resources and coral reefs being very much a canary in the coal mine for climate related changes in marine systems. Within NMFS, one can trace back again probably into the '80s, maybe before, certainly science efforts both to track changes in temperature and other things in marine ecosystems—particularly research efforts to better begin to understand the implications of changing temperature on fish production and that

kind of thing. Bringing it forward to the 2000s, this office has really spearheaded the agency's consideration of climate impacts and what information and science do we need. So, the person that was focused primarily on what science we need—and when I was asked to take the job, they asked me to broaden the scope of the position out of a realization that we knew we needed additional science and science capacity, but we also knew that we increasingly needed as an agency to be participating in many of the inter-agency and inter-governmental fora where climate change was increasingly being discussed. That we needed to engage our sister offices, the Office of Sustainable Fisheries and Protected Resources, to help them begin thinking about not just the science, but what are the management implications. How will we manage fisheries as oceans change? The answer was basically yes. There's a nice history, a progression of increased awareness, increased focus, but when I took the position, they asked me to particularly expand—lead the charge, in a way, on what science do we need and how do we get there to be making climate-ready decisions across the fishery service. But in addition to that, my job was to expand our participation in the policy fora both within the agency and within the inter-agency efforts to be sure that climate and marine resources issues were being considered as the nation, and particularly the federal government, began thinking a lot more and acting a lot more to prepare for a changing climate.

RS: Within other agencies—I think probably NOAA, you know, climate change is quite accepted here as an issue—but moving out to you said your expanding participation in policy-making, has that been difficult? Do you feel like people see a natural role there? That they are jumping on the bandwagon with the issue? How has that gone?

RG: Within the Fisheries Service?

RS: In inter-governmental agencies.

RG: There's been tremendous change. It's interesting to think about the discussions that took place and where we were in our thinking even when I took the position six years ago. There's been tremendous change in the sense of the urgency to prepare and the understanding that climate related changes are not out there in some distant future—that in fact we are experiencing some of that climate change signal even today, and maybe even for the past 20 or 30 years. So, dramatic shifts in awareness. It's mobilized tremendous activity, and I'm sure people will write a very interesting history of how concern and responding to climate-related changes has really transformed major sectors of the federal government including the focus of science. So, from my experience, my purpose, my goal was to be sure that climate-related changes in oceans and fisheries, for example, was very much part of the growing conversation within the Obama administration and the federal agencies about what's changing and what do we need to do. What's at risk and what do we need to do to prepare? Since I've been in the position, there have been—we have executive orders that have come out directing all federal agencies to assess the vulnerability of their mission to climate change and then develop adaptation plans. Extraordinary mandates, new mandates to actually institutionally say, wow, where are we at risk? How can be affected and what are we going to do about it? And so part of my job was to participate in those kinds of efforts and make sure that the marine ocean change and our mission was on the radar screen as well as all those other important issues that the federal government needs to think about

such as the effect of climate-related change on human health, transportation, coastal infrastructure, coastal communities, all those important issues. Also, the other natural resource sister agencies—the Forest Service, Department of the Interior. I'd have to say that they have been much more advanced, early on, in beginning to move out on those kind of assessing what's changing, how it may impact them, and then taking action. They've really been the leaders and set the pace and great examples for us.

RS: How well do you think that it's become established within policy as an issue? Are you feeling satisfied that it's been incorporated where it should be incorporated?

RG: I think certainly at higher levels. I don't think one could have asked for much more official policy guidance mandates coming from the senior levels from the White House. All federal agencies…the transformation that the administration has put in place both before and after the President's Climate Action Plan, which really kind of codified the direction and the need to begin preparing the nation for a changing climate. As I said, a series of executive orders basically saying federal agency-wide we need to assess risk and take action to reduce our risk from a variety of the climate-related changes. So, I think broadly, yes. Within our own agency, I'd say we've really just begun. I think we've made good steps. I think development of the climate science strategy was a critical first step. We decided to first assess, well, what information would be required for us to make climate-informed decisions and we worked back from each of our core mandates—fisheries management, endangered species conservation—and we worked back and we said, if we were to try and consider climate-related change in fisheries management, what *kind* of advice, science-based, advice, would we give to the fisheries managers? To do that advice, what data do we need to collect? What research do we need to conduct? What modeling do we need—see what I mean? Working back from our mandates into our science enterprise, we were able to identify and frame these six core—seven core areas that our Climate Science Strategy calls for that would enable us, that core science capacity that will enable us to provide the information for climate-ready decisions. So, I think we've made good steps. I think we are just beginning to wrestle with the questions about whether our management and framework to use information is…needs any tweaks or changes in order to use it effectively in a changing climate. I think we're—so, on a policy framework, we've certainly recognized that the world's changing, which was a very important step. We have recognized that we have gaps in our science capacity and we need additional information and capacity to do it, and right now I think we're poised on the doorstep of then also saying, let's look at our management processes, our decision processes where we take in information and then consider it and then make a decision about how much fish to catch or what a recovery plan for an endangered species would look like. There are—that's that next important step and once we do that, I think we can say we have fought through our entire mandate end to end and have set in motion the kind of changes that we might need.

RS: What departments within NOAA do you work with most often or most directly?

RG: Good question. Most directly—our most immediate partner is called our research office. It's the Office of Atmospheric and Oceanic Research, OAR. That part of NOAA—NOAA has five main branches or line offices—OAR, our research branch, is the group that's responsible,

that does most of the monitoring and assessment of how the climate is changing and provides the projections of how temperature and air temperature and rainfall and even ocean temperature—what the projections are for 20, 50, even 100 years from now based on these big global models. That's the group that we probably have worked most closely with and depend on because we depend on those forecasts, the projections—those outlooks for the future as the first step in trying to assess how a changing climate may affect a changing ocean that then may affect where the fish are, how many there are, and obviously then the implications for the people that depend on them. So, that's the group that we work most closely with and depend on for that kind of information. It's been a wonderful story of collaboration—identifying those kinds of needs, working with them to have the kind of products in the forms that we need and actually beginning to…I think, over the next couple of years, beginning to provide the kind of operational products that we need to do our forecasts on a more regular basis. So, that's the group we work most closely with. The other group we work with next would be the National Ocean Service that's responsible for coastal management, working with the states on management of our coastal zones, wise planning, wise use of those special areas. Their focus on this climate issue has really been about helping those coastal states and coastal communities begin to understand how water levels are changing both because of storm events and because of some sea level, and helping them with that understanding begin to plan for increased flooding. The interface for the National Marine Fisheries Service is those coastal areas are where the coastal habitats are, the estuaries, the mangroves, the seagrass beds that are the nursery grounds for many of the nation's fisheries. So, we are involved in protecting and restoring those habitats because of their benefits to fisheries, but they also have tremendous benefits to the coastal community for recreation and tourism, but they're also natural protective devices and they reduce the storm surge and they help protect those communities from storm damage and stuff. That is probably the other area where we collaborate and interface with another part of NOAA on our stewardship issues.

RS: It just makes me wonder, do you get involved in issues like wind farms that have been more or less at a state level?

