February 06, 2017, oc020617.mp3
Sex in the Sea- Strategies from the Sea!
Jennifer Stock, Marah J. Hardt

Jennifer Stock: You're listening to Ocean Currents, a podcast brought to you by NOAA's Cordell Bank National Marine Sanctuary. This show was originally broadcast on KWMR in Point Reyes Station, California. Thanks for listening!

(Music Plays)

Jennifer Stock: Welcome to another edition of Ocean Currents, I'm your host, Jennifer Stock. On this show we talk with scientists, educators, explorers, policy makers, ocean enthusiasts, authors, and more, all uncovering and learning about the mysterious and vital part of our planet: the blue ocean.

I bring this show to you monthly from NOAA's Cordell Bank National Marine Sanctuary, one of four National Marine Sanctuaries in California, all working to protect unique and biologically diverse ecosystems. Just off the shore of the KWMR listening area on the West Marin coast are the Greater Farallones National Marine Sanctuary and Cordell Bank National Marine Sanctuary, which together protect 4,881 square miles.

So next week is Valentine's day, where we celebrate love, and for animals in the ocean every day is Valentine's it seems, or is it? Without sex, or joining of Gametes in the ocean, there would be no ocean life today. We talk a lot on this show about ocean conditions, threats, habitats, ecosystem integrity, uses of the ocean and more, but what it really comes down to everyday is the ability for animals to GET IT ON, and sadly humans are acting as birth control. Author Marah Hardt took this topic on with her book Sex in the Sea, Our Intimate Connection with Sex Changing Fish, Romantic Lobsters, Kinky Squid, and other Salty Erotica of the Deep. Marah is a creative writer and storyteller, a scientist, and works at the crossroads of research, creative communication and strategy, to build a sustainable future for people and the sea. She currently works as the research director for a non-profit systems change incubator called; "The Future of Fish." When we come back, we'll dive into the book, and hear some of these salty tales.

(Music Plays)

Jennifer Stock: I'm so thrilled to welcome Marah Hardt on the air, by telephone. So Marah, thank you for joining us, you're live on KWMR

Marah Hardt: Thanks so much for having me.

Jennifer Stock: How did you get into the creative urge to research this topic and write this book?

Marah Hardt: [Laughs] Well it occurred to me during graduate school actually, I was looking for a way that I could write about all the issues that were threatening ocean ecosystems. You know, oceans are faced with a lot of different problems these days but most folks don't know about it or aren't really aware of what's going on,

and at the same time people don't wanna just hear the bad news stories, the doom and gloom isn't very motivating. So I was looking for a way that I could talk about the ocean that would inspire folks and motivate, and also capture the interest of folks from all sorts of different backgrounds, so, the business community, and the science community, the policy community, artists, you know we need all different minds to help us figure out the solutions to how we're gonna create sustainable seas. So I thought, what's fun, what's interesting, and I was at a cocktail party one night and I was talking with some friends, and the long story short is [Laughs] I wound up making a comment, we were bemoaning how women and men don't understand one another, and I sort of offhand made this comment, that "Agh, if only we could be like parrot fish." And, everybody sort of stopped and was like "What are you talking about?" and I said "Oh you know, parrotfish are sex changers, so an individual starts life as a female, and as they grow they change into a male." and so everybody was sitting there, and they were still listening, and they wanted to know more. So I'm at this party, and I'm having this pretty lengthy discussion about sex change, and how it affects Fishery management, because if you imagine, the rules allow us to take the biggest fish, and fisheries target those biggest fish, those in a sex change population are males, and that's not good for sustainability. So, I have this conversation and everybody's really engaged, and I went home that night and I thought, "that's it! Sex! Everybody's curious about sex, and the oceans have really weird sex, and sex is the heart of sustainability. We can't have future generations of fish and clams and whales if we don't have successful sex in the sea." So that's kind of where it all started.

Jennifer Stock: I love the conversation change from science to sex, because it really comes down to the science of sex to talk about the sustainability for these populations, it's great. It's so fun to read, I have to say you are an amazing storyteller, I have held myself laughing during this book, and it was really quite enjoyable. So I want to start talking about, the ocean is three quarters of our earth's planet, there are some species that are near each other and in close proximity, and there's others that are pretty far away, what are some of the strategies for animals that are finding each other, thinking about whales for example.

