06-24-2016

McBride, Richard ~ Oral History Interview

Joshua Wrigley

Recommended Citation

McBride, Richard. Interview by Joshua Wrigley. *Voices from the Science Centers*. Voices from the Fisheries, NMFS, NOAA. 24 June 2016.

This oral history was produced in 2016 as part of the *Voices from the Science Centers Oral History Initiative* conducted by *Voices from the Fisheries* with funding by the NMFS Office of Science and Technology.

Voices from the Fisheries
166 Water Street
Woods Hole, MA 02543

Interview with Richard McBride by Joshua Wrigley
Summary Sheet and Transcript

Interviewee
McBride, Richard

Interviewer
Wrigley, Joshua

Date
June 24, 2016

Place
Northeast Fisheries Science Center
Social Sciences Branch
Falmouth, MA

ID Number
VFF_WH_RM_001

Use Restrictions

Biographical Note
Dr. Richard McBride earned his bachelor's degree in biology from Eckerd College, his Master's in Oceanography from Stonybrook University, and his Ph.D. in Ecology and Evolution from Rutgers University. He worked at the Florida Marine Research Institute beginning in 1994. In 2006, he joined the Northeast Fisheries Science Center at Woods Hole where, as of this interview in 2016, he currently works as the Chief of the Population Biology Branch.

Scope and Content Note
Interview contains discussion of: Sea robins, Florida's sport fishing industry, ballyhoo spawning, researching spawning fish, winter flounder maturity, capital breeding fish, income breeding fish, fish spawning and climate change, shad research, fish response to climate change, structure of the Wood Hole branch.

In this interview, Richard McBride gives a detailed description of his work studying the reproductive cycles of fish, particularly with sea robins and baitfish. He discusses his experiences working at the Florida Marine Research Institute and at the Northeast Fisheries Science Center.

Indexed Names

Able, Kenneth
Bossoloni, Walter [sp?]
Brugger, Jerry
Burnett, Jay
Cowen, Robert
Conover, David
Depres Linda
Ferrere, Rosella [sp?]
Gabriel, Wendy
Hare, Jon
Hood, Edward
Jeck, Michael
Johnston, Robert
Mahmoudi, Behzad
Munroe, Thomas
Musick, Jack
Nieland, Julie
Roundtree, Rodney
Somarakis, Stylianos
Sheehan, Tim
Shepherd, Gary
Sissenwine, Michael
Williams, Roy

Transcript –RM_001

Joshua Wrigley (JW): Okay, now we're, now we're recording and, this is, this is an interview as part of the Voices from the Science Centers Project being funded by the Northeast Fisheries Science Center. It's also part of Voices From the Fisheries that's part of the National Marine Fisheries Service Office of Science and Technology. And I'm speaking with Richard McBride who is the Chief of the Population Biology Branch here at the Northeast Fisheries Science Center and it is the 24th of June, and we're speaking at 15 Carlson Lane, which is where the Social Sciences Branch is located. And unfortunately I have, I didn't hit the right button on the recorder, so we've actually been talking for about twenty minutes going back a long way. And Rich has been recounting his, his inspiration to go into biology, early experiences and work with bluefish population studies during his undergraduate work at SUNY Stony Brook.

Richard McBride(RM): That was my master's work.

JW: I'm sorry. Your master's work at Stony Brook. So there's been quite a lot of material already covered that unfortunately is not on record here. But I think it would probably be best if we just pick up where we sort of left off --

RM: Right.

JW: --and if at various points, we can sort of flip back in time--

RM: Okay.

JW: --then hopefully we can sort of recapture some of, some of what you were saying before since it was very valuable. So. As we, as we move forward here hopefully we'll, we'll sort of be able to get those, those glimpses back.

RM: Okay.

JW: So I, I apologize for the technological glitch here.

RM: All right.

JW: That was totally my fault.

RM: Well, maybe it's on there somewhere.

JW: I, that would, that would be a great thing if it was. I'm not, I'm not that optimistic. So we, we got up to, you were just talking about sea robins--

RM: Yeah.

JW: And your advisor, Ken Able, was supportive of your research--

RM: Yeah.

JW: --at Rutgers.

RM: Yeah.

JW: And so, should we, should we sort of take it from there?

RM: Yeah. So I, yeah, so I, you know, I had finished up with bluefish which I was kind of referring to as something that people were easily connected to, you know, the public and other scientists and it was a big management issue. It was well-funded, readily funded by a New York Sea Grant because they felt like that was a really bread and butter kind of fishery of the party boats in the summer and, and like I said, there were, you know, the, my Master's advisor, Dave Conover, had several, he had a string, he probably, he easily had over a dozen students working on bluefish, I was like the fourth. And then there was another professor there, Bob Cowen, who had a number of other students including Jon Hare, who's here at the Narragansett Lab, and Robert Johnston--

JW: Yeah.

RM:--who's here in Woods Hole, although, Rob worked down in the Caribbean on something else, but, but Jon Hare worked on bluefish. And so there was a large body of knowledge that was really, you know, forming a basis of work there, and, and I guess I took it for granted that people would be interested in what you worked on. So I went to Rutgers and I was really interested in the idea of comparative life history. I was interested in life history because it was the vital rates that are really the underpinning of productivity of renewable resources, you know, I mean, if you grow fast, you have more yield, if you reproduce more or you reproduce at the right times then you have more replenishment, and

so, you know, just understanding these things would be, you know, just the underpinning, I mean basically all stock, no matter how sophisticated the model becomes it's all, you know, whether it's age based or not, you know, it all depends on how fast the fish grow and how fast --

JW: Yup.

RM: --they replenish themselves. So understanding those basic processes as a biologist seemed to connect my interest, you know, in biology and being, you know, as a basic science and the practicality in fisheries. But I thought that we should think more broadly and maybe my Ph.D. was an opportunity to look at fish that were understudied and so I started getting interested in a variety of species but I thought maybe, but, um, sea robins. And there was some work there, New Jersey was developing a site off of the Tuckerton Lab, Rutgers had a lab down in Tuckerton called the Rutgers University Marine Field Station, RUMFS, and--

JW: Where about is Tuckerton? Is that down towards Barnegat or--.

RM: It's across from, yeah it's at the, well it's further south, it's uh, or, it's at the mouth of the Great Bay, or at the Mullica River. It's across, you can see the lights of Atlantic City across the bay, so it's down towards Atlantic City

JW: It's getting down there.

RM: And it's a small little location but heavily, you know, it's an old Coast Guard station, you know, that was stuck at the end of, at the end of a huge spartina marsh, that was at the entrance to Little Egg Harbor Inlet.

JW: Okay.

RM: Yeah, so they, they, when we first got there, they put in, they had, there were a lot of people working with the little mummichog in the marsh, or they were working in salt marsh, Rodney Roundtree, Barb's husband is, was working on tidal flow and how the juveniles were using, you know, the actual functional utility of how they were using salt marsh creeks--

JW: Is that where you met Rodney?

RM: I, I had met him--

JW: Because I know you guys go back a long way

RM: --at some meetings, yeah, I had met him at some meetings, like some American Society of Ichthyologists and Herpetologists meetings when I was at Stony Brook, but yeah, I mean, --

JW: Okay.

RM: --that's where I met him and actually we roomed together for awhile and that kind of thing. And he was very interested, so there were a lot of people working, like you didn't need a boat, but, or you didn't need more than a skiff, but they had just gotten this, a 27 foot vessel called, we, you know, it was the whole nine yards, you know, and then we, it was called the

Caleta, and it could just, it just could go pop offshore and they were trying to establish a site, they called it LEO, Long-term Ecological Observatory, in fifteen meters of water. And it was at a sight that had been considered, if you can believe this, for a floating nuclear power plant in the 1970s.

JW: That would've been a much worse fate.

RM: Well, anyway there had been a lot-- It was never built, but there were a large number of ecological impact statements, or environmental impact statements that had been done in preparation for this. And so there was a great deal of baseline information. Some geologists had been out there mapping the ridge, it was this little ridge that would pop up, and, you know, a much deeper area right off the inlet, and so we started going out there and, you know, people were jockeying "I want to study black sea bass and you know, things that people care about", and I just, I just thought, wow there's going to be a lot of room to study sea robins. I don't know, I just got fascinated. And the idea was that there were two sea robins, there was the northern sea robin, *Prionotus carolinus*, and then the striped sea robin, *Prionotus evolans*. And so you could actually, you know, compare them, why they're different. I was just really interested, you know, I kind of--

JW: Was there any interbreeding between the two?

RM: Uh, there shouldn't be. I mean, they're good species, I mean I think, whether you could hybridize them or not, you know, you probably could but I think, you know, they seem to be, be well, you know, good species, reproductively isolated, and I know niche theory was kind of dead by the 1990s, but I just, or by the 1980s, but I was just kind of like interested in how do you define a species and, and I was also interested, there was the potential that they used the shelf, and so a lot of people had focused on estuaries as nurseries, and I was interested in this idea of the shelf as an, as a nursery. And actually that was a point I was able to prove very well. We actually could literally go out there, we could collect the fish as eggs and larvae, and particularly *carolinus*, the northern sea robin, was the one that was so abundant that I did a lot of focused work on that. And you could literally see it getting deeper in the water column, growing older, settling onto the bottom and transforming into what looked, you know, I mean, it might have only been, you know, ten millimeters long, but it looked like an adult, you know, it had all the pigmentation, it had all the fin structures, so we were able to go through that whole ontogenetic development of the, the first flexion of the notochord, and you know, its' swimming ability, defining all these morphological traits, and, and doing it age specifically by using the daily age record in their otoliths.

