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The Dangerous diet of coastal condors

California condors don't seem to be able to catch a break, and their wide-ranging lifestyles can see contaminants spread across ecosystems. Carolyn Kurle explains their research.

The heat hits me as I step out of my car at the end of the questionable road that leads to the California condor capture pen at Bitter Creek National Wildlife Refuge, in a remote corner of southern California's San Joaquin Valley. Most of my fieldwork has occurred on remote Alaskan islands where it is damp and chilly even in August, so the dry desert heat at the height of summer is not something I normally contend with while working with animals. I worry I've not brought enough water as I unbuckle my then 4-year-old son, Jeremiah, from his car seat. He is along to 'help' as it is not every day one gets to witness the capture and handling of multiple California condors.

Condors are massive vultures, majestic in their black feathers, red eyes, strangely naked heads, and nearly 10 foot wingspans. They are the largest land bird in North America, and their prehistoric faces are captivating in their ugly beauty. At our first glimpse of the birds, Jeremiah grabs my hand and points as we both stare.

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Reading about their enormity is one thing, but being in proximity to their majesty is exhilarating. Particularly as they are so incredibly endangered. Having dropped to around 22 birds in the 1980's, a robust captive breeding and release program has boosted the population to its current level around 435 condors, over half of which are free-flying in the wild, affiliated with release sites in California, Arizona, and Baja California, Mexico. I know these birds are heavily managed by multiple agencies and their survival continues to depend upon near daily and exhaustive oversight by an incredible staff of biologists and volunteers, but seeing them soar in the sky over southern California makes me giddy with the knowledge that, despite all of the challenges, the conservation efforts for this species have been so extraordinarily well executed.

My role on this day at the condor pen is minimal. I am to collect blood samples for part of a highly collaborative study on the foraging habits of the two flocks of condors in California, which will help determine if their disparate dietary options may result in different risks

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of contaminant exposure. I am a food-web ecologist, conducting research to determine who eats what and why that matters for conservation, the structure of ecosystems, and the trajectories of animal populations. As scavengers, condors are drawn to dead animals and they are not picky eaters. Condors readily feed on the carcasses of feral pigs or ground squirrels, roadkill cats, and animals left behind by hunters. I was brought onto the project by Dr. Myra Finkelstein, a wildlife toxicologist at the University of California Santa Cruz, who had already gathered and published ample evidence that condors are threatened by lead poisoning as they inadvertently ingest spent lead while feeding on animals shot with lead-based ammunition.

But what of other pollutants? Our goal in this new study was to determine whether feeding on marine mammal carcasses on the California coast causes condors to ingest pollutants other than lead. The scientists and volunteers who monitor California condors in the wild had noticed that birds in the flock in central California

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Top: The Big Sur coastline. © Robert Schwemmer. Bottom: Condor makes a meal of a dead sealion. © Dave Evans

spend time on the coast in Big Sur, a gorgeous stretch of shoreline extending from near Hearst Castle in the south to Carmel in the north. While on the coast, these condors were sometimes observed eating beach-cast marine mammal carcasses. In contrast, the condor flock in southern California, at the Bitter Creek National Wildlife Refuge site I visited with my son, rarely spends time on the coast and is thought to never eat marine mammals. We sought to understand whether those potential dietary differences might translate into differential contaminant exposure for condors in the southern and central California flocks.

Understanding this difference could be important because marine mammals are known to contain high levels of contaminants. One of these contaminants, DDE, is a metabolite of DDT, an organochlorine pesticide widely used in agriculture and mosquito and fire ant control after World War II and made famous for its harmful effects on wildlife and human health in Rachel Carson's Silent Spring, the 1962 book that launched the modern environmental movement. DDT was banned in the United States in 1972, an action credited with aiding the recovery of populations of bald eagles, peregrine falcons, and brown pelicans, among other birds, all of which suffered egg-shell thinning and high reproductive failure as a result of DDE exposure.

DDT is one of many persistent organic pollutants, or POPs, so called because they do not readily degrade and will accumulate in tissues of animals. Other POPs we measured in the condors and marine mammals were polychlorinated biphenyls (PCBs), chemicals widely used in the electronics industry for decades, but whose manufacture has been banned in the US since the 1970's, and polybrominated diphenyl ethers (PBDEs), flame retardants, banned in a handful of states during the last decade. Finally, we wanted to measure the levels of mercury in condors as methylmercury can negatively impact wildlife and human health and is also known to be found at high concentrations in long-lived marine predators such as California sea lions, the marine mammal most often ingested by California condors.

The majority of California sea lions in the United States breed in the beautiful Channel Islands off the coast of southern California. These islands are magical, once home to at least two Native American tribes, made famous in the classic children's book Island of the Blue Dolphins by Scott O'Dell, and such prehistoric animals as pygmy mammoths and giant deer mice.

They currently host multiple endemic species such as the island fox, island deer mouse, and the island spotted skunk. When I was a fisheries biologist for NOAA's National Marine Mammal Laboratory, I spent several weeks on San Miguel Island helping monitor California sea lions. That island is home to three species of pinnipeds, northern fur seals, northern elephant seals, and California sea lions. We captured and tagged sea lion pups as part of a long-term monitoring project, and I marvelled at the sheer number of animals hauled out on the island to breed, nurse their pups, and forage in the productive waters around the islands. Nearly all California sea lions in the US return to these islands for their breeding season from May to August, then most juvenile and adult males leave southern California, spreading out along the west coast of

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North America as far as British Columbia, Canada.