RG: Yeah, absolutely. Yeah, it's an interesting—great example. So, wind farms, say out in the ocean, a proposal to put a wind farm out in the ocean, they have to get permits through—eventually they have to come to National Marine Fisheries Service for some consultations on where to put those things because one, we have responsibility for protected species and if they're proposing to plunk a wind farm off the coast of Martha's Vineyard, let's say, well, that may just happen to be the breeding ground for a whale or an endangered species. So, part of the way the laws are set up is they have to come and consult with us to see if that's the case, but also to try and mitigate and reduce any impacts on again our trust resources which may be endangered species, marine endangered species. They also would have to consult with us because it could have impacts on fishing and fisheries, so that's where we would mostly be involved in that kind of—again, the currency is that a project like that could affect the resources that we're entrusted with being good stewards of.

RS: Well, you know, another thought I had in your discussing going through the state level and federal level and departments within NOAA is to what extent are you involved in experts and scientists from other countries given that it's a global issue?

RG: Great question. Because the whole discussion of climate change and climate—what's at risk and how do we reduce risk and begin to adapt, has been such an international issue and discussion, and I think particularly, it's probably true in other fields, but we have been greatly influenced and affected by international partners, particularly in the National Marine Fisheries Service. In part, because many of our key partners in fisheries and marine conservation and stewardship were already thinking about climate impacts and how to respond, and were a bit ahead of us on that. And so, for example, Australia has been one of the world's leaders in initially tracking change and documenting climate-related change, shifting distributions of their marine species and changing abundance and even seeing impacts on fisheries communities that depend on them. It led them to begin, naturally, thinking about well, what do we do and how do we prepare and respond. We have been very fortunate in having good, strong relationships with that science community, with their equivalent agency for fisheries—I would say that much of…the progress we have made has benefitted greatly from looking at the example that they've taken working with their scientists to understand the rational. I'll give you a specific example—one of the key steps in getting to climate-ready decisions, no matter what you're thinking about, transportation or health or fisheries, is to assess one's vulnerability or what's at risk of change. And so, we realize we needed to be able to assess the vulnerability of our fish stocks, and that's not a trivial exercise because in our Northeast region—one region alone, and we have seven such regions—we manage between 80 and 90 species of fish and invertebrates critical to commercial and recreational fishing. To do kind of full-blown, detailed assessment of climate impacts on one species was taking us often two years of modeling and research, cost a post-doc, and we finished one or two species and everyone said great, that's really useful…when are you going to get to the other 85? [Laughter] And can you do it in two years? We need it now.

RS: In who's lifetime [laughter].

RG: Yeah, exactly. We quickly did the math and of course, said this is not going to work out so well. We need to be able to do a much more rapid assessment of which species are most at risk so we can prioritize the limited dollars and time to do the more detailed—really answer the question: what would be the top ten species we should focus on next? So, that kind of…doing vulnerability assessments to quickly understand of these 85 species in this region, which of those fish or invertebrate species are the ones at most risk, most vulnerable in a changing climate, which ones not so much, and some indication about why. To help guide us both on where we would prioritize the additional science detail efforts, but also to perhaps throw a flag—to use a sports analogy—for the management community, the fishery managers to say, these species appear to be really at risk or vulnerable to changing climate. You may want to think carefully when you next have to do some management action on them. You may want to think very carefully about that and they may be the ones to watch.

RS: Now, so how did you approach that? You wanted to do a more rapid vulnerability assessment, so did you develop a method for that here, or did you contract it out to some scientists, universities, say here's what we need, you develop the methods?

RG: Yeah, great question. We developed it here, and that's part of the story I'm going to link

back to international, because we began to look around and said because the terrestrial natural resource management community had been doing vulnerability assessments now for almost a decade, and they had begun to develop very sophisticated tools. In this country, a group called NatureServe had actually developed a web-based program where one could enter in your species and there were very sophisticated tools being developed and approaches to do vulnerability assessments for terrestrial species: birds, plants, lizards, deer, trees. And so we began to say, great! Look at all this wealth of knowledge and practice, I'm sure we can just build off these. The answer was basically we couldn't because those systems were all based on projected climate changes in the terrestrial system. They weren't built around changes in the ocean system, and it's a very different—I kid my colleagues on the terrestrial conservation community that they've got it easy because they can take the climate models from the experts that talk about changing air temperature and almost directly use that in their models for charting where plant distribution might go, because you can kind of say, well, plants live in this range of temperatures now. Those temperatures are projected to move north or change in this geography, and you can basically begin to say, well, based on that—it is more complicated—but based on that we have some idea that the habitat for this tree or this species in 20 years is not going to be here in the mid-Atlantic anymore, it's actually going to be up in New England as things warm and everything moves more polar. The problem, the challenge in the ocean system is we have a whole other step. In fact, the modeling of that step called the ocean is as complicated as it is as the first model was to model what the climate, atmospheric change is going to be. So, we take the atmospheric climate models and have to then have it push an ocean model before we can even get to the point of saying, what would that mean for our species X or Y? So, we went to NatureServe and these other—we learned a lot from them, and it was tremendous, but we also realized very quickly that we were probably going to have to develop our own tool, our own vulnerability assessment method. And that's where we turned international because the Australians had, several years before us, come to the same conclusion and had actually developed a nice methodology and there were published papers and there was also some work in the EU, the Norwegians or the English has begun walking down the same path. We work directly with our Australian partners, we engage them in a science collaboration, and they helped us over about a two year period. We then launched an effort internally to develop a vulnerability assessment methodology for fish and invertebrates that we could use and do these rapid assessments in all of our regions. We completed that, and then used it to do a full-blown assessment—the first one in the country—for 82 species of fish and invertebrates in our Northeast marine ecosystem.

RS: So, was it done by NOAA?

RG: We did it by the Fisheries Service. The team that led to this conclusion that then launched the team to develop the methodology. It was a beautiful collaboration within the National Marine Fisheries Service between our Office of Sustainable Fisheries, our fisheries management side, and the Office of Science and Technology because we both realized that this was a critical step in that cycle of getting to climate-ready fisheries management, we've got to understand who's at risk so we can both throw flags for management, but also focus the science on which ones we think are most important.

RS: So, then the output basically is a baseline for all these species that you would then have to

keep updating to monitor how they're being affected over time, right?

RG: Yeah, it's a baseline. It's a hypothesis—it basically says, based on the life history characteristics of each species and what the models say are the projected changes in ocean condition. One then uses a bunch of experts to say, well, this species only makes one baby a year and only lives in a very narrow temperature regime, so therefore it's probably pretty sensitive to changing temperature. See what I mean? A variety of its' characteristics—but look at that, the projection is that we're going to have a two degree change in temperature in this region, some significant ocean acidification…this is in its' habitats, so for each species there's that combination of the exposure to some level of change, its' sensitivity or ability to handle it, and those things then come together. That's what the vulnerability assessment ultimately does is say, wow, species A, few babies, highly sensitive—you're going to see a lot of change, your score is…

RS: It's a hypothesis.

RG: It's a hypothesis and it's intentionally—this vulnerability assessment, as we said in the beginning, it was intended to be a coarse-grained triage because we're talking 80 to 100 species in each region. And this is to give us a coarse-grained assessment of who we think is most at risk to guide additional detailed science. It also helps us identify as we go along where we have real gaps in our understanding. So, as we went along, for each species we end up with a profile that talks about the characteristics that led it to be either really sensitive, but also we have the experts—it's very clear in the system, clear where there are huge information gaps. If you get to a point and it says consider its' reproductive output or its' ability to disperse and move and change, if we don't have much information on it, that also is really important for us to know and that's where we can begin to fill gaps going forward.

