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!

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Jennifer Stock: This is Jennifer Stock. I'm the host for Ocean Currents and I bring this show to you once a month, the first Monday of every month from the Cordell Bank National Marine Sanctuary to help raise the awareness of what's going on out there on the ocean amongst the listeners…to you listeners. This show is part of the West Marin Matters series, on every Monday of the month, you can hear a show about local or global economy or environment topics. On Ocean Currents, we talk about all things relating to saltwater.

This is a blue planet we live on with over 70 percent of it being ocean. So, it does deserve a radio show of its own. We focus on ocean science, conservation, natural history, policy, ocean adventurers, sometimes focusing locally here on our local national marine sanctuaries and sometimes focusing globally. This time of year, we anxiously stand watch on the coasts looking for the southward migration of gray whales. Every year, gray whales make an annual round-trip migration of 10,000 miles between Alaskan waters in the Bering Sea, to the warm lagoons of Baja, Mexico to breed and give birth. Then, later this spring, they will turn around and head back north to their feeding grounds. Truly a remarkable migration and very visible for us land-based folks to observe and connect to.

My guest today, Dr. Liz Alter, studied the current population of gray whales while doing here PHD at Stanford University and looked specifically at the genetic diversity of the whales and what she found was quite a surprise. Liz currently works as a science fellow with the Natural Resources Defense Council, also known as NRDC, and makes recommendations based on science on marine mammal issues on policy matters and environmental issues. Liz joins us today by phone on the east coast. So, welcome, Liz. Thank you for coming on the show today. You're live on the air.

Liz Alter: Great. It's my pleasure. Thanks so much for having me.

Jennifer Stock: So, while most students who are working on a PHD come to their program with a question that addresses a knowledge gap or a

problem to solve, what was the question that you were thinking about when you started doing your work at Stanford?

Liz Alter: Well, as you probably know, one of the primary goals of conservation science is to allow threatened and endangered species to recover, that is, to provide conditions such that today's population sizes can match those that were there before human disturbance, but one important question is: How do you figure out how abundant the species was before human impact? And one way to investigate this question is with DNA. It turns out that genetic composition of a species alive today can give you an idea of just how many individuals were there in the past and so, we decided to try to apply this idea to gray whales.

Jennifer Stock: So, when…just to go back historically, when did gray whales…when were gray whales hunted as part of the whaling era?

Liz Alter: The major whaling era for gray whales was at the end of the 19th century. So, the late 1800's and they were hunted primarily in the lagoons of Baja. The lagoons provided a very convenient whaling ground because as you mentioned, the whales congregate there in the winter and the lagoons are quite shallow. So, easy for ships to get in there and find large numbers of concentrated whales. In addition, the whales are often there with their young and whalers took advantage of that by killing young whales in order to make the mothers stay nearby. At that point they would take the mothers. So, they were able to take large numbers of whales in a very short matter of years.

Jennifer Stock: What…do you remember what the population was estimated to be at when the whaling era ended, of gray whales, that is?

Liz Alter: It's a matter of some debate, but it's thought that the population at its very smallest, once whaling was kind of at its peak, was probably in order of a thousand or a few thousand individuals.

Jennifer Stock: Wow. Now, there were other gray whale populations around the world as well, are there not?

Liz Alter: Yeah. Today there are only the two. The one that you've seen migrating past your coast is the eastern Pacific population and then there is another extant population in the western Pacific, which is highly, highly endangered. It's one of the world's most endangered baleen whale populations. It's about 120 individuals at this point.

Jennifer Stock: Was that a…I'm sorry. Go ahead.

Liz Alter: I was just going to mention in the past there was a third population in the Atlantic and that population went extinct, we think sometime in the 1700's and what caused its extinction is still a matter of some debate. Whaling would be one obvious cause, but Atlantic whales, oddly enough, don't show up in whaling records very often. So, climate has been suggested as an alternative cause for its extinction.

Jennifer Stock: And the population over in…it's in the Russian part of the Pacific? Those…were those hunted as well? Is that a result of whaling as well?

