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!

(Ocean Sounds)

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, adventurers, archaeologists, children, 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 are the Greater Farallones National Marine Sanctuary and Cordell Bank National Marine Sanctuary, which together protect 4,881 square miles. So stick around for a great show here on Ocean Currents.

(Music)

Jennifer Stock: Just as there are growing seasons on land, there are growing seasons in the ocean as well. In California waters the start of the growing season begins in early spring when the first phytoplankton blooms. In California, as in many parts of the world, *Euphausia pacifica*, known as krill, are one of the beneficiaries of this early season production. Feeding on phytoplankton and small zooplankton helped krill populations expand and become a critical link in many marine ecosystems.

Krill are the bridge converting energy from the primary producer level into a form that is usable by animals in the upper levels of the marine food web. Krill are a major food source for salmon, the krill pigment help give salmon flush their beautiful characteristic pink color. Rockfish, Seabirds, and marina of lesser-known species also depend on krill. Mega fauna such as endangered blue fin and humpback whales migrate up and down the coast to feed on it, and many of the world's ocean's krill is a critical source of energy for

seabirds, penguins, seals, shark, octopus, and many species of whales. Without krill, our oceans would be a very different place. So, with November being the season of abundance and gratitude among us, I thought it was time to cover krill here on Ocean Currents. So with me in the studio today is Jeff Dorman. Jeff is the executive director of the Farallon Institute for advanced ecosystem research. As a scientist he is passionate about understanding what drives ocean productivity and how climate change will impact our ocean resources, so Jeff welcome to Ocean Currents.

Jeff Dorman: Thanks for having me here.

Jennifer Stock: So scientist like yourself, have reasoning to go into the field they do, what got you into krill?

Jeff Dorman: So my introduction to krill came when I moved to the west coast, I came out here to do a masters degree at the Romberg Tiburon center part of San Francisco State and immediately got on a boat, found out that three west coast of California right off Bodega and right off of Point Reyes Station is one of the windiest places on Earth. And we bumped around out there for a month, towing nets, and bringing them back on board and really bringing just krill, tons and tons of krill. And that's what I worked on for the next couple of years, analyzing those nets and looking at the amount of krill that came back, the number of females vs. males, the size of the juveniles and how many eggs were out there. So yeah, it became very quickly apparent to me how important they were in the ecosystem.

Jennifer Stock: That's great! Tell us a bit about the Farallon Institute and how krill is a major area focus for the organization.

Jeff Dorman: The Farallon Institute is a nonprofit based in Petaluma, California, been around for about 10 years with a goal of really understanding our coastal ocean ecosystems, so we can really better manage them and better utilize the resources that are in them. Make sure that what we take out of the ocean is appropriate and so there will be more to take out next year. So we work across the entire ecosystem; we work on climate variability and understanding how those changes year to year and drive the productivity of the ecosystem. We work the lower part of the food chain on phytoplankton. And then sort of where my heart is, is on krill and

other zooplankton, all the way up to top predators and understanding how they all interact. And krill and other foraged species anchovies and sardines and herring, their really right in the middle of this food web and you know everyone, all the top predators that we really care about from a fisheries perspective they all feed on those important resources. So understanding how they change is critical when understanding those fisheries.

Jennifer Stock: Absolutely! So I want to start with just some natural history about krill cause they are so fascinating and my time here on the west coast as an educator I have learned so much about krill and I feel there is so much more that scientist like you know. So here in California I understand we have two species, or are there more?

Jeff Dorman: Well up off this section of coast line, there are 2 dominate species: *Euphausia pacifica* and *Thysanoessa spinifera*. So those are their Latin names. There are certainly more that we will pull up in our nets, but those tend to be the two most dominate.

Jennifer Stock: So how often do you get other species? I am always interested why, how?

Jeff Dorman: Yeah, and it's a good question. We do get other species almost all the time. And some might be more oceanic species, so as you go farther off the shore and get out into the ocean well you will still find sort of our dominate species which are *Euphausia pacifica* and *Thysanoessa spinifera*. You will start to get other species in those nets, and it may be they are just outside of their normal range because they are plankton, they get moved around by the currents. So if the currents move them in that direction, there is not a whole lot they can do about it.