RS: Oh, I see. So, it's going to identify those gaps?

SG: The gaps, too. And then—but you're right, it does establish a hypothesis as we did with the 82 species. It said, these ten species based on this ranking scoring, we think are the ones that are highly vulnerable in a changing climate, and these other ones not so much. That is now our hypothesis as we go forward because we are tracking the condition of those species, their distribution, their abundance. And it will be interesting to see—we're thinking that we probably would redo this maybe on a four to five year cycle, because that's about the time that the new climate models come out. So, we would have some new projections of how each region's going to change. It'll be interesting to see how accurate our projections, our vulnerability scores, are as we go forward.

RS: Given that a lot of these populations are migratory and you've got your hypothesis generating methodology, is it—I'm thinking internationally then—does it work well with the work of scientists in other countries? Are they using something that is similar or produces a material that confirms what you are seeing?

RG: Good question, I think the answer's yes because we're not the only fishery marine resource

management agency that has realized this. Again, we followed in the footsteps of the Australians. They were ahead of us in part because their system is probably—their marine systems are changing faster than almost any other part of the planet. You look at, again kind of why humans respond to things, it's usually because something has reached the tipping point and it's time to respond, and they certainly had. But Canada, for example, on our shores and our marine ecosystems, we're, of course—we share marine ecosystems with Mexico, countries in the Caribbean, and then Canada in the north, and ultimately Russia and others in the Arctic. Canada certainly has followed suit, we've actually worked with them. As we were developing and nearing the end of our vulnerability assessment methodology, we were contacted by teams in Canada who had begun to—were scoping how they might develop a vulnerability assessment for marine species, and we worked with them. So, absolutely. I think the methodologies are very similar. We recently met with the new head of the Canada Department of Fisheries and identified actually doing some joint vulnerability assessments for the species that cross our boundaries, and that might be very useful as well.

RS: Interesting. Well, it's a huge issue and one that is right from your desk all the way out globally. Interesting to hear about.

RG: Yeah, it's been an interesting development just to think again how much our thinking has changed even in a very short period of time. I'll give you one other example of the kind of changes—this might go under the topic of the kind of changes that have taken place within the National Marine Fisheries Service just in the brief time that I've been in this position, since 2010. In 2008 through '10 for example, the question was: *should* we, the National Marine Fisheries Service, be considering climate-related changes in our endangered species or any of our mission areas? *Should* we, which was a very different place and it really was that transition from…I remember we had going a little bit further, even further back, my previous position, I was the manager of NOAA's Coral Reef Conservation program. That was about from 2000 through 2007. And remember, during some of that time was the Bush administration and during at least some of that time actually, we and the federal government were not allowed to use the term "climate change" or "global warming." We were not allowed to use that term. So, it was a very different time both in the recognition of the kind of changes that were taking place, the ability of a federal agency to prepare and respond. At that time, again, Australia was very active and in a very different place than our government was. Australia was really the world's leader in calling for—that the climate was changing, it was affecting oceans and everything else, and that really immediate action was needed both to address the cause but also to prepare for the changes that had already been set in motion. And as a Manager of a Coral Reef Conservation Program, we were very much interested in—we were trying to advance coral reef conservation both in this country but also internationally. I've got to admit that we were, we got together with the Australians, they manage the Great Barrier Reef Marine Park, one of the largest protected areas for coral reefs, and they looked at us and they said, what are you doing about climate impact? How are you preparing for climate impacts on your reefs? It is *the* most important thing we are focused on now. That caught us by surprise, because it was not on our radar screen in the same way. So, it was a major wake up call, and we ended up working with them to produce the first guides to how coral reef managers can begin to prepare their reefs and conserve their reefs in a changing climate. So, I say all that just as part of my own professional growth and recognition.

The power and really the transformation that began taking place largely in that from international colleagues that really sounded the alarm bell for us. But for me, it was also a real wake-up call of the kind of the scale and scope of climate-related changes in marine systems that I think was transformational but enabled me to step into the kind of position that I took here. Because, again, we weren't paying a whole lot of attention and we were also under, as I said, an administration that was not facilitating that kind of discussion and when the administration changed, it really allowed our agency and the U.S. government to begin catching up and really beginning to leapfrog in that call to prepare and respond.

RS: Well, this also makes me wonder about outreach. I know that you're probably funding a lot of science. In what other ways are you reaching out with information guidelines or ideas about preparedness?

RG: Yeah. I think we're just beginning to do that. One of the examples I was going to mention is of just that—that one of the things that we then, this agency recognized early on…we did a series of very important workshops to try and rapidly transform our thinking about this. NOAA sponsored several workshops about climate impacts on our different mandates and one of those was on the Fisheries Service and our endangered species work, and out of that it was a clear recognition that we really needed to better understand how to use climate-related information in all of our endangered species work. We were facing many—an increasing number of petitions and proposals to list species as threatened or endangered in part because of climate-related changes and their habitat. There was growing concern and question about should we re-look at our recovery plans for those species that have already been identified to make sure that those plans are still the best that they can be, given that things are changing? We didn't know—and those were important questions and we didn't know how to address those. So, we launched an effort to try and tackle those questions and we launched an effort to basically…the question was, how do we better incorporate climate information into our endangered species activities, from listing decisions to recovery plans and all the others? That effort resulted in clear guidance, guidance on seven main questions that we needed to answer as an agency in order to better incorporate climate information. It was a very interesting process, but that was, is probably the best example I have of how we've identified some areas where we're not quite sure how to do it, or we think that maybe we need to think about the best way to do it, and this has really been, I think, the model now for doing something similar on some of our other mandate mission areas. That guidance actually was just signed last week by our administrator, and it was just a great example, from questions about—I'm smiling because I remember the first question was, *should* we even be considering climate? And it's almost impossible to think that we would ask that question, but again, we were coming off an administration that had said, "Thou shalt not," in many ways. It was partly that political policy driver, but it was also some inherent question about well, if I did, what science would I use? Because what projection of what future should I use? There are multiple models that could give you a projection of what temperature or rainfall is going to be in 50 or 100 years. So, there were very good reasons to ask that from both a science and a policy question. And if the answer's yes, I should, as a practitioner, what information should I use? In some cases, there's some question about well, how would I use that given what our job is? Either in a recovery plan or a listing decision. So, that's probably our best example where we've gone from good questions to honing those to providing responses, and then

formalizing that as clear guidance—that actually, it was very interesting, the guidance is very much and clearly says in the memo from the administrator that this is really a great set of initial guidance, but the charge is to continue to identify other questions that need to be asked and clarify those as well. Towards that goal of—our goal is to be climate-ready, our goal is to make climate-ready decisions across all of our mission mandates.

RS: So, it's really now embedded in NOAA's strategic planning process and mission.

