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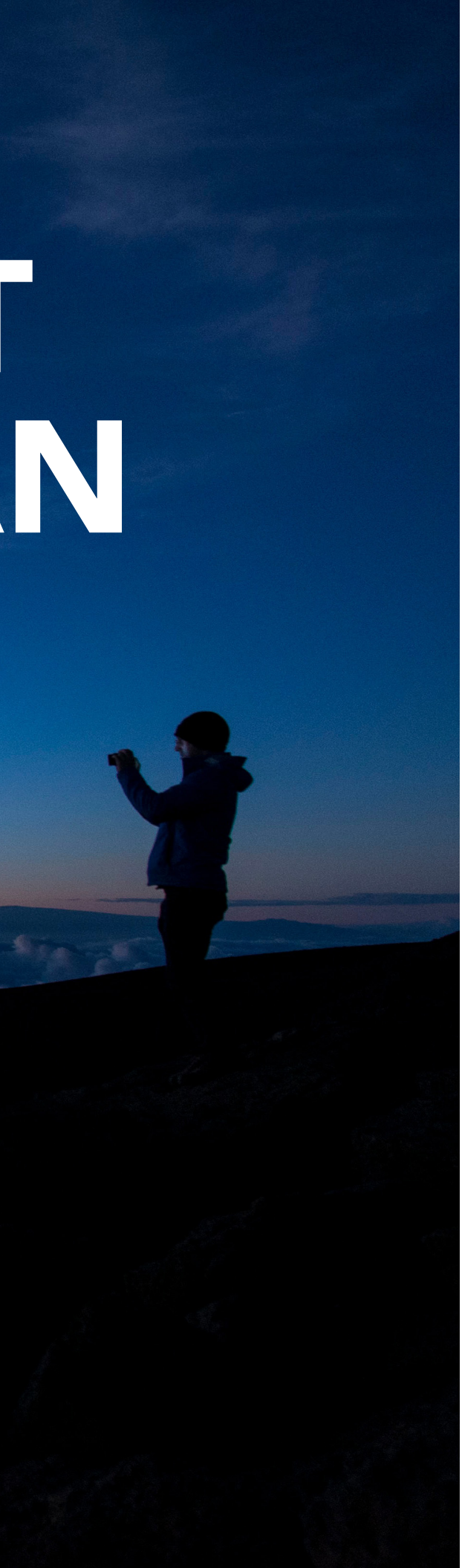
Understanding the changing ocean through Catalina Island

WRITTEN BY **DANIEL FURMAN**



As I sit on the towering seaside bluffs of Catalina Island looking out over the Pacific,

my view seems to reveal a window into what Earth may have resembled before the explosion of humanity. Fog clings to the cool ocean water, cliffs give way to beautiful crescent beaches, and the Californian coast is barely visible in the distance. The smell of kelp forests wafts up from below, where creatures such as dolphins, seals, fish, and abalones make their homes. This tiny island in the San Pedro Channel epitomizes natural beauty, from the famed kelp forests to the clear night sky.

Now imagine this destroyed. Although difficult for me to accept, the fate of this island remains uncertain in the face of modern and future realities. Scientists agree that Earth has recently entered a new geological age: the anthropocene, defined by humanity's dominant influence over our planet's climate and environment.[1] Of all the human-induced environmental impacts, those relating to the ocean are often the most severe. Yet, no matter how much experts harp on ocean acidification and sea level rise, it is far too easy to look at the ocean and only see a line separating water from air. The evidence for why we should change this perspective is undeniable. All of Earth's five mass extinction events documented in the fossil record reveal that life in the shallow ocean environments were affected.[2] Research today reveals that we are in the early stages of an eerily similar process causing the death of many different types of organisms in our modern shallow ocean environments. To put our impact on the oceans today into numerical terms, we are unsustainably killing a hundred million sharks each year[3], a species that predates dinosaurs and has survived four mass extinctions. Meanwhile, climate change is driving coral bleaching across the planet. There is no telling how and when we can cut our impacts on this sprawling yet fragile environment. The global implications reveal that

this problem is much more dire than the prospect of losing a tiny wild island off the coast of California.

Although attempts have been made to manage society's impact on the ocean, current inadequacies and incessant problems do not bode well for the future. Los Angeles, notorious for its air pollution and contentious acquisition of fresh water, has a rich history of polluting its oceans. To protect one of the greatest assets of its tourism economy, clean beaches, Southern California treatment agencies go to great lengths to ensure that the coast remains unpolluted. Counterproductively, the ocean has become a sink for vast amounts of agricultural, industrial, and urban pollution.

