Dr. Paul Montagna, Part Two

Interviewed by Dr. Jen Corrinne Brown

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Transcribed by Maxwell McClure

Jen Brown: Okay, it is March 9th, 2017. This is Jen Brown. I'm here with Dr. Paul Montagna to talk about his work with oil and gas environmental issues. Do I have your permission to record?

Paul Montagna: Yes.

JB: Okay (laughs), thanks. Um, this is Part Two of our interview. Last time we talked about freshwater inflow and your role in the creation of the Mission Aransas National Estuarine Research Reserve. Do you have anything that you wanted to add about any of those topics?

PM: Um, no, I guess not.

JB: Okay, well, I guess we could start today, do you want to tell me a little bit about how you got started working on environmental aspects of oil and gas?

PM: Well, after I finished my master's degree in Boston, I applied for a job in Oregon, and what that team was doing is they were supplying data to write the first environmental impact statements for opening up Prudhoe Bay oil and gas development. This was in the mid-seventies, a long time ago, and that's how I first got involved with working on oil and gas issues. We sampled four times a year for about four years, and that meant, uh, three times during the year, of course, the Arctic Ocean was ice covered, and we would do things like fly on helicopters, drill holes in the ice, lower devices to sample the water in the sediments, and then put—take everything apart, put it back in the helicopter, and fly home (laughs). And then we would bring all samples back to our lab in Oregon and work them up, and we discovered a whole bunch of interesting things that there was seasonality, which kind of surprised us, you know, it was always thought that the Arctic Ocean was relatively constant, and it wasn't. And then eventually, of course, I went back to graduate school. After about four years, I worked on more stuff again, but when I did my postdoc at Lawrence Livermore National Lab, I found myself working on oil and gas issues again because I was working on, uh, natural oil seeps, and the whole focus of the oil seep work was, "Can we learn anything about how the environment deals with natural oil pollution as opposed to man-made oil pollution?" and apply those lessons to mitigate oil spills. One of the things we discovered, probably the most important than we discovered during those years, was what I like to call the toxicity versus enrichment hypothesis. It's really interesting. A tiny bit of oil could actually fuel, connect, actually act as food for bacteria. You actually fuel the food webs, but a lot of oil, of course, is toxic. So there's this kind of balance between, uh, almost this Goldilocks moment, is it just right? (laughs) And the other thing about oil seeps, though, is that they're very tiny compared to an oil spill. It's not uncommon for oil seeps to have literally just, it’s more like a drip, drip, drip rather than a firehose being turned on, which is what an oil spill is like. And so, I think in the long run, they weren’t necessarily lessons in terms of mitigating oil spills because, as I said, what we discovered was a tiny amount is okay, but that never occurs in an oil spill, and (laughs) oil spills always get very large now. So when the Deepwater Horizon event happened, many people were saying that, “Well, this doesn’t matter because, you know, there are thousands of oil seeps in the Gulf of Mexico, natural oil seeps, and so the environment is already pre adapted to dealing with oil in the environment.” Well, you know, that’s like saying, “Just because I have a leaky faucet in the kitchen, I don’t have to worry about a burst pipe in my attic” (laughs). It’s just nonsense, and in fact, you know, the oil spill was about ten times larger than all the oil seeps combined in a year. Of course, the oil spill happens over a very small amount of time, and over a very small, concentrated area, as opposed to the entire Gulf of Mexico in an entire year. So what we saw in the Deepwater Horizon event was large areas of pollution and degradation of the bottom, which is what I was studying during that whole time. But anyway, in between, I kind of jumped ahead of the story, in between my postdoc and the Deepwater Horizon spill, I probably had about ten or twelve various oil and gas kinds of projects over the years, mostly sponsored by what was then Minerals Management Service, now it’s the Bureau of Ocean Energy Management. It’s an interesting organization, they’ve changed their names probably four or five times during my career (laughs). And I guess that’s all political stuff, you know, it’s nothing to do with reality. Basically, the federal government owns a lot of land in which there are large natural oil and gas deposits, you know, on the continent, most of that in the West, but in fact, most of the federal land is offshore in federal waters. So what the federal government does is they literally lease the right to the exploration and production on federal lands. That’s money that goes directly to the federal treasury, and so, you know, the government’s actually in the oil and gas business (laughs). It’s something that we don’t often think about, but it’s an important detail. It’s a mineral right owner, just like private individuals are in this country. So it was real interesting, throughout most of the nineties, um, our focus was on what I would call fate and effects. We wanted to know what effect both exploration and production has on the environment, what effects do all of the platforms that were built have on the environment, and what is the ultimate disposition of any oil or other pollutants that might leak into the sea, that’s where we invite fate. And it’s really interesting because we basically worked ourselves out of a job. After about twenty years of doing these kinds of studies, I would have to honestly say we really didn’t find anything. What we discovered was, when done well without accidents and without incidents, oil exploration and production is essentially a benign activity. When they do the initial drilling, there’s usually a little bit of pollutant second deposited on the bottom, but it’s usually only about the area of a football field or maybe two football fields, so it’s kind of a small aerial impact. It doesn’t have impacts that are far afield. Uh, those impacts last for a very long time, they’re chronic, so they’re not what we would call acute like an oil spill. In an oil spill, a large amount of pollutants get released in a short period of time, and during regular exploration and production, just a tiny get released over very long periods of time, and most of that is happening during the actual exploration of the drilling phase. Once they go into production, obviously what they want to do is keep all the oil and gas in the pipes, so there’s virtually no pollution at all. There’s a little bit of, you know, grease and maintenance activities that might come off the platforms, but that’s pretty small. I mean, if you think about it, uh, certainly maybe less than what ships and boats are putting out as they motor across the sea as well (laughs). So by the late nineties, the effects program was virtually finished and complete. And, you know, I really thought, “Well, that’s it. We’ll never do this kind of work ever again.”