Jennifer Stock: So these two species, *Euphausia* and *Spinifera*, little short names for them. They have kind of different niches in how they travel and spend time in the water column, is that true?

Jeff Dorman: Yeah they do, the big difference between the two is really just the size of them and it's very noticeable when you get full-grown adults of *pacifica* vs. the *spinifera*. The *spinifera* are a lot bigger. They are only maybe half a centimeter bigger in length, but the size, the girth of them, they are a lot bigger, and you can see that would be a lot more important if you were a predator you would

much rather eat a *spinifera* then a *pacifica*. But they do occupy, they do overlap slightly different niches, in which you have *spinifera* much more in shore and *pacifica* offshore a bit more. So you see them in different locations but they definitely overlap.

Jennifer Stock: And how about the sizes for those who don't have a relative gauge, how big are krill?

Jeff Dorman: So the adult of *Euphausia pacifica* get to be about 24-25cm, so basically, or 24-25 millimeters, so just about 1 inch. So the *spinifera* will get slightly bigger to about 30 millimeters, and that's really just the adult. Much of the krill in the water column are larva stages or even juveniles that are much smaller. They become adults when they get to be about 12 millimeters, and they start reproducing maybe at about 15 millimeters. So most of the krill out there are not 24, or not a full inch long, they are usually much smaller then that.

Jennifer Stock: What is a typical life span of krill?

Jeff Dorman: Well, it's an interesting question cause it really depends on where you are. There have been studies down in off Southern California that found that they would live about 8 months. Up here we think it's about a year to a year and a half. While up off of Oregon, in much colder waters they are often over winter and live for over 2 years. So really its dependent on the warmth of the water they are in.

Jennifer Stock: Does the warmth relate to the food in the water, or is it just more affect on the metabolism, the water my have that influence?

Jeff Dorman: Yeah, I think it is much more of a metabolic aspect; they might grow more slowly but live longer in colder waters, while they grow much faster but live a much shorter time in warmer waters. And these, yeah they exist all up and down the coast. I don't think there has been specific studies on that well in our region, so we just take the 6-8months in Southern California and 2 years off Oregon, and we think we are somewhere in the middle.

Jennifer Stock: So these are little crustaceans *Euphausia* and they have, well they spend their entire time in the water column. So here goes the

question about plankton verses nekton, nekton being something that can swim, and where do you consider them?

Jeff Dorman: So krill are almost always classified as plankton, in that they always get moved around by the water currents, they go wherever the water currents are. But I tend to think of them as right on the boundary of nekton verses plankton. They are pretty good swimmers, they can move around vertically in the water column quit a bit, but they can also move horizontally, it is just a matter of what cues might cause them to move vertically, aside from predation, which would cause them to move very rapidly. But there are certainly good enough swimmers that they can control their positioning very well; overall they are still considered plankton though.

Jennifer Stock: There is still a little bit of influence though; especially in their young larva stage they must be very planktonic. So how do they reproduce? Do they mate or bond or what?

Jeff Dorman: Yeah I can't say I have ever seen them reproduce so I don't know that.

Jennifer Stock: (giggles)

Jeff Dorman: Umm, but the males have little packets called spermatophores, and they will attach them to the females. And so one of the things, when you pull them out of the nets, one of the interesting things to look for, is to not just look at the males and the number of males verses the number of females. But looking at the number of females that have these spermatophore packets attached to them at varies times of the year. So it's still yet to be documented though, I think we could get a camera out there.

Jennifer Stock: Interesting I am sure. Well for those that are interested in February I have an author coming on to talk about reproduction in the sea, it's going to be very lively, I'm excited!

Jeff Dorman: Yeah it will be interesting to get some krill questions in there.

Jennifer Stock: So many different strategies. (Giggles)

So I guess they would mostly reproduce in the spring, because that's when we have the spring upwelling where a lot of the phytoplankton is starting up more food available.

Jeff Dorman: Yeah it's though that they do, they come to the surface in these large swarms that you see. It's thought that these large swarms are perhaps reproductive swarms, but it is not necessarily known. But they will reproduce throughout the summer time, during the summer time, the time of year we know the most about krill, you can find krill eggs in the water almost all the time, you can find females with developed eggs that they haven't released yet.

