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

(Music)

Jennifer Stock: Good afternoon everyone. You're listening to Ocean Currents here on KWMR, a show where we talking about the blue part of our planet, the ocean. We talk about science, natural history, discoveries, conservation, policy, and ways for us land based folks to get more involved. My name is Jennifer Stock and I bring this show to you through NOAA's Cordell Bank National Marine Sanctuary, one of three special ocean places off the coast of Point Reyes.

This show is part of the West Marin Matters Series where every Monday at one you can tune in to learn something about our local environment or economy and Monday…the first Monday of every month is the ocean. So, here we are on June 6th, and it's still raining. It's quite chilly and we have had quite a year in weather events. In conversations with friends and family, it's often come up, "Is this related to climate change?" Who knows? We'll discuss that a little bit today with my guest. We'll explore a very important ocean literacy principle, which is how does the ocean influence our weather?

If you happen to live far away from the coast or on any continent, this interconnection between weather and the ocean impacts everyone no matter where you live. So, the earth planet is only habitable because of our atmosphere and ocean. So, today, we're really going to dive in and talk about how these two things interact. We'll be talking with Dave Reynolds, a chief meteorologist for the National Weather Service Forecast Office in Monterey with us live on the air. So, stay with us and we will be back to talk a little bit about how the ocean and weather interact.

(Ocean Sounds)

Jennifer Stock: These are the sounds you probably don't expect to hear in late May and June here in the Bay area of California, but yet, we are all experiencing quite a bit of rain still and hopefully, we'll talk with Dave a little bit about this. So, welcome back. You're listening to Ocean Currents. My name is Jennifer Stock and my guest today is Dave Reynolds, who is the chief meteorologist for the National

Weather Service's Forecast Office in Monterey that provides forecasts, watches, and warnings for the greater San Francisco and Monterey Bay area including the forecast that KWMR provides its listeners every single day.

The National Weather Service is part of the National Oceanic and Atmospheric Administration, NOAA, which is within the Department of Commerce. They're kind of an uncle agency to the National Marine Sanctuary Program that I work for. David's primary interest is in quantitative precipitation forecasting and in climate change impacts in California. He has multiple degrees in atmospheric sciences, is a fellow of the American Meteorological Society and has received multiple honorary awards through NOAA for his work with atmospheric sciences.

David is a recent contributor to the recent report, "Climate Change Impacts," that Gulf of the Farallones and Cordell Bank National Marine Sanctuaries worked on that details the expected physical, environmental, and biological changes we expect with climate change in our local environments. So, we'll be talking a little bit about that today as well. So, David, welcome. You are live on the air. Welcome to Ocean Currents.

David Reynolds: Thanks, Jennifer. Nice to be here.

Jennifer Stock: So, we are sitting here on a cloud in Point Reyes. I'm wondering what it's like in Monterey.

David Reynolds: Well, Monterey was sunny up until about the last thirty minutes and then this cloud bank that had been moving south off the coast just started moving in here.

Jennifer Stock: Interesting. It's quite humid. So, I imagine the weather this year has kept you on your toes as a meteorologist. Would you characterize this winter and spring as odd weather from your years of forecasting?

David Reynolds: Well, I'm not sure it's really that odd, honestly. Years…the normals are always made up of these extremes, one way of the other, it seems. So, either dry years or wet years, but we very rarely seem to have a climalogical normal year. I think what may seem to be the oddity this year is that we seem to be getting these frontal systems that come through even into early June, producing cooler weather and chances of precipitation or some precipitation and this just keeps going and going and I think that if anything, that may be somewhat unusual.

Jennifer Stock: So, do you have an idea in terms of why we are receiving this weather? There's snow in the Sierras, tornados in California, rain into June. It may not be abnormal, but it's definitely not something we're used to. So, what are some of the physical reasons that this is created?

David Reynolds: Well, I think what we're seeing is what we call somewhat of a blocking pattern. That is the long-wave troughs and ridges that guide our storm systems throughout the northern hemisphere of the globe have been relatively parked in their positions for probably 6 to 8 weeks and this particular case, we have a ridge of high pressure that's backed off well off the coast into the central Pacific and that has allowed these storm systems to drop down through California, actually intensify as they get near the rocky mountains and produce all of this severe weather that you've heard about in the Midwest with these tornado outbreaks that's also added to the rainfall in the upper Mississippi and Ohio valleys, which has caused record flooding in the Mississippi and as we've actually gone and progressed through the late spring, this pattern is somewhat retrograded, meaning it's moved back to the west.