And then, of course, what happened was basically a technological revolution that allowed them to start drilling deeper and deeper and deeper with new technologies, and all of a sudden, you know, we went from a period in the seventies and early eighties where we thought we would run out of oil in fifty years to now that we can exploit the deep sea, realizing that we've got a ton of oil and we've got plenty of oil and gas to last us hundreds and hundreds and hundreds of years (laughs). And it's just a little more difficult to get out, a little bit more expensive to get out. Um, in fact, the other big change in the industry is fracking, which allows us to exploit remaining oil and more oil that wasn't exploitable in the past on land. And so you combine these two things, fracking and the discovery of huge deep sea deposits, and there's still a lot of oil out there to be exploited and mined by people. So nothing—so we still have a ton of work to do, and what we've discovered is there are all new questions and issues and problems, and particularly with the deep sea issue, and I think the Deepwater Horizon is a really great example of that. You know, up until the Deepwater Horizon, and again, this is still true that all of the spills occur primarily in transportation, whether it's a pipeline break or a tanker accident, and then, of course, there are the blowouts during the exploration phases. Those are the dangerous parts of the industry. Once they move to production, it seems to be pretty safe, we see much fewer accidents. So, when we had to blow out, because we had been focused on oil spills that were primarily affecting only the surface, and, you know, oil is lighter than water, so oil floats, right? When the Deepwater Horizon accident occurred, the assumption was, well, there would be no impacts of deep sea, all the oil is going to float to the surface, and we can use our traditional techniques to either scour, or scrape, or burn the oil that hits the surface and everything will be fine. But that's not what happened. So, one of the things about deep sea deposits is that those deposits were also much deeper in the ground as well. And so, the oil's under really high pressure. There's also a lot of natural gas mixed in with the oil. In fact, I think something like 65 percent of what came out of the well was actually gas in that oil. So it's a mixture of oil and gas. It's under high pressure, and it's coming out of this tiny little nozzle or pipe. Now what does that sound like? That sounds like a paint can (laughs). And that's exactly what happened. When the Deepwater Horizon actually occurred, essentially you had this vaporization of oil, or atomization of oil, just like you would see in the paint can (laughs), you know, when you press the nozzle of a paint can, and that happened at the bottom of the ocean. Now, when that happens at the bottom of the ocean, two things happen, again, things that were really weren't anticipated. One is, it gets caught up in deep sea currents and gets transported, and that's what was referred to as the deep sea plume, and those currents stay far below the surface and because the oil is literally atomized and dissolved in the water column, it just stays there and it moves, and it might literally impinge against the shallower areas of the slope, and we call that the bathtub ring hypothesis, and we can see at about a thousand meters all around that, the continental slope, you know, remnants of oil from the Deepwater Horizon. Excellent. The second thing that happens is the oil got entangled and trapped in what we call marine snow. Now, marine snow may not be something that most people know about, but every single oceanographer or scientist who studies the ocean knows all about marine snow. So what happens is, in the water column, where there is light, meaning mostly at the surface, there are a lot of plankton, and primary producers, and small algae, and bacteria, and a variety of microbes, and they're producing organic matter, or snot, if you will, what I like to call it, I call it snot. The scientists who study it just call it marine snow, and the reason they call it marine snow is because all these particles and aggregates kind of clump together and they all sink to the bottom, and in fact, that's exactly, that's sinking to the bottom of the organic matter that drives all productivity on the sea floors everywhere in the world. So we've known about marine snow for a really, really long time. And again, it's a mixture of organic stuff, and so oil is organic, so as you might imagine, the marine snow literally trapped and scavenged these tiny, tiny, tiny oil droplets that were in the water column and deposited all on the bottom. That we call the dirty blizzard hypothesis (laughs). And it's pretty amazing that these two, uh, mechanisms that we really didn't know were going to happen were responsible for large amounts of the Deepwater Horizon oil staying in the deep sea and impacting the bottom. So I was—and we have a real fancy acronym for this, by the way, called MOFSA, which is something like, you know, marine, oil, and flagellant snow aggregations. I can't even remember the whole thing, but it's become a whole field of study all in of itself is how this happens. And again, a big part of it, is that, again, the big difference between a blowout and natural oil seep, and this is really important, is when a bubble of oil comes out of an oil seep. Well, number one, there are very few bubbles, and number two, those bubbles are large. They're literally on the order of millimeters across. You can actually see them, and those things will rise to the surface, and we can actually identify where oil seeps are in the Gulf of Mexico by looking for sheens on the surface of the gulf and many people have done things like that. But in the Deepwater Horizon, all that oil got atomized, and the bubble sizes were on the order of microns, in other words, thousands of times smaller than you would see coming out of an oil seep, and that's why that stuff didn't float to the surface, and that's why it got caught in the bottom, and that's why it got trapped in the current, and that's why it got trapped by marine snow and got sedimented. So we learned something completely new that no one really anticipated or knew had happened. And it was really interesting in those early days, I think that blowout occurred on April 20th or so, and throughout April and May, everyone was saying, "Oh, it's not going to hit the bottom, it's not going to bother the bottom," and it really wasn't until June and July that we started realizing what was really going on. And so, by August and September, there was a concern that there was a large amount of oil in the bottom, and we needed to know how much and where it was, and if it could, if there was anything that could be done to pick it up, or vacuum it up, or clean it up. And so, I was part of a team that was asked to go out and perform sampling in the deep sea to see if we can find it on the bottom. But sure enough, we found a lot of oil over very wide areas (laughs). Um, the most intensive of, and highest concentration of oil, was surrounding the immediate, um, spill site, and covered an area about the size of a medium-sized to large city. What we discovered when we started analyzing the biological parts of those samples was about half of all the diversity was lost, and as we go a little further out, the effect was decreased, but still, about a third of all diversity was lost, and you go a little further out, and we started seeing a return to kind of natural background conditions. And so there was kind of like a little a bullseye effect, where the biggest effects were immediately and closest to the wellhead, and larger effects were further, and smaller effects were a little further away, and finally, it was diminished, and we couldn't really pick it up. But I have to caution you because one of the things that is very problematic about all our studies is the fact that the kind of work we do is ridiculously labor intensive, meaning it's very expensive (laughs). You know, we have to go out on a boat. We have to sample the bottom