Jennifer Stock: Such busy animals, I guess that's why there is so many of them on the planet. (Giggles)

Jeff Dorman: That's right, that's right.

Jennifer Stock: So I want to hear more about the diurnal migration, going from the surface waters to depth. Right off the coast here in California we have such interesting seafloor features. We have our shelf, and then it drops off to deep water, then in the Cordell area here with Bodega Canyon. And I heard that krill have one of the longest diurnal migrations, of any animal, based on there body size, meaning how far they travel based on their body size. Tell us a little more about this migration.

Jeff Dorman: Yeah this is something that I find, and it is not just limited to krill, there are many different organisms that undergo this daily vertical migration, up and down in the water column. And they do it really, during the daytime they are quit exposed in the upper parts of the water when it's well lit, they are exposed to predators. So they often migrate down a couple hundred meters to get into low light areas where they are not as vulnerable to predation. And then at night, when they need to feed, they will come up and feed basically under the cover of darkness. So krill will migrate down in the morning hours, and they go down to a couple hundred meters, if they are restricted by bottom depth, we don't really know if they get right down along, next to the bottom or if they stay a couple meters off the seafloor. They certainly get exposed to predation if they are down deep and in close relation to any bottom predators as well. But they do that migration everyday; there is certainly a lot of variability in it. If you have a lot of food at depths, why do you

need to come up at night to feed? So there is variability on whether an organism decided to come up or not. And then there is variability as far as the very young krill do not migrate, and so they tend to stay in very surface waters, feeding, and once they get larger they can undergo that migration. They do it.

Jennifer Stock: And one of the things I am not so clear on is swarming verses schooling, because there in mass abundance when their out there and so do you consider it, it sounds like there is a real difference between those. Swarming verses Schooling?

Jeff Dorman: Yeah, it is very interesting to read up on krill and people tend to think that the krill off of our coast tend to swarm. Which means there is no organization to it, there is no orientation of similar body, so not everybody is moving the same direction. But there is krill in other parts of the world, most notable there is a very large species of krill off of Antarctica, and they tend to school. They tend to maintain similar body position and move through the water as a group. So despite being the same organism, or the same type of organism they have these different behaviors, we tend to see mostly swarming here.

Jennifer Stock: All right, so what about, is this strategy for predation, avoiding predation, to stick together like that?

Jeff Dorman: Yeah, it's interesting because it also tends to draw predators when you are like that, right?

Jennifer Stock: Yeah!

Jeff Dorman: But is it overall a theory, or a strategy to be in a larger group and hopefully your neighbor gets picked off by the predator and not you, as well. Because being out there a lone, it's a more of a certainty that you will be picked off by a predator as well. They don't always swarm, but they are often together when you come cross krill in dense aggregations.

Jennifer Stock: Okay. So sometimes they can be a little more spread out?

Jeff Dorman: Yeah absolutely. And my knowledge of krill and most people knowledge of krill come from net tows. And so when you tow a net for maybe 200 meters up through the water and to the surface,

you don't know if the krill that are in the bottom of the net, you know a big handful of krill, you don't know if they came evenly spaced throughout the water column or if its just one little packet that you got. So that's one of the hard things, you know nets are commonly how we sample krill but it doesn't tell us as much about the spatial variability in krill, and its important, really important for predators especially.

Jennifer Stock: And that's a big deal for what your work is on too.

For folks tuning in, I am talking with Jeff Dorman of the Farallon Institute here on Ocean Currents and we are talking about krill, one of the biggest, well smallest but most important foraged species here in the Pacific Ocean. But from what I am learning they are also world wide, which I am fascinated by 85 species, 86 species.

So another thing is their ability to go without food and shrink, we were just talking about this earlier, and krill have the ability to just kind of respond to the amount of food and just shrink. That's amazing; I wish humans could do that so quickly! They do it pretty quickly!

Jeff Dorman: Yeah they absolutely do, and the krill we know the most about this is Antarctic krill, and Antarctic krill tend to be the most studied. Although, *Euphausia pacifica* off of our coast tend to be studied as well. But the Antarctic krill can go hundreds maybe up to two hundreds of days, without feeding. Their body weight, they shrink, they get smaller, and then as soon as their food resources kick off again then they can begin feeding again. And I think, I am not an expert on Antarctic krill, but I think a lot of that is due to you have a period there of darkness, where there is no phytoplankton and there is no food resources that are driven by primary productivity. So they need to be able to over winter and survive that.

