Dr. Paul Montagna

Interviewed by Jen Brown
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Transcribed by Alyssa Lucas

[Jen Brown]: All right, we are recording, and it is April 15, 2022. This is Jen Brown. I'm here in Corpus Christi, Texas, with Dr. Paul Montagna. For the record do I have your permission to record?

[Paul Montagna]: Yes, of course.

[Brown]: Okay, so we are here, um, as a part three to an oral history, and this is my first part three (both laugh) ever, um, but to talk about your work with freshwater inflow science over the years. So, can you tell me how you got started working with freshwater inflow?

[Montagna]: Uh, that's a really good question. It's a good story too. I was hired to be an assistant professor at the University of Texas way back in 1986, and one month before I was supposed to start the lab director called me up and said, "Hey, could you come down for a little meeting before you start?" and I said, "Sure" so I came down to Port Aransas. I think it was probably July in 1986, and we're meeting with a guy named Gary Powell who is the director of the Surface Water Division of the Texas Water Development Board, and he asked us all a simple question. He said, "Well, I need to know how much water has to flow into San Antonio Bay to maintain bay health" and at the time being both young and even probably a little overconfident, I thought, "Oh, that's a simple question. We could answer that in a year or two." Well, it took me twenty years to figure out how to ask that question the correct way, so it was answerable (laughs). As he put it to us, the question was a little bit like how many fairies dance on the head of a pin and so that simple question started a whole career for me. It started my research and a new career trajectory, but, you know, it did something really, really, really important because, as you're well aware, when you become an assistant professor, your first concern is I got to get tenure someday (laughs) so I can keep my job and, of course, in science to do that you have to, you have to build a research question or an area of inquiry that is easy for you to work on and also at the time the director of the marine lab I was working at, he wanted all of us to make sure you're actually doing something in the backyard. I mean, here we are right on the bay. Um, do something here, do something local, do something to help the state of Texas, and it was literally the perfect question for me because it allowed me to start taking samples in the bay systems right away on a question that is still vitally important today so many years later and it was a question that was so rich that no matter how much I did I always uncovered more things I needed to learn. It was literally like unpeeling an onion. Every time I dug a little deep, I discovered something I had to dig deeper into. So, on one hand, it was an applied research project, but on the other hand, I discovered early on that, wow, the science was not at the state which you could actually answer the question at the time because, like I told you, it took me twenty years to figure out to ask the question the right way and so if you want I'll just keep talking (both talking at once)—

[Brown]: —Yeah, go ahead—

[Montagna]: about that. And, you know, so, that was to 1986, so it really wasn't till like 2004 or -5. I can't remember the exact date now. Um, a whole bunch of us, actually, it was Andy Sansom, convened a whole bunch of us. So, by a bunch of us, I mean a bunch of scientists who had been working on inflow and environmental flow in general throughout the state. A diverse group of scientists and engineers, by the way, and geology, hydrology types because we were really stuck. We hadn't made much progress since the mid-eighties in terms of the science, and it was still unclear exactly how to move forward, and one of my good personal friends was actually an engineer at UT also at the time, a guy named David Maidment. All of a sudden he said, "Well, why don't we just use EPA's [Environmental Protection Agency] water quality paradigm, but apply it to water quantity?" and it was like this lightbulb went on in everybody's head collectively at that moment (laughs) because at the time we had been focused on trying to relate the physical movement of water to a biological process, and it wasn't relating well, the statistics weren't relating well, the models weren't relating, but by taking this other approach we realized, wow, all we need to do is figure out one, what is the end point we desire, and two, what kind of standard or flow values would you need to maintain those desired endpoints. And then, you know, I just skipped a step. So, one, what is the endpoint we desire? What kind of environmental water quality conditions do we need to meet that endpoint? And the last step is what kind of flow do you need to keep those environmental conditions the way you want them? And what we realized, it wasn't a direct relationship, between inflow and biology, it was an indirect relationship. So, we could understand how flow was affecting habitat, estuary conditions, water quality conditions, sediment quality conditions, those are the things that the animals and the plants are responding to, and we can come up with our standards and flow requirements that way. That was a huge breakthrough and that completely changed the way that we started doing business and so then we started focusing a lot more on making specific measurements between the organisms and how salinity changed, in particular affecting habitat quality and how the habitat quality was being affected by the physical environmental flow. So, if you think about it, it was like geology to physical environment to the chemical environment to the physical environment to finally the balance correspondence, and that's what I mean by we realized it was this, like series of dominos that had to fall, and then we were finally able to constrain the answers we were getting to a more narrow box whereas in the past, it just seemed like any flow could do something useful for any organism, which wasn't really true. Anyway, that really, really changed the way we looked at things and we really started making a lot of progress at that point on because then we started seeing different kinds of things that need to be measured, we started developing new models and analytical approaches to dealing with data, and we started thinking about new ways in which to put the diverse data sets together, and that's basically what I've been doing for the last thirty-four years, thirty-five years (laughs).

[Brown]: And so, what sort of new models and new connections were you making after that?