And then we showed how they settled out in this one area and you could see how those areas held on to some abundances; you could just see how they settled and they kind of hung there, and so their, their distribution across the shelf was all patchy. And I thought it was all very fascinating, we worked on a number of gear selectivity issues. We used this, we used this beam trawl and it was very effective in collecting all these early life stages of fish.

JW: What was their spawning season? Were they like the bluefish in their ability to spawn at various points throughout the year?

RM: No, they were much more local and they did move a little bit onshore, offshore, but when they moved offshore they moved in the deeper water and they just shut down. And so then they came back to, for example, we were focused on the Jersey shore, but there were

other collections that we had available. They come in and then they spawn really near shore, still on the shelf, particularly the northern sea robin. The striped sea robin would go into estuaries a little bit. But the northern sea robin would spawn and basically it would rain these larvae down, but basically where the aggregations were occurring, there'd be a strong rain and where they weren't--

JW: Okay.

RM: --you could tell this patch of where, you know, the larvae were settling either because of the spawning aggregations were sort of clustered in a certain way or because again, like that bluefish example in Jon Hare's work, you know, that there's just, and the work that I did with Dave Conover, and invenction matters, you know, I mean, they are plankton so they are at --

JW: That's they're at the mercy of--

RM: --the mercy of the currents for a few days--

JW: -- the ocean currents for carrying hither and yon--

RM: -- and then you get these batches and then if they're in a good feeding habitat, they're going to stay. So I was actually really, I thought the work was really nice and I thought it was a very nice complement, and but I really kind of learned that people don't care about sea robins.

JW: A hard fact to, uh--

RM: Yeah, it was kind of hard to take--

JW: --to internalize.

RM: Yeah, it was, you know, you go to meetings and people would really, like, be baffled that I was working on sea robins, that I'd committed myself to it. And I, that was kind of a hard lesson to learn. I thought that it might actually be a little bit difficult to get a job, you know. Even though I was, I mean it's literally if I was doing that same work on cod, people would be like, you know, they'd just, I would, they would've been like, oh, tell me more. And then everyone was polite, you know, but you could just see the look like, wow, you chose, you chose sea robins on purpose?

JW: Something esoteric.

RM: Yeah. And but I was just trying to show that I could, you know, do the techniques. And sea robins did prove difficult to work on in some ways. The very early stages were difficult to identify between the two species, um, and, you know, we kind of explored some, I mean obviously at that time there were, you know, monkfish was just taking off and it had just become this, you know, and today it's the most profitable fin fish in the Northeast, you know. So I mean, there was this chance that sea robins could've exploded, you know, and then we would actually have this information before that happened. But it didn't happen. So that, I mean, you know, they have really barely risen above that reputation of being bait stealers, and, you know, and just sort of like.

JW: Yup.

RM: You see kids at the aquarium down at Woods Hole and they're like, wow! Look at the-- you know, when the striped sea robin splays its' fins out, and then they, or you know, when they move along with the prehensile, you know, pectoral fin raised and looking for food, you know, they are cool. But, that's, you know, they're not universally accepted as something that people want to care about.

JW: Right.

RM: So, it was fortunate that I, I'm a very practical guy, so I mean actually the esoteric nature of that and the idea that I was going to explore something that was, you know, groundbreaking in science, probably wasn't there anyway. But I got this job offer at the Florida - well, it was called the Florida Marine Research Institute, which was part of the State of Florida. It actually, it was under different auspices; it was initially under the Department of Natural Resources, the DNR, for about a year when I first got there, and then it was under the DEP, the Environmental Protection, and then there was a Constitutional amendment to combine various fish and wildlife agencies within the State of Florida that created the Florida Fish and Wildlife Conservation Commission. And so during that whole period I was under three different agencies but it was the same thing, it was called, I took comfort to know that our institute was called the Florida Marine Research Institute, you know, like, okay I can tell people, you know, it looks like I haven't been changing jobs every, you know, two years.

JW: Right.

RM: And then right before I left in 2006, they changed it to the Fish and Wildlife Research Institute. So, anyway, but I worked in one place in Florida and I got this, for twelve years, I got this job in - well I actually defended my thesis on a July in 1994, on a Tuesday, and I got married the following Saturday and a month later I moved to Florida.

JW: So three life events, boom, boom, boom.

RM: Yeah, so that, that summer of 1994 was a little intense. But I went down to Florida and, you know, I had proven myself, published a couple papers. I had, you know, I was very much latched on to mission-oriented, like fisheries kind of work, you know, but I was always interested in the basic biology of the life history in particular. So age, growth, reproduction, feeding, so, you know, how fast do fish grow, how big do they get, you know, how big do they get when they first spawn, how old do they get, you know, who is eating them, who are they eating, you know, how are they moving and using different habitats, just basic biological questions that would, you know, that I was trained for at Eckerd College where I got my Bachelor's in Biology, Bachelor's of Science in Biology. Or ecological, you know, questions where I'd gotten my Ph.D. at Rutgers University in Ecology and Evolution, or marine science questions where I'd gotten my, you know, that oceanography that I talked about how I informed my bluefish work with oceanography because--

JW: Yup.

RM: --that was my degree at, my master's degree at Stony Brook University. So I was kind of leveraging all of those things, and I've lost my train of thought so you can get me back on track.

JW: What was the research focus at the Marine Research Institute when you first joined?

RM: Yeah. So you know they had, they were kind of like NMFS at a state level. You know, they had protected species interests. They had habitat interests so they were doing whale research, they were doing sea grass research, they were….The lab started historically as studying red tide, would be one of the main focuses, and they now produce red tide alerts, you know, so people can understand where and when red tides are. But a huge part of the Florida Marine Research Institute was fisheries. And of course, you know, in Florida, you know, sport fishing is a huge industry to them and they want to understand how to do that better. They want to understand how to do that sustainably, I think. They want to do it, they want to keep making money off of it and they want it to be there, you know, as a, as a, if anything, as a growth industry, and so it's just a very important part of the economy.

And I actually started there working for a guy named Behzad Mahmoudi and he was, had a small pelagics program. So I actually started working on small fishes, you know, that were primarily sold as bait. Spanish sardine was very important, you know, cigar minnows, the, what's the common name, round scad, so they were very interested in, there was something else, there was pilchard, there was something else, Spanish sardine, oh well and the menhadens, so they actually, you know. So we did some work, I learned some hydro-acoustics and we did, and we were doing hydro-acoustic surveys coupled with trawl surveys and you'd use these target strings from the acoustics to kind of measure a fish biomass and you'd use the trawl catches to kind of divide that out into species and they were trying to use that as--

JW: Was that a new technique at the time?

RM: It, uh, it's come a long way, it, we're using it, Mike Jeck uses that here, and a little bit more, I think, more tractable when you're targeting more single species groups like, you know, Atlantic herring, but you still have to separate them out from, say, red fish, you know, and other things here, other, you know, krill will act as necton in some ways. But, and so, but we were trying to develop this as a way of using it as an index to say about the health of the stocks and, because there was pretty serious, I mean if you're going to have a giant sport fishery you have to have a, you know, a pretty good bait. You have to bait and boxes and people sell bait and you go anywhere in Florida and they have pinfish live in tanks but they have, in the freezer they have, you know, boxes of cigar minnows. The middenan, they have the silver sides come from Canada, you know, but--

JW: Really?

RM: You know, in often cases, yeah, the big ones in particular. And so, you know, it's all about, you know, product dependability and so I started working with them and actually kind of drifted into my own projects. One of my first ones was on the half beaks and so I went down to south Florida and studied ballyhoo and balao which are two half beak species there and there was a small, you know, it was about a dozen boats that were prosecuting those fisheries right off the reef and so there were some issues about, I mean, they were incredibly skilled. They would set these gigantic purse seine like nets they called them lampara nets. They would set these nets right on, right off the reefs and they would pull these nets in, and of course, they didn't want to hit the reef because it would damage the net, you know, and they were really incredibly skilled. They would set these things, they would actually have up to, they would have, like, you know, hundreds of yards of line out there and the fish were so

oriented towards the surface that once they set the net out, which was only a few hundred yards, they would set out all this line and as they, and a big giant compass around where they saw the fish, and they would actually hit this line with a stick and it would reverberate like sine wave down, and it would slap the water and the fish would all stay inside the circle even though there wasn't a net all the way around them, and they would pull this thing in and then the net would eventually come around. And they actually couldn't do it to a point - I'm getting into fishing stuff now here - they actually couldn't surround too many fish because if the fish got tall in the net, the net only went down three or four meters, if they got too tall and one of them found out that there was no bottom to it, they would all swim out, you know. But they could bring in, they could bring in several hundred pounds in a net and they would set several nets and they would ice them down in a slurry of salt and they, and these were sold at very high end, they'd often be rigged with double hooks and, you know, wire leaders--

JW: Oh, pre-rigged?

RM: Pre-rigged and, and flash frozen and vacuum packed seals, I mean--

JW: Wow.

RM: -- the markup was pretty high, you know, on this fishery, so I went down there and I was studying it and we were interested in the habitat, basically there was some fishermen wanted to go into Florida Bay and the reason, I found out, they wanted to do that, because they didn't have to deal with balao. Balao would eat; actually, it would actually eat zooplankton, whereas ballyhoo would eat the plants. So balao because of the zooplankton turn acidic in their stomachs, don't hold up on the troll very long. Whereas ballyhoo--

JW: Is that because they just disintegrate--

RM: --their, their belly--

JW: --and break apart?