with very large devices. It takes a long time to get the samples, and then we have to bring the samples back in the lab. We have to run chemical analyses, biological analyses, geological analyses, and so those are all different teams. In fact, there might be three or four different teams of chemists, a team of geologists, a team, you know, two or three teams of biologists. So it's an enormous number of people, and they might have thousands of samples to go through. And that's why it takes a long time and it's very expensive. But the problem is, uh, it all depends on how many samples you can get, and, you know, when we would go out, we could spend, you know, like, let's say in a week, we might only get twenty or thirty samples (laughs). That's how much work it is to get the samples. And so, if you think about how area increases with distance from a bullseye, you know, think of a bullseye, you know, a dartboard. You know, the little red dot in the center has a really tiny area, that's why it's so hard to hit, but as you go away from the center, the area of each ring gets a lot bigger (laughs), so we could cover that center of the bullseye, what I'm talking about specifically was within about three kilometers, which is about a little over two miles, about two miles of the rig. We could cover that area pretty intensely with samples, but once we got a little bit further away, we were sampling a tiny fraction of the area that could be impacted, and so one of the things that has always bothered me is that there could have been a lot of oil pollution out there and we simply could have missed it because we were sampling such a tiny fraction of the bottom of the ocean, you know, it's almost, again, it's literally like throwing darts at a wall. You got your dartboard on the wall, and you get the tiny little bullseye in the center, but then there's the whole area of the wall, and you got to figure out, "Well, how many darts do I have to throw to really cover the entire wall?" And the answer is, "Many, many more than you can ever hope to actually throw," or in our case, "Many more of samples that you can actually ever hope to collect, let alone analyze." Even though it sounds like we found effects pretty much only localized, or in an area that's relatively small, and when I say relative, I mean, relative to the entire Gulf of Mexico, and certainly relative to the area that the surface slicks and even the deep sea plume covered, we really didn't sample adequately to find effects further away from the well, and that's just one of the realities of resource limitations. When I say resource, I literally mean time and money. So, the whole Deepwater Horizon story is, I think, a classic one of the iteration of science. We discovered new geochemical processes, but yet we were able to employ some of our tried and true assessment techniques. And one of the most important ones in my view was always diversity. And, you know, there are a lot of different species in the world (laughs), and the bottom line is that some species are tolerant to some things, and some species are intolerant to some things, and when you get any kind of disturbance event, the sensitive species disappear and the tolerant ones hang around. Heck, they may actually even expand their territory and grow. So, just looking at biomass and abundance, the number of things we find is not sufficient because the weeds can fill the space. It's much more important to look at the diversity of a community because it's the diversity of a community that maintains the functioning of the whole ecosystem. And so we were able to use diversity measurements to find, uh, you know, impacts and talk about the percent of the area that was degraded, and by what percent biodegradation occurred, by looking at how diversity patterns change in space. Now we've sampled the same exact places two other times. The initial sampling was in 2010. The second sampling was a year later, in 2011. We went back in 2014, which was four years later, and our 2014 samples showed virtually no change at all in the diversity. Um, that means the bottom that was impacted initially hasn't recovered at all. We still see the same low levels of diversity relative of background, and the question is, "How long will it take the deep sea to recover?" Well, here again, it's so different from shallow waters where we have really built our science of oil spills. The deep sea is very cold. It's uniformly about the same temperature as your refrigerator (laughs), and that's because cold water is dense and it sinks, and water is densest at about four degrees centigrade, uh, which again is about 45 degrees Fahrenheit, and so that's why the bottom of the deep sea is uniformly cold. It's dark. [26:15] Once you get below three hundred meters, even one hundred meters, which is three hundred to a thousand feet, it's total lights out. So it's cold and dark. Again, what does that sound like? Uh, that sounds like my refrigerator. Well, what do we put things in the refrigerator for? To keep them fresh (laughs). So the bottom line is that oil is going to stay there for a long time, and it's going to—and microbes won't be able to really chew it all up because it's just too cold, metabolic rates in the deep sea are very, very slow. And my theory right now is that until the natural sedimentation processes occur and we literally put a cap of fresh new sediment on top of the oil, it won't recover. And so, again, recall I talked about marine snow. Well, that marine snow also includes sediments, and that stuff is always falling to the deep, and so the sediment is always accumulating on the deep sea floor, and we did something really interesting. We asked ourselves, "Well, is there any place where we can try and figure out how recovery might occur?" And we realized that, well, we also had a deep sea, we also had a blowout in the Bay of Campeche, Ixtoc, back in 1979. Now that happened in very shallow water, it was about twenty meters, which is only about sixty feet, not a mile deep, like the Deepwater Horizon was. But, the oil traveled over a deep sea canyon so we were able to go, it traveled due north over the deep part, and so we were able to go and sample areas where we might have had a marine snow event depositing oil to the bottom. Sure enough, we actually found it, um, where we would expect to see it. And the interesting thing was, we found evidence of that oil about, and the evidence of the Ixtoc oil spill, about three or four centimeters below the surface. Now that means we had a cap of fresh oil, fresh new sediment on top, and that took about thirty-five years, and we were still able to see effects. And that's because the biologically active zone is about the top ten centimeters of sentiment. So my theory right now is until we get about ten centimeters a fresh sediment on top of the Deepwater Horizon oil, the deep sea won't fully recover, and based on what we know about sedimentation rates, I've calculated that that will take about a hundred years. So I think the Deepwater Horizon effect on the deep sea will probably last about a hundred years. And I think it's too dispersed and too heterogeneous, meaning it's very patchy in nature, it's not an oil sheen like you see on the surface. Again, if you think about a real snowfall, if you look at a field that's recently covered with snow, it's never perfectly flat. It's always a little lumpy-looking on the surface. That's a combination of wind and, you know, various patchiness of how it falls. And that's the way it is with the marine snow. The marine snow is actually, you know, more patchy, and the oil depositions are even more patchy. So, we can take a lot of samples in a very small area, and there will be a great variability in the amount of oil we find in those sentiments, and that's because of the patchiness. And heck, even in the middle of a field that's heavily oiled, we might find one with a very low value, you know, that just by dumb luck escaped it. It's all it's all a matter of scale and size, and so, I think that the oil has been distributed over a very large area, and it's going to take a really long time for it to all recover.