[Montagna]: Well, the first and simplest and most important thing was when we realized we weren't dealing with one variable. We weren't dealing with just flow or just something like redfish abundance in the bay. We realized it was a multivariate situation because when water flows into the bay it brings nutrients, and it brings sediments, and it dilutes salinity. So, if you think about it, if you measure ten or twelve water quality properties, they're all changing as a result of that flow coming in, and they're all kind of going up and down together or maybe they're going in opposite directions to, you know, indirect in a strong correlative way. For example, when river flow comes in, nutrients go up, but salinity goes down. So, that's what I mean by something's going up, something's going down, but they are all going up and down in a coordinated way, and so we use very simple multivariate statistical techniques to basically reduce all those things into one simple freshwater inflow index for example. That was our first, to me, that was out first real big breakthrough because that allowed us to take flow and relate it directly to habitat quality, both water quality and sediment quality, and then we started looking at what, what was the optimal range of those conditions for individual organisms and that allowed us to take the next key step. We were able to identify the bioindicators. Who was the canary in the coal mine, and again it took us twenty years, twenty-three, four, five years to figure that out, and, you know, in hindsight, I look back and go, "Jeez, I mean none of this stuff is really earth shattering or all these sorts of things were very well known in the 1980s, why did it take so long to just put it all together?" And, you know, the answer is, um, collaboration. You have one person sitting alone working in a room just putting so much brainpower towards something, but if you get ten, twelve people in a room, all of a sudden you've got ten, twelve times as much brain power going on, and it really was that getting people together, talking about where we've been, where we're going, what do we really want, and all different ways to get to what we want because the ways we're doing it now aren't working so well. It just, you know, pulling all those—I think it was a day and a half or two-day conference, like really more of a workshop where this came out. The other things we started doing is working on mechanistic modeling where we try and think about what does biology need to grow, reproduce, you know, what are the things it needs to sustain life, and can we measure those things and put those things into models with things like salinity and temperature and show how flows having a direct impact on growth, reproduction, diversity. Diversity is also a really, really important indicator in general because when there's a disturbance in the environment, and you can think of both floods and droughts as disturbances meaning a large departure from the normal condition, okay? When there is a disturbance, the tolerant species will either decline or even grow. When you think about how all the grass springs up after a farmer plows a field (laughs). So, you kind of get a monoculture of small, rapidly growing things. In contrast, the sense of a species will either disappear or decline and so that means the relative contribution of the different species of a community was a very sensitive indicator of environmental change and so all we had to do was identify those things that were either very sensitive to salinity change or very tolerant and then we could build these groups of bioindicators and we can just measure a few things real simply and now we have like a sensitive, like almost a thermometer to know exactly what state of disturbance the environment is under, whether it is severely disturbed or not so severely disturbed. We can look over space, what parts are still intact, what parts are hurting, and then we could look at the recovery easily as well. And so, another key component of the research over the decades has been long-term monitoring at very, at sentinel sites, at sites that we knew were placed in key locations in order to pick up the changes that were related specifically to inflow. That was really critical, and then something else we discovered, um, along the way was that the Texas Coast is very unique. There's this climatic gradient where the Louisiana border, it averages about fifty-five inches of rain a year. That drops down to about twenty-five inches of rain a year by the time you get to the border of Mexico at the Rio Grande, and so you have this gradient along the coastline of inflow, and we've used that gradient and analogous to how it will change in time. So, if you compare a bay with a lot of inflow with a bay with less inflow, it's like what would happen to that bay if it lost inflow (laughs), and so that's what I mean by we've used spatial differences as an analogy of what might happen with change with respect to time, and that's another really important step up because then we realized that the entire Texas Coast presented a unique estuary comparison experiment, a natural experiment presented to us by the climate gods and the geology gods, and it allowed us to look at these processes across space at one time and predict what would happen in the future with things like climate change or changes in precipitation patterns or temperature patterns and that was incredibly powerful. Um so, that was another really big change that occurred, but you know, it's really funny because when I started when I was young, not just when I was here in Texas, but also in jobs prior to coming to Texas, we were always taught never use the word monitoring. Monitoring is a bad word because no one wants to fund studies for the sake of studies. No one—no one values just doing something repeatedly over time with no real specific hypothesis being tested or specific research objective in mind. That's a terrible thing, but you want to know something? You can't answer the questions about something like inflow without understanding the long-term dynamics and that's because we go through this cycle of wet periods and dry periods and those changes from the wet to dry to dry to wet, and that's where we learn everything, and you want to know something? I don't have a crystal ball. I don't know when that's going to occur. So, you have to go out and sample at regular time intervals so that you can capture those events, and then of course you get fortuitous things happen like Hurricane Harvey. Hurricane Harvey went right over my study sites that I had been studying for thirty years (both laugh) and it was the first time we captured a really, really large flood in thirty years, you know, an event, Harvey was described as like a once in a five hundred year, a thousand-year event when it comes to rainfall. And so, we were able to capture an endmember, and that's the other thing that's really important. We learn the most when we compare the deepest droughts with the wettest flood periods. Uh, that's when we really learn a lot, and the interesting thing about Harvey is of course, um, not only did you get a flood which converted the bay from a salty bay to essentially a lake. It turned into, like, Lake San Antonio rather than San Antonio Bay (laughs) for a period of about three to four months, but all of the nutrients and organic matter that was flushed from the watershed into the bay caused an enormous metabolic spike and the dissolved oxygen concentrations went to zero. Well, organisms in the bay, the microbial organisms, the bacteria, fungi, they were growing—and the protists. They were growing so rapidly and metabolizing all that organic matter so rapidly that they literally sucked all the oxygen out of the bay, and because you had a lens of very, very fresh water on top, oxygen couldn't penetrate the bay waters from the atmosphere and so it stayed low at near zero, at zero for about a week. As you might imagine, the combination of zero salinities and zero oxygen basically killed everything in the bay so then we had an opportunity to study the resilience side, the recovery of the bay and it took about nine months which was pretty amazing. It just bounced right, in my view, that bounced right back. That's how I felt about it, but it was interesting because it didn't all bounce back. If you looked at just total numbers it looked like it had returned to normal in terms of the total number of animals in the bay and the total diversity, but when you looked at who was there you realized, wow, that's not what happened at all, because we went from a bay that it—the diversity actually didn't recover completely. We went from a bay that had a lot of different species, what we call evenness, to one that was dominated by just one species, a little small surf clam named Mulinia [lateralis]. Almost all the abundance was just little baby Mulinias. There was this huge recruitment event almost like a bloom (laughs). I use the example of a farmer plowing a field, and what grows back, only small grass blades. Well, that's what was happening in the bay, but in this case the small grass blades were this little, tiny clam, and there were just bazillions of them around, and I'll tell you the black drum, those are the favorite food of black drum by the way. Whenever we would go out and sample, the bay was just roiling with the tails of back drum feeding on all those Mulinia. So, as many as we were capturing, we were probably seeing the tip of the iceberg because they were being eaten very rapidly by all those black drum, and they were quite happy to see them. So, it wasn't a completely diverse community, and it took several years before the true diversity came back, and we didn't have dominance by a weed species, essentially. So, that actually took about two years, two to three years actually. So, on one hand, we had resilience in the fact that, well, total numbers, total biomass came back, but on the other hand, what we want to look at bay health is indicated by the integrity of the ecosystem meaning an evenly diverse community, but that actually took two or three years to come back so that was what I would call a fortuitous event, and again the reason why long-term quote-unquote monitoring was so important because there are processes that you just can't measure over the short term. Um, there are things that happen over many, many years that are part of the story and when we don't monitor, when we don't measure over several years, we are more likely to come up with the wrong answers and we think it's the right answer because we don't know what we don't know (laughs).