RG: Absolutely…absolutely. I think we're still struggling with what does that really mean, in some of our areas? The example I just told you was specifically on our endangered species activities and remember, those are ideally suited—I had a question from someone the other day that asked why did we choose that area of our mission instead of fisheries management to develop this guidance? And I said, well, it was a very natural decision and it wasn't an either-or, it was because the timeframes of doing our endangered species work are much more aligned with the kind of timeframes that people use in thinking about climate-related change. Considering listing a species as endangered or threatened requires us to go through a very formal process to evaluate the current condition and the projected future condition of that species. And so we're by law and process, a required science-based process, says look into the foreseeable future using the best available science and based on that assess whether we think the species is on the brink of extinction or not. Foreseeable future can be a long time, and usually is out multi-decades, 50 to 75, even 100 years if the science is there. So, the endangered species work is based on assessing the risk of that species over those kinds of timeframes, which are the kind of timeframes that the climate models and our thinking about climate-related change go. Fishery management is not on those time scales. It's on this year, next year, and maybe the next year out—but it's about harvest, you know, how many fish are in the sea, how many can we allow fishermen to catch and still keep the population healthy so that there are more fish to catch after that. And those are very near-term, so we're now beginning to address the fishery management and climate-related questions because we realize that although the climate signal is probably easiest to see as you get a little bit further away, the models really are probably best at saying, well, this is what we think temperatures are going to be like, rainfall, out 25, 50, and beyond. The reality is, though, that we are going to be experiencing those changes often on that nearer term. It doesn't mean that there aren't changes to come in this nearer term, it means that they're harder to predict, but the expectation is that all of the models and our experts tell us is, one should expect that we will probably see more extreme events and one should prepare for more variability in the system—that one should prepare for changes in what one might expect to be normal, because part of what happens with climate change is the system may not be what you expected based on past experience. So, all of that is to say, I think we've made great strides as appropriate where the science was that matched kind of our longer-term endangered species mission area. Our challenge now, instead of great model, now to begin looking at what are the climate implications for fishery management on the nearer terms knowing that we may really need to be asking, well, how do we manage fisheries successfully, effectively, knowing that oceans are changing, that we may see more extreme events in the oceans, that over time there's going to be increased warming and acidification? We need to be incorporating that into even near-term decisions. What's the best way to do that? How do we do that well, particularly on a decision system for fisheries management that was structured around an assumption that although oceans change, they

basically hover around kind of the same conditions. And so, I think that will be a challenge, but it's actually inherent in fishery management—the challenge for fishery managers for over 200 years has been to try and predict what the ocean's going to be next year and how many fish are going to be in the sea. So, in some sense we're well-suited, we just need to probably identify where we're perhaps assuming a little bit too much about that the future will be like the past, and how best do we keep our fingers on the pulse of the system so that we know we're making decisions on the ocean that exist now. We're using information as we can to make a decision on an ocean we think is coming—that we're not making decisions on a past ocean that may not exist anymore, if that makes sense…It is challenging. Anyway, that's—and our climate science strategy I think points…lays the blueprint for the kind of science and tools, forecasts and warnings, that the agency needs to be able to do that.

RS: When you have major changes in emphasis and direction like that in an organization, sometimes you find that you need new skill sets, that you need people who have different kinds of training for the future. Do you see that as an issue at NOAA?

RG: Yeah, I think so. I mean, I think we need some of the same core capacity. There are key gaps in even our basic tracking of ocean conditions—our observation system at the moment is not what it really needs to be. But it's an interesting question because I think the answer is very much yes. They certainly are things that people have called for before. It's not something, you know, that no one's ever said before but I think the focus, increased need is at both at an individual level but also on a science enterprise level is to be able to cross disciplines and to integrate information across physics, biology, and then the social and economic impacts. We still do a bunch of that kind of in isolation, or with kind of some rough hand-offs, but I think one of the really interesting areas that's come out of this whole focus on the world's changing, how do I prepare, has been the clear identification of the need to be able to do scenario planning. That's a term that people have used a lot, but to be able to play out scenarios that we think are likely for the future—so, we think that climate-related change may be this, that may drive the ocean temperature conditions to be like this. If so, here are a couple scenarios of what we think that might do to the fish stocks. Then, to be able to take it the critical next step is to say, well, let's see how things would work out if I managed with this way, or this way, or this way. That kind of play out that we think the world may be if—here's a future world scenario, let's play out how it would work out if I managed the fishery this way or that way. What would that mean? How would it play out for the stocks—would the stocks thrive, or would they collapse? How would it play out for the fishermen—would they continue to make the same amount of money, or would they not? The kind of social and economic outcomes of that. There's a critical need to be able to play out that kind of capability and what that is, is a series of modeling exercises where, again, you're kind of taking a model and pushing this model, and pushing this, playing out that scenario across disciplines. We just went from climate and physics and oceanography through to fishery biology, fishery management, and then out the other end to community well-being and social and economic science. That takes teams of people working across those disciplines and it takes a science enterprise that puts a premium on that kind of product and that kind of analysis. I think what we've seen—I look at Forest Service, Fish and Wildlife Service, US Geological Service, as really the leaders in natural resource—almost our sister agencies in natural resource stewardship. They're doing forests and terrestrial animals and stuff like that, but that is where they have gone.

I think they're five or so years ahead of us in both understanding the needs, beginning to address them, and they—I think, wisely—really have realized that this is the way to be able to come back to the decision-makers and say, well, we played out the likely scenarios and there's kind of a not so bad situation, and there's a really bad scenario, just to bound us. And then we played out a range of responses, and this is kind of how it worked out. That is a powerful set of analyses to give to decision-makers ahead of time to arm them to be able to think about climate-ready decisions. That's an area where those other agencies have really invested and have really advanced. I think that's a key direction that we need to go—we're beginning to pilot that kind of work, the agency has kind of identified that. I think we call it "management strategy evaluations scenario planning." But that's one of those key additional capabilities. I think the other one is in the modeling capability. To be able to play, take some global climate models and be able to have them drive some regional oceanography. Again, as I said to you before, the modeling of how the climate's going to change with the atmosphere and stuff is complicated, but the ocean is a fluid medium as well, and it's complicated. Increasingly, the global models of how our climate—our climate system technically involves both the ocean and the atmosphere—so increasingly, these models are increasingly sophisticated and include the ocean piece. It becomes a scale issue, because usually there are kind of big ocean basins, so you might say, well, here's the East Coast of the United States—kind of the northwest Atlantic—and they'll have some information, but it's usually not detailed enough. So, what we need to do is take that or work with oceanographers to be able to make that more detailed for the kind of decisions we need to make related to specific fisheries. So, that would be the second area, is really that kind of climate to oceanography to fish stock modeling.

RS: Well, thinking about skills and skill development, I wanted to ask you about your career development. What got you interested in science as a career to begin with?

RG: Yeah, that's a great question…

RS: And what was your Bachelors in?

RG: Yeah, so my Bachelors was in Biology.

RS: Was in Biology? Okay.

RG: Even in high school I've always been very interested in—it was a love of the outdoors, it was a fascination with lakes and streams. I was born in Minnesota and my earliest days I think, I was drawn to the edge of the lake, and so it's been water and aquatic systems from a very early age. I think it's been good mentors and people that have inspired me all along the way from biology teachers in high school, leaders in Scouts and other places that got us outside and would prompt good questions, and then really in college, just tremendous—being inspired by the complexity of all the different pieces of ecosystems and how they all connect and cascading effects. But again, being drawn back to aquatic systems and ultimately to invertebrates. So, my background was very much also linked to diversity—being fascinated by the diversity of life and all the amazing creatures. So, my focus was always on invertebrates while some of my biology colleagues were more the vertebrate types, and many of them went off and focused on the human

vertebrate, right—off to medical school and others became ornithologists. I actually was focused on that other 90-some percent of life on the planet, which is the invertebrate side. And that took me to grad school and marine science and led me to work on a fascinating group of burrowing shrimp in intertidal zones that, like earthworms, turn over sediments and nutrients and make those near-shore systems very productive and have an amazing lifestyle of living in muds and sands. It was fascinating.