JB: All right. Um, so when you—

PM: That was a very long answer (laughter).

JB: No, that's fine. Very interesting, thanks. Um, when you wrote this article, "The Deep Sea Benthic Foot Friend of the Deepwater Horizon Blowout," essentially you were measuring how to, actually how to measure those broad areas outside of the localized gulf spill. Could you walk me through the process on how you came up with this idea of measuring that footprint?

PM: Yeah, it was really interesting. What we were being asked to do, we have something called a Natural Resource Damage Assessment Program, which basically I like to call the "China shop rule," you know, if you break it, you own it (laughs). And so what happens is if someone has a large scale pollution event, it doesn't have to be an oil spill, it can be any kind of pollution actually, and there's a loss of a natural resource that's owned by the American people, then the company who damaged it is responsible for, number one, making the American people whole, meaning paying for the damage, and number two, restoring it back to its original condition. If you think about it, what we're being asked to do is we're being asked, "So, how much area was damaged, and so that we can assess a fine appropriately, what was the percent damage?" So, what was—we were being asked what was lost, and it became clear to me that this was going to be an issue of spatial variability, and kind of a percent change over space, and what I did is, again, I reached back into my experience going back twenty years, you know, when we studied, um, the effects of oil and gas platforms during the nineties when we were doing the fate and effect studies, our model was essentially what I like to call a bullseye model or the or the dartboard model. You've got something in the center, and one assumes that pollutants are radiating out away from it, and you have to assume at first that it's radiating out equally in all directions. We know that won't be true, by the way, which is why we don't sample just in one direction, it's why you have to sample lots of directions, because of currents, it's more likely that it'll flow downstream more than and across and perpendicular to the flow to the long-term average flow patterns. The second thing we assume is essentially an exponential decline of the pollutant away from the source. So what I mean by that is, the pollutants will be very high close in, and they'll rapidly drop off with distance away from that original source. So we start out with these two concepts. One, you know, a radial dispersal of all the pollutants from a point source. Number two, uh, some kind of decline with space. What we do is we try and take examples so that we can, you know, all around and far away, so that we can measure when the changes start to occur. Now, we measure a lot of things, and if you think about it, the impact is manifested both in the chemical realm and the biological realm. So, for example, if an area is being damaged, we expect to see high concentrations of oil, and the most toxic component of the oil, which we call a PAHs, and that stands for Poly Aromatic Hydrocarbons. Yep, and so, there's another interesting little thing, there was another problem we were going to have right away which is, "Well, how do we know that the oil and the PAHs we see are not due to oil seeps?" So we also need an indicator that would be unique to the drilling itself, and a long time ago, we discovered that there are certain heavy metals that are only associated with drilling that are not associated with oil seeps. And one, for example, is barium. So what we did is we used a combination of chemical signatures that tell us, "Yeah, that's oil spill oil, not oil seep oil." And then we look at the biological responses. So, for example, the diversity, and we also used abundance, and we used this for several different kinds of groups of organisms. And so the assumption is that if we look at all the variables we measured, by the way, we measured well over a hundred different variables, (laughs) um, we expect that when the pollutants are high, the biology indicators will be low. And so they're kind of, uh, inversely correlated to one another. Well, how do we take—so if you think about it, when we're done with the study, we have this matrix. You know, it looks like an Excel spreadsheet where every row is a sample and every column is something we measured. Well, how do we look at that matrix or Excel spreadsheet, and come to any conclusions? It's just a whole bunch of numbers. Well, we employ things we call multivariate analysis, and we have techniques that allow us to basically reduce all that information into one or two columns that kind of pack all the information to one or two new columns, uh, that specifically represent an oil spill index, exactly what I just said. So, tell me when, tell me in which samples the pollutants are high, and the biological metrics are low, because that's an oil spill effect, and then let's order all the samples according to that. That's the first step, and then the next step was, well, we also know exactly where the latitude launched through where we took all the samples, so let’s put all that information on a map. Then we were able to put it on a map, and then the third thing we did is we perform interpolation, uh, techniques on the map, and we start connecting the dots essentially, and that allows us to build, to calculate areas that are affected by what percentages. It was a real interesting combination of some very old approaches. The bullseye and exponential decrease with distance