Marah Hardt: Oh sure, so, it's true, it's quite a challenge, if we thought it was hard to find a date here on land, imagine in the ocean where you have three dimensions, right? So it's not just that animals have to know in front or behind, or right or left, they also have to know who's above or below them, and be able to identify that there's a mate in all that space, it's really tricky. But you mentioned whales, and whales use sound, so sound is really a wonderful way to communicate long distances in the ocean, it travels through water much more effectively than it does on land, or through the air. We know now through putting out hydrophones, which are listening stations in the sea, we are able to know that whales off of cape cod can communicate with whales off of Bermuda, or for you folks out on the west coast, the entire west coast of the US, imagine a whale can kind of, they can sing to one

another. So, it works really really well, and one thing that's been really neat to see, over the last several decades, is the communication likely to find mates happening in blue whales, so Blue whales were hit pretty hard during the era of whaling, some of their populations were reduced by over 90%. So there were very few blue whales left in the sea, and at that point, around the 1960's or so, the males (who are the ones who sing) weren't being too selective with who they were mating with, they just wanted to find another blue whale female [laughs] hopefully, to be able to seal the deal. So they would call as loud as possible, and that happens at sort of a medium frequency, so it was really a loud call just kind of shouting out to try to figure out how they can find another female out there in the ocean. So, they're calling and calling, but over time, once the whaling ban came into play, they were able to recover their numbers, and scientists have noticed that in the past decade or so, the song of the Blue Whale has gotten deeper, so I can't do a very good Barry White, but imagine, you know, they're "lower in their tone." [laughs] They're singing at this real deep bass, and the reason we think is that, all across the animal kingdom, whether you are a koala, or a human being, a deeper male sound is sexier for a female. And this goes back to the evolutionary roots where, we find that a bigger male can make a deeper voice, it's just the physics of having a louder sort of chest volume, so you can get a lower resonating voice. And bigger tended to be better in terms of finding a mate who can defend your territory, or defend your kids, or whatever… secure resources, the females are attracted to these lower voices. So, what we think is happening with these blue whales is that now that they don't have to shout quite as far, because there's more blue whales in the ocean, they are now starting to, the males are starting to compete and advertise their size and stature to the females around them by lowering their calls, and this means that the calls aren't traveling quite as far, but they're providing information to encourage that female to come a little closer and check them out. So it's a really neat example, in this case, of how we can see a shift in sex in the sea, in terms of this deeper voice, that's a positive sign, because we've stopped the whaling, and their numbers are likely coming back.

Jennifer Stock: And other whales are also using sound to hear their mates as well, aren't they? Humpbacks and also sperm whales?

Marah Hardt: Mhm.

Jennifer Stock: I guess all whales right?

Marah Hardt: Yeah, many whales, we find that the males are the ones that tend to sing these more complex songs, but in a lot of cases yes, they're all using different kinds of sound to communicate, and it's really how they navigate their world. And one of the consequences of that is, nowadays the oceans are a lot louder than they used to be because of our ship traffic and oiling gas exploration, and naval exercises, the sonar that the navy uses, and all of that sound has really created a cacophony in the ocean that makes it much harder for these marine mammals to hear their

fellow species. So, it's kind of, if you imagine trying to go to a party where you're looking for a date, or a singles bar and there's a ton of fog, that kind of roles in, and we can't see as many individuals. That's what we're doing through muffling the sound that these animals are creating in the ocean, so we really could be restricting how far they can hear one another, which restricts which mates they're able to come into contact with and pursue for reproduction. So that's one of the negative consequences that's happened because these animals are so reliant on sound, and because we've put so much sound, some folks call it sound pollution, in the ocean.

Jennifer Stock: So whales are some of the, well, they are the largest in the ocean, and obviously, can hear, and so they're able to communicate over large distances, but how about for some smaller species. I loved the part where you wrote about copepods, these small little zooplankton, and we have copepods here on the west coast, they're a real big part of the food web for nutrition for larger species. I'm just, part of me was, I'd love for you to talk about it and explain to everybody, but also how do we know all of this about copepods and this tiny little animal and how they reproduce? I'd love to hear about the research behind it, how we know these things.

