How Development and Plastic Waste Destroyed the Beauty We Came to See

From the Caribbean to the Celebes Sea

By

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Introduction:

A terrestrial biologist, not a marine biologist, learns to scuba dive in the Caribbean Sea, not as a researcher but to personally observe marine ecosystems. Shocked by what she saw. This story is a personal account of a novice scuba diver in a post–8-billion-human world. Guided by an expert diver with over 20 years of experience, Marina embarked on an odyssey to evaluate our local Caribbean Sea and compare it to the Celebes Sea, which is known for its rich marine biodiversity and stunning coral reefs. She discovered distinct environmental challenges and diverging forms of deterioration each of these seas endure. Marina comes to realize that both seas suffer from a unique set of environmental stressors, resulting in different types of degradation. However, through observations and interviews a stark commonality is revealed, governments in both regions are failing miserably in their regulatory duties. It quickly became clear that the scope of restoration efforts by individuals and NGOs is limited. The onus falls on governments to enact stringent regulations addressing marine pollution and overfishing. These governments are composed of democratically elected officials that we, the citizens, vote into office. It is imperative for individuals to collectively exert our influence by electing officials and influencing policies. Marina concludes that the responsibility lies in exposing politicians' financial dealings, utilizing social media effectively, and employing every means necessary to ensure our voices are heard.

Author biography:

Marina E. De León is a wildlife biologist and microbiologist living in Puerto Rico. She has traveled the world documenting rare animals. Marina is a passionate environmental conservationist whose work bridges disease ecology, molecular biology, and microbiome research to address pressing environmental and ecological challenges. Her fieldwork spans Central and North America, where she conducts extensive surveys of amphibian populations, investigates the spread of chytrid fungal pathogens, and contributes to the understanding of microbial symbioses and bacterial taxonomy.

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During the summer of 2022, Central California and the West coast of the United States had experienced its typical weather, which feels akin to the fiery depths of hell on one of those record breaking 45°C, breezeless days in areas like California's capital city, Sacramento. The news covered extreme heat warnings and ocean water temperatures in Southern California rose well above a refreshing level. Earth's ecosystems are declining in biodiversity and overall health. The average global ocean temperature has increased by about 0.14°C per decade over the past 10 years. The heat of the summer in 2022 created an urgency in me to explore marine diversity and ecosystems at more profound depths, before it's too late.

I learned to scuba dive in the Caribbean Sea solely to enjoy marine ecosystems. Guided by Erik, an expert diver with over 20 years of experience. We arrived in Tulum, Mexico where my adventure observing and documenting corals began with a discovery scuba dive tour. Erik wanted to share with me the mesmerizing beauty that exists under the water's surface. With a tank full of air, I jumped into the first dive site on my list, a freshwater cenote. Before tourists discovered the Mexican cenotes, the unusual natural pools must have once been quite a sight, with their crystal clear water, full of aquatic life. I was excited to submerge, and I gladly let the cold water enter my wetsuit. Yet, as I descended into the depths, leaving the other tourists' legs kicking above, I immediately noticed that the cenote appeared devoid of life, and it didn't seem right. I was confused. Wasn't it supposed to be full of fish and plants? Instead, particulate matter filled the [probably] once-pristine water. A single plant, a solitary, fragile semblance of life, clung to existence, covered in algae. Our guide, a local, chain-smoking naturalist, searched for marine life to show us, a desperate attempt to find a flicker of existence. He had done this before. His determination was an endeavor to justify our journey beneath the surface. Despite his positivity, it was apparent he wrestled with the emptiness surrounding us. In this still beautiful, nearly lifeless pool, the vitality of the tourists who converged on this cenote served as a stark contrast. Our guide showed us to a juvenile crocodile that sat at the quiet end of the cenote, and a small flounder laying in the sand. There were some fish that wandered around, none memorable. The cenote teemed with human visitors, their enthusiasm undeterred by the underwater wasteland they were unwittingly exploring.