Normally our storms move from west to east. Well, we've seen over the last couple of weeks this pattern of, sort of, backed up to the west and that's allowed these storms to drop right down the coast and so the one we had this weekend was a rather deep storm that dropped right off California, in fact, right off Monterey, producing upwards of seven inches of rain in our mountains south of Monterey here over the weekend.

Jennifer Stock: Wow..

David Reynolds: …which is very unusual.

Jennifer Stock: That's quite a bit.

David Reynolds: Yes.

Jennifer Stock: So, in terms of these fronts and these systems, what are some factors that influence them? Is it temperature in the air, temperature in the ocean, northern hemisphere, southern hemisphere? What are some of the conditions that are created because I imagine it's quite a bit of interaction between the atmosphere and the ocean?

David Reynolds: Yes there is. In fact, I would say a lot of what controls the weather, especially in California, can be tied back to the sea surface temperatures and what effects that has on deep, tropical thunderstorms and so, this past winter, we had what was categorized as a strong La Nina, which is the phase of the sea surface temperatures that is cold in the central and eastern Pacific rather than warm. Many people are probably more familiar with El Nino in California. That's where we have warmer than normal waters in the Pacific.

This past year, we had very cold waters in the central and eastern Pacific called La Nina, just the opposite of El Nino, and that pushes the deep, tropical thunderstorms much further to the west in the far western Pacific Ocean, near Asia, and, in fact, even as far west as the Indian Ocean and what this tends to do is force the jet stream into a certain pattern and so, I think what we saw this past winter is this ridge of high pressure that was well off the west coast to allow these colder storms to come in to California and build up this record, I shouldn't say record, but it's a near-record snow pack in the Sierra Nevadas because it was so cold and the freezing levels were down and kept our temperatures low and actually gave us more than usual precipitation for this time of year and this pattern just has lingered into the late spring.

Jennifer Stock: So, you think it's partially La Nina conditions, this cold water?

David Reynolds: Yes, I think the driver of this is the strong La Nina that we had this past winter, but even though the…if one were to look at sea surface temperatures right now in the tropical Pacific, they would actually see an anomalous warm tongue of sea surface temperatures coming off of South America and starting to extend out in to the Pacific Ocean near the tropics. So, we've actually started to change the sign of this inso effective…it's called…we're actually flipping from a colder normal to a slightly warmer than normal, but the atmosphere has a memory of what occurred over the winter time and so, it's not realizing those warm temperatures yet. It's still being driven by the pattern that was set up by these colder than normal temperatures. So, that can linger until the sun starts moving north in the northern hemisphere and it's going to shove the jet stream farther north and we will see summer. So...

Jennifer Stock: We will.

David Reynolds: …don't think we won't see it. We will see it and it'll probably be by the end of this week.

Jennifer Stock: All right.

David Reynolds: You're going to see much warmer temperatures and think that we'll get back to something that looks like normal.

Jennifer Stock: That's exciting. It's funny. As a backyard gardener, a lot of the weather…what's going on in my garden kind of indicates somewhat of the weather. I'm sure that is the same for a lot of other gardeners out here. We didn't have a good year of tomatoes last year. It was really cold and things are having a tough time getting started. I'm just hoping they hold on right now until we do get those warm temperatures.

You know, when you were just talking about the La Nina and the memory of the air temperature and what not, something I read earlier today was about something called the negative arctic oscillations, some big word for some of us here who are not familiar with weather terms, but this was really interesting to me. It said that a typical condition is a positive arctic oscillation, but when it's negative, that means arctic temperatures and weather can come down to the United States and Europe, but it said that it flipped so that we were back in positive conditions and so, I'm just curious where this specific weather pattern or atmospheric condition effects our weather?

David Reynolds: They certainly can. As I said, I tend to look and a lot of us in forecasting tend to look at what's going on in the tropics, but there's also mid-latitude features. These are features that occur in the, normally, the mid-latitudes or the northern latitudes that can control our weather and can actually be stronger than the force that can occur from the tropics and so, in a negative AO, as we call it, arctic oscillation, that's basically just reflecting the fact that ridges and troughs of changes are normal climatological formation and so, this ridge that normally sits near the west coast, that also backs off into the middle of the Pacific and allows the colder air to come down into the continents and so, if you get the La Nina pattern to get in phase with the arctic oscillation, you can have really cold temperatures and persistent-type of weather for weeks and weeks and so, I think we've seen a little bit of that this past winter where the two of these processes came into phase with each other and just aggravated the pattern that we were in and so, a lot of times, there's arguments about, is it these mid or northern latitude features that are driving our weather or is it the tropics and sometimes, it's very difficult for us to differentiate on a given day as to which one is the driver.