Jennifer Stock: Do we know about our krill population off our coast, in terms of winter? We know the summer and the spring is a big time for the web and krill, but what about the winter, do we know much?

Jeff Dorman: We don't know very much, and I think a lot of that is like what you said, the productivity is really at its peak in the summer time and its easier to go out on boats during the summer time, although, it

certainly can get very windy out there. There is much less known about the wintertime, it's an area where we probably need to do more research to get a better handle on it.

Jennifer Stock: So we have noticed, and I am curious to see if this is something that your folks have studied, is that spring upwelling the winds are getting stronger and more persistent, meaning they keep blowing and blowing and blowing, and that time when the water typically relaxes, is sometimes not happening. What happens to the food web then, or I guess krill or all the larva that are getting released when we have these stronger windy conditions in the springtime?

Jeff Dorman: Yeah so the interplay between wind events and relaxation events is really important for maintaining productivity over the continental shelf and you made a reference to, potentially these winds are getting stronger, and we think that maybe the case. As climate change occurs and as the difference between, the difference in temperature between the ocean and the continent changes, that will potentially increase winds on our coast and cause more upwelling. On the face of it, that sounds like a great thing, more upwelling tends to bring more nutrients to the surface and have greater productivity but if things aren't retained over the shelf where that productivity happens, they can be pushed off shore then those krill aren't going to be in a very habitable location to grow cause there typically isn't a lot of productivity off there, and also to reproduce. So in some ways, having the interplay of an upwelling event to pull nutrients into the upper photic zone, basically where the photosynthesis happens, then having it relax so things tend to stay in that region is important. And yeah that maybe changing, we expect it will change if we changed the wind patterns.

Jennifer Stock: Interesting I think it also affects other species too and their larva like rockfish, if they get pushed off shore off of kelp beds, so other species too. It will be interesting to see.

Jeff Dorman: Absolutely, Dungeness crab is another one.

Jennifer Stock: Yeah! So what is the ultimate goal that you love to understand about krill?

Jeff Dorman: There is so much we need to learn about krill, and I, you could look at it on a very large scale or very small scale. I tend to think

of it on a small scale, there is a lot of behavior in krill that I don't think we understand, and it goes back to really how we sample them. We sample them with big nets, we sample them with acoustics, but that doesn't really tell us much about the individual krill and how it reacts to changes in temperature, how it reacts to changes in these currents pushing it farther off shore. It has a strong ability to migrate, to move up and down in the water column and to move away to situations. Maybe not spatially or horizontally like a fish could, but it can move itself vertically, and that changes the type of environment you are exposed to off our coast very quickly. So I tend to wanna, I think about the small scale krill and think about what the individual does, when it's migrating when it comes across food. Does it stop, why does it come up to the surface and be influenced by predators? So that's where I think there is a lot to learn, and that really will have to happen more visually with cameras, with videos, and potentially other means like that.

Jennifer Stock: Is there much understanding about krill presents with other models like chlorophyll that we study from satellites?

Jeff Dorman: Yeah, I don't know a whole lot about sort of, I mean there is often, there are regions that tend to be hot, we call them hot spot for krill. Are those related to increased food productivity or just currents that move them around in those regions, and I think it is probably a little bit of both. I mean the chlorophyll is at the mercy of the currents; the krill are mostly at the mercy of the currents, so if they move together they co-exist together.

Jennifer Stock: So your organization got a Google impact challenge, challenge in the bay area, a special grant, to help a little bit more with your understanding. What is your plan here, with your big project?

Jeff Dorman: So the Google impact challenge was an event that was open to any bay area non-profits, and we applied, and they really liked the idea that we put forth. Which was to, try to, take traditional ocean geographic samples, which is really important and has taught us a lot about the ocean. Take the idea of going out and towing nets, and instead of doing that, can we put out some cameras in the coastal ocean, and just take pictures, and send us back imagery of krill, so we can get an idea of how much krill is out there at different times when we aren't out there towing nets. It cost so

much money to go out on a boat, for you know a week at a time, and to go, and then you know you get these jars full of krill.