Marah Hardt: Yeah sure! So I'm so glad you brought them up because I really tried in the book to not just focus on the big charismatic megafauna, right? And copepods are, as you said, a really critical link in the ocean food chain, for folks who don't know, they're a tiny crustacean, many can be smaller we can see with the eye, to about the size of your thumb nail. And so, trying to find a mate in the ocean when you're that small is a huge challenge, but then you add onto it that for some copepods, the males only live for about a year, it makes the challenge even bigger, right? Because you've got a time clock now ticking. And so, one of the ways they do this, was described at first to me by a professor at Scripps Institution of Oceanography named Peter Frank, it was actually during my intro biological oceanography course, [laughs] and he refers to the copepods getting together in an area of the ocean that he calls "Copepod singles bars." And, these are, areas of the ocean, so instead of thinking of the ocean like a giant pool, it's really much more like a layer cake, where we have layers of water that have different densities, due to either different temperatures, so warm and cold layers, or sometimes different salinities, so fresher or saltier layers. And where these layers stack on top of each other, there's a boundary, there's sort of a little bit of a thickness, and it can vary how thick it is, but a few centimeters. And it tends to be very still there, because the water in the layer below and the water in the layer above, doesn't tend to like to mix across that boundary, unless you get y'know, strong wave action or storms or things like that that really churn it up. So you have this very still, sort of, strip in between these layers that is a very distinct sort of chemistry and temperature, and copepods are extremely sensitive to this, they can feel their environment very very well, they're covered with these little hairs, and they can really tell the difference in temperature, or the difference in salinities. And so they, as they

move throughout the water column, they kinda move up and down at different depths, and then they'll hit one of these boundary layers, and they tend to stay there. It's a very distinct piece of real estate in the ocean, and by honing in on this sort of thin section, it means that many copepods can gather up in a small area, which increases their density. So that helps them to increase the chance that they're going to bump into one another. The other thing is that copepods leave trails, so when you're as small as a copepod, the ocean feels more like molasses than it does water, so they're actually kind of pushing through this thick fluid. And as they do that, they leave little wakes, little trails, behind them, and these trails can be sensed by other copepods that come across them. So, in wonderful experiments, you're asking how this is done, in wonderful experiments by a researcher named Janet Yen, she has looked at copepods in the lab under a microscope, and often she'll use, I believe it's sugar water, that they're swimming through, and she has special filters to be able to see these trails, and you can see a male coming in, swimming along, and he'll cross the trail of a female, and he just immediately starts spinning, literally doing somersaults, in a zig-zag fashion, until he can hone in on which direction that trail was left, they can figure out by how strong the trail is. Some females also will scent their trail, so they leave a little pheromone in there, so it's like a little perfume corridor that the male can follow. And because this is in these boundary layers, where there's very little water movement, the trails tend to last a little longer, so that also helps the males be able to hone in one where the females are. So you've got a thin layer where the copepods can congregate, which ups their density and ups the chance that they'll bump into each other, and then you have the stillness in that area so that the trails they leave are left a little bit longer, which again increases the chance that a male can come across one, and find his way to the female.

Jennifer Stock: And do they actually mate?

Marah Hardt: Oh yes! They do. They mate, right on top of each other, it's actually an internal fertilization, the male will deposit his sperm up inside the female into to her little, sort of receptacle area that she has. And, they can have quite a vigorous, sort of, mating dance if you will, often times the male will sort of jump onto the female, and she, in some species, she will really shake quite violently, it's like trying to ride a bucking bronco for him. And we're not really sure why she does this, we don't know whether it's to test his strength, and make sure he's fit enough, and therefore it's a way for her to select a better mate, or whether she really isn't interested, and just does not want the mating to happen. But, if he holds on enough, they actually have two different, a right and a left appendage that they can slip the sperm in, and the female has two openings, so he has to align with the side that is available, cause if she has mated previously, in some cases one of her sides will be full already with a sperm pack, and the male won't be able to get in there, and have to use his other appendage. So there's a little coordination that needs to happen, but it is a very intimate, close contact reproductive act.