from the source concepts, we have those old concepts, we have the old concepts of “What are the indicators?” We have some new concepts of, “Wait a minute, we’ve got to be able to tell oil seep oil from oil spill oil,” and then we used some newer mathematical approaches that weren’t available to us in the nineties, to be honest with you, because the multivariate analysis stuff has been around a long time, but not mapping software, and really, it’s only in the last ten years that just about every student here now has mapping software on his desktop, just like they might have a spreadsheet software or a word processing software. Now that was just not true ten to twelve years ago. So now, you know, because of advances in computer technology, we have to vet the ability to draw very nice, pretty pictures of exactly the areas that were affected and areas that were unaffected. And again, when you—and we took a very simple color code approach, or took what I like to call a stoplight approach, so we called the most degraded areas red, the areas that were so-so yellow, and the areas were okay green (laughs), and we use some colors in between, like orange for medium bad and light green for somewhere between yellow and dark green, and so we had these five categories that when you put the five categories on a map, it was amazing how much like the bullseye actually looked like, because the red area was only in the center, very close to the well had, though you move to an orange area surrounding that, and finally a yellow area, and then finally the green areas, and it literally followed this kind of bullseye pattern exactly like we anticipated, and that pattern extended over huge distances. The hardest thing for us to deal with was, what I like to call that yellow or the “so-so” case. Now here’s something, because that area was enormous, that that area was like, uh, I can’t really remember the exact size, but was absolutely enormous. Um, this is an area where things are kind of just a little bit below average, and it’s, so what I did, I took a very what I would call a conservative approach. We just declared it a zone of uncertainty. There may be impacts, there may not be. And again, getting back to my examples of the bullseye, the biggest problem was the area’s so large that it is represented by so few samples that we really can’t be sure, and I’m convinced in my own mind, or I can theorize that if we take a lot more samples, we might not have been so uncertain about that zone (laughs). But again, as you move into the larger areas, you need a lot more samples to represent it effectively, and that was a weakness in the study. We just ran out of time and resources, you know, to sample far away, and of course, you’re trying to optimize, uh, your resources. One of the things I’ve had to do my entire career was figure out, “What’s an optimal sampling design?” Because I’ve always done a lot of field work, and again, fieldwork is ridiculously expensive both in time, labor, [42:08] and money, and we’re always struggling with, “How do we optimize the deployment of our resources so that if something’s there, we’re going to find it?” Because we always want to avoid, uh, what we, what scientists like to call the type II error, there’s an effect, but you’re sampling is so insufficient you can’t find it. There’s something wrong and you can’t detect it. Those the errors we try and avoid. And again, because it’s all a function of the sample size, the only way to really combat that is to, you know, either pick the places you sample in a very strategic way, and try and take as many samples as you can, so I always like to say, “The thing about these kinds of analyses is you can never have too much data.” (laughter) There is no such thing as too much data.

JB: Why do they call it a type II error?

PM: Oh, that's statistics jargon, I'm sorry, I shouldn't have used that. Anyway, in statistics we do hypothesis testing, and we have things we call type I errors and type II errors. So a type I error is you say something's different when it's not, and a type II error is you say something is not different, when it actually is (laughs), and type I and type II, those are just jargon words that we use. You know, the bottom line is, we want to always get it right, and there's two different ways to get it wrong (laughs). One of the things we always have to be careful with is we have to do what we call power analysis, which is, "What is our ability to detect change?" So I'm getting a little technical now, but it gives you an idea that, um, this is a complicated business (laughs), and, we take it real seriously. We employ not crazy difficult kinds of analyses. In fact, all the things I'm telling you, you know, particularly about the kinds of mistakes you can make, you would learn in a freshman statistics course. You know, it's one of the first things we teach, college students about statistics is we always want to make sure we understand whether or not we should believe our own work, believe our answers, and we always have to be cognizant of that. We could make mistakes. And so we always want to make sure that whatever outcome we get, it's an outcome we actually believe because we know we have sufficient power to detect change. And again, power is a jargon word. It literally means how sure whether we get the right answer, and we can calculate that, and it's always a function of sample size, you know. Essentially, the more samples you take, the more certain you are that you got the right answer. And it's just, you know, just statistics (laughter), probability theory.