[Brown]: Um, a lot of your research, uh, seems like in the last ten years to be on those hydrological variabilities, droughts and floods, and that sort of things. Can you talk about what was driving that work?

[Montagna]: Well, you know, I already kind of answered that in the first question. I—the main, you know, it's funny. When you're saying this, it's hard to do a lot of different things. Now I'm a little unusual in that I actually have had like three major research thrusts over my entire career. I've always done a little bit of what I would call environmental informatics. I've always had a program where I was using computers a lot. I was creating programs, computer software. I was building computer models and I've always had that kind of interest. I've created very large databases. I've worked with them. I'm really into what you would call the big data thing right now for the environment, and in particular data complexity because whenever I do anything it's not one variable. No, it's thousands of variables that we're looking at the same time and we work over time series so you can't work with large complex data sets like that if you don't have a pretty strong interest and background in math and computer science. So, I've always had one research program focused on that. I've always had a second research program focused on offshore, deep sea, biology, ecology, you know, particularly the effects of oil and gas development and that I've been doing since, believe it or not, since 1975, (laughs) but then when I moved to Texas, it's funny. I did both my master's and PhD on estuary ecology, but I never really considered myself primarily an estuarine ecologist. I always thought of myself more as a deep-sea guy, an oil and gas guy, and a math and modeling person. And so, when I moved to Texas and got so deeply involved in the environmental flow work, it really solidified, it's funny, it brought together everything I had been doing in the coastal zone and it gave me a real reason for focusing on estuary processes for the first time, and, of course, an estuaries where freshwater mixes with saltwater and so then I just became a lot more interested in what were rivers doing to bays, and once you start thinking about rivers, you've got to think about hydrology and flow and all of a sudden you get interested in the physics of flow and then you realize wait, that mixing is causing the estuary to be this big soup, biogeochemical soup of all these different compounds that are being brought in from different sources and they're changing in the bay, and then it gets shoved out on the ocean and it does something different there and so then all of a sudden you start getting interested in chemistry (laughs). So, I spent a lot of time measuring various chemical parameters as well as the biological responses so, um, it really was moving the Texas and just getting so deeply enmeshed in studying these huge open bay systems that completely transformed my, my view of estuary ecology.

[Brown]: One thing you mentioned in your article that was the overview of your career was that those kinds of droughts and floods and looking at that was a good proxy for climate change. Can (both talking at once)—

[Montagna]: —right—

[Brown]: —you tell me more about that?

[Montagna]: Yeah, so this is the idea that by looking at big changes and looking at those end members. What does the bay look like under really dry conditions? What does the bay look like under really wet conditions? It allows you to predict what would happen if the bay changed so that it was always dry or always wet. I mean, let's face it, climate change could mean it gets rainier as well as it could get dryer. Now, in our part of the world, all of the predictions and all of the data we have to date shows that our part of the world is getting a little bit dryer which is interesting because at first, when I say at first, I would say twenty-five years ago, we thought the opposite would be true. We thought it would get wetter. We thought that warmer water would cause us to have El Niño conditions more often and that would make it wetter in Texas. It was turning out as having the opposite effect. We're getting more La Niña conditions (laughs) with the warming and so as we actually see much deeper droughts, you know, instead of a drought lasting one year they can last three, four years now. We also see the droughts being more intense, meaning that the temperatures are even higher than they have been in the past. Well, higher temperatures mean more evaporation, more evaporation means the salt and all of the things that are in the bay get more concentrated, and we're seeing how that is having a big effect on things like the pH meaning that we're seeing acidification effects in the bays now. So, looking at those extreme events is what allows us to predict what could happen with climate change.

[Brown]: Um-hm. Um, so can you tell me more about the "Bible" and why you wanted to rewrite it?