RS: All outdoor work.

RG: It's all outdoor, yeah. It was all very much outdoor work. I was not—I knew I was not built to do the laboratory, be in the laboratory all the time, so my goal was always to be out learning about amazing—in amazing places learning about the diversity of life and all the amazing creatures that are out there. Hopefully, I think the realization that I kind of wish I'd come to earlier than I did in my career was that combined with that was a real passion and concern for the health and conservation of those systems. Finally realizing that were I to be a successful scientist and to have many dozens of published papers and all…that would not be enough. The real desire was to be able to have some impact on leaving the planet in a little bit better place, being able to protect these systems that I was fortunate enough to be able to see form the lagoons and marine systems of Baja California to incredible tropical systems, the coral reef systems of Jamaica. Realizing that I really wanted to try and use my energy to help make wise decisions and conserve these marine systems that I was so interested in.

RS: So, what lead you to end up at NOAA?

RG: It's a great question, too. I was trying to finish a Ph.D. at the University of Louisiana, actually, and was realizing that I was really interested in getting into how could I apply this for some conservation effort? And was very fortunate that I saw an advertisement for a fellowship that took scientists, people in science fields, to Washington D.C. for a year to have them experience the interface between science and policy. I ended up applying—it's called the Knauss Sea Grant Fellowship—and I was very fortunate to get it and to be offered a position to come to Washington to compete with 50 different… 40 other fellows and offices in D.C. to spend a year. I was fascinated by, of course, the NOAA offices and one in particular, and that's where I spent my fellowship year, was the Office of Policy and Planning at NOAA Headquarters downtown in Washington. I could not believe that they wanted me to come and help them—help advise, be part of an office that advises the head of NOAA and the political lieutenants there on where NOAA should go, particularly on conservation of marine biodiversity.

RS: Wow, what an opportunity.

RG: Yeah…yeah. Because at that time ,NOAA was beginning to develop one of its first overall strategic plans and they were thinking about well, what would the main themes be and…yeah, incredible opportunity. I found in that year that I loved the job and the environment. It was the perfect application for me because, you know, I could use my science background to help advise these very smart people that had very difficult decisions to make. I've often said that when I advise, now I often advise Sea Grant fellows and others, that probably the best training for the

job, other than the science background, was teaching non-science majors ecology, summers in grad school, in part because one had to be able to boil down a lot of information into three points and make it relevant—present it in a context that was relevant to people that were heading to business school or other kinds of things that may not have had any context, or interest necessarily, in the natural world. My job was to give it to them and hopefully have them leave the class with some interest. That isn't to say—again, we were serving very smart people, but often not with a science background. My job as a policy advisor was to synthesize the information and basically present it as one does in a policy staffing for senior leaders in a concise, three or four-points way that says, here's the information and you appear to have three choices—door number one, door number two, and door number three—and let me tell you about the science context for door number one, two, and three. They then bring every other political and other considerations into it, but I found that I loved it. I love teaching and so that was a nice mixture for me.

RS: So, then you were able to transition to a permanent job?

RG: I was. I was hired into that office, I was increasingly involved in the planning. So, we helped lead kind of cross-agency strategic planning, which then led to budget planning and requests, shaping requests for NOAA that would go into the President's budget.

RS: Who was your first boss there?

RG: First boss was Susan Fruchter. She was the head of that office and she was the Chief of Staff to the head of NOAA at the time, who was Dr. James Baker. It was an exciting time—those were the days when federal budgets were growing, remember that was the early Clinton Administration.

RS: So, it was the early 90s?

RG: Early '90s, '94 was my Sea Grant fellow year.

RS: So, then you were hired full-time in '95?

RG: '96. I was on contract for about a year, and that was a fascinating time because we were in a stage of thinking very expansively about NOAA's mission and what should NOAA be doing, where are we going? It was a very exciting time, partly because one could also think about budget initiatives and growth. But a lot of thinking about NOAA's mission area in, particularly in—I was obviously working on what we call our stewardship side of NOAA, marine resources but particularly coastal issues.

RS: What was—how would you describe NOAA's research focus at that time?

RG: Strong. Robust. I wasn't involved as much in the research side, for different issues. I wasn't as familiar really with the National Marine Fisheries Service side. I really handled our coastal stewardship portfolio, which involved our coastal zone management and our National Marine

Sanctuaries Program and our Estuaries Reserve Network. So, I would say robust. At that time there was growing and there were clear indications of the need to expand and begin thinking about climate-related change. But not with the kind of urgency—the urgency really didn't kick in until almost probably 2000, almost a decade later. At least for us.

RS: So then, you mentioned that at some point you began working on coral reefs.

RG: Right. So, I was very fortunate in that position—really interesting history. Again, during those kind of growth and real progress days during the late '90s, the Clinton administration launched a whole series of efforts and it was driven largely by international influence, but also internal influence. I was involved in writing several Executive Orders that launched a significant new effort. One was there was growing concern about coral reefs and we were able to raise it to the visibility, senior visibility so that the Clinton administration issued an Executive Order directing all federal agencies to identify what they could do to help coral reefs, basically establishing a U.S. coral reef task force, launching a whole bunch of—really codifying and directing that we should be trying to conserve reefs both domestically and internationally. We also were able to get a budget initiative in the president's budget that, again, different time, the Congress appropriated money on. And so that launched, to NOAA, that launched to develop and establish our coral reef conservation program. We had bits and pieces of activities that affected reefs—either studied some to help conserve them or manage—but they were not knit together in an effective way and that appropriation and those kinds of directions enabled NOAA to create—establish a coral reef conservation program which actually built on kind of a matrix model of how to knit together these existing efforts, but then provided the five or ten million dollars seed money to be able to really launch some efforts. That grew to…I think it started at five, then went to ten, but by the third year, we were a thirty million dollar program, and we've maintained that level partly because of the champions on coral reefs from the affected states and territories. We had Hawaii, Florida, and then the territories.

RS: Thinking back to that executive action and all the money that was applied to it and the organization's efforts—if that had not been put in place, what would you say about the state of coral reefs? Did it have a huge impact? Thinking about your applied side now.