Jennifer Stock: They have to be processed.

Jeff Dorman: It takes a long time to sit there and look through a microscope and smell formaldehyde drifting up at you. And it is not easy to do, so it might be that it would take 3 months before you really understand what the krill productivity was from when you sampled. And then the problem is, you have to go do it again, and it's expensive again. So the idea that we can put cameras out there in the coastal ocean, that can take pictures of what's there at different times and maybe its every day, maybe it's every hour we get a picture back. And then we have the information must faster, we have so much greater temporal resolution, so instead of knowing what's happening every 3,4,5,6 months, we can tell what's happening everyday. And how did the krill, the abundance, how did it get moved around, how did it change in relation to this big wind event? We really cant get that with the type of sampling we do now and so yeah, google.org liked our idea, and I think they would like the idea of bringing new methodologies and technologies to get better data. And that will allow us to you know hopefully, better understand krill and other foraged, and manage the coastal oceans better. And better understand how they are changing, or how they are not changing.

Jennifer Stock: Well you know I think also another piece that is interesting is the application of predicting where whales might be. We have talked on the program before about the challenge that we have in the bay area, with having a major shipping port in San Francisco Bay and also an area where there a lot of endangered large whales like to be eating, and do you think we could ever get to a point maybe with predicting where krill is, and maybe predicting where whales might be to help with shipping? That's like a big goal! Right?

Jeff Dorman: It is a big goal, but it would be wonderful. I mean shipping industry is a huge industry for the region understanding. I mean obviously these ships do not want to be striking whales. These two large organisms out there, these big ships and these big whales, if we can keep them separate, it would be fantastic. And often those whales are in the place they are at because of krill. So we have on our website on Farallones Institute, we have 16 years worth of

acoustic data which we have analysis. So krill can be sample acoustically, where a ship drives over a certain part of the ocean and it pings down acoustics.

Jennifer Stock: It's like a fish finder, type of thing?

Jeff Dorman: Its like a fish finder, basically with looking at the different frequencies that it uses, and the differences in how those frequencies comes back, we can say with a decent amount of certainty, that you know, this signal is from krill. So it's a very easy way to sample, and we processed about 30 different cruises for about 16 years. And when you have that length of time series you can begin to say hey, krill tend to be in this spot, almost every year, even if it's a high productivity year or a low productivity year, they tend to be right here at Bodega Canyon. And so yeah it begins to allow you to make really broad generalizations. And then what gets difficult with maybe shipping traffic is, well that tells use seasonally where they are, but then the day to day. How do we take that next step?

Jennifer Stock: Yeah that will be interesting to see, I am sure we will be tracking it from the sanctuaries stand point and of course NOAA National Marine Fisheries. Okay we are going to take a short break, half an hour of krill talk and I have so many more questions, your tuned to Ocean Currents here on KWMR this is Jennifer Stock.

Jennifer Stock: We are going to return to our conversation here on Ocean Currents about krill, this incredibly important species that is worldwide. We have species here in California, a big part of our food web. And talking with Jeff Dorman from the Farallones Institute, all about the work he is doing and his fellow colleagues about understanding krill and their movements and what affects them. So I wanted to talk about, since its just a big species in terms of their importance to the food web, what are some of their effects of warming oceans, warming ocean on krill, that we know about?

Jeff Dorman: Yeah I don't think we know a whole lot about it, but we do know about their metabolism, and how they work. I have done a decent amount of work trying to model krill, so trying to understand how they, actually the way their growth happens the way their reproduction happens, changes in response to both food and temperature. And one thing we have really found is that, if you put

krill into warmer temperatures, they aren't able to grow as fast, and that's often because so much of the energy they ingest goes out to respiration, just to keep their metabolic activity going. And so I think that is one of the biggest concerns for krill, they might not die, but they might not grow as big or as fast. And so if you're a predator who rely on krill, the krill that your eating might not be as energetically, or you may not get as much energy from that krill. So you have to feed more to get the same amount of energy for yourself.