[Montagna]: (laughs) So, again when I first moved to Texas, I was asked to study San Antonio Bay and Nueces Bay and try and determine how much freshwater it needs, and that work we did at the University of Texas at the time eventually was used by the Texas Water Development Board and Parks and Wildlife Department to create this book called *Freshwater Inflows to Texas Bays and Estuaries* and, of course, I have a copy of it right here at my desktop, at my left hand, and that work we had done, we completed all the work in 1989, and it took Parks and Wildlife and the Water Board five years to get that volume out. So, when the book came out it was already five years out of date (laughs) and then of course it was the result of the laws that were passed in 1985. And in 2007, the state of Texas completely changed the way we do environmental flow regulations in the state and so now by time 2020 or so rolls around, these books are twenty, twenty-five years old, the data is thirty years old, the laws are completely different, meaning the objectives and the goals of the environmental flow programs are completely different. We went from a species management approach to an ecosystem-based management approach. From a scientific viewpoint, that was the most important change in the law. From a regulatory viewpoint, for the first time, we had environmental flow standards for every bay and river in the state. Um, the science when the first volume came out was as I pointed out earlier somewhere between negligible and nonexistent (both laugh) and a lot of our fundamental thinking was wrong, thinking that flow directly affected biology, and that's true in rivers, but that's not true in the bays. In the bays, it's these indirect effects. The flow creates the estuarine conditions, and the organisms respond to the estuary conditions so it's more of an indirect effect. We also realized today that, wait a minute, climate is driving flow so it's actually four dominos in a row that have to fall to build a redfish (laughs). That's what I'm saying. And so, one of the days one of my students, um, looked up to me and he said, "You know," He was holding a copy of the book in his hands. He says, "You know, this is every one of your students' 'Bible,' but it's so horribly out of date and everything's wrong. You need to redo this," and, again, it's one of those lightbulb moments I thought to myself, "Yeah, we need to do a new volume of that because everything is so different today." So, that's what we're working on. Um, a year or so ago I got a grant from the Texas General Land Office to help me put together a team to create a new volume. We're going to use the same title, but with a different subtitle, and the publishers tell me that's perfectly legal. They're not going to call it a second edition. We're just going to use the same title and a different subtitle because we are not going to just simply take the old text and edit or add. We're basically going to rewrite it from the ground up. It'll have a completely different organization. Uh, in the past, and rather than have case studies in the old, the first version, there are only two case studies, one from Nueces Bay and one from San Antonio Bay. This time we'll again do this estuary comparison across the entire state so rather than have a chapter on each bay we are going to have a chapter on each process, and then how does this thing vary across the entire state. And the importance of that comparison relates directly to the unique climatic gradient along the coastline because we learn more by comparing how bays with vastly different inflow regimes respond. We learn more from that than by looking at how each bay responds to, like, various flood and drought cycles. That's the other thing we discovered over the years.

[Brown]: Um-hm. Who's publishing it?

[Montagna]: It will be published by Springer Nature which is a major scientific publisher.

[Brown]: Yeah. Um, so, you had mentioned that part of the science was changing water policy to look at sound ecological systems. Were there any other ways in which science shaped water policy and management practices?

[Montagna]: Oh, yeah. I think the biggest, and this transformation occurred right around the year 2000. Um, environmental policy in the United States and all the individual states was always pretty much a species-based management approach. In other words, legislators thought, "I really like redfish, let's make a rule to make sure there's a lot of redfish in the bay," or, "I really like flounder. Let's make a rule to protect flounder." In fact, in the 1985 version of the environmental flow law, it specifically listed just seven species that the object was to maintain black drum, red drum, spotted sea trout, flounder, uh, shrimp, blue crab, and oysters. That's the seven species and that was it. That was our goal. Well, problem is when you're managing an environment for one species, you actually may be hurting another, and in fact, it's kind of like if you're growing tomatoes in your backyard. You don't ensure a healthy crop by measuring each tomato every day (laughs). What you do is you nurture it, you add fertilizer, you add water, you clear out the weeds. In other words, what you do is you build an environment that is conditioned for the growth of the things you care about and then you don't worry about the specific crop you may be growing, but that's the way the bay works too. And so, right around the year 2000, there's a real transformation in the US, and that's probably the whole world, where environmental regulations and rules started focusing more on, well, let's protect the habitats, kind of like if you build it they will come, and we started realizing that rather than trying to protect an individual species, we'd be better off protecting the integrity of the environment and the habitat and then all the compliment of native species would do well and if you think about it this also gives you a reason to start worrying about invasive species, things that can alter the environment or compete or harm the native species. So, the goals, and I would call this an ecosystem-based management approach, so we really moved towards this idea that if we protect the environments, protect the ecosystems, try to maintain healthy ecosystems in general, then all the things we care about will be there for the next generations. We don't have to worry about targeting specific species, per se. Now, don't misunderstand me. I'm not saying that targeted species are not necessary. For example, redfish, black drum, flounder, spotted sea trout, you know, those are targeted by fishermen so you have to have specific, what do you call them, slot and size and bag limits on those kinds of organisms, and of course that's where our fisheries management regulations come in, so they're important, but if the bay is no longer conducive for a black drum or redfish to grow in, they aren't going to grow there no matter what you do with your regulation side of it. So, we kind of realized that the fishing regulations must be, um, enhanced by also having in general environmental and habitat protection programs.

[Brown]: How would you evaluate how that's worked out after 2007?