RG: I think it definitely has, and I think I say that for two reasons. One, I think it was able to mobilize significant additional actions from federal agencies that were not happening at the time. For example, one of the major threats, impacts on coral reefs is near-shore runoff. It's sediment, pollution, other things running off the coastal area into, that can either smother or contaminate the reef. And so, we were able to work with U.S. Department of Agriculture that works with local communities and land owners—in tropical areas, it's not usually farmers, but it's other land owners—and the Department of Transportation. Again, work through federal agencies to the action agencies which are usually the state equivalents, Department of Transportation or Department of Agriculture, which actually have the mandates and tools and resources to prevent, reduce the runoff of sediments and pollutants into near-shore waters. And I think we were able to mobilize that partly because of the nature of the high level directives that we were able to get. But then through a lot of hard work and networking through those individual agencies, that opened a door to work with the Natural Resources Conservation Service, the Department of

Agriculture who has again, people on the ground in each of those counties and part of their job is to reduce runoff from land. So, I think in that sense, it has made some progress. The other thing I'd say it did was it created—it empowered a network, a relationship with the state or the territory governments that resulted in kind of collaborative efforts to identify the major threats to reefs in each of our jurisdictions, whether it be the State of Florida, U.S. Virgin Islands. There were intentional efforts to sit down and say, okay, well, what's threatening the reefs here? Great, what can we do about it? How do we tackle those? And then be able to focus some of our limited resources on helping the state or whatever county, whatever the actor was of the federal agency and do that. It directed us to begin to do that. We were able to do it and institutionalize that. And then the other thing I think it did was it enabled us to connect—it connected us internationally with Australia and other folks that actually are some of the world's experts in coral reef conservation, and that really—bringing it back to climate as I said—that came to us and said, we're focusing, we're really worried about climate-related changes. We're using that as a lens through which we look at all these other threats to reefs. Aren't you doing that too? We said, huh [laughter] that's a good point, and quickly transformed and helped shape our coral reef efforts, even to this day.

RS: Well, you know, mentioning Clinton's executive orders and mentioning some of the legislation that came out of Congress, how would you compare that to the legislative support you have now for marine science, for climate change? What direction has that been going in?

RG: It feels very different now, probably for a variety of reasons. In general, at that time there were many more champions, it appeared to me. It seems to me many more champions, and this is people who know much better, who have been working longer than I have reflect this, too. During that time, there were many more and some real leaders within the Congress, both in the House and the Senate, that were real champions for marine-related issues. They were some of the senior members in those bodies and so marine and ocean issues, from fisheries to reef conservation, had a visibility and had support and attention at a level—even coastal zone management, which is money to the states to do wise things with their coasts, in retrospect, it was a heyday for support and for concern, value of the nation's marine and coastal resources and areas. There has been a significant change because many of those champions are no longer there. It does not appear that that interest or the energy has been replaced. It's a different Congress, different values, different focus areas—but particularly from a marine ocean perspective, it's very clear that we don't seem to have nearly the kinds of champions or interest levels in the kind of marine-related issues. I don't have an explanation for you, but that's at least one observation. Certainly the whole issue of, is the world changing or not and should we be preparing, obviously has been very polarizing. It's very unfortunate that the whole climate change topic has been so polarizing because I think it really has stalled the kind of efforts that are needed to prepare and respond. Fast-forward to the National Marine Fisheries Service, I mean, we have been putting—we have identified our critical science needs and capabilities. We have since 2004, early 2000s, this office and my predecessors were beating the same drum within the agency, saying climate's changing, ocean's changing, we need additional science to understand the implications and how to prepare. In 2004, we received—we had a budget initiative to fund some of that. It actually made it up through into the President's budget and Congress appropriated what I think is the only funding this agency has ever received specifically to advance our understanding of climate

impacts on marine resources in our job. 2004, and it's that little two million dollars that we've—it was designed to be a national program to be one or two million to increase our science capacity in each of our regions. I think my predecessors hoped that was the down payment. That two million went to the Alaska region, because that was undergoing…it was the place changing the fastest, and still is—the Arctic system. It allowed us to start, set in place a series of buoys to track the change, research efforts to understand the mechanisms, and then modeling to understand the forecast: what should we prepare for? That effort plus combined with other efforts and the fact that you had science partners all on the same page, has made that region—that system is now the longest-serving observation system of climate-related and ocean change in the Bering Sea. The Bering Sea is where the nation's largest fishery is by weight and almost by dollars. It's now the critical piece, backbone, of our ability to track climate-related changes in that system, and it's at least part of the reason why that region is the one we point to if you were to ask, well where is the National Marine Fisheries Service, where do we feel like we're doing this the best? Understanding climate and preparing for it, it is in that region partly because of those initial investments made in the kind of ability, the science capacity we have to track the change, predict what that means, deliver that in scenarios to the fishery managers. That's our model for what we need in each region. But obviously the Congress and the whole dialogue around climate impacts has gotten convoluted around well, what's the cause. We've lost sight of what should we be doing to prepare, and that's really…we've been able to move forward in part with using existing resources from other places. We didn't receive any other appropriation—it's basically that money. We've been able to take money from other places, and then continue to advance our internal thinking and policies because of the directives from the current administration that has said very clearly we need to prepare, and we've got to figure out what's at risk and how to respond.

RS: So really, you're dependent on the Executive Branch more so than in the past for that kind of support?

RG: Absolutely, yeah. We're obviously, you know, very thankful and blessed that fisheries—they're obviously, still is high on some radars of Congress, but I think anyone would say that it certainly is not the same level of attention and support that it was in those '90s and even into the early 2000s, where you had such senior members of Congress that were such champions for fisheries and marine issues. In fact, many of them are no longer there, and then also a change, I think, increased hostility to anything related to climate preparation, increased hostility to even efforts on our other portfolio of endangered species, conserving endangered species. A lot of hostility around that from current Congress. I think you were asking have things changed. I think dramatically so, certainly from the time I came in as a Sea Grant fellow and those years I spent at NOAA Headquarters where we worked actually very directly with staff and members of Congress. And maybe some of that happens, but again, there seemed to be a lot more interest at that time.

RS: Well, it's a different day than it was at that time.

RG: It's a different day, exactly.

RS: I think there were a couple, like Senator Inouye from Hawaii. He was a proponent of NOAA and of fisheries and marine science probably throughout his whole career in politics. Very supportive of everything for the Pacific region. So, the loss of people like that is really incalculable. It's really a shame. Well, let me ask you then about—going back to the issue of climate change in your current engagement. Resources and staffing, you know, budgeting and everything…do you feel like that is where it should be? Maybe nobody ever does, but what are your thoughts about within the whole organization, climate change, the resources for climate change?

RG: So, at least on the question of do we have the kind of resources needed to deliver the science and advice for climate-informed, climate-smart decisions, whether it be fishery management or endangered species—for our mission within the Fisheries Service—I think the answer is clearly no. That's what our Climate Science Strategy concludes and calls for. It was very clear as we worked back from our mission mandates the kind of decisions that we need to make, the kind of information that's needed, climate-related, and then whether or not we had the science capacity and enterprise to do that—it was very clear that we really did not. That ran the range, ran from do we have the ship time and the buoys to be tracking the state of the oceans now, the kind of baseline information. That was clearly no, because, in fact, much of our monitoring of ocean conditions, our basic marine ecosystem monitoring, our fisheries oceanography work, has actually been eroding under the current budgets and over the past few years. Things have gotten tight at our science centers, and historically, one of the toughest things, I think, to ever fund is kind of long-term monitoring of conditions. The implications of skipping a year or even losing a whole monitoring program are, unfortunately, not always clear and those often get cut. In a changing world, though, long term information data sets are like gold because they're now the only things that we have that give us a historical perspective on the kind of variability and cycle that we're on. They also are the only thing we have on which to develop our models and projections for the future. So, if we have strong, long-term, fifty year data sets on ocean temperature and chlorophyll and all kinds of climate-related things in the ocean, that is perhaps the best position to be in, that would allow us to develop some robust models to then project into the future because the future projections are all based on something on the past. Without that information, our future projections get very weak. One, are we there? Certainly not there yet. Climate strategy says that baseline information is critical to almost everything else. Certain tremendous needs to then—for additional research to understand the mechanisms of change, so if the ocean begins warming up by a degree or so, what does that mean for the reproduction of fish X or habitat Y or that kind of thing? And then the modeling ability to then take all that information and start producing robust future scenarios that we have some confidence in. Those are the three big areas.