Jennifer Stock: Here is a crazy question, and it might not be the right question for you, but people ask me this all the time, how do whales find krill? This is probably more of a whale person question, but maybe you have some insight.

Jeff Dorman: I don't know, it's a great question, I would think, we are able to detect them with acoustics right? So I would guess that whales are pretty good at detecting them with acoustics, especially if they are all packed together and have a big signal as well. I have never, you know I have not been out in the ocean to see them feeding on krill specifically, so I don't have a lot on that.

Jennifer Stock: Jeff we need to get you out on the ocean

Jeff Dorman: I am telling you I used to spend a lot of time out there, now I tend to model a little bit more unfortunately.

Jennifer Stock: AWWWW, well we will have to get you out, cause watching whales feed on krill and fish is amazing! Yeah I was asking about that cause we have had El Niño years, and this interesting phenomenon happening called the Blob. And I remember very keenly last year we did our annual field seminar out at Cordell Bank and there were not a lot of whales around, it was very warm water. And you could tell the ones we did see were moving, and looking for food.

Jeff Dorman: Right, there is another aspect to this, I mentioned the direct impact on krill, but you know warmer coastal ocean makes it much harder for upwelling to occur, for upwelling nutrients to break through that, the barrier of warm water on top of cold water, and so you might just have less productivity on the overall ecosystem, and that will certainly impact. If there is less phytoplankton out there, it

will impact the krill and the other phytoplankton, the other foraged, excuse me the other zooplankton, the other foraged species, anyone that feeds on phytoplankton, so yeah.

Jennifer Stock: So from the response in the food web with that, the years we don't have a lot of krill, we know passing Cassin Gutlocks on the Farallones Island, you might forgo reproducing or abandon their eggs or their chicks and that's a result of less food availability. And so they may have a slower time recovering as a bigger species, higher on the food web. But how about for krill, if they have a bad year, do they come back?

Jeff Dorman: They tend to come back very fast.

Jennifer Stock: That's amazing!

Jeff Dorman: And I think that does have to do with the shorter lifespan, but yeah there is not a whole lot, if you have a bad year one year, it can be boom the next year if there is a lot of phytoplankton.

Jennifer Stock: Interesting

Jeff Dorman: Yeah.

Jennifer Stock: Well along with warming, the other big impact that were considering, especially here on the west coast which is really going to see the effects of ocean acidification first is, what's the impact of more acidic water on krill? I don't know if there have been many studies done, I know there has been a lot on shell fish, especially in their larva stage, and we know some new research on Dungeness Crab, that is not so promising for crab, but how about for krill?

Jeff Dorman: You know I have read a few studies that have looked at ocean acidification, or have done more experimental studies with more acidic environments on krill, and the biggest impact is on hatching success. So I think those young larval stages or just the eggs themselves, where you have maybe a 20% decline in the hatching success, so yeah that may have impacts down the road. They tend to define that the adults did okay under those environments. I mean the west coast is a naturally more acidic environment then other areas, so the organisms out here maybe slightly more adaptive to

deal with that sort of thing, more acidic events. But certainly not on the level of what we expect to see due to climate change.

Jennifer Stock: Well and they seem to be very adaptable species as they are able to adapt with food, reduction, and being able to still survive through that. And so maybe that is another contributor to being a very adaptable species, lucky for krill.

Jeff Dorman: Yeah.

Jennifer Stock: Well we have just a few minutes left, and you know I want to ask you a bit about the bigger issues with krill, we focused on them cause they are such an important species with the food web, and fisheries, and mega fauna, but we have some larger issues of harvesting for krill happening around the globe, where are the hot spots for harvesting happening?

Jeff Dorman: Yeah the largest harvest of krill happens off of Antarctica, and that is by far in a way the largest. There is harvesting that happens off of Chile, some off of Canada, and some off of Japan as well. And yeah it is an interesting resource to take because so much of the upper trophic levels that we are also harvesting especially here in the California Current, they all rely on krill, they eat krill. So if you shortcut them, if you take that krill out of their system, then you basically are goanna have less of those top producers. California, or Pacific Fisheries Managements Council, that manages the federal fisheries have been very forward thinking in that they have limited harvesting, or excluded harvesting of krill just for that reason. And even other unmanaged foraged species that sort of filled that middle role that krill does, those have recently said, until we know a little more, lets not harvest these, cause these are what's feeding so many of these fisheries, which are important for our coastal communities and for the wonderful seafood that we enjoy.