Los Angeles's wastewater system is sufficient, operating in a very controlled and stable manner. It is only upset by periods of rain, which trigger the flow of direct urban runoff through the city's storm drain system. In the normally dry California climate, the San Pedro Channel receives a relatively constant flow of secondary treated-ed wastewater. Three main pipes discharge this human pollution, known as effluent, into the ocean off of Manhattan Beach, Palos Verdes, and Huntington Beach. The end of the pipes are located between 2 to 5 miles off the California Coast, roughly 25 miles away from Catalina Island, and are embedded 60 meters deep in the sloping continental shelf.[5] The effluent carries higher levels of nitrogen, organic matter, pathogens and bacteria than the surrounding waters and poses a threat to marine habitats.[6] To ensure that the dense human tourist and citizen populations of Los Angeles's coast are unharmed, the treatment agencies place these outfall pipes in regions where the effluent remains below the surface and adequately distanced from the shore. The movement of the bays' circular currents, or eddies, traps and quickly dilutes this pollution.[7] The wastewater system is well designed to minimize human exposure and marine life disruption.

The system can function under the past level of Los Angeles's pollution; however, in an uncertain future, it may strain with rising pollution levels. It is dangerously ignorant to assume that the ocean will forever be able to dilute the plumes from the effluent outfalls, given the potential harms of a larger path of pollution. This reality is particularly concerning for nearby off-shore terrain such as Catalina Island, which struggles to manage its own pollution. Catalina's population consists of a set number of 4,096 people, while the island received 624,000 tourists in 2015. In contrast, the greater Los Angeles area is home to 18.9 million residents with 45.5 million tourists in 2015.[9] This means that the population of Catalina is .022 percent of the residents of Los Angeles, while the is-

land received a tourist population that is 1.37 percent of that of Los Angeles. Its relatively miniscule size seemingly suggests that Catalina's own impact should be small; however, managing its pollution has been a well-documented struggle.

Water quality in the bay of the city of Avalon, the largest city on the island, has historically remained dangerously unsafe due to its problematic sewage system and flow of tourism. Treated wastewater used to be released a mere 50 meters off of the city into its protected, often stagnant cove.[10] Coupled with leaky pipes and other issues, this system was not an ideal way to manage pollution from a city burdened with hundreds of thousands of tourist visitors. This was a dire issue for Catalina's economy, a reality that eventually forced the city to back a $5.1 million renovation of Avalon's sewage system in 2011.[11] Beyond the effects that the dirty water had on the human population of Catalina island, the famed kelp forest and marine life in the Avalon dive park also faced a grave threat. Catalina's only other city, Two Harbors, has minimal potential impact on its marine environments compared to Avalon. The main sources of pollution flowing from the city remains mainly from tourist traffic in and around the region's 700 mooring sites. Only during periods of rain does the city runoff because the small amount of treated wastewater produced is not pumped into the ocean. Indeed, all of California's coastal landscape and marine life has been threatened by human activity beyond what can be addressed by pollution management. Wetlands and natural coastal environments have been removed to accommodate urban, industrial, and agricultural development. Direct impacts from overfishing, pollution discharge, and destructive fishing techniques also continue to damage habitats near and far from shore.[12] These tangibly evident processes represent, according to Dr. Kirk Johnson in the documentary Racing Extinction, "the direct hand of man" impacting the environment.[13] An additional and perhaps more threatening impact comes as a result of what Kirk terms "the indirect hand of man," the driver of impacts we make on earth that are less immediately tangible. The prime example is anthropogenic greenhouse gas release, concretely proven to raise the ocean's acidity, temperature, and water levels while also causing global anthropogenic climate change.