RS: Well, I'm wondering about how you get all of this done. Do you have a big staff? Do you do a lot of it through funding out to universities?

RG: Yeah, good question. So, all of this is done—we have small pots of money here in the headquarters office that we try and fill some critical gaps every year. All of this work is done institutionally through the NOAA Fisheries Science Centers in each of our regions. You know, as you spoke with Richard Merrick, he's our Chief Scientist. His overall job is to manage and

advance that system of science centers, one in each region, that is the science enterprise that creates the information for our decisions in fisheries and other things. We depend heavily on that science enterprise, includes the science centers, but then heavily on academics and the academic community that we work with that we fund either through grants or we get joint-grants for joint efforts from other sources like NASA or other places. That's really that core science enterprise that, when I talk about the NMFS science efforts, that's what I'm referring to—is building the capacity in each of our regions and science centers to be able to do this both with the academic partners and ourselves.

RS: Do you find that within the field of science, that climate change is attracting the best talent?

RG: Oh I think so, very much. I think so. I mean, fascinating questions about how systems are changing, will they go this way or that? I mean, the most visible sign of climate-related impacts on, in marine systems. First and foremost is the changing ocean temperature. It's kind of the easiest thing to track, we can now see it from satellites. But the second one is the shifting distribution of the species—many of them are following their preferred temperature. So, really interesting questions about well, are they moving? Are they shifting? How fast are they shifting? Are they all shifting the same rate? So the community assemblage of fish, you have red fish, blue fish, orange fish, all together and they stay that way? Well, no [laughter]. The red fish, blue fish are really fast, but that green fish is hanging back and so you have this really interesting situation of assemblages of species and communities beginning to pull apart. Boy, what are the implications of that? Predators meeting new prey, new competition…I think that I'm playing out the kind of science questions that I think it's attracting—because those are really interesting questions if you're an ecologist or fishery biologist. I think it's attracting a lot of interest and many of the best and brightest. It's really great to see.

RS: Within…let me think how to phrase this. You know the rise of the development of big data and analysis using models that take advantage of big data—is that something that's playing a role in climate science that you would want to comment on? What's going on there?

RG: You know, I don't completely understand the term "big data," I must admit, but I think it is playing a huge role. Increasingly, what is needed as I said is this integration of information across marine systems, across physics, the air, the ocean, the physical water properties and then through what does that do to the biological creatures swimming around in it? What does that do to the people that are chasing them and raising families once they go home? Tremendous amounts of information needing to be accessed, layered, integrated…and so to me, there's tremendous information management challenges and access challenges. I think that's actually—certainly at the climate end of it, which again is based on information pouring off across the planet, often from models that take tremendous computer capacity to run and run for days before they have any outputs. So, certainly at that end. The oceanography models that then would run would kind of attach to that—also very data intensive and memory intensive. So, a lot of information. I think that is one of our challenges. Again, I think we are…in the marine environment, I think it's a huge opportunity for us and also a challenge is that I think we are not—to really come into the 21st century in our ability to access multiple layers of information across multiple time frames and different spatial scales, to visualize that…Look at the kind of

tools and data management and visualization capability that exists now for terrestrial environments and planning and natural resource management is really outstanding. I think we are much behind when it comes in the ocean resource realm. It's really fascinating. So, opportunity, but quite a bit of challenge as well. And I think that ties back to another thing I wanted to say. I think one of the critical next steps is increased awareness that ocean and fisheries and marine resources are changing. I say that not that we have the answers and somehow the fishermen are sitting on the docks wondering, needing to be informed because in fact, it's an interesting situation that the fishermen, who are out with their fingers on the pulse of the water all the time, are the ones that are beginning to say—and actually, probably are the most well aware—that their ocean is changing. Because in places where the climate-related signal and the changes are happening, it's the fishermen that have really been coming back and beginning to say something's going on.

RS: Well, I was going to ask you about how local communities and states have adapted to the scientific knowledge, but it sounds like you're saying that in a way some of it is they see it first and are becoming proponents of some action or knowledge about climate change.

RG: Yeah, and it's a really interesting thing, and because in some places where the pace and scope of change is happening now and it's been happening over…it is the fishermen that are saying it and they are the sentinels out there, and they are in places where there are avenues for them to share their knowledge. It's fascinating that—the Gulf of Maine, for example, happens to be one of the places, the U.S. ocean areas, that's changing…actually it's changing faster than almost any other place on the planet. It's in that kind of place on the planet, and the currents, and the climate that it is changing very quickly—it's warming up. The fishermen there have seen dramatic changes in what they catch, where they catch it, the kind of ocean conditions they experience. The other combination was that there are fishery associations and fora that have been established by some NGO-type groups that work with fishermen in that area that have been able to —that were actually established to allow fishermen to talk about the kind of changes they're seeing. That has allowed the fishermen to actually be talking about it and in those kinds of situations, it is coming from the fishermen saying, things are really changing.

RS: So, are they then influencing their state?

RG: They are, yeah. And it almost tracks the pace and scale of the change with the volume of their input. Also, then if you throw in what's happened, you start throwing in some sharing of information from the research community about well, what we saw was with a one degree warming in Long Island Sound over the past ten years, the lobster population with a little warming began to look fine, but then with a little more warming, it completely crashed in that fishery and went extinct. Basically, you couldn't make a living on it any more. So, what happens is, say there's a little bit of additional information from the science community saying you know, here's what we've seen in this other place. We might be watching for this because there were signs—like that lobster in Long Island situation where disease started showing up with the temperature increase, and then it began to spread, and then the collapse came. So, it's been a really interesting example where there's that awareness building on the fishery side, the local people side, that then can again, if it's kind of mobilized in the right way, there's avenues for