Jennifer Stock: Its so great to hear the precautionary principle works, and that we are doing that here on the west coast. And we will hear a little bit more about that on our Positively Oceans segment coming up. Where does this krill harvest go? It's used for a couple different products; lets just talk about that for a little bit.

Jeff Dorman: Yeah the one that everybody may have seen, unless maybe you do some aquaculture you may have seen it in other places, but I have seen it as krill oil, as an alternative to fish oil high in Omega 3's and very good for you. So you do see that a little bit. Most of it goes to aquaculture to feed maybe a fish farming operation, so they harvest the krill and feed it to the fish that they are trying to harvest.

Jennifer Stock: That's crazy we have to take fish out of the ocean, or krill out that are being…

Jeff Dorman: Right

Jennifer Stock: UGHHH, that's a topic for another show, but that's one reason to eat locally harvested, sustainably harvest salmon because they eat krill, and so you get all the health benefits from eating the fish.

Jeff Dorman: Yeah that's what gives it their little pink color. Which is kind of cool. When I heard they had to dye the farm fish because they don't get that same color, its kind of interesting.

Jennifer Stock: That's sad, and scary. Wow, well any last things you want to share before we turn it over to the last segment of our show today Jeff?

Jeff Dorman: No thank you so much for having me here, it was so fun to share the thrill of krill to you and all the listeners out there.

Jennifer Stock: And avoid the krill pill. (Giggles)

Jeff Dorman: Ha-ha, yeah I like it. But yeah I mean krill and all the others foraged we tend to think of, rightfully so we think of the whole ocean and we think of the fisheries that are wonderful and provide wonderful seafood to us Californians. But they all depend on what's happening lower down on the trophic, on the food web, so understanding what happens with krill with other foraged species like sardines, and anchovies, and heron, its really important and important for the whole ecosystem. They are at the center of the whole ecosystem.

Jennifer Stock: Thank you. And how about the website for your organization, for if people want to learn more about the projects you are working on?

Jeff Dorman: Yeah we can be found at FarallonInstitute.org, its really a great organization that's doing holistic ecosystem science, and trying to understand the whole ocean, so we can better manage for the changes that are coming and better manage our fisheries so that they continue to be healthy and sustainable, so its great work we are doing.

Jennifer Stock: Thank you, that's excellent, that's great to hear about more science happening around here applying to our incredible ecosystem of California. Well thank you Jeff, I'm going to turn it over here in little bit to our new episode of Positively Ocean, this is a segment that is being produced by a volunteer of mine, Liz Fox out of Berkeley, which on todays program focuses all about krill, so stick with us here on KWMR Ocean Currents.

Positively Ocean

Liz Fox: Hi this is Liz Fox on Positively Ocean, where we celebrate the ocean and look at what is doing well. This week story takes us off the Ross in the southern sea off of Antarctica to the entire west coast of the continental United States. Although Antarctic fishing grounds are extraordinary remote, fleets from dozens of countries compete for the bounty of fish and crustaceans, including krill. But things are starting to look better for wildlife there. Just over a week ago 25 nations agreed to protect a 600,000 square mile area, making the worlds largest Marine Protected Area. That's more than 3.5 times the size of California, and it will be off limits to commercial fishing, including krill, starting in December 2017. The Commission for the conservation of Antarctic Marine Living Resources, which coordinated the multinational effort, also renewed the limits they set for krill fishing, and specific areas outside of the marine protected areas for 5 years, instead of the usual 3-year renewal. Bill Douros, regional director on the west coast for NOAA office for the National Marine Sanctuaries sees the importance of the Marine Protected Area and the krill kill limits in the Southern Sea.

Bill Douros: In one of the central purposes for that is to protect krill abundance, which is really important down in the southern ocean. Which has been fished pretty heavily down their and that new marine sanctuary down off Antarctica is designed to protect krill among other species.