Jennifer Stock: For those just tuning in, you're listening to Ocean Currents, my name is Jennifer Stock and I'm talking to Dave Reynolds from the National Weather Service and we're talking about the interaction of the ocean and weather and how the effect each other. In terms of all this forecasting, this is an incredible amount of science based on a lot of data and I'm curious if you could just describe what are you consulting to be following these atmospheric patterns?

These are pretty much invisible for those of us in one location, but what…can you describe some of the technology and the data that you use and is this something that other people can see so they can get an idea of these pictures?

David Reynolds: Well, what we normally use for our forecasting and anything beyond about 6 or 12 hours is computer models, which we have a bevy of computer models to look at. So, we have something called the National Center for Environmental Prediction, NCEP.NOAA.Gov.

So, if you were to go to that website and you were to click on their computer models, you could see the computer models that our NOAA agency runs for us. Some are global models, some are regional models. The global models cover, obviously, the whole globe and they are run out to fifteen days into the future and we can look at these models and look at the patterns that they're generating, look at the precipitation, look at the winds, and we tend to go with the forecast of these models since we've been looking at them for years and we understand how they operate and we understand some of their biases, but it's really these computer models that we focus on quite a bit.

Jennifer Stock: And this is all based on satellite data?

David Reynolds: Yes. So, what goes into these computer models? Lots of surface observations, lots of what we call weather balloon observations. These are these weather balloons that are launched all over the globe by all countries that take a weather balloon, have a little instrument pack on it, launch it twice a day, and so, those observations of the vertical temperature and winds and moisture profile gets fed into these computers, but what's really revolutionized and improved our computer modeling over the last 15 years or so is satellite information and this is satellite information not from the ones you'd normally see on TV that show California and give an animated loop of clouds and precipitation.

These are polar orbiters. That means they come over the same location on earth maybe twice a day, but it's those instruments on those polar orbiters that really have provided so much more information over the oceans where we had no data before that has really improved our capability of forecasting out five to seven days from before, maybe 15 years ago, we had virtually little skill in the 7-day forecast. Now, our 5 or 7 day forecast is as good as our 3-day forecast was, say, 15, 20 years ago.

Jennifer Stock: Interesting. That's amazing the technology has improved the forecast that much. What is the rate of accuracy in terms of a forecast? Some people don't trust the weatherman very much, but what is the actual accuracy rates?

David Reynolds: About 80 to 85 percent.

Jennifer Stock: That's pretty good.

David Reynolds: It is. I think what people focus on is the forecaster said it was going to rain and it didn't rain, said it was going to rain at 2 o'clock this afternoon and it was sunny. The details, you know, are difficult, but to say it's going to rain on Saturday, which I think we were forecasting as early as Monday of last week for this past weekend, but to get the specifics right, well, does it rain all afternoon? Could I have planned something in the afternoon? We can't get that specific five days out, but knowing it was going to rain Saturday, I think we were right on.

Jennifer Stock: Yeah. Well, I was actually here in the studio last week and reading the weather warning, I had a feeling that I should be planning different plans for the weekend. So, going back to some of these anomalies like La Nina and El Nino, there's also something called the Pacific Decadal Oscillation and that's something I'm just not that familiar with as a casual oceanographer in terms of what I know and I'm wondering if you can explain this a little bit, how it relates to our ocean conditions here in the California current off the coast here and how it also effects weather?

David Reynolds: Okay, well, the PDO, as we call it, we like these acronyms in NOAA, the Pacific Decadal Oscillation is really some might describe it as in the cold phase, or the negative phase of the Pacific Decadal Oscillation, you tend to get more La Nina-type patterns to set up, which is the colder waters in the tropics and during the positive phase of the Pacific Decadal Oscillation, you get more El Niños or the warmer waters in the tropical Pacific and so, these tend to be…the trend in terms of getting more La Ninas or more El

Ninos tends to be on a ten, twenty, thirty year time frame and so, if you look back at the records of the frequency of El Nino and La Nina, you will see that from about 1948 to about 1978 we were in a negative phase of the Pacific Decadal Oscillation and from about '78 to about '98, we were in the positive phase of the PDO and we've now flipped back over into the negative phase of the PDO and really what that means is for our weather in California is we tend to get colder waters along the California coast.

The strong current that's driven from the Alaska current down the coast is what's driving that and keeps those waters quite cool and it also tends to have weather patterns that are much more meridianal, meaning that we have very high amplitude in the jet stream during these winters whereas in the El Nino years, we tend to get a straight shot of jet stream right from Japan right across the Pacific, what we call morzonal flow. So, you might expect less extremes in temperatures during the warm phase of the PDO and more extremes of temperatures in the negative phase of the PDO. So that's the real simple idea of how it may affect our weather here in California.