RM: --their belly just kind of like falls apart and then everyone says, oh, this was a bad one. Well, that's just that species, it was more off shore on the reef and ballyhoo was more inshore. And so some fishermen had kind of decided that they could fish in Florida Bay and there was a lot of controversy about that. And so we were able to show that balao didn't occur there, so that's one of the reasons it was more profitable. I don't know what's happened now, I mean, they've, they, the fishery, I think it's still running, but it was very high profitable fishery at that, at that time. And so we were supplying information about how big they were and, you know, sort of where they go and, you know, just kind of providing, and one of the things is, we've found out, that they actually spawn near, the older ones spawn nearly all year round. So we were talking about the bluefish doing that.

JW: Right.

RM: And of course bluefish do that because they actually spawn at a similar temperature, you know, but what they have to do is they have to move with the isotherms and then spawn again and then they go back down and spawn a third time. Where, where of course in the Florida Keys, the temperatures, they, the temperatures do vary but, you know, I mean, the--

JW: But I guess there's a much narrower--

RM: --the conditions--

JW: --narrower range?

RM: --yeah the conditions are generally suitable for spawning. But now ballyhoo only live about, they, the oldest fish was four years old. And most, for most, to see a two year old was unusual, I mean, it was certainly possible but it was uncommon. And so just the difference in spawning between a one year old and a two year old was significant in terms of the spawning frequency and the number of eggs they produced per spawning event. So this became, early, a theme of mine to, this realization that, you know, just a year can make a huge difference in the egg production of a fish. And--

JW: Did the number of eggs increase with age, or did it decrease?

RM: Well, it increases with body size and body size increases with age, so basically, you know, most fish will, are constrained to their body size in terms of how many eggs it can produce. It can't produce, I mean, they don't have a cart to put the eggs in, right? So they have to carry them in their coelomic cavity but one way they get around that is they have batches. So they get all their eggs yoked up and that's only maybe half the size of the eventual egg size, and then they hormonally create a batch, that batches up maybe ten percent or five percent, and then they spawn those and then, you know, a few days later they spawn a few more, and they keep doing it until they're spawned out. Well, the two year old, and certainly the three-year-old, ballyhoo basically were spawning every single day. Now they were only spawning a few hundred eggs but they were spawning a few hundred eggs every single day. And they were continuing--

JW: All year long?

RM: All year round. And but they were basically spawning till they dropped. You know, because this was, because they are never not forage fish. [laughter] They just are forage fish, you know, and eventually they're eaten, maybe they come, maybe they become, you know, exhausted from all that, you know, they don't, but I mean they were, they were basically skimming stuff off of, you know, sea grass blades, so I mean, I don't think there was a lot of food limitation in that system. We looked at some parasite loads that they had. They would have these black dots on their silvery sides and those were some kind of worm. And they had this big, giant isopod in their mouth, but that didn't seem to be knocking them all off.

And so what was interesting and what I learned very early on was the value of fishermen's knowledge, because the fishermen, when I started talking to them about this, they said a couple of things. They said, they said, I, I tried to show them that the fish spawned mostly during the summer and I remember in a public meeting several of them got very, well this one guy got very agitated, he goes, I know they spawn in the winter, I've seen it. And I had this data from a publication and I hadn't, I had been out on like one trip and I had read this, you know, I had read a bunch of reports and I wrote things up and there was this, this, this diagram that showed the gonad weight would increase and then it would decrease seasonally so that they were primarily summer spawners. Well, that was among all fish. Later on, when I collected my own data and I broke them down to different ages, that, that, that curve is the one year olds--

JW: Okay.

RM: --but if you lived past one year old, you basically get a big gonad and you keep producing eggs. So the fisherman was right. But it was also kind of like I was right, too. I was saying, but I was talking about an aggregate and he was talking about a part of the population that he said, he didn't know it was a part of a population, he just said, I know they spawn at other times of the year. So he was correct.

JW: Yeah.

RM: And so I eventually figured out why he was correct and how I could, and that became part of the paper. The other thing he said was, they would, they would say, the fish don't become, they become aggregated and then they disperse in the summer so the fishing boats would all haul their boats out in August and repair them, you know, scrape them down, and they'd take summer vacations with their family and everything and it was, it was kind of a way to kind of self-regulate. It wasn't a really hard driving fishery. And but I was always curious about that, like the fish would suddenly change their behavior? It just didn't really make sense. [laughter]

JW: As if they were on a schedule as well.

RM: Yeah, right? Yeah, exactly, like, ah, yeah, let's go down to Cozumel, you know, something like that. [laughter] I just didn't understand that. And but that's what they would always say. And then finally I started doing the math on the age structure and I said, no, they're, they're only, they're essentially annual species. You know, I mean, there are some two and three and even, maybe, I think there was one or, there might have been one or two four-year-olds in our collection. We aged over a thousand fish, but I said, if you look at the math, if you look at a survival curve, basically what happens by August is they have, you know, most of the population has died and the one, the spawning by the one year olds began in May and those fish haven't recruited to your nets. So you're at this nexus where you don't see so many fish because they're dead, you know. And the new recruits haven't arrived in your nets.

JW: Right.

RM: So there was --

JW: You're not measuring those larval fish yet

RM: -- yeah, so their observation was correct, their mechanism, I had a disagreement with their mechanism. And when I showed it to them they're like, oh yeah, well that could be true too. So we had a really good, you know, I mean it was a very, you know, like, exchanging and engaging kind of relationship that was, was wonderful as my first serious cooperative research project, because not all of them have been that way and, you know, it's important--

JW: Yeah, I was going to say --

RM: --that you have a good experience--

JW: --it's kind of interesting to have that sort of positive collaborative--

RM: Yeah, it was a good--

JW: --relationship--

RM: --I think I have made a lot of--

JW: -- you know it's not always that way.

RM: --them that way. But some fishermen are just like, you know, when you walk in and you say you're from the government, that's the end of the story. So they don't want to talk to you or whatever. But I know, I know that often when you break that down you can also, you break down what is really just a superficial barrier too. But I had a really good experience that way and that kind of launched me off in, in a series of cooperative research projects. Eventually the baitfish project was broken up as a project, per se, and Behzad went on to the stock assessment group and I went and, went on to, you know, the fish biology group.

And so I started doing that project, I started doing that kind of work on anything. I wasn't tied, I started working with meat fish, you know. I worked with reef fishes like hogfish, again in the Keys. I worked on dolphin and wahoo along the entire East Coast and the Bahamas. I did quite a bit of work. I continued some of those surveys and I also did some other, and I, you know, did work, I published on the cigar minnow biology with Behzad, and I did some work in the northern Gulf on some deep reefs that were kind of related to what was then called, funded by Mineral Management Services, I think it's called--

JW: Before it became BOEM [Bureau of Ocean Energy Management]?

RM: Before it became BOEM. And it's interesting, we did some nice work on the, on the, the prey species and, you know, the Alabama Alps, or whatever they called those deep reefs off of, uh, in the northern Gulf, and showed that, actually some of the species, what, you know, were considered prey, there were some small sea basses. There was one called, I don't know the common name, it's [unintelligible] was the, is the small little reef fish that was, you know, it was hermaphroditic, it changed sex in its' life. And by all accounts, it could have lived only one or two years. And we published on that; we found that it could live up to fifteen years old. So I think that actually had a lot of, and I've tried to promote this, there was the horrible oil spill there years later--

JW: Yeah.

RM: --and I tried--

JW: Deepwater Horizon.

RM: --I even wrote in the publication, I said, well, you know, I mean it's one thing if these fish only live one or two years old because then, you know, a population from somewhere else could replenish it and the science structure will be just, bam, it'll just be back there. And these were really important fish that the amberjacks and the scamp, you know, the amberjacks, *Seriola* species, or the gag and the scamp and the other grouper species were feeding on. But of course, if you have an oil spill that wipes out a population then, you know,

it's going to take a lot longer for that population to ever reestablish itself if they live fifteen years old. So, not a lot of traction on that. Probably shouldn't have published it in the Gulf of Mexico Science, but, uh. But you know, I just kept, I kept putting out these life history studies. I worked quite a bit on shad in the Northeast. So I actually worked all around the state in various times in my twelve years there with the Fish and Wildlife Conservation Commission.

JW: So going back to before, when you were talking about the spawning of the ballyhoo and, you know their ability to just continuously spawn throughout their, their, the year and their lives, I guess,

RM: Yeah.

JW: Was that spawning behavior typical of other forage species as well, or was that something that was unique just to the ballyhoo?

RM: We don't really know that much, you know. Like when I studied round scad, or the cigar minnow, *Decapterus punctatus*, in the eastern Gulf of Mexico, we had a series of cruises in April and so I knew that cruises were in April and I knew cigar minnow was one of the most abundant fish that they would catch in the net. And obviously I wasn't going to do a seasonal study, if we only collected them in April. But I also knew that it was really abundant and we would be able to collect them all day long and there were some select night tows. And so I did a study about the [unintelligible] and I was able to show that they spawn on the corpuscular period between, at dusk. And so I did the, you know, I did a very detailed study of the, what was going on inside their gonad, and sort of the cellular development and how this batch processing that I was talking about, where you would have mostly a pool of yoked eggs and then you would bring up these subsets of them and hydrate them, fill them with water so that they would float, because the eggs were pelagic themselves, were floating planktonic eggs. And then ovulate them and expel them.

And so that was really interesting because if you read the literature that group of fish, the carangids, the jacks in general, that bigger group, you know, which has jack crevalle or bumper, or blue runner, you know, horse eye jack, you know, all those things. It seems like they spawned at all different times of the day, but when you, when you actually read all the papers and read what evidence they were using, they just had like, it was very circumstantial that they, they would say, they would see courtship and they would attribute that to spawning, but of course, courtship is courtship and it's not the actual event of spawning. And, you know, another person, you know, collected the fish at night and said they couldn't find any spawners so they said they spawn during the day, you know. So there were all these holes in it, so that was the basis of the paper, was to say, you know, actually, if you study spawning directly, you find out that they spawn at night, which is when, or right at that early night period, when you expect that a lot of fish to do that.