[Montagna]: The environmental flow process in general, I think it's had a mixed history I would say at best. The problem, so here's the good thing. The good thing is for the first time we built environmental flow standards for every bay, every basin, every river in the state. That was a really good and important thing and the, again, the object and the goals of those programs was to maintain a sound environment, or in more general terms, maintain the ecological health of the environments. Those are all good things. So, we've got a nice environmental management approach, ecosystem-based management approach, and we're looking at the most important thing that makes the bay and coastal zone and estuaries what they are, that's freshwater mixing with seawater. So, that part we got right. When you look at the specific regulations that came out of it, they're just complicated. So, if we're worrying about is a fish safe for a mother to eat, we've got a number. If it's got over either half a part per million of mercury or one part per million of mercury a woman of childbearing years shouldn't eat that fish, okay? We've got one simple number. That's not the way environmental flow standards work. The environmental flow standards are this complex three-dimensional table where on one side you have periods like wet periods, dry periods, average periods. On the other side you have seasons, is it winter, is it spring, is it summer, and on the third side, you have space. What part of a system are you in? And the bottom line is if you've got this three-dimensional cube, and each cell in those cubes has got a different number. So, the bottom line is at any given place you can have two numbers. One related to well, is this a wet year, an average year, a dry year, or is it what season are we in? That's at any given location and the problem is how do you know whether the flow rate today at any given space is the right number because any number could've been true at any point in the past or any point in the future (laughs) so any number will eventually occur at that particular point through time and so it's like, I guess that means it doesn't matter what the flow is today, it's going to be within my cube. That number will occur somewhere in my cube, and it makes me wonder, "Well, how do I know at any given point in time, at any given location whether I'm meeting the standard or not," and I'll be honest with you, I can't figure that out (laughs). So, we can go back and look at some distant point in the past and say, "Oh, what was its probability of occurrence, and was it within the standard at that time," but I don't know how you figure out whether we're within the standard today (laughs), and, like I said, the standards are so broad, the range of numbers acceptable are so large. Again, it's not one number like one part per million of mercury in fish flesh. It's not a number like that. It's not a standard like that. I don't know how you come to the conclusion that you're either within the standard or not within the standard, so I think the standards are just too darn complicated. I just don't quite understand them, and I don't understand how to apply them, and I especially don't understand how to link them to any biological responses (laughs). So, I think we have some work to do on this and there's a whole other problem, so, that's one problem. The other problem is the people who are applying the standards, who are creating the standards, adapting the standards, we have an adaptive management program as well which is a wonderful idea, but adaptive management means if it doesn't work, you can change it, but that's a wonderful idea.

The problem is we have this volunteer stakeholder process running all of that. So, what happens if you throw a party, and nobody comes (laughs)? This was my biggest fear when I was sixteen years old and my parents threw a birthday party, "What if nobody comes?" Well, that's what's going on. We have some—so, there's seven of these stakeholder committees across the state for each main basin system and many of them haven't met since, you know, in ten years. They just don't show up, uh, and so many of these systems, there have been retirements, people move, and there have been deaths. Half of the committees aren't even populated anymore and in particular some of the committees, the chairman is either retired or moved away, and so now these things are totally leaderless and we don't know how to reconstitute them. We don't know how to come up with a new leader. And we've also gotten to the point, ten years after this process began where there's been so much turnover in all the different resource agencies and communities that I discovered that most people don't know what this issues about and don't even care about it anymore and that's something I'm real concerned about because we're supposed to be entering, we did enter the adaptive management phase in 2021, and it's supposed to go between 2021 and 2024, and I don't see any activity happening anywhere and here we are in 2022, throughout the state. So, that part is broke (laughs) and the other thing that's broke in the system, I think, is the idea that we can come up with a number to fix a bay. I'm starting to have serious doubts that that's true anymore. If you think about it, our bays are huge. The Texas bays are enormous. They are very, very large volumes of water. Well, that means you need enormously large volumes to dilute them and that's not really what happens in droughts and in fact during dry periods, if you think about it, the only time the bays are getting diluted is in either an average or a wet period. Well, what about the other fifty percent of the time? Something still has to happen to protect bay health and that's made me start thinking that maybe the focus should not be about average or wet periods, which is where we're focused today. Maybe we need to focus on the dry periods and the below-average rainfall periods and making sure that enough water is reaching the head of the bay systems so that we protect the critical nursery habitats because if we protect the nursery habitats in the upper reaches of the bay then when average does come back or wet does come back the bay will recover more quickly and this was a lesson I learned from Harvey (laughs). Okay? It's all about recovery when it does rain again and that means we should be thinking about the opposite of what we do today. So, today we basically have something called pass-through regimes meaning that if it doesn't rain the bay gets no water. Well, maybe that's exactly the wrong thing to do. Maybe we've got to make sure during those droughts the bay gets just enough water, so it doesn't die like I described happened after Harvey. Well, after Harvey it happened because of a huge flood and oxygen went to zero, but the bottom line is, if you kill the bay, it's not going to come back (laughs). We don't want to kill bays anymore and so we really need to be thinking about protecting those upper reaches of the bay where the critical nursery habitats are during a dry period so that they don't get completely destroyed. I call this concept focused flows. It's my newest idea I'm working on very hard, trying to build a scientific justification for this approach, and then hopefully once we prove that, yeah, this is the right way to go, you know, legislation will change, and we'll be doing an even better job than we're doing today (laughs).

[Brown]: Okay. Um, one of the, a couple other things I wanted to ask you about is one, can you talk about or walk me through the relationship between freshwater inflow and benthic habitats?