February 06, 2017, oc020617.mp3
Sex in the Sea- Strategies from the Sea!
Jennifer Stock, Marah J. Hardt

Jennifer Stock: That's Amazing! This is ocean currents, and my guest today is Marah Hardt; author of Sex in the Sea, and we're talking about copepod sex right now, and copepods are crustaceans, and you write about another crustacean that is just fascinating, and very seductive. The lobster, very elaborate, kinky and romantic, and I was wondering if you could talk about the lobster, and I wanted to know, is it east coast lobsters and west coast lobsters, the whole species as a whole? Just as a side question there?

Marah Hardt: So, to answer that first, so everyone can picture this, the studies that were done and the observations that we know of the ritual I'm about to describe, were all done in Maine lobsters, so these are the big ones, the ones with the big claws that we tend to put on the bib and dive into. So, I've been asked and I haven't yet found a good answer, but as far as I know, and I need to dig a little more, but as far as I know we really don't know if this translates for the other species, it's possible, but we're not sure if they go through the same kind of courtship. And part of that's because, as I'll describe, the Maine lobsters have a really amazing capacity to be able to individually recognize one another, and that's really important. And that means not just recognizing a female of the same species, but the unique individual female, and this is all done through scent, so again through pheromones. So what happens in lobsters, which, it is, it's totally kinky, and then it's really romantic, so they kinda mix it up, but, the best time for lobsters to mate is right after the female has molted, and the reason for this is that, once she molts, and her old shell comes off, she discards a sperm pouch, or sperm receptacle, which is located on the underside of her tail on this *audio cuts* so once she has molted, she has a fresh new empty sperm receptacle, so the female, she wants to fill this as soon as possible so that she can *audio cuts* that sperm store *audio cuts* he wants to be the first one to mate with her so that he can fill up that entire receptacle, and not have to be worried that his sperm is mixing with another males sperm that maybe had mated with her previously, so for both of them it's advantageous. The problem is for the female, right after she's molted, cause she's extremely vulnerable, and the male is a total brute, during reproductive season, males are really battling it out for territory *audio cuts* dens or shelters that they live in and mate in, and *audio cuts* anybody else that comes near including females, so it's not just male on male, so she, a female is faced with the predicament, where she has to present herself, in her most vulnerable state, to this really aggressive, large clawed male *audio cuts* so what she does, is, she approaches her den, and kind of goes up to the front of the den, and in lobsters right by their brains, there's two little sort of nozzles, just below their eye stock, and they can squirt urine, out of their nozzles, so she goes up to his den, and she literally shoots pee onto his doorstep, and then runs out of there as fast as she can, before he can retaliate.

Jennifer Stock: It sounds so teenager-like!

Marah Hardt: I know, it's, yeah I mean, a urine stream is not normally what we think of as being the most seductive. But what it does is, by about the third or fourth day, when

she's doing this, the male sort of starts to transform, it's like a love potion, and it takes this effect of really calming him down, and turning him from an aggressive to a much more recessive state. And he'll wind up welcoming her into his den, and she will live with him for another week, and they'll go out and they'll hunt, and they'll sort of just hangout side by side in this den. So, it's a very powerful pee love potion, and once it's taken hold, and she's been able to move in, they sort of just hangout for the week, and then right before she's about to molt, she circles around in front of him, and he sort of puts his big claws out to the side, and almost bow his head down, and she takes her big claw, and she will tap him on one shoulder, and then the other. And the researcher who studied this, doctor Jelle Atema, called this knighting, and this behavior really sort of does look like she's coming down and knighting him, and we think it's a signal to the male, from the female that says; "this is all about to happen, don't go anywhere." So she goes to the back of the den, and proceeds to molt, and the male at this point actually goes to the back of the den, and he sort of stands guard over her, and he takes his little walking legs, which is where in lobsters their taste receptors are, so basically they have taste buds on their feet, and so he rubs her with his legs, so it's almost like he's licking her [laughing] which is pretty interesting. And he sort of strokes her with his antenna, and it's all very gentle and sort of this sweet caressing going on. After she's shed her shell, I think that, it probably takes about a half an hour, and she, she really, she can't even stand up, she can't support her own weight but she sort of signals to him that she's ready. And he comes around behind her, and again he braces himself, putting his big claws down into the sea floor, and then his tail down, and then he uses his walking legs to sort of scoop her up. So if you imagine, she's sort of laying in the hammock of his legs, and he rolls her over, so that they're belly to belly, and in that missionary position he then inserts his appendages into her, and deposits the sperm into the sperm receptacle at the base of her tail. So, the actual mating is a very traditional [laughs] position, he then lays her back down on the seafloor, and walks away to the front of the den. She will take about 3-4 days for her new shell to harden, and she will stay at the back of the den for that time, and he basically guards the den, which provides her protection, when she is this soft bodied creature. As soon as she's ready, and her shell is hard, she leaves, taking this sperm store with her, and she will go off and fertilize several batches of eggs with it, over the next few months. He then, umm, will be doused with more urine from the next female, who's been waiting [both laughing] Because in this species they call it serial monogamy, so they're very faithful for that two week period, and then they're like "Ok next one in." Kind of a rotating door.