Liz Alter: We don't know very much about it unfortunately, whereas we have really good whaling records and log books for this side of the Pacific, we have much less information about the western Pacific, the other side, but almost certainly that was the case and between Russia and Japanese and Korean coastal whalers, they took the population numbers down.

Jennifer Stock: Now, we have a pretty, what most people think, a pretty healthy gray whale population on the west coast and some folks have said it's recovered and the approximate population is about 20,000 animals. Your research suggests differently. Can you talk a little bit about how you went about your research and some of the findings? So, talk a little bit about how you went about to do the genetic sampling and also the results that you got and I think they're quite surprising.

Liz Alter: Sure. Absolutely, yeah. So, as you mentioned, the purpose of our study was to determine whether gray whale populations had actually returned to pre-hunting levels as some in the scientific and regulatory communities had declared. So, we wanted to provide a historical context for today's population numbers and trends and the way we did that was by using DNA. So, the premise of the genetic study is pretty simple.

The idea is that the amount of genetic variation in a population indicates how big that population was in the past and that's because a large population of breeding individuals can sustain much higher variability in DNA than a small population. The larger population has a greater probability of mutation and it's also less likely to lose variations through random chance or through inbreeding and so the technique we use had been used with human populations as well and with grizzly bears and some other terrestrial species, but to our

knowledge, it's the first time it's been applied at this scale to a marine species.

So, as you mentioned, what we found was that the levels of variation in DNA were too high to have come from a population that numbered 20,000. So, in fact, the population that would be suggested by the amount of variation we found was about 100,000 animals. So, you know, roughly five times as many as we have now.

Jennifer Stock: That's outstanding. It's almost unfathomable to think that it's almost five times as many whales that we have now. Now, with the…these are whales that are baleen whales. They sieve through their baleen plates, but unlike humpbacks and blue whales that feed up in the water column, gray whales sift in the mud. What exactly are they feeding on in the mud? How deep do they go and what types of things do they pull up?

Liz Alter: Yeah, so, you know, we think of gray whales as sort of marine bulldozers. They're bulldozing through the mud with their baleen, not going very deep. They're dredging up marine invertebrates, primarily anthropoids, and other small crustaceans, but really, just about anything that lives in the mud that they're picking up, but they do target these very high calorie anthropoids in the Bering Sea and northward. So, we know that in the way that they feed, they have been an important component in nearshore and pelagic ecosystems, but we just haven't had very much information about what their pre-whaling population was and so, that's really prevented us from understanding what their historical roles in ecosystems might have been.

Jennifer Stock: For those just tuning in, we're talking with Liz Alter, who is talking about the study of gray whales and the genetic diversity that we have in our current populations suggesting that our original population of gray whales was much larger than the one that we have today. We're estimating that based on the genetic variation that there potentially may have been about 100,000 animals at one point. That suggests that the ocean probably was able to support 100,000 animals. What does the 20,000 animal population say recovered mean as far as ocean conditions go?

Liz Alter: You mean ocean conditions today and what we're seeing with the gray whale population today?

Jennifer Stock: Right. How do you think that ocean conditions have changed since the population was supporting 100,000 animals and now, a population only supporting 20,000 animals?

Liz Alter: Right, so, yeah. This is a really interesting question and very relevant as we're continuing to see this phenomenon of skinny whales and you may have seen some off your coast this year. So, for the last few years, scientists working in Baja and observing the migration in southern California have noted roughly 10 percent of gray whales looking kind of skinny and when you see a whale in this condition, it's pretty obvious.

Their scapula is sticking up and you can see their vertebrae which is not the case for a nice, healthy, fat whale and so, one hypothesis right now is that we're seeing a big shift in terms of what these whales are able to find in the way of food. It goes along with the observations that whales have been moving increasingly northward for feeding.

So, whereas in the 1980's, we saw large concentrations of gray whales feeding in the Bering Sea, now they, a lot of them, move even farther north up into the Beaufort and Chachi Seas, all the way around to Barrow where once it was pretty unusual to see a gray whale and now, Eskimo whaling tribes up there see them quite frequently and so, the hypothesis is that, basically, climate change is changing oceanographic conditions in their feeding grounds and gray whales are in this period of adaptation where their population is catching up with oceanographic changes.