I had seen enough, I came to the Caribbean sea to witness the dense and colorful ecosystems of the documentaries, not an empty pool of water. We left the cenote and ventured into the ocean by boat. Erik was excited to show me the magical underwater city he floated through over 20 years ago. As my eyes adjusted to the submarine surroundings, I noticed through the clear water, the light sandy bottom and a few purple gorgonians that struggled beneath the weight of encroaching algae. We both expected a spectacle of vibrant coral reefs and their kaleidoscope of inhabitants. But instead encountered a barren seascape that looked more like a desert or the Martian terrain. Tunnels and rock formations offered a visually stunning backdrop, but the marine life was an ephemeral mirage. A large crab here, a tiny marine worm there, and a few fish came within our field of view. The once-teeming abundance had been usurped by eerie emptiness. I realized the striking documentary-style encounter I had hoped for was an echo of the past. The reality was an abyss of solitude. As our dive neared its end, at 12 meters beneath the surface, my tears flowed into my mask. I was overwhelmed with disappointment from the expectation I had versus the reality in front of me. I resurfaced and, surrounded by fellow divers on the boat

recounting their experiences with unbridled enthusiasm, “Wasn’t that beautiful?”, “Just amazing!”. I couldn't help but wonder: how could they not know? Had they never watched a nature documentary? How could they perceive this desolation as beauty? Our guide sat on the boat’s edge, silently smoking. We returned to Tulum where unfinished concrete structures loomed, juxtaposed against completed high-rise condos, and walked amongst discarded glass and plastic bottles lining the streets. Tulum's growth and humanity's encroaching presence made me think that perhaps the burgeoning construction, waste, and human activity was responsible for the failing reefs. I imagined that my dive into Tulum's aquatic core mirrored the broader narrative of our times. A story of beauty and profound loss, where preservation of fragile ecosystems becomes an urgent and shared responsibility, lest the irreplaceable be lost for good. Tourism and coastal development increase pollution, sedimentation, and boat traffic, all of which destroy coral reefs by smothering them, blocking sunlight, introducing toxins, and physically damaging the ecosystem. The irony is that tourists flock to Tulum and other wild vacation spots to enjoy nature at the expense of nature itself. Tulum is no longer the bohemian town people once traveled far to experience. It’s become a sprawl of condos and restaurants catering to crowds year-round. At some point, tourists and locals have to ask if destroying the marine ecosystem is worth lounging on a white sand beach. The Yucatan peninsula is known for its underground rivers and stunning cenotes, yet these have been replaced with artificial "adventure parks," turning the region’s once-pristine appeal into a diluted imitation.

Marina De León diving in a cenote, Tulum, Mexico. Photo: Erik Laurenceau

I spent the summer in Puerto Rico instead of enduring another sweltering Central California season. Snorkeling along the island’s northern and western coasts. Shallow waters revealed sea urchins, elegant needlefish, and schools of yellow, blue, pink, and green reef fish. Yet, a subtle unease stirred in my biologist’s brain. Bleached, lifeless coral skeletons marred the underwater

shoreline. Algae blanketed the ocean floor, and plastic floated in the swaying sea grass. I wandered, expecting diversity but saw mostly the redundancy of resilient urchins, rockfish, and hardy reef fish. It felt like scarcity, not like the marine abundance I anticipated after Mexico. When I began scuba diving around the island, I observed cloudy water and algae-covered seagrass giving way to shyer animals; green sea turtles, cautious squid, and skittish stingrays. Curious remoras and a few reef dwellers flitted by me. A plump, amethyst sea cucumber added charm to the underwater decline. While more alive than the snorkeling sites, the reef felt heavy with loss. Change seemed elusive; recovery, uncertain. Steel structures of artificial reefs had been placed under water to restore what had been lost. These coral “gardens” aim to regrow reefs and revive marine life, a symbol of resilience amid destruction. Caribbean coral reefs have suffered major die-offs from warming seas, bleaching, disease, overfishing, and the lingering effects of the Deepwater Horizon spill. Though not a perfect replacement, they support these ecosystems threatened by tourism.