Jennifer Stock: Amazing

Marah Hardt: And that's it, yeah, it's pretty neat, and again, a lot of that work was done by professor Atema, and it was done through experiments in the lab and observations out in the field.

Jennifer Stock: And I can see where knowledge like that is really important for understanding how to manage that as a fishery, lobster being such a popular seafood, and having a better understanding of harvest times, and the amount that can be harvested. Has that been part of the fishery management plan in terms of just understanding reproduction for lobsters?

Marah Hardt: Yeah absolutely, so, especially at the name, it's a really impressive tradition that goes way way back, I think to the early 1900's, where any female, any gravid female with eggs, was put back into the water, so there was no take at all on females that were carrying egg, and they were notched, they would make a little notch in their tail so that other fisherman would know overtime, that this female was one that had been returned, and they should return it too. And some folks really credit that practice to the reason why the Maine lobster fishery is doing as well as it is today, one of the other things, besides understand, how often they reproduce, and the way they reproduce, one of the things we learn, is the importance of that chemistry. So these lobsters, like I said, can identify individuals, and that individual recognition is critical for them to be able to have successful reproduction, especially for the female right? If she's not recognized she's in trouble. And we know the receptors on the lobsters, to be able to receive this chemical pheromone signal and respond to it and understand it, is really sensitive, and some concern has been raised recently that with ocean acidification, which is the result of climate change, communities climate change putting so much carbon dioxide in the atmosphere that gets absorbed by the ocean, that changing pH that's going on, might affect the ability of the receptors to work correctly, or it could actually change the signal itself. So if you imagine this pheromone is floating through the water, it is reacting to the chemistry of the sea water as well. And it might be that these signals just get a bit scrambled and aren't as clear, we don't know, but it's a concern, because it's such a fine tuned chemistry based stem for that communication.

Jennifer Stock: Thanks for that elaborate description of both of those and the changes we might be experiencing with ocean acidification. I know there's many more stories about that with potential changes in many species communicating with each other or smelling each other. We need to take a short break so I'm just gonna put you on hold and I'd love to come back and keep talking, we're at ocean currents here and my guest is Marah Hardt, author of Sex in the Sea. So Marah please stay on the line, we'll be right back.

Marah Hardt: You Bet!

(music plays)

Jennifer Stock: You are tuned here to ocean currents on KWMR radio, community radio for West Marin, and here today on the show we're talking about Sex in the Sea with author Marah Hardt, she has written this fantastic book, Sex in the Sea, Our Intimate Connection with Sex Changing Fish, Romantic Lobsters, Kinky Squid, and other

Salty Erotica of the Deep. And we're hearing some great stories here, so Marah welcome back thanks for staying with us, you're live on the air.

Marah Hardt: Thank you! I love the music you're playing.

Jennifer Stock: I know! It's so fun! Well I have to say I was very inspired because, I forgot to mention to listeners, but Marah provides a playlist for each chapter of this book, and I love it, there's the "Sex Sea Soundtrack" and there's all these songs listed, it was just awesome. So thank you for that inspiration, I though "Agh, I gotta play some extra music during this show!" So I wanted to talk a little bit about sex change in the sea, because I used to just think it was a couple animals, and then obviously after reading your book, it's so much more common, as a strategy, and I'm kind of curious why, and from the slipper shell story, to oysters, and some of the fish in the sea, it's just a fascinating thing and I'm kind of curious as to why?