Jennifer Stock: There have been some local reports here of resident gray whales, specifically around the Gulf of the Farallones, Point Reyes area. There have been a couple of gray whales that seem to stick around year-round, even coming in to Tomales Bay and what not. Do you think that whales that might be doing this local residency, it's the same thing? If the food's good here, why go all the way to the Bering Sea where it may not be as good?

Liz Alter: Yeah. You know, and that mirrors what other folks in British Columbia have seen too, sort of, these increasing numbers of so-called resident whales or local feeding aggregations and I think that's absolutely right that whales right now are looking for any additional feeding opportunities and if they find a good patch that's further south, it makes a lot more sense to conserve calories and stay there rather than traveling north where you might not find as much.

Jennifer Stock: As far as an ecosystem connection, when gray whales feed and they're stirring up the mud, I'm assuming this also has an effect on the surrounding ecosystem, other fish that might be nearby finding stirred up food, maybe even birds coming to forage? Has this big shift, do you think, changed the greater ecosystem as far as food availability, not just the amphipods for the gray whales, but the birds and the nearby fish and other animals?

Liz Alter: Absolutely. As you said, they're picking up crustaceans and other invertebrates in the mud and basically, stirring up the mud in a way that really effects the benthic ecosystem and that also brings leftover food and nutrients to the surface and nutrients and food, which otherwise would have stayed on the ocean floor. So, in addition to changing nutrient cycling, they're also providing food subsidies to communities in the water column and terrestrial communities including seabirds. So, in our study, we estimated that the historical population of gray whales, that is, the population of about 100,000 would have supplemented the diet of about a million seabirds.

Jennifer Stock: Wow. So, those are in decline as well, I'm sure.

Liz Alter: Right. Yeah, well, yeah…or at least, we don't have any evidence to suggest that right now, but that may be because we just don't know what historical populations of seabirds used to look like.

Jennifer Stock: One of the contributing factors then, probably, as far as food change.

Liz Alter: Yeah, exactly.

Jennifer Stock: Talk a little bit about how you did your sampling. How do you get samples of DNA for gray whales? How many animals did you sample from? I also read that you did some work at some Macaw sites in Washington, the Macaw tribe have rights to be able to hunt gray whales through their Indian Treaty Rights. Can you talk a little bit about how you did your sampling to get the DNA?

Liz Alter: Sure, yeah. This is one of the first questions that we often get. Getting samples from whales is not an easy process and for this study, we were lucky to be able to work with the Southwest Fisheries Science Center, which is part of the National Marine Fisheries Service and they maintain a collection of DNA samples from marine mammals that have stranded along the coast of California or Washington or Oregon and in addition, they maintain a collection of any animals that were biopsied.

So, we were able to utilize some of their samples for this study, which was great, because it gave us a very nice random sampling of the population. So, one of the issues with going out and biopsying a whole group of whales in a short period of time is that you may be very likely to be sampling family groups and that can really bias your study because, obviously, family members are more closely related to each other genetically.

So, you would get a much lower estimate of genetic variation than you would otherwise. We were very grateful to the Southwest Fisheries Science Center for helping us out with the samples.

Jennifer Stock: That's neat. Is there any bias as far as sampling from whales that have washed up dead as far as they're not alive anymore?

Liz Alter: So, not to our knowledge. You know, it's…an open question as to whether disease played any role in the massive stranding events that happened in 1999 and 2000, but to our knowledge, there's no bias in those samples. So, the stranded animals should represent a random subset of the population.

Jennifer Stock: So, what was your purpose of going up to the Macaw tribe and sampling ancient, I guess they were bones? How did you sample up there?

Liz Alter: Yeah, that's right. So, the purpose of that study was to follow up on the work that I've been talking about. So, this study that used the modern DNA showed that we had a population of 100,000 gray whales, give or take, but the next big question is, well, when did we have such a big population? Was it 200 years ago? Was it 2,000 years ago, et cetra?