Jennifer Stock: Really influences La Nina and El Nino, which is always flipping around and also, one of the things that's typically been known is La Nina usually means wet weather or usually it means drier weather and this year we've seen more wet weather. So, is our understanding of what La Nina is and what El Nino changing as our global temperatures are changing?

David Reynolds: Well, I think you have to put El Nino and La Nina into…characterize them as to their strength and what we see is that the main signals from…in terms of precipitation in California that come from El Nino is in the strong El Niños. If you have a weak to moderate El Nino, the signal is pretty weak in terms of precipitation on an annual basis in California.

We've seen some of the driest years on record in California when we've had a weak to moderate El Nino and when you start getting these very strong inso cases, meaning your strong El Nino or strong La Nina, of which this last winter was one of, if not, the strongest La Nina we've seen in 50 years, those tend to stand out and tend to produce anomalous weather. The strong El Ninos certainly produce some of the wettest winters we get, but this strong La Nina that we had, we have another one in '55, which produced one of the most devastating floods in California history, December '55 was the next strongest if not strongest La Nina and that was an extremely wet winter in California and this past winter

with a very strong La Nina also produced very high precipitation and very high snow packs.

So, it's these really, really strong ones that tend to drive our perception of wetness and when you start getting into the weaker ones, it's actually pretty difficult to resolve a strong signal out of the weaker one.

Jennifer Stock: What are the…is the El Nino, La Nina, and the Pacific Decadal Oscillation, are they fairly predictable in terms of when they will occur?

David Reynolds: No. Climate...

Jennifer Stock: (Unintelligible)

David Reynolds: ….you know, we can start to see a trend in our climate models now. They're getting good enough where we've now coupled, one of the big things we've done now is couple the ocean with the atmosphere. Before we couldn't really have the computer resources or the know-how to couple in the same model, the oceans, the ocean currents, and everything that goes on in the oceans with the atmosphere and over the last 5 to 10 we've actually been able to put all that physics in one model and that's really given us the hope of trying to forecast what the signal of inso is going to be in the next year or…we're still sort of in the baby steps of that, but there is some capability to do that, but I would not say it's really strong right at the moment.

Jennifer Stock: So, where are we at right now, it's June 6th, and so, where are you seeing the next few weeks in terms of La Nina, El Nino and our weather here in the Bay area?

David Reynolds: Well, I think, as I said, we've turned the corner from a cold phase to somewhat neutral. We really haven't gone into an El Nino type phase, but we've certainly taken…got away from the cold waters out in the tropical Pacific to neutral. So, the forecast right now is for a neutral winter, meaning we're not going to have warmer than normal waters or colder than normal waters, but we're going to be near neutral in the tropics and so, the tropical drivers are not going to be these large-scale sea surface temperatures out in the central and Eastern Pacific, there have to be other mechanisms to drive our weather.

So, I think what we're going to see is the weather patterns get more typical here over the next, in fact, starting this week and I think

we'll be back into a normal type of regime of (?) in the morning and low clouds at the coast and hot inland for the rest of the summer.

Jennifer Stock: You heard it here folks from Dave Reynolds himself, the forecast was looking up. How about the ocean conditions, though? Last year it was incredible. We had super cold temperatures and lots and lots of upwelling and krill and huge amounts of whales in the area, humpback whales and blue whales, and what's the prediction for this summer in terms of the ocean conditions?

David Reynolds: Well, I was looking at the upwelling index, which is calculated by our fisheries group here in Pacific Grove, actually. They've been looking at this…tracking this sort of thing because it does have an impact on fisheries in terms of the krill and how productive the ocean is and because we've had these transient weather patterns, the upwelling has sort of started getting going and then it stops because the weather pattern comes through and it reverses the northwest flow that we normally have starting in April to a southerly flow and so, it breaks down the, what we call the spring transition.

So, it really hasn't gotten going real well this spring. So, really, the index is pretty neutral right now. It's almost…it's not above normal like we saw the last two springs. It's close to normal and because we've had colder water than normal because of the negative phase of this Pacific Decadal Oscillation, that's helped. So, just having colder waters helps the krill, but we're not getting a real driver from the strong northwest winds that normally develop in the spring because the weather patterns have just been too transient to get it going, but I think we'll start to see that improve here very shortly.

Jennifer Stock: Well, we have observed some very strong winds in the last few weeks, extremely strong north to south winds and it seems that those have been pretty regular in the springtime. They seem to be increasing, and I'm curious, what do you think…and those winds we don't think are affecting the upwelling?