Marah Hardt: That's a great question cause it takes a lot of energy right, to start with one sex and then be able to sort of transition all your equipment to be the other sex, it's not an easy or cheap, in terms of energy, thing to do it's all about maximizing reproductive output right? So it's all about making sure you are you are trying to put out as many offspring as possible and in many invertebrates, so like you said oysters and shrimp and many fish species they are able to take advantage of the ability to sex change in ways that we don't see in mammals for example. But the type of sex change that they do and the reason for doing it depends on the strategy of the species so for example if we look at a species like parrot fish and I mentioned this at the beginning of our story, they transition from female to male and the reason for this is that parrot fish, some species keep harems, so you need to be a dominant male who's big enough and tough enough to defend either a territory where the females want to hang out, or just to be able to ward off other males from coming into your region where your females are so that takes some size and girth, so if you imagine if they could not exchange it would mean that fish born as males but has to wait quite a long time before they were able to reproduce in order to grow big enough that they would be able to defend this Harem, so there's a lot of lost opportunity there cause it might be sexually mature but just not big enough, instead because they're sex changers they're all born as females and as a small female they are still able to reproduce with the big males and then once they are big enough to either challenge their male or go off and secure their own harem, then they transition to that male sex. So it allows them to reproduce much more in terms of overtime much more than they would if they couldn't, and we see a great contrast and if you think about on your on the coast there in California right now is prime elephant seal mating time, actually they tend to mate right on Valentine's Day these are the northern elephant seals, and they don't sex change, and what we see is that very few males are able to reproduce because these males also control Harems of females and the big males have been battling for the past 2 months to defend that territory in the right of access to these females, and so, I think it's less than like 1 or 2 percent of males ever get to mate at all, because of the need to be so big and burly, where as the

parrot fish get around that but just going through a sex change, so it's a great solution for that reason. The sex change that works the other direction, like we see say in clown fish, where the individuals are born as male and transition into large female, there are several reasons for this but one of them is that unlike mammals where a female is born with all the eggs she will ever have so as humans we are we females are born with the total maximum number of eggs that we have and that number goes down over our lifetime, in fish that's not the case as long as the fish is healthy female who grows bigger can hold a manufacturer more eggs, and this can be exponential, so a fish doubled in size can sometimes carry 10 times more eggs ,and we call these big females "BOF," the big old fat fecund female fish and they're really important for the reproductive success of the population, and in sex changing fish, they can take advantage of this in the sense that a small male has enough sperm to fertilize a lot of eggs, as many eggs is a female can carry, even a big female, but a big male might have too much sperm for a smaller female, it gets a little complicated but if you, it works much better, especially for fish that pair up, for that pair to maximize its offspring by having the biggest individual be the female cause then she can make a lot of eggs and the smaller male is still able to produce enough sperm to fertilize all those eggs.

Jennifer Stock: So I understand, and it's interesting how it goes both ways there, I understand Pixar got it all wrong with Finding Nemo and Nemo's dad should have really had a different name by the time…

Marah Hardt: It's true!

Jennifer Stock: ...his little Nemo hatched out there.

Marah Hardt: It's really true so again like I said with clownfish sex change work with male transitions into a female and so in Nemo when, when his mom got eaten by that barracuda, his dad would have been the largest fish left in the anemone so his dad would have actually transition to his mom and Nemo would have wound up meeting with his father turned mother, so you can see why Disney took some creative license there in order to keep things at G-rated I think.

Jennifer Stock: Yeah, got it. Now the slipper shells, the stacking thing, I found that really fascinating, so you were talking about how they stack on top of each other and each time one lands on top of them like they can sex when they land on a slipper shell and then when another slipper shell lands on top of them they change sex again, right? is that how it works?