JW: At dusk.

RM: They might be, yeah, at dusk when they might, you know, be covered by, you know, twilight themselves and the, and you know, and there's not only fish that want to eat the adults particularly a little cigar minnow, but also they want to eat their eggs, you know, the, what's that whale shark that goes around scooping up eggs and stuff like that. So I adapted to what that cruise was, you know, best at. But it occurred to me that there was some, there was

some ichthyoplankton data in the eastern Gulf of Mexico that Ed Hood had collected in the '60s and '70s and published on. And there was a suggestion that a lot of fish, they had a, they actually, they don't spawn year round, necessarily, although, then again, it's not broken, you know, it's from the larvae, you know, so you don't know if you had the old, see I say, for the ballyhoo, it's only the oldest fish, you know, that's spawning year round.

And so what, but what the data suggested was there was a protected spawning, it started for *Decapterus* in late March, early April, and so I knew that I could catch some of the spawning fish. It was supposedly to go on till October, which is long, I mean, that's pretty long. And one of the hints of that, I always wish if I could have put together a series of cruises, what I, now that I knew what time of day to collect the fish to show whether they're spawning or not and I could get the fish in spawning condition which was, you know, like in the late afternoon, early evening, I would have liked to have a series of cruises because there was a suggestion that it gets too hot in the Gulf of Mexico in the summer and so that the spawning comes up and then it drops and then it comes back up again in the fall. And before it finishes. And this is a, this is that theme that I think is poorly measured because--

JW: That was--

RM: --I brought this up--

JW: --that was--

RM: --with blue fish--

JW: --the thinking of the fisherman that you were describing before too, right?

RM: Yeah, that, yeah, they were saying that--

JW: That they take a hiatus?

RM: Yeah, that they yeah, and so, and that this was also the example with blue fish where there's a spring spawning cohort, there's a summer spawning cohort, there's a fall spawning cohort, why are they so discreet when the, they presumably the same fish, but then the question is, are they the same fish? Maybe it's only the largest fish that can spawn three times, and the medium fish can spawn twice and the smallest fish only spawned once, for example. Or Jon Hare's hypothesis that says that it's many fish are spawning continuously but their larvae are suffering higher mortality in the middle so there's the appearance of it. So those questions exist in, here in the eastern Gulf of Mexico that question is, it's just that it's physiologically intolerant, of course, that has a lot to do with how climate change might actually make things worse, and might actually dampen down reproduction even more. But the actual data--

JW: As temperatures rise?

RM: As temperatures, if temperatures are rising, which seems to be what's going on there. So those are great hypotheses, but assembling the large-scale data sets that actually have direct inference rather than, sort of indirect inference from, say, the larval survivors. It's important to ask what the larval survivors look like for certain questions, but if you want to know

whether it's a production versus a mortality hypothesis, you actually have to, you have to sample the producers and the results, the propagules, and it's, it's virtually--

JW: And that I guess requires a survey--

RM: --unknown--

JW: --that can go year round?

RM: And requires many months of surveys over a large spatial scale or at least some, in the case of blue fish a tremendous space of scale. I would've been happier right off Tampa Bay for the little study on, on cigar minnow, but to sample literally, you know, probably every other month probably wouldn't have been enough, right, if I wanted to see a dip, you know, did I get the right month? What if the dip's only a month? Did I-- you know?

JW: If you blink--

RM: And no one's, I mean it's like, if we can tag all the fish and, you know, name them all, Bob, Sarah, and all that, we could know a lot of stuff but you're not going to, you know, be able to get the funding or maybe the tag return rates to make, to justify it. So there are just some things that are, with current technology is unknowable. Or just hasn't been done.

So those are some of the things that opened up in my mind. And eventually I started, you know, like I said, I started working with a variety of species, you know, often trying to find something about their natural history, particularly their life history, that could feed into a management recommendation. And that usually is not difficult, you know. One of the, I think you could ask Mike Sissenwine, what does he think about the recommendation to just let fish spawn once before you harvest them. Now that's, that can be very difficult to implement in fisheries that are not selected, that, you know, that don't select things for size particularly well, or--

JW: Well, that was part of the strategy for reviving the striped bass population at one point, wasn't it, to raise the minimum size so that at least fish would have the ability to spawn--

RM: Yeah, I mean, they had, had--

JW: --once before they're harvested.

RM: -- had a moratorium, you know, on that Hudson River one for awhile and then they finally had a recruitment event. And then, once they realized that, that recruitment event they protected it. And as it got bigger and bigger, they would actually increase the size limit till they realized, we're wading around in striped bass and they seemed to be way abundant, and then they kind of cut things back, you know, that was a, that, that's, that was at least a healthy sense of adaptive management, whether it was triggered just perfectly, I'm not sure, but I, same thing with haddock, you know. They've protected that year class and, as a result, now you have large spawners.

JW: Which year class was?

RM: Well, for the, the, haddock, it was the 2003 year class.

JW: Okay.

RM: I think the 1999 year class was decent, but it was the 2003 year class. And we've had several year classes since, and I don't think that's by accident. I think once you had, I think the 2003 year class, which was the largest year class on record, it was certainly larger than the 1963 year class which was heavily exploited by foreign fleets to the extent that it led to the law of the sea and the closing down of the foreign fleet fisheries. The 2003 year class of haddock has been protected well, and as you get more larger spawners, so the, the, the expression in the field is "BOFF," big old fat females, because you, because, and not to be sexist, but in the sense that the fecundity of the females is really tied to their size. Probably males and females their, their reproductive success is tied to experienced both. But sperm, spermatogenesis, the cells become smaller and smaller. And whereas with ovagenesis, the creation of eggs, the cells get larger and larger and the female actually takes nutrients and provisions the eggs so the propagule has a yolk sack, you know, when it's, when it's, before it feeds in the water column. And so, I mean--

JW: So large females have a much greater ability then to reproduce with eggs.

RM: Yeah, females, your reproduction is much more, generally much more stressful, energetically, on a female fish. And so if you're bigger then you actually have more general energy, you can actually, if you, if you have the energy, you can produce more eggs. You can't produce more eggs than your body size, you know, the body cavity, but you can always produce fewer eggs, you know, because you're not, you're not feeding well. And this is the case with winter flounder, so we're kind of shifting to my new job here, the work, one of the first projects with winter flounder when I came here in 2006 as the Branch Chief for Population Biology, we, I basically talked to Jay Burnett, who's now retired, but he was a source of information and a mentor to me. And he said "there's something wrong with the reproductive biology of our estimation of maturity with winter flounder." So, you know, and of course you want to make a hit when you're first, you know, when you first came here. So we started working with winter flounder and one of the things I found, one of the things we needed to correct and we eventually did, was we used gonad histology to say, look under the hood, finally. Instead of saying, you know, you know, what the engine probably is based on looking at the car without looking, you know, we finally started looking under the hood and like actually, you know, taking the gonads, sectioning it, staining it and looking at the actual cell structure--

JW: So that hadn't been part of the process before?

RM: That had not been done here in any, in any significant extent. And since I've been here, we've been doing it every year on a variety of species. And what we found out is there was a, there was a stage that they were actually, they were starting to mature for the first time and people were at sea were confusing them as mature. What they were doing was they were maturing in the spring when the collections were being made for the determination but they wouldn't, they looked mature but they actually wouldn't spawn for the first time until the next year. Because they actually, it takes so much energy for them to produce a batch of eggs that they actually start, literally, you know, almost a year before that. And, and the older fish that have matured, and actually have spawned, you know, are doing the same thing but they're so obviously mature because their gonad is shrinking because they just finished spawning, so it was this small number of these newly, first time maturing fish, that were getting confused. And so we were able to show that and we were able to, you know, work that through in our,

our, you know, workshops, maturity workshops, which is part of our QA/QC [quality assurance/quality control] determination. And, and actually, there was this other data set, basically our data set disagreed with another data set and when you made this correction, they came together and it all worked out and we realized oh, that was, that's the problem. And so, so what the, it really didn't change management because--

JW: Yeah I was going to ask what the implications were for that then.

RM: Well, the implications were which maturity curve was correct and what it turned out to be was that the Center had conservatively picked the larger maturity curve which was larger than they were recording but someone else was recording, the State of Massachusetts was recording from their trawl survey. And they, they were sampling at a slightly different time of the year when that confusion was not so apparent. So they had, what they were doing conservatively was actually just correct. So we weren't, we weren't making the wrong choice, but you know, now we, we, now people can stop arguing every time they had a stock assessment about winter flounder, you know, about what, why there was this dissonance between the two surveys. And actually I would argue that actually it went back to twenty-nine centimeters and I would argue actually that really that was the size at fifty percent maturity, that's not the size at fifty percent spawning, that's not even certainly the size at ninety-five percent spawning. And if I was a manager, you know, if someone asked me, I would say you should put it at ninety-five percent spawning, you know, because actually what happens is we've, what became really concerning is that when winter flounder females, and, don't feed well in that, in that period right after the spawning period, they may not actually advance a clutch of young, of yoked eggs.

JW: So they'll have a gap year?