David Reynolds: As I've said, yes, they've come and gone. We've had, yes, I would agree with you. We've had very strong north-south winds after one of these fronts go by that the high pressure builds in and we have very strong northerly winds and it helps the upwelling, but then we've had another front come through and they kind of die off and we get south to southwest low for a couple of days and then we get a northwest low, whereas once and normally what happens is the

storm track will proceed towards north starting in April, late April and in May we don't see, climalogically, we don't see fronts coming through here very often.

So, that northwest wind pretty much blows every single day and you need that sort of persistent northwest wind to get that real upwelling going and make it very, very productive. So, yes, we've had bursts of these northwest winds, but they're not continuous like we normally would like to see for real strong upwelling and real strong spring transition. So, it's been about normal.

Jennifer Stock: Ok, so we'll have to see what happens in the coming weeks. These weather systems have kind of prevented the upwelling from really getting going. Well, Dave, we're going take a quick break here and I hope you'll just stay on the line and we'll bring you back on live in just a minute and in the second half I'd like to talk a little bit more about climate change and how climate change is going to impact our weather conditions and I know you've been very interested in that. You've participated a lot in making some educated guesses as to what is about to happen to us in the next decade or so. So, please stay on the line, Dave.

David Reynolds: Thank you. I will do it.

Jennifer Stock: Those of you just tuning in, this is Ocean Currents. My name is Jennifer Stock and we are talking about the interaction between the ocean and weather with Dave Reynolds from the National Weather Service in Monterey and when we come back we're going to talk a little bit more about how climate change may be impacting weather patterns on the horizon as we are moving towards new atmospheric and ocean conditions. Please stay with us.

(Music)

Jennifer Stock: We're back. You're tuned to Ocean Currents on KWMR and today I'm talking with Dave Reynolds from the National Weather Service and we're talking about weather and how the ocean influences our weather, specifically here in California, but of course, globally as well and Dave, welcome back. I wanted to take some time to talk about climate change. I know this is an interest of yours in terms of how climate change could impact our weather and you were a contributor the climate impacts report recently with the sanctuaries here and going through the report, it seems like there's some very clear ideas of what could happen on the horizon with temperatures.

According to the San Francisco tidal gauge, 1850 to 2000, there was an increase in intense winter storms since 1950 as well as observed increase in the largest waves, new wind speeds that are going to increase upwelling, ocean acidification on the horizon, how about the weather in terms of what can we expect in terms of different weather patterns as we enter climate change on the horizon?

David Reynolds: Well, as you said, these are educated guesses because we're just going by what we've seen in past and what we understand, how the atmosphere works, in California especially in the summertime. So, one of the things we speculated on was the fact that as…in fact, we've actually started to see this since about the late 70's and that is during the summer months as the interior starts to warm due to climate change and global warming, the on shore flow will increase because we replace that warm, hot air in the valley that's rising rapidly like a chimney with cool marine air and so the coastal areas, we've actually seen a decrease in their summertime temperatures, the max temperatures during the summertime because this ocean breeze has incased and produced more coastal onshore flow right near the coast and so, that, we speculate, as the temperatures get warmer and warmer over the next ten to thirty years or so that that trend may continue and that may also produce more stratus in the coastal areas because of the strong upwelling that would occur due to this persistent northwest wind, as we talked about before the break.

We'd actually see that be more persistent because the driver of that is hot interior low pressure that develops because of the heat with the Pacific high pressure that sits off the west coast all summer and that drives this pressure gradient out of the north and keeps the winds blowing and so, more upwelling causes more stratus and more stratus would help keep our temperatures down as we saw last summer. So, last summer may be more typical than we'd like to think about for the next 20, 30, 40 years.

Jennifer Stock: Interesting. How about…I've read about drier dry years and wetter wet years. How does that work?

David Reynolds: Well, we think one of the things that may occur is that as the atmosphere warms globally, the jet stream is going to move further north and so, in those cases where we don't have a strong (?) from let's say, an El Nino or a La Nina, real strong El Nino or La Nina, the jet stream may tend to be further north than it normally has

been over the past thousands of years, let's say because we're just going to be in a much warmer environment.

So, that's going to change where the jet stream resides and so those dry years that we've had in the past may be even drier because we're just not going to get…the few storms that we do get during a dry year may not even get those. So, there may be a possibility that the driest years we've had in the past would be even drier because we're not even getting a few storms to help add to the snow pack or to add to the water supply and then in the opposite of that would be because the atmosphere holds more moisture when it's warmer and because the sea surface temperatures in the tropics are going to be warmer.