[Montagna]: Right. So, it's interesting. On one hand, obviously inflow is freshwater mixing with saltwater, which means the big changes are occurring in the water column. The salinities are changing. The nutrients are changing. Uh, when the nutrients are there, the phytoplankton can bloom, the phytoplankton of course feed the entire food web, but all of that is incredibly ephemeral. It's changing that and it's not only changing all the time, but it's changing all the space because when the flow is strong, it's moving downstream and when the tides come in it moves back upstream and when the flow is weak it maybe moves a little further upstream and when the tide goes out, it moves downstream and if there's a strong flow when the tide is ebbing than it also moves further downstream. So, the real thing that's going on is the water mass in the bay are constantly sloshing to and fro, back and forth, and so if we try and just measure all those changes in the water alone all the time, it just gets incredibly complex and we need an enormous amount of data on an incredibly small, spatial and time scale. It's going to be way too complicated to measure all the time, so the question is, well, how do we just take the pulse of the ecosystem? How do we know whether—how can I go back once a month, once a quarter, and find out how have you've been doing (laughs)? Kind of like when you walk into the doctor's office and he takes your temperature or measures your pulse, right? How have you been doing? Well, the answer, I think, is to look at the things that live in the mud. Why? Because they're fixed in place yet they're sampling and integrating what's going on over their head 24/7/365. They're always affected by the conditions above them and they literally integrate everything that's happened since the last time that you visited them and so by looking at the critters that live in the mud we can literally take the pulse of the ecosystem, you know, once a month, once a quarter, at larger intervals in time and they're literally telling us, "Oh, here's what's been going on since the last time I've seen you," just by looking at the things that live in the mud and so even though they're not something that's charismatic or very large or in the public eye, it turns out they're the most sensitive indicator of change in the environment over time and so that's why I've always focused my research on the bioindicators for inflow on the kind of things that live in the mud.

[Brown]: Can you describe what kind of things do live in the mud?

[Montagna]: Oh, there are three major groups. There's shrimpy things called crustacea, uh, a variety of arthropods, tanaids, and small shrimps and then of course there are the worms. They're the dominant group. These are the annelids, so they're related to, like, the earthworms you see in your lawn, but they're all polychaete worms so the marine worms are all the polychaete worms, and they're different from the things in your lawn in that they have little, uh, they're called parapodia, they're like little swimming legs. So each segment will have a little leg, and there are a variety of them because they exploit every kind of food web that's possible. So, some are just ingesting mud and literally stripping organic matter out of the mud. Some are eating other organisms. Some act like shrimp. They have tentacles they put up in the water column and they take particles out of the water column. So, the worms are incredibly diverse so they're the largest group, most dominant group, most diverse group, and finally, you've got the mollusks, and we've got lots of different kinds. We have snails. We have clams. Those are the two dominant ones, the snails and the clams, but there are some other ones like the tusk shells. So, imagine a snail with a straight shell (laughs) and, of course, the mollusks have very diverse feeding groups as well. Some are just browsing the surface looking for materials that have fallen on the bottom of the ocean and some are filter feeding again, or suspensive feeding, eating particles that are in the water column. And of course, the most famous mollusk is an oyster. The most famous crustacean is the shrimp. So, two of these things grow to size that have become commercially exploitable, and as you might imagine, those two species are some of the most important bioindicators we look at all the time. Luckily, the Texas Parks and Wildlife program has extensive monitoring programs looking at those sorts of things, so I don't have to measure them, so I just focus on the things that live in the mud, and we use data from Parks and Wildlife all the time in conjunction with our own data to try and build a complete view of all the benthic critters and habitats.

[Brown]: What happens when the benthos declines?

[Montagna]: Well, all the fish that people care about, the red drum, the black drum, sea trout, flounder, they all feed on the things on the bottom, the critters, on the things that live in the mud. So, if the bottom critters start to disappear, they can literally starve, and we've seen this happen in Baffin Bay a few years ago. The fishermen on the black drum started reporting that all the black drum, their fish had basically turned to jelly. They called it the jelly conditions and that was happening because the black drum were starving and the reason, they were starving was because all the benthos was disappearing and we're becoming really concerned about this. We've noticed that in several bays in the state, particularly Lavaca Bay and Matagorda Bay. Nueces Bay is another one. We're seeing a long-term decline in the benthic critters over the last thirty years and at first, I thought it was just climate effects. It's also—but it's not just climate effects, it's pretty clear that we're seeing a general habitat degradation coast wide. We're seeing diversions to the point where average salinities are going up coast wide. The problem, and the average seawater temperatures are going up coast wide. Well, the problem is the solubility of oxygen in the water is the function of salinity and temperature. So, in the summer there's always less oxygen in the water because it's hotter and it's saltier and in winter there is more and we're seeing that, I've predicted that by 2035 it's possible that none of the bay waters in South Texas will be meeting water quality standards because it'll just be to hot and salty and the water won't be able to, the oxygen won't be able to dissolve into the water (laughs) because it's so hot and salty. Obviously, the fish need oxygen to breathe, you know, whereas the atmosphere is twenty percent oxygen even under the best of circumstances the ocean is only six or seven percent oxygen and we're often finding it a lot lower. We find it can go, like I said, near zero or below a measure called two milligrams per liter, which we consider hypoxic. So Texas Commission of Environmental Quality has a standard and the dissolved oxygen in the bays has to be at five milligrams per liter or above or it's considered impaired and what I'm telling you is, is that we may get to the point soon where the bay will be so hot and salty, it won't be able to hold that much oxygen and that's one of my biggest concerns and so that's a global climate change problem, you know, the global warming issue, and we've got the monitoring data now. This is not in the future. This is not theoretical. This is not a model. This is the instrumental record. We have seen since 1970 where we've been measuring bay temperatures all over the state very intensively for long periods of time, there's been this gradual increase in the temperature in the bays and a correlative gradual decrease in dissolved oxygen just about everywhere we measure so that's one of my biggest concerns. So, you know, it's funny we worry a lot about industrial discharges. We worry a lot about pollution in general, but the thing that may really be driving bay dynamics in the future is going to be climate change. It's my biggest concern. Of course, one of the other issues related to climate change is going to be sea level rise, and you just look out my window, it's as flat as a pancake as far as you can see and that means there's no place on earth that's probably more vulnerable to climate change than the Texas coast simply because it's so flat and we've already seen changes in the coastline because of that and the potential changes in the future are even greater.