RM: So they'll have a gap year, which they call skipping, skipped spawning. And that's most common among the youngest fish. So being mature doesn’t automatically mean you're going to spawn, so, you know, you may be hormonally active, you may be able to capable of, but if you don't feed well, you don't--

JW: If you're undernourished, then you might--

RM: --you don't actually spawn. So I think I personally, you know, just from a life history perspective, I always go to that kind of, you know, that place of, why don't we let them all spawn once and then we can, you know, harvest them. There are some problems with that, I mean, if you just, if you absolutely crop, with the fishing power today we have, you know, you could actually crop them off pretty hard. And, and the gears aren't that selective anyway, so it's, it's not that easy but, I always kind of fall back to that position and I wonder, since you know, winter flounder struggles, you know, since we really are, we are catching, that, that means a lot of the fish that we're catching at those smaller sizes aren't mature or have, and then there are still even more that are mature but have not spawned, and that bothers me.

I always, you know, am very concerned because in Canada, skipping rates can be as high as twenty percent of the population. Now, Canada is Canada, you know, I mean I'm talking about off Labrador, and that's a very extreme situation where the temperatures are extremely cold, the summer growing season is very short, that's not necessarily the U.S. So we went around and started doing more collections so we expanded from the maturity to actually the

skipping issue and we showed that off of, this, uh, the Scotian shelf, so we sample up there, you know, in Canadian waters, the rates can be like ten, twelve percent. But in U.S.--

JW: So is that just more temperature dependent then?

RM: Well, essentially it sounds temperature dependent; it's the length of the growing season, you know, for the fish. So when there's food for them to eat and when they are metabolically active, so temperature is triggering it.

JW: Yeah.

RM: You know, their metabolic activity and their ability to feed, their need to feed, their ability to grow, and so, in this, in the U.S. if you back up, in the U.S., you go back further south to U.S. stocks and there's three U.S. stocks for winter flounder, the rates were more, more like zero to three percent. So then it becomes a little bit, you know, I mean, there's, that--

JW: Longer growing season so that they're able to feed throughout the length of time.

RM: Yeah and it's warmer, and you know, they have more time, yeah, they can start earlier, you know, they presumably, you know, if they can start feeding they still have a little bit more time to yolk up the eggs, so it's not like they don't skip, but, you know, you know, I would say, you know, it's something like two or three percent at the higher end, the stock assessment can't absorb that small level of precision, you know. I was, but we were deeply concerned, so this has actually been sort of my experience up here. There's these biological issues that rear their ugly head, you know, and then I go and investigate them and it turns out, like, well, it's probably okay, you know. But we can at least take that off the table as something of concern, move on to other things, you know, that are concerning, whether it's by catch or something else that's, you know, plaguing the assessment and needs more energy focused on it.

JW: So were there any other sort of, I guess, uh, lessons or challenges as you made the transition from working with, I guess, tropical, subtropical species in Florida to when you arrived here in 2006?

RM: Well I suppose the only challenge is that, I came up here and people, I mean if people knew me like--

JW: Because it seems like a very radical departure--

RM: Well--

JW: --going from working in one environment to some--

RM: Well, I actually looked forward to it. I looked at it as an opportunity. Because that goes back to something I was talking about earlier about this idea of working with comparative, you know, fish, you know, comparing fish life histories and trying to work out more general rules about what fish are doing in the world, you know, any fish. There's 20,000 fish, 20,000 species of fish presumably, there's a lot of variation out there. But one of the challenges is, you know, people like Gary Shepherd that might have known me from when I was at Rutgers

or whatever, and he, he knew Ken Able. Well, you know, some people knew me, but actually quite a few people, you know, if they worked on cod their whole life, they didn't know about all my work in the subtropics. And they didn't know about my work with sea robins because nobody cared about sea robins anyway.

JW: Back to the sea robins. [laughter]

RM: Yes, yeah. And I mean it didn't damage me too bad, I got a job, you know, and I never had a post-doc--

JW: You weren't blacklisted for being a--

RM: No, no, it wasn't to that extreme--

JW: --sea robin.[laughter]

RM: No, but I got a job right out of graduate school, I didn't even post-doc, you know, I mean I got a job that I liked, and uh. But when I came up here--

JW: That's pretty fortunate these days.

RM: Yeah. Well, it was back then too, so, maybe, but it was still. I mean, I remember it being just as, you know, as, certainly stressful, you know, trying to find a job there at that time. But then, um, and then actually when I went to Europe, you know, and trying to connect with the ICES [International Council for the Exploration of the Sea] community and all that, it's sort of like, you know, hogfish, huh? Okay-- Like, so you don't work on Atlantic, if you don't work on Atlantic cod or Atlantic herring, well, hopefully you work on place, you know, or something-- There's only so many species that they care about up there.

And so I did have a little trouble connecting with people who were not familiar with my work and all that, but I would say actually it was an opportunity for me to say "look, I've actually studied all these fish, you know, and I know all this stuff about life history that I can work on other fishes" and really, really kind of, I don't think of them all as cod, you know. I mean, I joke with Tom Munroe from time to time, we've gone to flat fish meetings and people say, "flat fish do this", and you're like, "which flat fish?" I mean you know, there's lots of flat fish and they, they actually do many different things. So when we got some cooperative research money here at the Center, we started work on winter flounder, yellow tail flounder, and, and, summer flounder, because they actually are very different fish in terms of how they recruit their eggs and how they spawn their eggs out, the seasons, the numbers, you know, the sequence and all that and, because, you know, we didn't want to say one thing fits all. So we, I've been working on that, and that, for example we, you know, basically working with the ICES community, NAFO, the North, um, Northwest Atlantic Fisheries Organization, as well as the ICES, what's that, the International Council for Exploration of the Sea--

JW: Yes. Yup.

RM: And those communities, I actually was, got on some, a working group as a co-chair with Dr. Stylianos Somarakis in Greece and we led a group where we actually got people to look at, we looked at thirty, the breeding types of thirty-nine species globally, freshwater, marine, diadromous, and we did a, we did that kind of survey, and I don't think I could've led

that if I didn't have that experience from the south and going up to the north. In fact, I had my doubts about it along the way, you know, but eventually it became much more, it was a huge event for me to get that publication, it's in *Fish and Fisheries*, uh, because now I kind of, I just feel more confident about, whatever, "what fish you got, we'll just, we'll take that, we can answer a question." So I'm working on wolf fish, I'm working on white hake, I'm working on halibut, you know, what do you got? I mean, we don't know anything about it, that's fine. I've got, I've got a structure in my head to imagine what could happen and how to design the sampling so we can start whittling it down to what really does happen. And so, certainly there were some challenges but they've all turned into an, I've made them into opportunities, I think that's worked out very well.

JW: Well, it's really interesting in hearing you talk about, you know, the reproductive biology here of winter flounder and of ballyhoo and of bluefish and, you know, sea robins. And, you know, I'm just wondering, is, as you sample so many different species, are there more generalities or individual nuances that you encounter when, sort of, drawing conclusions about, about the reproductive biology of all of these, these fish?

RM: Well, you know, if you have 20,000 species and each species is defined by, as, as unique, you know, reproductively isolated population, you could say maybe there's 20,000 nuances. But that would be overwhelming. One of the things that we wrote in that *Fish and Fisheries* paper, is there's capital breeders and there's income breeders. And so, of course you like to have a frame of reference to kind of, something that's familiar, and so here you're talking about some fish, actually, will store energy well ahead of the spawning period and then draw that energy later to produce their eggs, so they're storing capital, they're capital breeders, and these are, particularly in the North, you've got the cod, you've got winter flounder is a great example like I just described; it starts building its' gonad and storing energy in its' liver--

JW: Right--

RM: --almost a year--

JW: --a whole year--

RM: --before that's, it's doing that all year in preparation for that spawning event. Atlantic herring are extreme capital breeders. And so these fish, of course, have the advantage of spawning at the time when feeding is not very good for them. But might actually be really good for the propagules' survival. But you can't do that unless you frontload and build capital and all of that. Whereas a fish like the *Decapterus punctatus*, the round scad, or say bay anchovy, or these little, little small fishes, that are severely constrained by the eggs that they produce, you know, by, by their body size. Well, these fish are literally, when they hit the feeding season, when they hit the spawning season that's overlapping with their feeding season, well, they're continually feeding and they're, they're diverting certainly, their supply and their own basic needs of the body maintenance and, you know, and, and maybe some growth, although most fish when they hit maturity, their somatic body growth slows down, but they literally are converting that energy into daily, you know, into, often batches of fish. With, you know, I talked about ballyhoo being a daily spawner. The bay anchovy is known to spawn every day, you know, every day. And it's basically, in a year it, it, it spawns the eggs, the eggs that it spawns are the equivalent of like three or four times its' regular, what it would need, three or four hundred percent of its', what it would need to just live. So it's taking that

energy and putting it right into the gonad. The eggs are expelled so you keep weighing the fish, it doesn't really seem to change its' body weight because it's constantly throwing that off as reproduction.

JW: It's amazing.

RM: So you get this sense, if you're measuring the adult, like, oh, it just stays the same. And in fact it's, it's churning energy and putting it back out in the population. And if you didn't think about it, you know, well, how, how do other things eat? You know, where--

JW: It almost doesn't seem sustainable--

RM: --do they get all those eggs?

JW: --for the fish.

RM: Yeah. Well, well, and these are typically short-life fish. But their, but their egg production is no longer limited to their body size because they can, this rapid turnover. So these are income breeders. And actually in the review paper that we, that's in *Fish and Fisheries*, we talked about, there's mixed types which was actually poorly understood in the literature, you know. So it's not just like fish are at these extremes, there's other fish that, that, there's actually like an extreme examples of butterfly fish that basically only lives one year. And it starts, it starts, from the moment, basically butterfly fish don't do anything more than eat coral polyps and have sex. You know, so, until they start finding a mate--

JW: It's a very limited existence [laughter].