And, you know, in order to make these results relevant for management, we'd really like to know if perhaps the bottleneck in gray whales, that big decline from 100,000 to the 20,000 we see today, if that occurred before whaling even started due to some natural cause and that's very difficult to…it's a difficult thing to study using modern DNA data alone, but if you have DNA samples from multiple points in time, then that can give you a much better idea of historical and ancient fluctuations in the population.

So, with that in mind, I worked with the Macaw Tribe and some archaeological samples that they had in their collection in Mea Bay in Northwest Washington state and that work is still in progress.

So, I won't speak about the results quite yet, but look for it in the next year or so.

Jennifer Stock: Interesting. How about other samples that are in geologic formations, like I know here in Point Reyes out at Drake's Bay we have this layered sediment out where you can just see layers and layers of rocks and there's fossils in there and I've heard there's quite a few gray whale fossils in there. How would that help? Would that contribute to the study as well as far as a time period that you would be looking at?

Liz Alter: It would depend on, like you said, the time period. Most of the material that is useful for DNA that tends to be sub-fossils. So, it tends to be Holocene material and from the last 10,000 years or so. Much older than that, it's absolutely possible to get DNA out, but it becomes harder and harder and once true fossilization is taking place then it is is just about impossible as far as we know, although, you can always hold that hope that one day we'll get real DNA from T-Rex and that sort of thing.

Jennifer Stock: That's amazing to even think that you can get a living tissue like that that has so much genetic information from something that's been dead for so long.

Liz Alter: It is. Yeah, it's a remarkable thing. It's always amazing to me just how much information there is about populations in literally micrograms of material from an organism.

Jennifer Stock: Incredible. Has this type of sampling, genetic sampling, been used in other marine mammal populations?

Liz Alter: Certainly, genetic information from marine mammals is widespread and important. It…typically, genetic information is used to try to determine how many separate breeding populations there are and occasionally, it's used to do mark recapture studies and something like that, studies of that nature in order to determine the exact number of individuals alive today, but this kind of historical work is a bit rare, although, certainly, there's lots of potential for applications to other species.

Jennifer Stock: I know in the Pacific here, there's a humpback whale study called splash where they're doing genetic work amongst all the different populations of humpbacks to see how they're related or not related and...

Liz Alter: Exactly, yeah.

Jennifer Stock: …if there's crossbreeding. It's really cool.

Liz Alter: Yeah, and it's also very…it's sort of a new trend and a really important trend, I think is to compare genetic data with data from other sources like stable isotopes or photo ID data and…I was a geneticist by training and I got into these other fields, sort of secondhand, but the more I learn about them, the more I realize how incredibly valuable it is to have information from all of these different sources when you're trying to learn about these populations that only surface for seconds at a time and are very hard to find.

Jennifer Stock: When you do the genetic studies, is there a specific number of genes or type of genes that you are looking for that quantify, like you said, you had a much bigger diversity of genes available suggesting the bigger population size. What is kind of a threshold or specific genes that you look for when you're doing this?

Liz Alter: The main points of importance there are that you want regions of DNA that are not subject to natural selection. You want them to be evolving mutually. In other words, changing randomly and in addition, you want to make sure that you have as many different regions of the genome represented as you can and that's because just by chance, different genes change at different rates. So, in order to get an idea of the true population size, you want…you're looking for a random selection of mutually evolving genes.

Jennifer Stock: It's pretty hard to explain it. I had a hard time in genetics in school, or most folks anyway.

Liz Alter: The other thing I should mention though, is that it's also important to know the evolutionary rate of all these genes and so that was something we had to measure in this study as well and one of the interesting things that we found was that on average, whale DNA, gray whale DNA was mutating at a much slower rate compared to your average mammal and it's though…we think the reason for that is because of the large body size and slower metabolism of whales compared to, say, rodents.

Jennifer Stock: Well, we're just coming up to about 1:30. We have just a few minutes. So, Liz, if you don't mind staying on hold for a little bit, we're going to take a short break and we'll come back in just a few minutes and talk about some of these results and what do these suggest for future management of gray whales and other marine

mammals. So, please stay with us. We're going to take a short break and we'll be back in just a minute.