While in southern California, the sea lions unwittingly eat fish that could be contaminated with POPs left over from their deposition in the middle of the last century. The sediments on the Palos Verdes Shelf near Los Angeles are contaminated with millions of pounds of DDTs (DDT and its metabolites) and PCBs. The DDTs were dumped from Montrose Chemical Corporation's DDT manufacturing plant in Torrance, California via the Los Angeles sewers from the 1950's to the early 1970's. The PCBs were from several industries, also released into the Los Angeles sewer system, then discharged along the shelf and continental slope. Mercury in marine systems comes in part from the atmosphere, as human activities such as burning fossil fuels emit mercury into the environment, and is deposited across the landscape including in marine and freshwater habitats. Finally, PBDEs are flame-retardants used in ubiquitous items such as furniture and electronics, and their presence has been recorded from the deepest ocean trenches to the end of the Earth at McMurdo station in Antarctica.

With these facts in mind, we had several questions we hoped to answer with our research. Are condors in Big Sur spending substantial time on the coast? Are they eating California sea lions in significant quantities? Are the sea lions contaminated? Are these pollutants finding their way into the California condors? And what are the possible consequences of their contaminant exposure?

Our job as scientists is to gather adequate data to support or reject our hypotheses, akin to an investigator collecting facts to solve a case. When working on a research project, especially one involving a conservation icon such as the California condor, data gathering and analysis must be as complete as possible and performed with the utmost attention to rigor. The group Dr. Finkelstein coordinated reflected a wide-range of conservation-minded biologists with differing skills, underscoring the collaborative nature of such a multi-disciplinary project. To augment Dr. Finkelstein's toxicological proficiency, my food web expertise, and the natural history knowledge of several condor biologists, Dr. Victoria Bakker from Montana State University was brought in as the third senior investigator on this project. Her research incorporates mathematical modelling to predict survival and population trends for species of conservation interest such as the island fox from the Channel Islands and California sea lions in the Sea of Cortez. Her previous work with condors showed that birds spending more time on the coast had higher survival than those that did not, and she and her collaborators attributed this finding to condors on the coast having a lower risk of lead poisoning. Her role in this project is to estimate which condor behaviours are associated with contaminant exposure, then predict how that risk may translate into the potential for condor reproductive failure.

We analysed contaminants in the whole blood and plasma from condors and blubber from marine mammals and found that condors in the coastal flock had 12 to 100-fold greater concentrations of DDE, PCBs, PBDEs, and mercury than condors in southern California. We used a technique called stable isotope analysis to measure certain biogeochemical markers in condor whole blood which allowed us to estimate that, depending upon the individual, the diet of coastal condors contained from 8 to 52% marine mammals. Finally, we found that the more time a condor was observed feeding on marine mammals, the higher that condor's contaminant levels, and from this we predicted that about 40% of breeding-

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age condors in the central California flock have DDE levels that have created eggshell thinning in bald eagles. This is consistent with the observations of our collaborator, Joe Burnett of the Ventana Wildlife Society, who found egg shell thinning and reduced hatching success in condors breeding on the coast when compared with those breeding inland.

Our findings may leave one feeling helpless about the future of wild, free-flying condors. If some of their land-based food is unsafe due to lead-based ammunition, and their marine-based food is poisoned by legacy pollutants, then how can condor populations possibly thrive in the wild? The way forward is not clear, but there are several beacons that give me hope about the successful future of the California condor. In 2015, more wild condor chicks hatched and fledged than wild adults died for the first time since the breeding program took effect. In addition, the state of California was the first state in the nation to enact a ban on lead-ammunition for hunting that will be fully implemented by 2019. However, only a small amount of lead on the landscape is still very dangerous to condors. Dr. Finkelstein's previous research estimated that if only 0.5% of carcasses on the landscape are contaminated with lead, then, over a 10-year period, a condor still has an 85 to 98% chance of feeding on a contaminated carcass, and condors have a lifespan of over 50 years! Yet, sportspeople and ranchers are heeding the call and switching to non-lead ammunition (for more information go to huntingwithnonlead.org), actions critical for the health of California condors as well as other scavenging species, such as golden eagles, that are poisoned by ingesting spent lead fragments. Ultimately, our study highlights a harsh reality: wild animals are exposed to multiple contaminants throughout their lives. There is no easy solution, but we should do what we can to minimize exposures we have the most control over, such as using non-lead ammunition, and push to reduce our use of toxic chemicals as a society.

Five years later it is a warm August evening and I'm with my now 9-year-old son at the San Diego Zoo. As we walk through the Elephant Odyssey exhibit designed to highlight extant animals that echo those that used to roam southern California during the Pleistocene epoch, I'm struck by giant, side by side paintings detailing ecological landscapes from 12,000 years ago versus those we see now. Very few megafauna are pictured in the present-day diorama, but the California condor flies high over both landscapes, still holding its niche and looking every bit the prehistoric wonder as its ancestors. I am heartened to know their population is holding steady, potentially even growing, and that the huge conservation efforts of so many dedicated people have brought this beautifully ugly bird back from a precipice of extinction. I point that out to Jeremiah, asking, "Do you remember that super hot day in the desert when we worked on these birds?" He laughs, "Of course, mama! How could I forget? They're amazing!"

Kurle, C. M., Bakker, V. J., Copeland, H., Burnett, J., Jones Scherbinski, J., Brandt, J., & Finkelstein, M. E. (2016). Terrestrial Scavenging of Marine Mammals: Cross-Ecosystem Contaminant Transfer and Potential Risks to Endangered California Condors (Gymnogyps californianus). Environmental Science & Technology.