Marah Hardt: Yeah? This is what's happening, you see this in in a couple of different animals, it's really fascinating, so slipper shells, they're pretty sedentary so they attach onto a hard substrate on the bottom, a rock or a pier piling or something like that, and then they tend to stay there, they don't move very much, they really kind of glue down, they use their foot to do that. And to the first slipper shell to arrive to a new area will transition to be female, they sort of start off as this juvenile with a little

bit of a male kind of tendency and the first ones to arrive sort of blow right through that male stage and go immediately to female, and start sending out pheromones to attract other slipper shells, those slipper shell larvae will come in and land on her back, onto the shell, and they sink through some of the chemical that the females putting out it sort of stunts the transition of these new arrivals so that they get stuck in the male stage basically, they don't continue on to become females, they stay males. And they have a very long penis but they can actually reach out from under their shell, and reach down and up and under the female who's on the bottom to inseminate her and fertilize her eggs until you wind up with this Tower where there's a big female on bottom and then there's more and more and more of these stacked males and the ones that are farther up, you know, if you're the fifth or sixth male on top, you've got a really long distance, to be able to reach that female right? And what happened as a tower grows, at some point the males are just too far to reach the female, at that point, the second shell, the first male, transitions to female, so then the tower doesn't have to reach quite as far, right? Cause now they've got two females on top, stacked on top, and then the males go above, so it's this really cool system where there's sort of adjusting which sex and whose changing sex to make sure that sort of as a whole the group can continue to fertilize eggs and pump out as many offspring as possible.

Jennifer Stock: That's wild, that's so amazing!

Marah Hardt: Yeah, it's really really neat.

Jennifer Stock: Let's talk about different strategies, so, y'know there's a lot of species that just do a lot of spawning, and hope their larvae meet each other in the water column, and there's mobile invertebrates that do this, there are sessile invertebrates that do this, and fishes, and fish aggregations, horseshoe crabs, I think you refer to this as "oceanic orgies"

Marah Hardt: Haha, yep.

Jennifer Stock: What's your favorite one to talk about, in terms of the mass spawning events and the timing of them?

Marah Hardt: It's always a toss up, probably a toss up between, like the Nassau grouper, and groupers in general or coral, so we can do a mobile example, and then…

Jennifer Stock: Yeah! Let's do both!

Marah Hardt: Yeah? Ok, so what I love about the Nassau grouper, so again, all of these animals, unlike whales and sharks, and the copepods even, where the fertilization happens inside the female, so sperm is deposited in the female and eggs are fertilized inside the body, for many, many species of marine life, the eggs and sperm are released into the water, like you said, so it's external fertilization, so this is where I say "sex is like and out of body experience" [both laugh] and the challenge

there, if you imagine, oceans are pretty dynamic spaces, and you have to make sure that the sperm and eggs are going to collide and meet, and currents and things can make that very difficult, as well as distance. So what I love about the Nassau Grouper is it's a wonderful example of how fish come together to maximize the chance of fertilization and successful reproduction. So, Nassau Grouper are beautiful sort of camouflage color fish that live on Caribbean reef, they are currently endangered, they have been overfished quite a lot and it relates to their reproductive strategy, so we'll get to that. But they're also very territorial, very aggressive fish, so they live by themselves on the reef, except for right now actually. So the full moons of January and February, these fish, they change their coloration, so they sort of dawn this dark back and light bottom, so it's a really distinct coloration compared to their normal camo pattern. And they swim out to the edge of the reef, sort of in this new bicolor outfit, and they wait and watch for other Nassau Groupers who are swimming down the reef, and they join in. So they think that this change in coloration, first of all is a signal to the other fish, that "Hey yeah I'm joining the party, I'm friendly, I'm not gonna, y'know, attack you, we're all in this together." So they have this wonderful coloration change, and then they form these caravans basically, where all the adult fish from around the reef leave their territories and stream together, and they all hone in to one specific spot on the reef, and in the Cayman islands, which is where the largest aggregation still occurs, they go to the southern tip of one of the islands. And its timed perfectly with the full moon, so they're arriving right in sync with the full moon to a few days after, and they hangout in this giant school that amasses, and researchers who have tagged these fish put little pingers in them that give off a sound signal, and they put hydrophones, again listening stations, all around the island. So they've actually been able to map where these adults are moving pretty exactly, and the researchers that are doing this, it's part of the group removal project, which is jointly run by a professor named Bryce Simmons at Scripps institution of oceanography, as well as Reef.org. So it's a really really neat project, and they've been able to monitor where these fish go, and they've found that literally every fish from the island goes to this one spot, so it is the entire breeding population of the island, in this one tight, tiny area of ocean. What that does is it allows all these fish to get together and get in sync, and come sunset, as the light dims, they tend to get really excited, and they will start to go off into these group bursts, and the female will lead the charge, she rockets up into the water column, and the male will sort of follow behind her, and she does this big arc, and as she reaches the top of the arc, she lets loose this cloud of milky white eggs, and then the males come in and *poof* off all their sperm. So it looks like these erupting geysers or mini volcanoes that are shooting off out of this dense pack of thousands and thousands of fish, and they repeat this for about up to an hour, and then sort of it gets dark, quiet down, and they just sort of hangout until the next sunset. So it's a really cool, amazingly beautiful thing to watch, and a very tight synchronization that helps make sure that the sperm are being released right into these clouds of eggs so that the likelihood that the sperm are gonna find and connect with eggs is increased. The challenge is that, the predictability that