(Music)

Jennifer Stock: This is Ocean Currents. My guest today is Dr. Liz Alter with the NRDC, Natural Resource Defense Council. We've been talking about a study she did on gray whales and learning about their potential future…past populations being much higher than they are right now. Now, Liz, what…how do we think that gray whales, when we came back to about the population we have now, why did we think they were recovered? What pointed to them being a recovered species?

Liz Alter: Sure. Well, the historical population estimate for gray whales was based on whaling log books and then the numbers for those varied between about 15,000 and 30,000. So, that roughly matches the numbers that we see today. However, there's many reasons to be skeptical of those estimating historical populations from whaling log books alone.

Obviously, there may be lost records that we don't know about and in addition, there's a big question about how you get from numbers of whales killed to the total population in the past and with gray whales, it's particularly tricky because the historical numbers are based on the numbers of barrels of whale oil filled and the records for those and so, in order to make that calculation, you have to make some pretty broad assumptions about how many barrels of oil you get from one whale, et cetera and you have to take into account the number of whales that may have been struck and killed, but not taken aboard for various reasons.

So, there's a lot of assumptions that go into those calculations and we know that they're almost certainly going to be on the low side. So, that was the initial reason for assuming that this population was recovered, but second was that in 1999 and 2000, as I mentioned earlier, we saw this die off of gray whales, an increase in stranding, a decrease in calving rates, and many people looked at that trend of a population that had been growing very quickly and then, all of a sudden, hit the wall and said, "Oh, okay. So, the gray whale population has reached a level where ocean resources can no longer support it. So, it must have reached the level it had in the past before whaling had occurred." So, those were the two primary reasons why some in the scientific and regulatory communities hadn't declared that gray whales were recovered.

Jennifer Stock: You say some…were there some that believed this was not a recovery? That this was just a reflection of the changing ocean conditions?

Liz Alter: Yeah, and I think, you know, in the years in between 2000 and now, I think a lot of scientists that work on gray whales have found…have seen that, in fact, the changes in the population point to some fairly new and dramatic changes in their habitat, their feeding habitat in particular and that rather than being simply a case of these whales hitting their long-term carrying capacity, that we're seeing something really different now than what may have happened in the past.

Jennifer Stock: Well, one of the most…things that really struck me in reading this paper and the media surrounding it was that if gray whales were a number of 100,000 at one time and our current population…the ocean can barely support the current population of 20,000 now, what does this mean, not just for gray whales, but for other marine species and ecosystems? Is there a worry that the ocean cannot support life like it used to?

Liz Alter: Yeah. Absolutely. I mean, I think this is one of the more depressing aspects of this sort of study. You know, the genetic results suggest that gray whales haven't fully recovered from whaling, but what's going on now with the population suggests that they may not ever be able to fully recover and that the changes in the oceans that have happened in the meantime may prevent them from recovering fully and, you know, it's not just climate change. It's pollution, both chemical and noise, coastal development, commercial overfishing. You know, gray whales are a highly coastal, which is one reason why they're so familiar along the coast of California. They're, as you mentioned, they're really easy to spot and they're a very familiar species, but their love of coasts puts them in greater risk of various human impacts along the shoreline.

Jennifer Stock: With that in mind, as far as we're seeing huge climate shifts already…climate-created shifts compared with other industrial shifts of human development along the coastlines and pollution and what not, what do you think are the most important recommendations for scientists and resource managers for persevering what we have for the remainder with this incredible change? What do you think are the most important things to focus on for conserving based on this huge amount of change we're seeing right now.

Liz Alter: Yeah, it's a really good question and obviously a very difficult one, but you know, there are things that we can change and there are things that are more difficult to change, of course. Unfortunately, climate change is one of those things that we're now reading studies that say that even if we stop everything today, we're going to be in the same fix for about 1,000 years.