JB: Yeah, well, maybe I will ask you to follow up with a science question, then. Um, how would you explain these benthic invertebrates that you were measuring the diversity and abundance of to non-scientists?

PM: So it turns out, if you think about it, something like 67 percent of the world is covered by water, right? Well, that means 67 percent of the world is covered by bottom habitat. And by the bottom, we call that, that's the word, you know, we refer to as the benthic realm, and something like 95 percent of the ocean is actually deep sea, only 5 percent of the ocean is the coastal area. So the point is something like 60 percent of all the habitat on Earth is deep sea benthic habitat so it's actually the largest habitat on earth. One of the things that was discovered way back in the 1960s was that, in spite the fact that it's cold and dark and life grows very, very slowly there, it's actually one of the most diverse environments on Earth. Now it's all small, marine invertebrates, wormy things, shrimpy things, clammy things. You know, the three major groups are what we call polychaetae worms, these are segmented worms. Another important group of the crustaceans, and there are lots of different crustaceans, people are familiar with things like shrimp, crab, and lobster, but that's kind of just a small fraction of the diversity of different crustacean life we have. [47:13] And then there are all the mollusks, the things like the clams, the snails, and other kinds of mollusks. What we do is we literally go out and we census these things. Now, why do they matter? They matter because they're the only things living in the deep sea essentially, and they're food for the fish and the other stuff that's there, and so they form, essentially, the bottom of the food chain for the entire deep sea. That's why they're important. There's some other interesting things about the deep sea that are not related to biology that are probably pretty important, and one of the most important is the carbon sequestration. You know, the deep sea is a huge reservoir and sink for CO_2. Again, this is kind of related to the deep sea snow story, as we deposit organic material on the bottom, it gets consumed on the bottom, and that CO_2 stays on the bottom. So that's very important regulating the climate in the entire globe. So, the deep sea plays probably two enormously important roles that are important for people. One is climate regulation, literally the entire planet. The weather you see in the entire planet is regulated by what's going on in the deep sea. That's all physical, chemical. That's not biological. On the biological realm, um, you know, it really is the basis, it's the formation of the food chain and again, since it's the largest habitat on Earth, it's much of what life on Earth is.

[49:11]

JB: I think that's all the questions I had on oil and gas environmental issues. But, um, could we talk a little bit about your experiences starting at Harte Research Institute and why you decided to come here? (Montagna laughs)