The drivers that drive…it's not the sea surface temperatures, per se, that drives our weather, but it's the thunderstorms, these large complexes of thunderstorms that develop over the tropics that drive the jet stream that drive the storms into California and there's a certain threshold of about 83, 85 degrees Fahrenheit, once the sea surface temperatures rise above that, they generate these large thunderstorms and you can imagine if we raise the sea surface temperatures just a few degrees Fahrenheit, we could tip the scales into some larger areas of these deep thunderstorms and then as this jet stream is shifted south because of the force into these thunderstorms, the air is going to hold more moisture as those jet streams come into California with higher moisture content, we could see bigger rains and thus, bigger floods.

Jennifer Stock: So, there's a lot of land planning that needs to happen on the coast and on the edges. I mean, just like we were hearing in Missouri right now with the river and all these communities and the entire economy is affected by it.

David Reynolds: Absolutely and California is so sensitive to our winter snow pack supply and if you can imagine at the freezing level, because the atmosphere is warmer, the atmosphere is going to produce more rain higher up on the Sierra, Nevada, let's say, than it does now/ That's going to produce runoff in the winter time that normally resides as snow pack until the spring.

So, our reservoirs, instead of being able to store that in the spring, that water is coming down in the winter time and because we may have heavier rains in the late winter, early spring, we can't store it at that time. We have to let it go and keep our reservoirs for flood protection. We just won't have as much water in the springtime…you know, say, a climatologically warmer climate

over the next thirty to fifty years, which would certainly impact the water supply for California.

Jennifer Stock: So, how do you feel…agencies that manage our water supply and these edges of rivers and estuaries, how are they handling this information that we're starting to think about in terms of the future?

David Reynolds: Well, I think from a, say, a water supply or a flood management situation, I think we are starting to think about how are we going to keep that water, how are we going to store that water when we need it and so we have it during the growing season and in the summertime and, you know, that becomes a difficult question environmentally because we have to think about more reservoirs or more storage areas.

You have to pump it back into the ground for soil recharge or build more reservoirs or offsite, offline storage areas to keep the water that's coming down during the wintertime. I think the other thing is, if you're in an estuary or something like that you may see much higher flows if they get one of these very heavy rainstorms, which could cause quite a bit of damage due to very high flows and a lot of sedimentation coming down, or just the opposite. We may go…we could go several years without very high flows at all.

So, the fisheries could be affected by the fact that we just don't have the flows we need during the springtime when the salmon are trying to come back upstream. So, you'd have to manage those reservoirs so you'd have the water in the water temperatures kept at a certain temperature so that those salmonoids can get back upstream without dying due to either the hot water or no water. So, it's a very complex problem.

Jennifer Stock: It's extremely dynamic. That's the word that just keeps coming through my head as we're talking about the ocean and the atmosphere and the interactions and all these different phenomena happening and so much that we don't know. It's just very dynamic, this science is extremely active and I hope that we'll have more scientists coming into the field to be working on these topics because they are so important for the economy and for our communities for sustaining.

David Reynolds: Yeah, I think one of the real helpful things that young scientists can think about is to improve our regional climate models. Right now, our climate models are so coarse that they have a hard time picking up on what the precipitation, rainfall may be in California

specifically and what specifically may happen in certain important locations, say, in northern California versus southern California. We just don't have the resolution, but with time as computers get better and we get better science put into those climate forecasts, we might have a much better handle on what the impacts will be on a regional basis.

Jennifer Stock: So, for these just tuning in, I'm Jennifer Stock, this is Ocean Currents and I've been talking with Dave Reynolds from the National Weather Service about our weather and how the ocean and the weather are interacting and Dave, we have about five more minutes left. One thing we haven't touched on too much is the biological aspect that somewhat, the second half of after all this oceanography and atmospheric science plays out is the biological reaction and it seems that for the upwelling that we may get more of with these additional winds, some of us might think, "Well, that's a great thing because upwelling is good. It's great for the food web, but what are some of the downsides of that in terms of the biological food web?

David Reynolds: Well, I'm not an expert on the biology of the fisheries, but I know that upwelling is good, but if it's salmon, even if you have a large returning population, they have to have a stream flow and rivers that are a certain temperature so that they can make it back to their spawning locations and I think one of the challenges is going to be, which has really been the most important driver for our salmon population?

We know it's decreased over the last couple of years. It seems to be picking back up, but was that a combination of dry winters and poor stream flow or was that the lack of upwelling we had in 2005 and 2006? Again, that is a complicated issue to say the least, but it's hard for me to speculate because I'm an atmospheric science type of guy, not the biologist in the ocean. So, I'll probably leave that up to another guest someday.