the fish use to time these aggregations, and to know where to go, is also something that fishers have used to fish the fish. So you have all of these large adults in one place, they're normally scattered and hard to find, but at this one time of year they're all together, it makes for really easy fishing, and over the years, we have sequentially wiped out spawning aggregation after spawning aggregation. It's not just Nassau Groupers, who do this, many species of Groupers do it, Snappers do it, and it really has led to some serious problems in terms of management because it's really hard to tell that you're making as big of an impact as you are, because there are so many fish in this one dense location that it seems like you could fish half of them out and they'd be fine, it seems like there are still a lot of fish left, but that's not the case.

Jennifer Stock: I'm sorry to interrupt, cause we're getting close to the top of the hour, we have to wrap it up in a few minutes, I wanted you to share your personal blog that you keep as well as the website for the future of fish that you work for so people can dive in and learn a lot more, cause your resources online are fantastic, so, would you mind sharing those?

Marah Hardt: Sure! so for more on sex in the sea you can just go to sexinthesea.org , and there I have resources for folks who are interested in learning more, I have a blog, I also have for anyone who's a science teacher or professor out there, ways that you can use sex in the sea in the classroom, so I would love for folks to check it out, and you can get in touch with me through the website as well if you have any questions. And then for those who are interested in more about future of fish and our work to help develop fisheries, into sustainable long lasting resources for people and the sea, go to futureoffish.org

Jennifer Stock: Marah thank you so much! I'm sorry to cut you off while you're getting ready to talk about your favorite species, I just really want to thank you so much for writing such a wonderful book, and as an ocean educator I find myself taking notes of some great things that you're talking about, that I'll be sure to use as I continue with education, so thank you so much and thanks for coming onto ocean currents today.

Marah Hardt: Aww, thanks so much for having me and thanks so much for all you do to share all these wonderful stories of the sea with such a wide audience, it's really fantastic.

Jennifer Stock: Thank you, have a great afternoon!

Marah Hardt: Thanks! Take Care!

Jennifer Stock: We're just at the top of the hour and about to end the show, and it's such a shame, because there are so many more stories that Marah has, and I just can't even tell you how funny they are, you have to read the book "Sex in the Sea." Ocean Currents is the first Monday of every month, one to two p.m., we have a podcast,

you can go to iTunes to get that for ten years of programs at this point, and they're all also archived at the Cordellbank.noaa.gov website, as well as transcripts! And ocean currents has a twitter feed, you can follow along @oceankwmr to get more information about this program, and I'll be sharing supporting links of information that was shared on the program out there as well, I love hearing from listeners so if you have ideas for topics, questions, comments, please email me at cornellbank@noaa.gov or you can tweet @oceankwmr and I'll get it there as well. I just wanted to say thank you for listening, enjoy the bay, water, ocean, whatever body of water you can get into safely, please be careful with the large waves and big swells on the beaches out here in Point Reyes, and if you haven't had a chance to go check out those elephant seals, this is a great time to do it, to witness some of this exciting behavior as we approach valentines day. This has been ocean currents here on community radio for West Marin, KWMR, have a great afternoon.