[Brown]: Um-hm. Do you need a break? We've been going for about an hour.

[Montagna]: Sure.

[Brown]: Okay, I'm going to turn this off.

(pause in recording)

[Brown]: Okay, we are back, part three of the oral history with Dr. Paul Montagna. Um, so one of the things I wanted to ask about is your involvement in the whooping crane case, and can you tell me how you got involved in that court case?

[Montagna]: Oh, well, you know I was studying San Antonio Bay since 1987 and we're sampling there regularly and in twenty, is it 2011 or 2009? About 2009 or so. It's hard to remember now. Maybe it was 2008. Anyway, all of a sudden something like twenty-eight whooping cranes died, and of course, it was during the middle of a drought. And a lot of people were suspecting that the problem was the way we managed water during droughts. Remember what I said, in Texas, if there's a drought, the bay doesn't get any water because we have a pass-through philosophy, not a release philosophy, and so a group called The Aransas Project, t-a-p, TAP decided to sue the state and the Guadalupe-Blanco River Authority because they mismanaged the system under the endangered species act and the lead attorney was a guy named Jim Blackburn. He and I had known each other because we'd worked on inflow issues in the past and this seemed to be an inflow issue and I was asked if I could testify on what effect inflow has on bay health and bay ecology, and I was glad to do it. Uh, we also looked at how the crab population might be doing during droughts, and we were able to demonstrate that, yeah, there's definitely a big reduction in potential prey. So, for the whooping crane, a lack of water created two problems. One was a lack of literally drinking water. They rely on the little ponds to drink, and so their habitat quality was degrading, but the second thing was their food sources were scarcer as well, so it was those two things that we primarily were able to demonstrate. To this day I still believe that it probably was the drought that killed those birds. The bird population had been increasing steadily from, oh, I guess as early as the 1940s and fifties, and there hadn't been a large drop off like that previously, so I think the data indicating it was due to the drought is pretty strong. The courts eventually disagreed that the state nor GBRA had any role in that and so the case was dismissed I guess or overruled. Um, TAP won the case at trial, but it was overruled on appeal, and of course, all the legal details you probably want to get from somebody else, but (Brown laughs)—

[Brown]: —Right. Well, do you remember what was like the mood or the atmosphere in the courtroom when you testified?

[Montagna]: Hm. Well, you know, courtrooms, they're contests so it's never completely friendly, but I have to admit that I really feel like it was just a bunch of people trying to figure it out. I never felt intimidated or anything like that. Um, clearly when the other side is asking you questions, they're adversaries, it's an adversarial situation, which is not what my life is like every day. You know, science—my view is that the role of science is to provide the best technical information in an unbiased way, and it doesn't matter whether it was whooping crane people who wanted to use my data or if it was the defendant, the state, who wanted to use my data. I, you know, I feel like my job is to provide the best information in an unbiased way. So, they provided their own experts who had different views than I had, but all the experts they provided didn't study in this region, and they didn't know this region very well, and some of them were clearly, didn't know as much about the system as they probably should of before they were testifying in my view (both laugh), but anyway, the judge wrote, you know, I remember reading the opinion and I was stunned. I mean it was a great dissertation. That judge was able to take all the complex scientific information and synthesize it in a very clear way and in a way that supported the claim that it was the drought and the mismanagement of the water system that caused the death of the cranes, that's considered a taking on the Endangered Species Act, but it was fun (both laugh).

[Brown]: What happened, um, you had mentioned you had some consequences for testifying before?

[Montagna]: Well, you know, it (sighs), it was interesting because it definitely became nearly impossible for me to find research funding for the next four or five years (laughs). It took quite a while, had to pass before people, you know, at the state agencies, and the different water authorities were willing to talk to me again, which I thought was silly. I remember speaking to—see the funny thing is, all the people on the other side, I knew them very well. They're people I had worked with, people I had collaborative relationships with, and all of them agreed I didn't go in there and say, I didn't exaggerate or say a single thing that wasn't true so, but you know when you're in an adversarial situation, you kind of start dividing up into tribes and those silly things happen. It's just part of the business at hand, but yeah. It didn't really bother me that much.

[Brown]: Hm. Okay, the other thing I wanted to ask about is this idea that you coined, the hydrological switch?

[Montagna]: Oh, yeah.

[Brown]: (laughs) Can you define that?

[Montagna]: So, you know, um, Mike Wetz and Xinping Hu and I were working on a new research question. We were trying to understand both if acidification was occurring in the bays and if inflow might play a role in that. Let me start all over. Okay?

[Brown]: Okay.