Jennifer Stock: Well, we've talked about that, actually, on previous shows with John Largier. He was also on our show talking a little bit about this climate report, but the one thing that just comes to mind is I don't think people really realize that with a lot of extra upwelling, it will be bringing up potentially more acidic waters, waters that have been sitting further down on the sea floor where there's more carbon dioxide. The ocean is a big sink for all this carbon dioxide we've been putting into the atmosphere and it may come up and be biting us on the food web.

David Reynolds: Yeah, there is another…you can get too much oxygen, because if you get too much of this growth in biota, it can sink to the bottom and consume all the oxygen and so, if you get too much oxygen, then there's none at all because it's consumed by the rotting plants and then you can get toxicity to the fish, especially if you get a real burst of upwelling, lots of production, and then that all dies off and sinks to the bottom and I know that's an impact that can occur, especially up in Oregon and Washington. They have that quite often.

Jennifer Stock: Is that hypoxic?

David Reynolds: Yes, I think that's the term.

Jennifer Stock: Interesting. What are some of the things you'd like to share in terms of just these last few minutes in terms of the sciences here and as citizens that are paying attention to the weather and keeping an eye on things, are there any last recommendations you have for us or...

David Reynolds: Well, one of the things people might have heard over the last couple of years that we've started to discuss in terms of weather impact that is driven by sea surface temperatures and tropical convection is something called a Madden-Julian oscillation, which is something that occurs in the tropics, starts out in the Indian Ocean and moves east into the tropical Pacific, but it's on an intra-annual basis, meaning it has a cycle of about 30 to 45 days and it's most important during these neutral winters, meaning we don't have a strong El Nino or strong La Nina, but we have neutral conditions, which we're expecting this upcoming winter and this MJO, you can think of it as like a mini-El Nino.

It's strong, convection that develops, but it moves out as a disturbance out from the Indian Ocean and our into the western Pacific, then out towards the Central Pacific. It can enhance the jet stream, just like El Nino does and produce these strong rivers of very high moisture content into California. We call them atmospheric rivers and these atmospheric rivers are what produce most of the flooding in California. So, if we do have a sort of a neutral winter coming up, people should pay attention to our discussions or when we start mentioning something like the Madden-Julian oscillation they should sort of perk their ears up because it may mean that we could be looking at a fairly major wet storm, which would produce some of our worst flooding.

So, it's just something to think about. They do occur during these neutral years and we appear to be going into one of those types of years.

Jennifer Stock: Thank you, David. That's actually very important to think about as we've just had a pretty wet winter here and we may have more coming up in just a couple of months as we head into the winter…well, we're in the summer now. We've got a ways to go.

David Reynolds: Enjoy the summer.

Jennifer Stock: We have to figure out how to store this extra water is what we need to do.

David Reynolds: Right.

Jennifer Stock: Thank you so much, David. This has been so interesting and it makes me realize how much I didn't know about atmospheric sciences and I really appreciate you taking the time to explain some of these phenomena to us and predict our weather.

David Reynolds: Alright, thank you. It's been my pleasure.

Jennifer Stock: Thanks again.

David Reynolds: Bye bye.

Jennifer Stock: That was David Reynolds from the National Weather Service, part of NOAA and the National Weather Service forecasts the weather that we look to every day to find out what to wear and do I need my umbrella. David's been talking a little bit about these interactions between the atmosphere and the ocean and the main thing I'm taking away here is just the incredible dynamics of it all and how interconnected we are as a planet with living on land and receiving the effects of weather that are so tied to our atmosphere and sea conditions as well.

We didn't really touch too much on the biological aspects of that, but we have talked about some of that on past shows and we will again. We're going to take a quick break here and when I come back I have some other announcements to share with you. Thanks for staying with us.

(Music)

Jennifer Stock: Alright, you've been tuning into Ocean Currents here on KWMR. We've been talking about the ocean and the atmosphere and our weather. I thought I'd share with you a couple of websites that have some great information regarding this topic. One thing I found that I didn't even know existed before, but is a really nice source of information for all things water. It's called Water Encyclopedia.com and if you go on that website, you can go through a series of topics regarding water and ocean and you can type in, I typed in "Ocean Weather" and "Weather Ocean" and so many great things came up with wonderful references as to where the information came from.

That's waterencyclopedia.com, of course, there's the NOAA website that the National Weather Service is a part of,www.noaa.gov and David mentioned the National Climate…or…the NCEP.NOAA.GOV, I can't remember what that stands for, but environmental predictions, he was talking about how they get a lot of their data from that website in terms of predicting the weather that we have, ncep.noaa.gov. And also, the last part is the climate change work. The climate change impacts report that I referenced earlier is a really great source of information of what we're potentially expecting here on the horizon.