RW: Yeah, you know, I mean, you know, for many people that would be just fine, you know, but I mean for, until they find a mate, they basically just eat coral polyps and they actually do store some mesenteric fat. And then they find a mate and they spawn all the time, they're monogamous, they continue to spawn until they die, and they, they die about 400, 500 days old. And so, they're income breeders as spawners, but actually, the work that's been done in Hawai'i on some of these butterfly fish that suggests that their actual lifespan depends on how much energy they stored in that mesenteric fat at the beginning. So it, you know, they, you know, if they don't have, kind of that buffer, they're going to have a shorter life than because you just don't always have great feeding opportunities from day to day.

So, there's, there's a lot of nuances that, so that, that capital income breeding continuity I think is really important to frame that as a generality because it incorporates really the key ingredients. It's, it's, you know, it's growth and reproduction that are driven by energy. You have to find the energy and then it's how you allocate the energy. And how fish allocate the energy is going to, you know, have a lot to do with how they respond to environmental variation. For example, a fish that's a capital breeder, it can get to the end and it can be, you know, it can be a great, it could be a great spawning environment that could produce incredibly high productivity for, for, the, high survival for the propagules, but you're limited to how much energy you stored. You can't suddenly get any more energy than that. Now, they are known, capital breeders are known to get to a very poor environment around spawning and they actually cause some of their eggs to die. The smallest eggs will die and just be lost. So they can down regulate--

JW: Yup.

RM: --but they can't up regulate at the end. Whereas the, you know, see the capital, the income breeders they, if suddenly it's a great year the productivity can just instantaneously be turned on. So these are some of the most basic structures in my mind, the processes that can cause recruitment variation that begin inside the gonad at the cellular level. So I think these are things that kind of would have, like we've looked at a lot of issues about how, you know, climate change has caused fish to change their distribution. So some of them are heading north, you know, if they're warm water. Some of the, if they're cold water species, they're retreating into deeper water, or they're, they're actually going further north too, because they need to get colder water.

Okay, fish move, we get that, but I think fish adapt. And I'm not necessarily talking in an evolutionary argument, although, you know, because that, I think that's going, I think the fishing power that we've expressed on fishes is causing evolutionary adaptation, for sure. But this capital income breeding is not strictly controlled by genetic processes. It's just the flexibility of fish. So this flexibility of fish is going to, I think in the long term, dampen some levels of the climate change effects. I mean, if fish have this flexibility and they essentially have an ability to prioritize their own survival, you know, by not spawning in a year, or delaying spawning for a year or just producing fewer eggs so that it, that the adult is more likely to survive and spawn again, and if it actually grew, it would actually be bigger and its lifetime fecundity could be better because of that.

So, you know, in a sense we think of fish, you know, well, of course they want to spawn. Well, actually, the argument is that they don't always want to spawn if it's, if it's definitely going to risk their own survival and they have the chance to survive in the future. So this is the thing, is, when we've cropped down fish that are big and increased mortality of the biggest fish, then we've changed the structure that the fastest growing fish are removed from the population and the slower growing fish are left. Whether it's genetic or not, the outcome is the same. You're going to end up with smaller, at the individual level they're going to be resilient but they're going to be smaller. You know, we're going to have smaller fillets. We're going to have less productivity. We might have less opportunity for these out years to just burst out and have strong year classes that we can protect and keep around forever.

And so, to me, there, that's where I think of the ecology. I don't necessarily think in food web models. I think of just simple principles of, leave some of the big, the BOFF fish, the big old fat females out there, that have this potential to capture pulses of energy and suddenly replenish a population that we can protect with some management that's structured around what our goals really are. Do we want trophy fish? Do we want sushi fish? Do we, you know, you know, but we, we don't have any of those choices if we're just hanging along to these straggling, you know, undersized populations.

JW: So do you, do you foresee in the future any, like, I guess, you know you had said that there's some, a little bit of crossover between income and capital breeding fish--

RM: Yeah.

JW: --but do you think that, um, you know, income breeders will eventually, um, evolve different breeding strategies to be, you know, I guess, more similar to capital breeders if that gives them some greater predisposition for survival?

RM: Well, it's not always that simple.

JW: I might be, not phrasing that--

RM: Well, it…

JW: --in the best way here.

RM: Well, because, it, it, can change if we don't, if we actually fish so hard that we're selecting only the fastest growing fish and so those are just like, taken out of the population. In some cases there's serious concern that it's gone that far. But I think that drives an individual into this capital breeding continuum is the environment that's there. And so it's, it's, the fish have this flexibility to kind of, you know, like, you know, move back and forth a little bit. And it's not fixed in their genes. Because, the inheritability of life history characteristics is rather low. And so I think you, one of the reasons there's a lot of arguments about it is, it really takes some extreme event to actually see it showing up as an actual concern. But there are extreme events. You know, I mean, what's happened with cod, you know, is, is, is very deeply concerning. But there's always an, I think there's always, you know - how are we doing on that?

JW: Good. The battery is running down

RM: Okay.

JW: …so I just want to try to--

[Recording stops]

JW: Yes, we're back on here. Okay.

RM: All right. So, um, I'm back on, Rich McBride. Talking about, I guess I, I'll just, make that transition of coming here was, you know when I was at graduate school at Rutgers, actually when I was at Stony Brook I went on a NOAA boat with Bob Cowen--

JW: Yeah, I read that on--

RM: --to study bluefish

JW: --the website, that you were on a--

RM: Years ago.

JW: --on a bluefish survey cruise.

RM: Yeah, yeah, years ago. And then, and then when I was a student of Ken Able, Ken Able was from, had got his Ph.D. at VIMS [Virginia Institute of Marine Science], he was a student of Jack Musick, and Jack was big on putting people out on, on NOAA survey, well, NMFS--

JW: What year did you go on the cruise?

RM: So I went on, um, I went on the *Albatross IV* in, uh, probably in 1991, or something like that. It was early '90s. They were still on paper. It might have been, it might have been 1990 because they were still on paper.Tthey hadn't gone over to the computers, scientific system yet. But they did change over in the early '90s, so it, I, for that matter it could've been '89 or '90. I don't, I'd have to look it up. But, you know Linda Despres was, was the Watch Chief back then, and--

JW: I'll be doing an interview with her--

RM: Oh, she's--

JW: --later in July.

RM: She'll be a great person to talk to. And she was, she was very steady, calm person and friendly person. And a great, great person to have as a, she was the Chief Scientist. Yeah. And so, but yeah, but we were writing stuff down on paper back then. It was crazy. You know, when you think about the volume of materials and, you know, but, but, and of course, but that was always, that was something. So when I left, the idea that I kind of knew what this place was like and I had met people and that, you know, and I had been to sea and they knew me, you know, I knew some of those people and made it, made it more real for me to come back here and, like you're saying, just the, it seemed like a place that I wanted to go work some day.

So I came back here and I'm just trying to do my part, you know, the Population Biology Branch is a data-driven branch. You know, like the survey runs the survey ships, you know, I'm in the scientific side of it. And we're collecting samples from, well, you know, certainly the fishery independent surveys, but also the commercial catches through the port samplers, through the observers. We have strong ties with cooperative research programs, particularly the study fleet, we're getting, we'll get, we'll get samples wherever we can get samples from because, you know, I mean, particularly when you're studying reproductive biology, you need to often get a fish at a particular time of year at a particular place. I mean, if it's six years old, it's going to be six years old for a whole year, but I mean, if it's actually about to spawn, as I said with the round scad example, it might be only spawning, it might be only in spawning condition for a few hours of a day and then it might not be in spawning condition again for another week. So you have to, you have to pick things very carefully when you're doing reproductive biology. But we, we get those samples and then we make more data and those, so then those data go into the assessment. So that's where we fit in; we're a very, we're part of a data division and we're handing off data streams to the Stock Assessment Division.

JW: Before you had mentioned your work on shad, and then we, we sort of diverted and began talking about some of the other species that you've worked on. But I was wondering if you might be able to say a bit about your research on shad and anadromous fish, in general.

RM: Yeah. Shad, shad are great to work with. I started the work in Florida and it started the most unassuming thing, you know. Back, I talked about working for Behzad Mahmoudi at FWC on the baitfish. And they have a project down in Florida, we were mostly working with the coastal, small coastal pelagics, like the ballyhoo and the, the round scad, the Spanish sardine. And there was a call from the Atlantic States Marine Fisheries Commission to have a Florida representative on the Technical Committee for shad and river herring. And as I recall it was sent to the Division Chief or whomever and that person was out and their secretary

decided, "well, herring, you know, a shad is like a giant herring, so I'll call up somebody in the bait fish group" and, and then nobody was around, and she decided, "well, Rich McBride's new", and so she put me on that committee. And I would have to say, I, you know, I was from Chicago and I, I don't have stories about catching shad and riding my bike home holding the shad on stringers with the, you know, balancing the, the fishing pole on my leg, you know, going home--

JW: Not that Normal Rockwell image?

RM: No, I didn't know shad at all, period. And then on top of it, Florida, which does not have an intense shad culture, I didn't know anything, I mean, there's, there was not a lot of information there. But we--

JW: So was Florida the southernmost--

RM: Southernmost population, yeah.

JW: --extent of the American shad population?