PM: That's a good story. Well, I spent twenty years at the University of Texas Marine Science Institute. That's what brought me to South Texas, and in those latter nine years, I created the research reserve [Mission Aransas National Estuarine Research Reserve (MANERR)], and when the research reserve was created, I had this crazy feeling of almost like a little depression, almost like. Yeah, so what am I going to do next? (laughs) I spent all this time working to create this thing, and now it was there, you know, I mean, that's great and all, and I always assumed that I would hang around and manage it, but I was kind of looking for new opportunities, and new challenges, and really not thinking about anything specifically, and that's when I was actually approached by—right after MANERR was designated, I was approached by the people at the Harte Research Institute, and they were telling me that, "Well, we've got this new program we started." At that point, they'd only hired two other scientists, and they were only just getting started and they were telling me how they wanted to build a new kind of marine sciences institute, one that integrated natural science and social science so that we could really solve problems, and that was very attractive to me. Um, most of my career I've done what's called applied research, and so what I've done is I've worked on problems and tried to come up with solutions. A long time ago, I had realized that even science-based decision making is not based on science alone (laughs). At the end of the day, we still have to take into account economic issues, social issues, and then everything gets constrained by policy and law. What can you do? Even if you know exactly what the solution is, if it's not allowed by law or there's no way to actually—no one is authorized to do that change, then it can't happen. So a long time ago, I realized I wasn't going to be able to solve some of these freshwater inflow issues, some of these oil and gas issues, some of these conservation issues, you know, without working with economists, and lawyers, and social scientists. I just realized that, you know, I just can't do this alone, we've got to have some kind—and so to find out that someone was going to create a whole institute dedicated to this approach was like, I thought it was just an amazing thing, and when they offered me a position, to be honest with you, I leaped at it (Brown laughs). And again, it was because it seemed to be the perfect time, twenty is a nice round number, I literally had just completed my twentieth year at UT. I had just finished the NERR project, and I really wanted to get back focused on freshwater inflow environmental flow issues. I really felt like that part of my life had not been given the focus it needed, and this seemed to be a good opportunity to really get focused on trying to do some new things. And sure enough, that first year, I managed to get two projects funded with the economist, David Yoskowitz who works here, where we did economic evaluations of environmental flows, and we've had several projects since then that have been interdisciplinary with both Rich McLaughlin, who is a lawyer, and David, and Greg Stunz who is a fishery biologist, and a bunch of other people. It has really worked. So I have been here now eleven years, I'm in my eleventh year, and I have to say that for the most part, uh, the promise has come true. And in fact, what's happened here at Harte is nothing short of remarkable. Uh, when you do this kind of science business, it's really all about competition (laughs). We're always competing with other universities and programs for grants and contracts, and we're always competing for journal space, and it's all about, um, who's going to win the competitions for these things, and to win, as you might imagine, you have to have the best ideas and you have to have the best approaches because everything gets judged by what we call these peer review panels, and if anything has changed in my long career, it's that success rates seem to keep dwindling year after year after year. It's not uncommon to have programs today where the success rate is like 1 to 5 percent. It's just, the competition's got ridiculous. Um, and so we've experienced the exact opposite, we've had enormous growth and HRI, and we've become very prominent in a very, very short period of time. And when you consider that we are based out of one of the smaller regional universities and not at a major university, that itself is amazing. And when you consider our ability to compete on national, international scales, that itself is amazing. And so why have we been so remarkably successful in such a short period of time? I think the answer really lies in, we kind of know who we are, and what we're doing, and the unique aspect of our program. So the found—what made the Harte Institute possible was a gift by Ed Harte. And he gave us, he gave the institute, he gave the people who are creating the institute a three-word mission, "Make a difference." That's all he said (laughs). Now there was a little bit more, but that was his main message, "Make a difference." What has evolved from that is this idea that the institute would be focused on the conservation of both the environmental and economic health of the Gulf of Mexico, and that it would be done in a truly international partnership with all gulf countries, meaning both Mexico and Cuba as well as the United States. And so that kind of focus on the Gulf of Mexico means that we—and that focus on the conservation of the resources is both again human, economic, and ecological, environmental. [57:03] That's what makes us unique, and we know who we are. The other thing that's so important, I think, is that those words "Make a difference," because we also know that we're doing science not for the sake of doing science. We're doing science to try and make the world a better place, to try and help people come up with solutions to problems. And so the most important thing, and this is where this interaction with the lawyers, and economists, and the human dimension side is so important, in the past, scientists have kind of taken the, um, I would say the "UPS approach" to try to help out lawmakers and policymakers, we would show up in our truck, we'd dump all our science as the delivery on their doorstep, we'd turn around and walk away and say, "Here, here we did the work. You figure out what it means to you." And that's what's really different. We don't do that here. What we have here is we have people who could help explain how to implement the work in the context of either economics or policy, and that's what makes us, the combination of all these things makes us very, very unique, and it makes the entire approach that was created your very, very powerful. In fact, we've given this a name. We call it the "Harte model," and what we mean by that is we're going to take—we're going to integrate social natural science to actually come up with solutions to problems. And again, the key part of that is the translation, the translation of the natural science, and the things that make sense in the economic world and inthe policy world to make people's lives better. And so, you know, I don't cure cancer (laughs). Right? I’m not doing research to find a cure to cancer or any other disease. Uh, I’ve always felt the work we did on freshwater inflow, environment flow, was very important both to the environment, to people, but what was always lacking was a way to translate into something concrete into real solutions, and that’s what we could do today. I think that was a huge step forward and that’s what makes Harte so successful. [59:20]

JB: All right, thank you. Is there anything else you wanted to share? Anything that I missed or we hadn’t talked about yet?