I've brought this up on past shows and we've had John Largier and some others talk a little bit about some of the findings in this report, but it's really nice to read all the different things that we could potentially be planning for here and the national marine sanctuaries, I know, are taking it as to how are we going to manage these special marine protected areas with climate change and looking at adaptive management and what does that mean and how do we mitigate all the other human caused threats to the ocean while we have this large-scale climate change event coming on as well…very, very complex. So, I encourage you to look at that.

You can get it off of either the Cordell Bank or Farallones websites, cordellbank.noaa.gov orfarallones.noaa.gov and it's almost like a good textbook. So, if you're interested in learning more about that, definitely check it out. Let's see…we've got some other things happening. This week, the Cordell Bank Sanctuary Advisory Council has a meeting at the Red Bard at Point Reyes National Seashore, 9:30 to 2pm. the sanctuary advisory council is made up of volunteers representing different constituencies to help advise the sanctuary on what to do. Gulf of the Farallones has an advisory council as well and we have people from conservation, research, the maritime industry, education, public at large, a couple

local residents here are a part of both of these councils and they're always open to the public.

So, you're welcome to come and learn more. This coming meeting, there will be an update from the vessel working group that is looking at issues with big vessels coming in and out of the sanctuaries and how to mitigate impacts with large mammals or oil spills and what not. So, that's going to be a good report out there.

You can get more information on the agenda there and find out more at our website, cordellbank.noaa.gov and kind of a fun thing for those of you that are wildlife enthusiasts, we are at a period where the ocean conditions are changing and this time of year is when a lot of pelagic seabirds start making their way to this part of the Pacific because of the upwelling that we have here all of this really good food and some scientists from Oikonios Ecosystem Knowledge, a nonprofit and the USGS have been part of a pink-footed shearwater tagging project and these beautiful birds that are completely pelagic, they only come to land to breed, come up from Chile, these small islands, the Juan Fernandez Islands off of Chile to feed up here in the north Pacific and they've been doing a tagging study to look at exactly where they're going and you can follow along online. So, if you go to Oikonos.org, that's O-I-K-O-N-O-S dot org, right there on their homepage there's a link where you can follow along, go to these maps and see where the birds are. It took about a month for them to get to the United State from Chile.

So, these birds are booking, looking for food, coming on up to the California current. It's very exciting. This is also National Ocean Month, in fact, this week is World Ocean's Day on June 8th and it's a time where both our communities as well as our government really takes a look at our ocean. We have oceans week in DC happening, a lot of sessions with different nonprofits and special speakers talking about the importance of the ocean and the economy. This year they're focusing on clean energy in terms of ocean conservation.

So, that's pretty exciting. Oceans Week is happening in Washington DC this week. It's also the same month of Jacques Cousteau's birthday as well as the anniversary of his death. So, an important person in the ocean conservation movement that we recognize in June and lastly, I have an interesting factoid about the Titanic. On May 31st the world's best-known shipwreck turned 100 on May 31st. This boat was launched out of Belfast Northern Ireland in 1911 and this is what I found rather interesting.

The Titanic became the catalyst for the development of international law on safety of navigation including the international convention for the safety of life at sea as well as for the establishment of the International Maritime Organizations Agency that's responsible for the safety and security of shipping and prevention of marine pollution by ships. So, just a little tidbit there of maritime history. I always think it's interesting to think about events like that that have stimulated different changes in how we look at things now. It's pretty important all from this incredible ship that is very well known.

Thanks for tuning in today to Ocean Currents, I'll be back live in the studio in August, I don't remember which date it is now, but my guest is very exciting Curtis Ebbesmeyer. He is an oceanographer and avid beachcomber and for those of you that follow beach-combing stories, this is the oceanographer that studied the container ships that spilled Nike shoes and rubber duckies some years ago and he mapped out where they landed and really used marine debris somewhat as an indicator and a way to study oceanography.

So, pretty interesting information that we'll be talking about in August with Curtis Ebbesmeyer. You've been listening to Ocean Currents. You can catch past shows on cordellbank.noaa.gov on our podcast. If you click on the "Tune in to the Ocean" link, it'll take you to all the past shows that I've had here on Ocean Currents in the last five years. So, thank you so much for tuning in.

(Music)

Jennifer Stock: Thank you for listening to Ocean Currents. This show is brought to you by NOAA's Cordell Bank National Marine Sanctuary, on West Marin Community Radio, KWMR. Views expressed by guests of this program may or may not be that of the National Oceanic and Atmospheric Administration, and are meant to be educational in nature. To learn more about Cordell Bank National Marine Sanctuary, go to cordellbank.noaa.gov.