RM: And they go all the way up to Canada. So we, so we were really, you know, we did, and, and, and actually Florida was in a position to declare de minimis, which means that they actually land less than one percent of the total coast wide landings and so they could just opt out completely. But, I don't know, they decided to put somebody on the committee and I was chosen. And they actually had a small krill survey in, you know, so they had a boat going around asking anglers what they were catching. And so I would go out, there was a guy that was operating out of De Leon Springs, so there was, it was, it was on the St. John's River near Orlando, to give you a frame of reference that people would recognize, and I would go over there once a year and I'd go out on the survey and I'd talk to the guy and they would hand in a report at the end of the year. I was like a technical monitor for a couple of years. And then I would go to these committee meetings and I would hear people arguing about shad like they really cared about shad, you know, in, in Maryland and New Jersey. And they just didn't care about shad in Florida. I just was, was just kind of playing along, I was asked to do this so you know, but I was on that committee for about ten years. But I eventually became the chair of the committee and I started really to understand that shad were actually quite interesting. And we started building up this krill survey and it, it, it started to shift from asking people, "what did you catch? What do you got today?" And they'd be like, "hey I got this silvery fish I caught, you know, can you tell me what it is?" Because they're out there looking for specks or black crappie, and, and largemouth bass. And they would hold up a shad and we'd be like, well that's an American shad. And they're like, "wow, really, I've never heard of it." They actually asked, like, and they would act like it was, you know, something exotic, you know.

And so we kind of worked from there and the thing was, is I started researching it and shad in Florida had been so important to the ecology of that system that they were talking about building a canal in the St. John's River for some commerce and, and, and, and Jerry Brugger and Roy Williams, back in the 1970s had done a series of studies and showed where the shad spawning ground was and they realized this canal is going to go right through this shad spawning grounds. And shad require flow rates; they require shallow water with certain flow rates, and the eggs kind of roll along the sediment. And this was the kind of fish that actually stopped that, the building of that canal. Which was probably a horrible idea, I mean, you can

just imagine in the '70s how we were screwing things up left and right without, you know, the environmental movement was really just coming into its' own and a lot of stuff was really still propelling itself. And shad actually even had that international importance. I mean, there was, they were going to build a huge power facility, a tidal power facility at the mouth of the Bay of Fundy, I think. And, until it was revealed that all the shad stocks from Florida to Canada would go through this, these turbines and be chopped up. [laughter]

JW: Would've been the end of that.

RM: And, so shad had some, has some influence in sort of stopping some kind of, well, certainly large-scale and maybe certainly debatable, maybe even crazy, you know, development schemes. And so, you know, I thought that was really interesting and in fact, shad actually could be really important in minimum flow level discussions. We got, we got a lot of support from the water management districts about knowing about shad because they really are facing a serious issue about water in Florida and how much development is proceeding and whether Florida can really sustain that kind of development, you know, in terms of just having a basic source like water available for people to drink. And after going to Sicily I, that's not a hypothetical example. I mean, every, you know, I mean, if you want to drink bottled water everywhere you go, I mean, I think Florida's right on the right track.

So, so shad, you know, and like other fish, requires some water in the rivers. So we started studying that and got involved in that, had some Wallop-Breaux funding for sport fishing restoration funds that are given to the states, and had a series of cruises, and a series of sampling seasons, and worked cooperatively with the freshwater side of our FWC and it was very good, positive interactions. And I actually learned quite a bit about shad and published a number of papers and shad gets a little bit more attention now and the water management districts are watching closely because this is kind of an indicator species and now they know something about it.

JW: How many rivers in Florida are there where shad are actively spawning?

RM: Well, the St. John's River is really the river.

JW: That's it?

RM: Yeah.

JW: Okay.

RM: Now, it's the longest river in Florida, so, I mean, it's a major river. A lot of the other rivers are much small, the St. John's River's mouth, it's a peculiar river that's flowing north. And so its' mouth is at Jacksonville and, and really temperature-wise, it's, it’s just at the southern limit of its' temperature tolerance. So consequently there's some interesting ecological issues that basically that, when they get south of Hatteras, they basically are boreal species that has steadily expanded over, you know, eons. Geological time to invade all the rivers all the way down to Jacksonville and the St. John's River. And, but, they can't make it more than once. They can't go back up, so they spawn in the river, like a good anadromous fish, and the young actually sometimes stay over winter and but eventually they eke out and they go north and they feed. Most, it's generally regarded that shad go up to the Bay of Fundy

area, or the Gulf of Maine to feed in their life. And then they come back down and they go through not only that long migration from, literally the Gulf of Maine down--

JW: So these are Floridian fish heading all the way up to--

RM: Yeah. All the stocks--

JW: --the Bay of Fundy.

RM: --all the stock from, you know, Florida, Georgia, South Carolina, all the way up to the Mid Atlantic Bite, all of them are going up to a feeding ground in the north. And so when they come back down they not only have a long distance to come back down, once they've matured, and they kind of have a hormonal cue to spawn, they come back down and then they get in the St. John's River which is one of the largest, longest rivers that they spawn in, and they have to swim like 300 kilometers to get to the spawning grounds. And basically they're wasted. So they, they're semelparous; they spawn once and die. Whereas the fish in the north spawn more, more times. They actually have the capacity to spawn multiple times and they do, and they get much older--

JW: Those are oviparous?

RM: Uh, iteroparous.

JW: Iteroparous.

RM: Yeah. So the fish are repeat spawners. So they, they, and that's one of the reasons why they get bigger in the North, because they actually can live longer. They all go into an estuary to spawn for the first time, about four years, five years old. Maybe six years old. But, it, for Florida fish that's it, you know, whereas the other fish can come back and they can live to ten, twelve years old. So that suddenly became very interesting ecologically. And I wrote a number of papers and people were, they, they thought it was helpful. Some of the papers were on hickory shad. Another couple of papers on blue back herring, we don't actually have alewife in Florida, so that was not covered, but, those, those papers have been very useful for people as those, you know, river herrings have become very, a hot topic, because of their seemingly decimation in many areas. Hickory shad is of interest because seemingly it's kind of come back and we didn't--

JW: Really?

RM: --do anything to do it. And so people have been kind of interested in what did we do right for hickory shad? But hickory shad are very different, they don't go as far up into the river as American shad. They're much more of a coastal marine species than a fully anadromous fish. And, and they eat when they're spawning, so they're just, you know, they, they, they're just a very different animal. But, so, you know, a lot of, a lot of good attention, you know, I served on that committee, there were a lot of issues about the coastal spawning. That was the time that the coastal spawning, or coastal fishery, the harvest fishery by gillnetters, not coastal spawning, was being hotly debated and eventually was shut down. And from a Florida perspective, you know, the idea of having all these gillnets, you know, that our fish had to run the gauntlet through, seemed like that coastal fishery was, you know, problematic. We had passed a net ban in the 1990s and yet we couldn't control offshore

mortality. And, and a lot of states felt that way and a lot of the coastal gillnetters were kind of getting out of the business, you know, I mean, it's just not, I mean that's just the general trends in fisheries. A lot of people, they're not as profitable, they're not as lucrative or they're just, or they are lucrative, or they are profitable but they're just hard work.

JW: To what extent would shad mingle with menhaden and with river herring offshore?

RM: Well, when you put out large nets, you know, you can occasionally get both in the net. River herring has been a big concern about the mid-water trawls. But these are often, these are not consistent events; these are often that just sometimes you put the net down and you get a whole bunch of river herring. And of course, they're not necessarily in the same schools, they're just like, there's a school here, there's a school here, the net goes through both. So, I mean, it happens, I think some people think it happens a lot but the data suggests that it's actually more unusual than, and the timing of the nets, those mid-water trawl fisheries have not really timed well with the declines in river herring populations. So, and shad are, I mean in my mind, like hickory shad is more of an inshore, you know, is much more inshore than American shad offshore, when they're in coastal shelf waters. So they're not, they're not completely aggregated, but nor would you expect them to be.

What was interesting for me was, when I came up here I thought my shad days were over. You know, I actually had to finish up a couple of the manuscripts and publish them and stuff. But shad has been kind of heating up and so, you know, I mean, certainly, I mean the decline of river herring has made a lot, caused a lot of attention. And I just thought there were a couple of simple questions we would like to answer, so I started sampling in 2013. I remember going up to the Conte lab for a day because I met some people at USGS [United States Geological Service] and they said, "yeah, why don't you come up and take a look at the fish". And so we, I went up there one day and we collected some fish and it was so refreshing, I mean, they, they kind of close the trap on the, on, on one of the fish passageways and the fish all bundle up and then you dip, dip six or seven fish out and you get in your car and you drive down a way and you have a coffee and you're sitting in the lab and you're looking at the fish, I mean, comparing that to a trip on the *Bigelow*, I mean, and having to go offshore for several days and you might catch a shad and you might not catch a shad, you know, I mean, I was like, "wow, this is awesome".

And, so anyway, I started opening up the fish and I said, "oh, well this is in spawning condition, this one's not", and this guy that's been working on them for several years but he tags them and he does other, he does very nice work but he was just like, "wow, this is really cool, I always wondered what was going on". And I realized there was really a lot of potential that I could work with these guys, I mean, they're often, you know, at the Conte lab, they're focused on engineering issues like nature fish ways. They're tagging the fish, trying to understand their behavior. But when it came down to basic life history, it seemed like there was plenty of room to cooperate and collaborate in a complementary way. So we went up the next year and collected some more and that's where I started. I built this collection that was, that was very useful to actually, it turned out, while I was collecting those it turned out that they were taking a population model from Maine, Tim Sheehan and Julie Nieland and somebody else, developed an Excel population model for salmon in the Penobscot. And they used that for what-if scenarios. About what if you, you know, removed this dam. What if you removed that dam.

JW: For reinvigorating the population?