Liz Fox: Although krill live throughout the world ocean, Antarctic krill is harvested the most. Researchers and scientist worry that taking too much biomass out of lower parts of the food web is dangerous for the fish, mammals, and birds that feed on them. What makes krill so special is that they are primary consumers. That means they transform what they eat, teeny-tiny photosynthetic plankton, into energy that bigger organism can eat in a form of their 2inch shrimp like bodies. Fish as small as anchovies, sea birds like penguins and even the largest animals that roam the Earth, Blue Whales, feed exclusively on krill. That's why California scientists, conservationists, and decision makers in the fishing industry banned a krill call before it began. In 2006, Douros was superintendent of NOAA's Monterey's Bay National Marine Sanctuary when he proposed a krill banned to the Pacific Fisheries Management Council, which sets catch limits for fishing on the west coast from California and to Washington. There was no local krill industry at the time but the fisheries council valued a policy that would protect food from sea life in the National Marine Sanctuaries. But human pressures increasing jeopardizes krill populations throughout the world ocean, putting all the animals that depend on them at risk. Our burning of fossils fuels changes temperature and acidity in the oceans, wind patterns, and ocean currents, which impact how and where krill can live and reproduce. And human demand for krill is on the rise people eat krill in traditional dishes throughout Asia, and in the west dietary supplement companies market the krill pill for omega-3 fatty acids. But the baulk of caught krill becomes spotter for fish in aquaria and aquaculture and for livestock on farms. Taking krill out of the oceanic food web and placing it on our tables in one form or another, can further stress species already in peril, like the endangered blue and finned whales, salmon, and rockfish. So to protect prey in the Pacific, in 2009 the Pacific fisheries management council expanded the krill banned to span the entire range of California, Oregon, and Washington shores out 200 miles to sea, in perpetuity. That's a lot of commitment at the federal level. But that's not all, again Bill Douros.

Bill Douros: Another cool thing that took place as part of this process down here, was the state of California closed some loop holes that existed in state law to prohibit the harvest of krill in state waters, and the landing of krill on any ports in California. In Oregon and Washington, they also adopted a few of the legislative changes

that made this a complete and consistent banned along the west coast.

Liz Fox: With nowhere to land and process krill on the west coast and with protections that cover most of the national range of krill in the sea Douros is content.

Bill Douros: So far, I would call it the success story, so no news is good news on this front.

Liz Fox: This is an example of how to do right by the ocean folks. Until next time, I'll be searching for all things Positively Ocean. For Ocean Currents Radio on KWMR in west Marin, this is Liz Fox reporting in Berkeley, California.

(Music)

Jennifer Stock: Thank you Liz Fox for another wonderful segment of Positively Ocean, really highlighting some of the conservation successes that apply to krill. And that took some leadership from our West Coast National Marine Sanctuaries that proposed this ban of krill to the pacific fisheries management council, and that was applied even across the other states as well to help protect all that feed for fisheries and for all those mega fauna seabirds, and whales. Excellent! And also the raw sea marine protected area in Antarctica which I believe I just the first step in protecting larger areas down there too, so we will have to keep our ear posted on that.

I want to say thanks to Jeff Dorman for being on the show today, and Liz Fox, producer of Positively Ocean featuring things that are working well in the ocean. Ocean Currents is the first Monday of every month, 1-2 P.M., and we have a podcast, you can go to iTunes and look for Ocean Currents there, or go directly to Cordellbank.noaa.gov to hear past episodes. This is the 10th year here of Ocean Currents on the air here on KWMR, and in the 10th year I final started twitter feed. So Ocean Currents is on Twitter, you can follow Ocean KWMR to get information about this program and other programs supporting web links that we feature here on Ocean Current's Radio. I love hearing from listener, so if you have idea, topic, comments, or questions please email me Cordellbank@noaa.gov, or tweet at Ocean KWMR. We will be

back next month, focusing on rockfish, another west coast species issues is the rockfish conservation Aries that have been here on the west coast, so were going to catch up and find out what all those are all about and how rockfish are responding to that, so stay tuned on Ocean Currents. Thank you so much for listening, enjoy the ocean, bay, or whatever body of water you can get into safely. This has been Ocean Currents here on Community Radio for West Marin.

(Music)

Jennifer Stock: Thanks to BENSOUND. Com for the ocean currents free music

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