them to share that and vocalize that. Begins to build that kind of interest and concern, discussion, that then can be woven with some of the other understanding that's going on, some of the validation. It's been really interesting that we've been able to go to some of those fora and everyone sit down around a computer and say, let's look at the temperature, how temperature has changed in the Gulf of Maine over the past 20 years and look at that with their experience and go, wow, so you saw that starting about five years ago? Look at that, that's when we started having this real peak in hot summers. So, I think it's a beautiful example and it's the kind of thing that I wish was happening in more places in that sort of way. And that's one of our other major challenges, is how do we share information with affected communities, hear from them on what they're seeing, and then have that spark a discussion about what's at risk? What might be affected? And then what steps might we take to prepare? We held a workshop here with our partners in the NOAA Sea Grant office exactly on that topic, which was what do we need, what science and tools do we need to be doing to begin to engage fishing communities, or the fishing industry, in thinking about change and the implications for them? And it was really interesting that whereas my colleagues in the National Ocean Service have done a tremendous job in developing tools, workshops, entire engagement programs to engage mayors and coastal communities in thinking about inundation and flooding and rising seas. To the point where there are websites you can go, you can type in your city's name, type in a year you want to see, and maybe another assumption—do you want to see worst-case [laughter]? And then a beautiful visualization comes on of Charleston, South Carolina let's say, under a projected—and how the flooding may look 20 years from now, or 10 years from now based on our best estimates of rising seas. You can also then say, well, how would it look under a certain storm, kind of an average storm? Incredible tools to enable these decisions, for coastal communities to begin visualizing change, then think about well, what might be at risk so they can think through well, how many people do I have and actually the tools are very sophisticated, it helps them say, well, how much of my population is within that projected flood zone? How much of my core infrastructure? Should I put the hospital there or not, you know what I mean? Incredible toolbox and then training courses to help decision-makers use it. My point is, tremendous example. We've done the same thing for water managers in this country—it's spent 15 years of developing an information system to provide water manages with better forecasts of how much water they're going to have next year, and five and ten years out. Those are excellent models that can help us think through how we would do something similar for fishing-dependent communities, fishery decision-makers, fishery industries. Although it's a different set of stressors, a different pace of change, perhaps, I think we need to be thinking about well, what would be the tool, set of tool and how would we engage those communities in helping them understand what's changing, what's coming and help them, arm them so that they can think through risk and solutions. I think that's really a critical direction for us.

RS: So, is that something that is on your plate for development?

RG: Absolutely. Our Climate Science Strategy is not just about understanding kind of the climate impacts on the oceanography and the fish—it very much calls for exactly what I just talked about is how do we play this information out for the affected communities, and businesses, the seafood sector? All those affected. We've taken some of the models of how we're engaging coastal communities on inundation and flooding, and some nice basic protocols and

methodologies, and we're beginning to pilot them and say, well could we use the same approach to engage lobster fishing communities in the Gulf of Maine? Talk about change, what they're seeing but help them think through where they're at risk and what they might want to do about it.

RS: And are there good international models for that kind of communication projects?

RG: Yeah, I think there are. Australia, again, leads the way because again, the pace and scale of climate impacts there is probably the most extreme in the world. Their systems are already quite a bit, a degree or more hotter than they were 20 years ago. Their species have shifted, the fisheries are shifting. That's one of the best models. There are some in Europe, as well. The changes have been dramatic and so they've had to address them in ways that we really haven't yet. So, those are the kinds of places. And again, I'll bring it back to the key tool—one of the key tools is that ability to play out scenarios because where the liability of where groups can get stuck is saying, well, I don't know what the future is…what is that one future? No, no, no—we don't know that, but we know enough to say well, it's somewhere between here, this condition, and this condition. We can play out scenarios of a kinda of not so much change or a whole lot of change. We don't know the pace, the shape of the curve between here and 20 years from now, 25 years from now where we're going to go from now to say, an ocean along the East Coast of the United States that is another degree warmer on average. I can't tell you if that's a straight line, you know. It may be exponential, we're not quite sure, but we know we can play out a couple scenarios and then frame risk and possible solutions around what we think are reasonable scenarios to plan for. It's kind of…I'm picturing—my son turned 12 yesterday and I hope very much that he decides to go to college and hope that I'll be able to finance some of that. Do I know what college he's going to go to? No. Do I know how much it's going to cost? No. But I can plan for a couple scenarios, and at least that enables me to begin taking some action and have something in mind rather than shutting everything down and saying, well, I don't know if he's going to Carleton College or University of Maryland therefore I can't plan. No no no no no. We must plan [laughter]. We must prepare.

RS: Let me ask you to recount a project or a contribution that you would say, in terms of your career here at NOAA, you're most proud of. And it might be something you've already mentioned.

RG: Hmm…During my career at NOAA, as a package, as an effort kind of over multiple time frames that I think both I found most satisfying but also I think had probably some of the most important contributions to marine conservation and management—it would have been that series of events leading to establishment and then of the NOAA Coral Reef Conservation Program. And then the standing up of that program and I think then having it make quite a difference. I think a very successful program. So, it would have been with a small group of us, both internationally and within the U.S., that began to say, we need some serious, significant attention and investment from the U.S. government on coral reef conservation. It's really the only way that we're going to try and reverse the tide of reef degradation. And that was able to take advantage of a receptive administration and NOAA leadership and a few of us in kind of the right place at the right time in Washington D.C. to begin putting forward the idea of an Executive Order, of a funding initiative, and actually establishing both the program within NOAA, but also the vision

of a cross the U.S. government task force that would link into international coral reef conservation bodies as well. So, I think advancing the effort on coral reef conservation probably was very—the group of colleagues, tremendous group of people that were very strategic and thoughtful and were able to see opportunities and then take advantage of those —I think that would be one. I think the second, more immediate, one would be I think development of the NOAA Fisheries Climate Science Strategy. And that one, because obviously my hope is that it is a blueprint for transforming the NOAA Fisheries science enterprise so that it can deliver the information so this agency can make climate-ready decisions. I very much hope that people look back on it and say that was the call and the blueprint and was set in motion the broader discussion within the agency about how do we get to climate-ready? What would a climate-ready NOAA Fisheries Service look like, and how do we get there? And this, at least, laid out a road map to, at least—how do we get to the science we need, and that science organization part of it? But it really was a step towards the broader conversation about what would a climate-ready Fisheries Service look like and how do we get there, from the science to the management framework and decision frameworks we need?

RS: It's quite an achievement. I mean, what a key step. Well, I don't know if there's anything else that I didn't ask you about or whether I've pumped you dry. Is there anything else you would like to mention?

RG: Well, I guess on that last one I meant to say, also, that the reason these things happen—if you were to ask, well, why do these things happen when they do? I was thinking about that, and it often is there is someone in a leadership position that makes it possible and so in thinking about both of the examples I just gave you, there were again people in the right place at the right time, but then leadership in particular that allowed things to happen and enabled it to happen. So, in this case for the Climate Science Strategy, we had a very visionary Chief Scientist who realized both the need and the opportunity to begin transforming the science enterprise within the agency. So, it was Richard Merrick's vision and direction that called for, said we've got to get to climate-ready, we need to talk about and figure out what that means, and how do we get there, and let's start with identifying what our science and information needs are and what is the science enterprise we need to do that. I want to clearly recognize the key part of the ingredients in these things are people in leadership positions that are the facilitators and pave the way for that kind of thing.

RS: Create that vision.

RG: Exactly. Vision, and then the door and the path to be able to have an effort walk through. And that takes a lot in the front end, and then it takes determination and continued care and feeding and promotion all along the way. Because these efforts can often die [laughter] along the way, as you know.

RS: Yes. Yeah, it has to get established and take on a life of its' own.

RG: And obviously this is all a work in progress, you know. We're developing regional action plans to try and turn a national strategy that calls for six or seven bold things into real action in

each of our, from each of our science centers. And that's what those regional action plans are supposed to do, is customize this and say, well, here are our strengths and weaknesses in Alaska or in the Southeast right now. Given that, and the challenges we're facing, climate-related challenges, here are the steps we would take over the next three to five years to begin implementing the strategy—to begin filling those critical gaps. It's a key step, and that will make this strategy actually come alive with real actions and hopefully real progress.

RS: Well, I don't have any more questions and I'm sure I've taken up all the time that was allocated, but I appreciate your time very much and I'm going to sign off now.

RG: Thank you.