RM: Yeah. How would, how would the population respond? And they were very successful at that and it was very useful. And the goal had now become to see if you could adapt it to other rivers and, of course, a lot of other rivers didn't have salmon, so other rivers and other species. And so there was a big push to adapt that model for the Connecticut River and Connecticut River on American shad. And, because actually, by all accounts, American shad, fish passage is, up passage is great, but it's not clear about the down passage which involves turbines and can induce mortality that way. And it'd be nice to have an open, transparent model that could ask those questions.

So one of the things they needed was fecundity, or the number of eggs produced. So there's, you know, here's Rich McBride, I study reproductive biology of fish. Actually, they came and found me and I said, "well, I happen to be collecting some fish, you know, and I was looking at their gonads and they're pretty interesting". And they needed this model and so NOAA had a Habitat Program that I got some funding from to devise a field-sampling program. And then I realized I was kind of getting ahead of myself, the field sampling program was coming up and I hadn't really looked at the samples from the last year and I needed some help and, and so this is, we talked about some colleagues I have from Sicily that have always wanted to come to the United States and work with me, and so we made that the goal, is they would come and help me work up these samples, kind of, accelerate the throughput and, and look at those. And we actually have a manuscript I'll probably talk about in a minute, that's provisionally accepted with [unintelligible]. So we're hoping to get that published.

So, but anyway, we used that to do the design and then we eventually we went out and we did the measurements. We, we had to look at some basic, you know, just how the ova sites are developed and, and based on how, what we saw we said this method should work. And we did this one method and, there's actually a more complicated method and we, we actually did the independent way, this more complicated method to estimate the number of eggs, this annual fecundity, and we found out they agreed. And no one had, I don't think, as far as I know, no one's ever done both methods because usually you'd want to do just the cheap method. But we were able to pass on this information because we had some good funding and we, we were really interested. Could these, I mean, if these two agree, if these two independent estimates agree then you can say, I really am confident that this is the number, plus it also says the basic process of how the eggs are formed is, is what I think it is. Because they would have to agree for that to be true. And so we passed that information on to the modeler who really kind of takes a, he takes like a point estimate and creates a bell curve around it based on your variability. It seems like I working and working on it with, you know, up to four other people for a year and, maybe not every day, but, and then this guy says, "okay, I'll take that, you know, 320,000 and put a bell distribution around there and we'll fit it in the model". You're kind of like, okay, all right.

But that was very important to them, because the, they wanted to make sure that that was a defendable number and so that was, that went right into that model and I understand that that's going to be very helpful because there's a lot of FERC [Federal Energy Regulatory Commission] relicensing issues on the Connecticut River and that's the model they'll use. So in a sense we, we did get to go forward with that. And that's really turned my attention to, perhaps where I want to go next, is this idea of - well, shad spawn from Florida to Canada, and when they're doing that, they have a very narrow temperature range that they spawn at, it's like sixteen to twenty degrees Faren-- uh, Celsius. And so what they have to do, is that to spawn earlier in Florida when the temperatures are that range, and--

JW: Yeah, I was going to ask, is it ever that cool in Florida? Or--

RM: Well, water-wise, yeah. No, no, actually it gets cool in the winter, hot in the summer.

JW: I just think of the water there as being warm all the time.

RM: Well, this is the river water too.

JW: Okay.

RM: And, um, and so then they progressively spawn later. So they spawn as early as January in Florida, and they spawn as late as, as July or even August in Canada. So this is, fits into this idea of wide-ranging fishes. And what we've found is one of the ways that the fish do this is they change their pattern of how they recruit their yoked eggs. And so there's this thing that, there's actually the most fundamental process of ovagenesis is flexible enough to allow this kind of, this, this adaptation to occur. And these are known to be, actually, genetic adaptations that, you know, it actually supports the idea of natal homing. You home to the river you were spawned in because your life history traits are all, are all set to take advantage of that.

JW: Right.

RM: It doesn't make sense for you to be a repeat spawner and go to Florida if you're not going to be able to make the migration back out of the spawning run, you know, so you go back, if not exact river, I mean they're strained, you go back to the same state, that kind of thing. And so I think this is really where I want to go next, is explore this, how do wide-ranging fishes do it? You know, so when I went to Sicily in April, we picked horse mackerel, which is distributed from the Mediterranean up to the North Sea. You know, same kind of thing. It's one species--

JW: Is that, is that a, is that the blue fin tuna? Or is that another, uh--

RM: Horse mackerel is *Trachurus trachurus*, it's a--

JW: Oh, okay.

RM: --a Jack, it's a carangidae, it's like--

JW: Oh that's interesting.

RM: --it's a little bit bigger, it's a lot like a blue runner kind of thing

JW: Okay. I've only ever heard the term, actually, used, I think, in the late 19th century, as a, as a, sort of casual name for blue fin tuna. I know it's been--

RM: Oh, okay, well those--

JW: I think it applies also to--

RM: --kinds of names float around--

JW: Yeah.

RM: Yeah this--

JW: Bluefish too.

RM: Horse mackerel does not occur--

JW: So I was just wondering.

RM: --in the, uh, western Atlantic. It's an eastern Atlantic species.

JW: Okay.

RM: But over here we have *Trachurus lathami*, which is what, very similar, but like I said, it's more like blue runner. Blue runner is *crysos*, uh, *Caranx crysos*, you know, it's just kind of a small, you know, not completely baitfish, but um, and, kind of like [unintelligible] or, what's [unintelligible] um, I forget the common name for that. Saylar, crumthum, thallus [phonetic spellings]. Anyway, I'm, I'm going back to my baitfish days. But, anyway, we, when I went over to Sicily and saw, so I completed the international exchange with the Sicilians, Walter Bossoloni [sp?] and Rosella Ferrere [sp?] , we worked on horse mackerel.

And so I've been thinking more about this, like, okay, you know, fish are responding to climate change by moving, but not all fish are going to be able to move, or they're not going to be able to move rapidly enough. So we really ought to be looking at these fish that actually have figured out that they don't have to move. Now they often are defined, like, like essentially, American shad could be viewed as every river is reproductively isolated stock. And in horse mackerel there's three stocks in the Atlantic and three stocks in the Mediterranean. I mean, so they basically don't completely intermingle; they have these like little subunits that kind of have adaptations, have adapted to that climate. But in the south, in the Mediterranean, they don't get as big and they spawn at a much smaller size. So--

JW: So the horse mackerel aren't anadromous, right?

RM: No, no, they're entirely marine.

JW: Okay.

RM: So they, and but the American shad also are smaller, you know, reproduce earlier and don't live as long and get as big. So one of the good news is fish can probably adapt to climate change. But will they adapt into something that we actually want to fish for? Maybe not. So this is a direction--

JW: Something to ponder over.

RM: --this is a direction I'm going to go in.

JW: Well let's see here. So, I think we've covered just about everything that was on my list of--

RM: Good.

JW: --of questions here.

RM: I've brought you from birth to where I'm going next. How's that? [laughs]

JW: You did. It's a long trajectory. Well, we certainly focused on what you've been doing for, for work and research prior to joining the branch here. And sort of the state of things when you arrived at the branch. Well, I, I guess we can probably let it rest there, and, you know, we can always do a follow-up interview if you find that you have things that have been unsaid now that we'd like to return to.

RM: It's pretty free form.

JW: Unless you wanted to comment on any other changes in, in science, in reproduction biology over the last couple of decades or--

RM: I'll probably make a couple of comments about the branch, for historical purposes.

JW: Sure.

RM: The Population Biology Branch is in the data division, which has recently been going through reorganization. It was called FEMAD, Fisheries Ecosystems Monitoring Analysis Division and they're taking the observer, or they're taking the Fishery Sampling Branch, the observer program, out, putting it in its' own division. We're going to become PEMAD, Population and Ecosystem Monitoring Analysis Division. So I'm going, so we're making that change right now. Wendy Gabriel is the Division Chief, and it'll be two divisions, two branches there, Population Biology Branch, which I'm the Chief of, and then Ecosystem Survey Branch, which Rob Johnston is the Chief of. And so, you know, like I said, he, he will operate, you know, a fishery sampling program on any number of boats, you know. The *Sharp,* the *R/V Sharp* for the scallops or the *Bigelow* for the groundfish survey, and we're taking a lot of samples from wherever we can get them.

And so three programs, there's the Population, there's the Fishery Biology Program which has traditionally been doing age, uh, and reproduction of teleosts, or the bony fishes, and then there's an Apex Predators Program that does pretty much all things elasmobranchs, mostly sharks, age, growth, reproduction, feeding, movements, and they're located in Narragansett. And then there's a food web, uh, food habits, what's called the Food Web Dynamics Program, and they take, from the groundfish survey, all the stomach contents, the prey identifications that are done on the groundfish survey, and put that into a database. And so each of these programs have, you know, they're housing, they have large, they're, they're entering data into Enterprise, the Oracle tables, and these, are accessible to, certainly within the Center, primarily the Population Dynamics Branch, for the bony fishes.

The shark work is done out of the Southeast through the SEDAR process, South East Data Assessment Review, whereas the northern species are the SAW/SARC [Stock Assessment Workshop/Stock Assessment Review Committee], and the TRAC [Transboundary Resources

Assessment Committee] , or special things like that. So, really, we're, we're trying to create data streams. And we're trying to feed the machine, whether it, traditionally the single species population models, primarily through the tens of thousands of ages that we produce, or the maturity estimates that we can help to define spawning stock or mature stock biomass. And they go on to these mathematical models. But we're also, the Food Web Dynamics Program is trying to feed the monstrous data requirements for multi-species and ecosystem models. So that's where the branch is today. And I thought it might be nice to comment on some, I mean, for historical purposes--

JW: Absolutely.

RM: --where it is. Yeah.

JW: Great. Well, thank you very much for giving such a rich interview, Rich, today.

RM: Okay. Thank you, Josh.