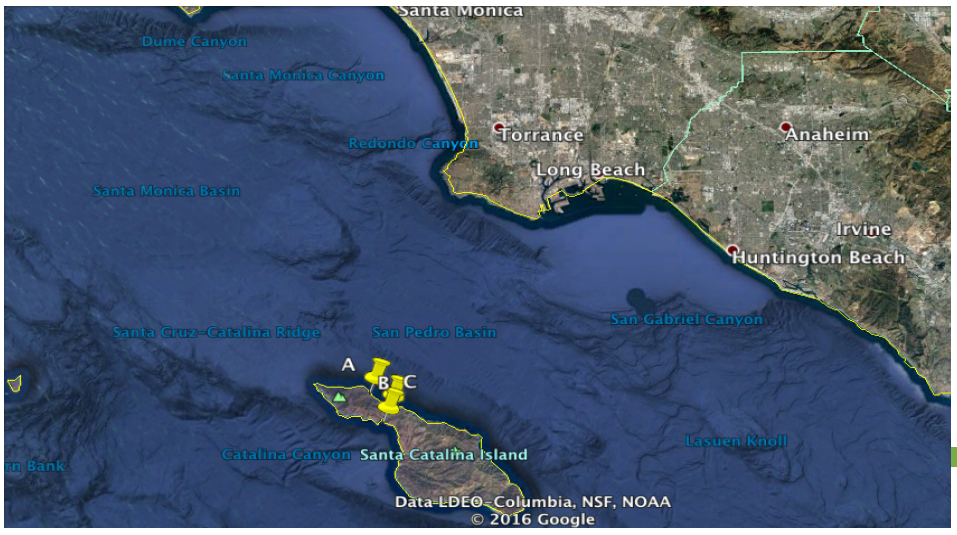
What indirect impacts could Los Angeles effluent have on the surrounding environment? I decided to search for evidence of our "indirect" human impact on the environment on a smaller scale by investigating whether the apparently pristine northwest section of Catalina Island was really "safe" from anthropogenic pollution. Since Los Angeles is only an hour long boat ride from Catalina, the vast amount of pollution produced by the coast's ur-

"Thinking about the massively complex and intertwining indirect impacts of burning fossil fuels made me question the complexity of factors on a smaller scale.

ban sprawl seems a potential threat to the island's marine environments beyond the flow of tourism to the island from the Port of Los Angeles. I began to ponder what the future of Catalina would look like if Southern California's pollution directly reached its protected marine habitats, and I quickly realized that the quest to preserve these ecosystems would not only worsen, but complicate exponentially.

Before starting my investigation, I hypothesized that Catalina was situated far enough offshore to avoid the current pollution flow from Los Angeles. The depth, expanse, and normal circular current patterns of the San Pedro Channel has been understood in the past to dilute Los Angeles's pollution relatively quickly, protecting offshore and onshore environments. To test this assumption, I turned to science. I set out to obtain water quality data from three different locations on Catalina Island between June and November of 2015. The three sites were all located within the protected northwest region of Catalina island, the largest Area of Special Biological Significance in the state of California (ASBS). ASBS categorization originated in a piece of legislation passed in the 1970's by the State Water Board demanding that zero anthropogenic pollution enter the designated regions.[14] I picked one site on the backside of the island, the site theoretically least exposed to the California coast, one on the northern front side of the island, the site most exposed to Los Angeles and Orange County, and one in the bay of Two Harbors.that zero anthropogenic pollution enter the designated regions. I picked one site on the backside of the island, the site theoretically least exposed to the California coast, one on the northern front side of the island, the site most exposed to Los Angeles and Orange County, and one in the bay of Two Harbors.

Water quality at all three of the sites based on this environmental designation were expected to remain consistently uncontaminated. My research also included mapping the movement of San Pedro Channel during the three days leading up to each collection day. I accomplished this using three tools: an online current map, wind data readings, and a computer drifter model used to predict the movement of an imaginary "drifter" released at a chosen depth and location along the San Pedro Channel. To track the pollution's potential plume, I specified the exact location and depth of the each outfall pipe off of Los Angeles and Orange County. These two



Santa Catalina Island relative to the California coast

data sets were combined to determine the potential correlation. A decline in the Catalina water quality during a period of general offshore ocean movement could suggest that Los Angeles's discharged pollution affects Catalina. With my mountain bike in hand, a Camelback stuffed with supplies on my back, and a craving for adventure I set out to investigate Los Angeles's indirect impact on the surrounding environment.

As my six month journey wound to a close, my results began to support my hypothesis, suggesting that Catalina is adequately distanced from the Southern California's direct flow of pollution. The water quality did not change during different current patterns and suggested clean environments, even in the Two Harbors cove. The maps of the movement of the channel suggested that the effluent plumes normally returned close to their original sources while drifting parallel to the coast. While two days did suggest some offshore movement, the consistently normal water quality readings reveals minimal impacts during these events.

My stab at investigating indirect pollution impacts highlights the importance of questioning pre-established norms and understanding the true ways humans impact the environment. The experiment does not resolve or lessen the necessity of implementing more educated management of human impact on the environment. Regardless of the results, it has developed my awareness and concern about the future of life and natural beauty on the Earth, and broadened my understanding of everything we take for granted. So many of the impacts we make as a society are not immediately obvious. Peeling back the layers of ignorance and mystery reveals that nature is connected in wide-ranging patterns.

A seemingly insignificant choice we make in one place could have countless indirect consequences, a reality we need to more widely recognize and address.

Daniel Furman is a freshman in the College intending to study Environmental Science. He is on the Varsity Golf team at Penn and loves camping, surfing and hiking in the great outdoors.

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