PM: The only other thing I’d like to talk about is we live in a very interesting time, by the way, I probably could’ve said that for every phase of my career, which spans more than forty years now (laughs). But, uh, one of the most amazing things to me is how we’ve come to live in this kind of post-truth world. I’ll never, you know, throughout my entire career, one of our favorite, um, little sayings was always “Everyone’s entitled to their own opinions, but you’re not entitled to your own facts.” And that’s been turned on its head in the last few years (laughs), where now people feel like they’re entitled to their own facts, too. And I just find it’s stunning that we live in a world where there are entire industries devoted to creating alternative facts, alternative realities, and I just don’t understand how that benefits anyone, and how that has come to be. And I think, you know, I think it’s really, really, really, really dangerous. I think the power of science is knowing, and it’s a way of knowing, and the other power of science is that it’s iterative, meaning that we know we don’t know everything perfectly or completely today, and that’s why we do more work, and that’s why we revise our facts, our theories, our ways of understanding, and what’s happened is this whole thing called the denial industry has taken the scientific process and used it against itself so that when scientists do say, “Oh gosh, we just discovered something new,” they go, “See there’s uncertainty. They don’t know what they’re doing.” The other thing they’ve done, and they use it against you like it’s bad or there’s not a consensus when in fact there is. The other thing they do is they completely misuse words. So, for example, in science, we use the word hypothesis all the time. Well, what does hypothesis mean? It means our current working view of the world. What they do is they say, “Well, it’s just a hypothesis,” implying that the word hypothesis means guess. No, hypothesis doesn’t mean it’s a guess, or it doesn’t mean we’re uncertain. It means the opposite. It means this is the way we really, this is the way we think it works, and we’re going to try and prove that that’s wrong, and that’s the scientific method. So we build a framework and an understanding and an explanation for how the world works, and then we try and tear it down. And if we can’t tear it down, we know it’s correct (laughs), okay? And if we can poke holes in it, or it means we can improve it, we can make our explanation even stronger. So the word hypothesis doesn’t mean a guess. It means it’s our working model. It’s our current understanding of how things are. And you know, it’s funny. In a way, this has been around for a long time. [1:03:06] I’ll never forget, um, when I was very, very young, just a college student and an initial graduate student at the time, you know, we’re still fighting evolution battles back then. Heck, we are still fighting evolution battles today. And one of the things people who were anti-evolution used to love to say was that, “Well, it’s just a theory.” You know, again, theory doesn’t mean a guess. It means, you know, our working, understanding, our model. The thing that used to drive me crazy, the thing about evolution was what was all it means is that species change, and the crazy thing is, this is in the record, these are facts. Dinosaurs used to exist. They don’t today because things change (laughs). We saw in our lifetimes in the post-World War II period, the evolution of drug-resistant bacteria. Well, how do you think that happened? We created drugs to kill the bacteria. If some of those bacteria survived, they proliferated, and now you have drug-resistant bacteria. So the bottom line is evolution is actually a fact, that things change is a fact (laughs), and we have seen it in real time and the same thing can be said about climate change. Climate change is not a theory, it's not a model. It's a fact. The world's getting warmer. That's a fact. We can see changes in the environment. Those are facts, and I could go on and on about a bunch of things, and I guess the biggest thing that bothers me is that if we persist to live in a world without facts, how could we ever make the right decisions? If we persist to live in the world where we deny facts, or where people who have different facts are attacked politically because you assume they have a bias, how are we ever going to make any progress? I'm a really, really big believer in what is called the honest broker approach to science. I believe that the role of science is to provide the best technical information possible in an unbiased way. Scientists are not the decision makers, and scientists are not doing people a favor when they also become advocates, and so there's this huge difference, so I get very upset when people call me an environmentalist. No, I am an environmental scientist. An environmentalist is an advocate, you know? Think someone who works for the Sierra Club (laughs), you know, they tell you what their job is. Their job, they have a point of view, and they're going to push it just like people, uh, who want to exploit resources have a point of view. They want that natural resource regardless of what it is, and they see it as an abundant and inexhaustible supply, and they shouldn't be fettered in being able to take it. The question is, "What's going on in the middle? What are the real facts and who are the real decision makers?" And if you think about it, every single issue in front of us is going to have advocates on both sides. But somewhere in the middle has to be the scientist who is giving you an honest, unbiased assessment of the facts, and then the decision makers, the policymakers, whether that's a judge, a regulator or whatever, or a legislator, you know, who's going to hopefully make decisions by weighing the facts, and again the needs of the people. So the important thing here gets me all back to the Harte stuff. So what makes Harte different is we actually try and integrate both those social and economic issues so that we can give a broader view of what the options are available. Anyway, that's my little soapbox (laughs).

JB: So what do you think has changed, then, from the seventies when you started working in science to now?

PM: And that's the other thing, when I started, you know, they did these surveys of respected professionals and scientists who were always on the top, and that's no longer true anymore. Um, what has changed? What has changed is that the world has gotten more complex, I think. And you know, I think a good example is all of discourse. People want, people seek simple solutions to complex problems, and I understand why you do that. And again, in science, we have an approach we call parsimony. We always want the simplest answer or the simplest approach to a problem. But what that does is it means you'd have to ignore the complexity. But yet in political discourse, everything has to be boiled down to your elevator speech, you know, how can you get it out in thirty seconds? And so what we have is, and then there's such strong—so we have politicians who have a need for simplicity and they can't deal with complexity. And then we have the advocates. And today the advocates that are well heeled. And today, the advocates literally have created industries to sell their point of view. And I heard something remarkable the other day from someone who is a self-proclaimed, um, brainwasher (laughs), the person said, "I can sell anything as long as I can wrap it in about eighty percent of the truth." So again, the—

what we’ve got is we’ve got these well-heeled, well-funded advocacy groups peddling a lot of nonsense because they have a point of view that they’re peddling. And they just don’t really care what’s right and wrong. They have just got their ideology and they’re just peddling it. And so they got that chatter going on, and then we have, you know, both the politician and the public, let’s face it, I mean, you shouldn’t have to be a PhD to understand problems and come up with solutions. We have to be able to explain things so that they could make sense to everybody, and so everybody can feel comfortable with the solutions. How do we deal with the world as it keeps getting more and more complex? And don’t underestimate the information explosion that is playing a huge role in all of this. I think that’s been very important, and the fact that most of it is fake news (laughs), you know, it’s the reality, that that’s a thing now. I’m not so sure that was, uh, much of a thing in the more recent past. [1:10:15] It was in the far past, by the way, we all know that from history, and we all know from history that if you keep peddling lies, you can have very dangerous consequences. So—

JB: All right.

PM: Here we are (laughter). I think that science plays a really important role in society today, and we’ve got to keep fighting back against the non-facts and the alternative facts. You know, we’ve got to keep saying what we know to be true, and I think it’s really important that scientists not become advocates because once you do that, you lose your credibility. Does anyone believe a scientist that says, “Smoking doesn’t cause cancer,” and you find out all his research is funded by the, you know, the tobacco industry? No, I mean, we have got have, we have got to be viewed as an unbiased, reliable source. You know, we have got to be driven by just what we know and not by, we have got to, it is almost like a pyramid, we’ve got to build our credibility on our foundation of knowledge and be careful that as we get more and more out of our realm, we are not so glad that we want to say something about everything (laughs). Anyway.

JB: Anything else?

PM: Uh, no, that was my soapbox (laughter).

JB: Okay, I’ll turn the recorder off now.