[Montagna]: Let me start all over. I don't remember when we started. So, when Xinping Hu first started here at Corpus Christi, I usually meet assistant professors and talk about my research and the research opportunities I see in the environment and Xinping studies carbon dynamics and, in particular, is very interested in acidification and the carbonate cycle, and I remember him asking me, "Well, have you been measuring pH?" And I said, "Oh, yeah, of course," and then he said, "Well, is anything going on over the years?" I said, "Oh, no. There's nothing going on with pH, nothing going on with acidification issues in the bay," and a couple of years later he came back to me, and he said, "By the way you're wrong. I looked at your data and I've looked at the TCEQ data, [Texas Commission on Environmental Quality] and I have discovered that during droughts we have very severe acidification and acidification can also be caused during a deep flood events as well," and I was shocked and sure enough by that point, we had also been doing some work with Jenni Pollack, and we realized that during droughts we got virtually no new oysters being born and settling, and we started discovering that the reason was, during a drought, no nutrients come in the bay. That means the phytoplankton don't grow. That means there's no food for the baby oysters and the bays start to become very acidic and of course oysters, we call them spat when they latch to the bottom, the first thing they have to start doing is building the calcium carbonate shell so if the pH is very low that inhibits them, and so we started being able to correlate droughts with very poor oyster sets because it was too acidic and there was no food in the water. So, we got together with Mike Wetz and Xinping Hu and we wanted to create a project where we coined the term the "hydrological switch," and this idea that when the rivers are flowing, you have one environment that's very conducive to marine life that's got very high pH, a lot of nutrients, you're growing a lot of phytoplankton, you're fueling a big food web, and everybody's happy, and during droughts, all that gets turned off and all of a sudden the pH goes lower and organisms start to starve because no phytoplankton are being produced because there are no nutrients around and the bays are unhappy, and sure enough when we completed that research we were able to prove that that was true. And the funny thing is just that research was supposed to end in August 2017 (Brown laughs), August 31, 2017. Well, guess what happened on August 25, 2017? Hurricane Harvey. So, we had spent three or four years studying the water chemistry in the Coastal Bend bays in very fine details to test this hydrological switch hypothesis, and then all of a sudden, we get one of the largest floods on record. So, we went immediately to the National Science Foundation and we said, "We need what's called a Rapid Grant to get out there next month and start sampling again (laughs) because we just finished this big project, we've proved our new hypothesis correct, and now we need to see exactly what's going on with a big flood," and of course, that got funded as well and that allowed us to sample for the next two years and discover something new which is the interaction with the low oxygen that I described earlier as well. So, the other thing that happened after a flood was not only did you bring—when you get a small flood, they're good, but when you get really, really big floods, they can act as a disturbance as well. Because what happened during a huge flood was that not only are you bringing just nutrients, but all of a sudden you start flooding the bay with a ton of organic matter. Now, that fuels the bacteria and the other microorganisms to metabolize that organic matter very rapidly and that all of a sudden sucks all the oxygen out of the water (laughs), and of course, that causes hypoxia and anoxia and now you've got this horrible mix of very low salinity, very low dissolved oxygen left and that pretty much kills everything. And that's our hydrological switch, and one of the nicest things was that a month ago I saw our new paper where they use that word, the hydrological switch, in the title so we know we've coined a term that is catching on and is helping us understand the dynamics of inflow and biogeochemical processes even more so.

[Brown]: That's cool.

[Montagna]: Yeah.

[Brown]: Okay, what else did I miss in terms of things we haven't talked about with freshwater inflow and—

[Montagna]: Well, you're so complete. Well, I don't know if we've talked about the other really important big change that's occurring right now (coughs) is this concept of hydrological restoration and a few years ago a group was put together—oh gosh, I'm going to have a hard time remembering all the partners. It was Ducks Unlimited, the Nature Conservancy, the Sierra Club, the National Fish and Wildlife Foundation, and The Nature Conservancy, and of course, the academic partners HRI [Harte Research Institute] being primarily me. We all got—and the Meadows Center, and the Mitchell Foundation. So, there were like all these partners and we got together to create something called the Texas Environmental Flow Initiative and our idea was: can we put together a program that takes advantage of the new water trust and water markets that are all created by the 2007 Senate Bill 3 because if we can, then we can start to buy or lease water or water rights and dedicate them to an environmental flow purpose and the question was how much water would you need and how much would that water cost and where could we get that water from and what kind of opportunities exist to convert a water right to an environmental flow and it was a pretty long complicated process and we worked together for three years and came up with several with the research that eventually changed my view of the world and that's when I came up with this focus flow concept because I realized that, wait a minute, water is incredibly expensive and if we can find some that we can purchase or lease, it's going to be a pretty small amount and it's going to be really expensive and we're going to have to put it where it really matters and it's what made me realize that, wait a minute, a small volume of water can only dilute another small volume of water and the only place where it really matters is in those upper reaches of the estuary and the critical nursery habitats and that's how I came up with the focus flow hypothesis and so since then a subset of us, a subset of the group has morphed into something called Texas Water Trade and they have successfully founded, gotten a few purchases or leases or hydrological restoration programs going. I had also been involved with a hydrological restoration project here in up the Nueces River into an area called Rincon Bayou in Nueces marsh and that had been successful with, again, with small volumes of water and so, you know, in general, this whole concept of can we build a water market in Texas, can we take advantage of all the restoration funds that were generated because of Deepwater Horizon to start putting that money not only into building oyster reefs and planting marsh grass or seagrass beds, but also purchasing water rights and converting them to the environmental flow needs and I think that's a really important program. It's still in its infancy even though it's four, five years old. I still consider that infancy. Um, but there have been several successes and I think it's an important program for the future, something that really excites me a lot. I don't think we talked about that before.

[Brown]: No, I don't think we have.

[Montagna]: Yeah. Yet, another one of the things I'm involved in (laughs).

[Brown]: Busy. Um, anything else?

[Montagna]: Well, I think another important development over the years is something that I've had absolutely nothing to do with, but I think it's important is a big change in Texas law that allowed oyster agriculture. Of course, oysters are near and dear to my heart because they're probably one of the best environmental flow indicator species and now that we're allowed to have oyster agriculture in Texas, I kind of look forward to a whole new industry blooming that will depend on freshwater diluting seawater, and I think that's kind of exciting and I know that Ed Rachal foundation has hired away two people from HRI, both Joe Fox and Gail Sutton, and they helped them build oyster farms and oyster farming capabilities throughout the state and I think that's a real exciting development for the state of Texas and I had nothing to do with it (both laugh).

[Brown]: Something to look into for me for the podcast. Okay, well, if that's it, I'll turn off the recorder.

[Montagna]: Sure, let's.

[end of recording]