The wheels are already in motion and while it's important to try to slow the train down as much as we can, there's certain ecosystem changes that are inevitable at this point and that's very frightening, but there are things that we can control and those include some of the other impacts that I mentioned like coastal development and pollution, particularly chemical and acoustic pollution. So, you know, these whales and all marine creatures and especially those that are close to the coast deal with this incredibly suite of impacts and making sure that we reduce the ones we can and helping wild populations in whatever way we can adapt to the ones that are inevitable at this point, I guess, you know, is what's important.

Jennifer Stock: I heard Jane Lubchenko and Sylvia Earl speak at a climate change Senate hearing last year and two things that really struck me that they said were about protecting the biodiversity that we do have and protecting the edges of the ocean where there is such extreme biodiversity and healthy habitat and we have that here in California. It's really important that we focus on that as far as one of the best things we possibly can do for preserving ocean life in the future.

Liz Alter: Oh, that's absolutely right. I couldn't agree more and, you know, you mentioned before that you're seeing gray whales feeding off of Point Reyes and, you know, that's as climate influences their habitat farther north, areas like that are going to become increasingly important. So, for making sure that we preserve what we do have and protecting large swaths of habitat that we can. It will be really critical.

Jennifer Stock: What are some of the marine mammal-related issues that you're working on with NRDC right now?

Liz Alter: So, in my current work, I'm striving to try to ensure that the best available science is used in policy, particularly marine mammal policy and one of the things I'm working on is the science underlying the impacts of human-caused noise, both acute noise from things like maybe sonar and then sort of, more general ocean noise. Chris Clark at Cornell University has a very poignant term for it, "acoustic smog," I think kind of says it all.

Marine mammals are extremely acoustically sensitive and species…they depend on acoustics for navigation and for communication, for feeding, for avoiding predators and so, the amount of human-cashed noise that's in the ocean right now has the potential to really be impacting their very basic activities like finding mates and being able to find their way around.

So, one of the things that I'm working on is trying to figure out whether we can identify areas of the ocean that are particularly important to marine mammals and try to put those areas off limits to loud noise sources. So, it's, you know, like, expanding a bit beyond the idea of marine protected areas to sort of more generalized, the idea of ocean zoning and marine spatial planning.

Jennifer Stock: That's great. That ties in really icily for my show next month. I'm interviewing Dr. John Hildebrand from Scripps Institute in San Diego talking about acoustics in the ocean and his original story or original research area was using acoustics to study populations and movement in the ocean of those animals, but he's also working in the area of disturbance and what not. So, we'll be tying into that next month.

Liz Alter: Yeah. Dr. Hildebrand is just one of the foremost experts in marine mammal acoustics and I'm sure it'll be a fascinating interview.

Jennifer Stock: Wonderful. Well, Liz, thank you for taking the time to talk with us today about the gray whales. I was just stunned reading this and thought that it was really important to share because it really illustrates our changing ocean and the effects it may have on other parts of our ecosystems and urges us more to participate in conservation. Is there any resources or last words you'd like to share as far as ways to learn more about what you're doing?

Liz Alter: Well, I would encourage everyone to visit the NRDC website, nrdc.org, where we have a lot of information about our marine mammal program and how we're trying to protect marine mammals when it comes to human-caused noise disturbance and as a closing note, I would just say that the phenomenon of shifting baselines in the ocean, I think, is just a really insidious problem that I think it seems like your show really helps to fight against. So, thanks very much for having me on.

Jennifer Stock: Thank you. Have a wonderful afternoon.

Liz Alter: Thanks so much.

Jennifer Stock: Take care.

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Jennifer Stock: Thank you for tuning in today for Ocean Currents. This show is always the first Monday of the month and if you want to catch up on previous shows, there is a podcast available on the Cordell Bank National Marine Sanctuary website at cordellbank.noaa.gov and you can hear all the past shows that have been hosted here on KWMR and even sign up for a podcast if you'd like. Next month, we will have Dr. John Hildebrand on, who is an acoustic specialist. We'll be talking a lot about sound in the ocean. This has been a really interesting topic. It's been in the news a lot and John is a great speaker about the topic.

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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.