Over a decade ago, Erik said diving off the Yucatán peninsula near Cancún and Playa del Carmen, was incredible. So was Puerto Rico, which he called a jewel among global dive spots. But human activity and construction have caused the ailing state of these once-pristine waters. My rough estimate of reef death was around 90% at hyper-touristy dive and snorkel sites, based on coral skeletons, algae overgrowth, and low vertebrate diversity. I was shocked again, but Erik had witnessed the slow decline and he wasn’t surprised. I asked him if there were still healthy reefs left anywhere, and if so, where? The Great Barrier Reef has lost about 50% of its coral cover over recent decades, largely due to bleaching and high algae growth. I wasn’t confident Australia still had healthy reefs to explore. The Coral Triangle, however, was said to still thrive. Semporna, Malaysia, on Borneo’s northeastern edge, lies within a region dubbed the "Amazon of the Seas" for its vibrant, diverse reefs and marine life. It sounded promising.

We read about seas around the world in our shared determination to seek solace in living reefs. Sipadan Island, off the eastern fringe of Borneo, showed promises of abundant populations of unique bony reef fish, chondrichthyes, and mollusks. We packed our backpacks, not forgetting our masks and snorkels and fled for Borneo. We made the Trek from Puerto Rico through New York, a layover in Abu Dhabi, another in Kuala Lumpur, resting shortly in Kota Kinabalu, before our next flight across the island to the Tawau airport, and finally driving an hour through palm monoculture to Semporna where the last ‘best’ diving on Earth was said to be.

The morning after arriving in Semporna, an old fishing town, a lady at the dive shop told me about witnessing changes over the last ten years. She had moved to Semporna to work as a divemaster, and now she did administrative work. She gave me her version of what happened with the reefs at Mabul and Sipadan islands. Mabul, once renowned for its vibrant "micros" and "macros," full of colorful nudibranchs and reef sharks, is now in serious decline. But first, I learned, Sipadan had declined. After booming tourism and the rise of water bungalow resorts on Sipadan, the reefs began to fade. The reefs were declining due to tourist development, but in 2000 something shocking happened. Filipino criminals abducted 21 tourists and resort workers, holding them hostage and demanding a $3 million ransom. Tourism plummeted, and the government intervened, closing the resort in 2004 and restricting access to advanced divers only. Once

development stopped on Sipadan, bungalow tourism moved to Mabul. Steps are being taken to preserve the environment for sustainable tourism. Sipadan is now closed during November each year to let the reefs rest and recover. Officials are trying to close the island for a second month in spring, reducing tourism to ten months annually. Unfortunately, the restoration and regulation saving Sipadan have shifted development pressure to Mabul, where healthy reefs are now suffering. Meanwhile, the resorts on Mabul, closer to the mainland, grew in size and demand, creating a clear negative correlation between tourism and reef health.

Stilt homes, Semporna, Malaysia. Photo: Marina De León

We dove at three sites around Mabul and Kapalai islands. One Mabul site was completely dead, but for the artificial reefs. The artificial reefs brought some corals, pipefish and nudibranchs, but visibility was low due to waste particulates, comparable to Puerto Rico. The Kapalai island site was thriving with diversity of life. Our dive guide, a 26 year old man who had been diving for seven years, and chain smoked, told us that the artificial reefs at this site were constructed over ten years ago. The structures attracted frogfish, resting sea turtles, tiny squid, and an abundance of brilliantly colored feather stars waving back and forth forming a false garden of Eden. Feather stars, or *Crinoids*, are the most ancient group of echinoderms, these animals have a small body at the base with five arms that fork, forming what looks like luscious, healthy plants. And somehow

through 16-20 meters below the surface where other organisms' bright colors are muted, these shine bright in their fluorescent yellows, reds and greens. Echinoderms were the main characters of the artificial reefs, with brittle stars, chocolate chip sea stars, and thick, granular sea stars stealing the show. A sunken ship site brought some coral growth, along with hiding octopi and tiny seahorses. The ship attracted huge groupers and schools of silver jackfish. Visibility remained relatively low due to the particulate. The reefs were clearly losing the battle against human traffic, but humans were also helping the reefs to stay in existence by constructing artificial reefs for tourism's sake.

With his advanced diver license, Erik dove around Sipadan island. He compared his past and present dives recounting how rich in color, but poor in fishes Egypt's Red Sea was in 2022, a stark contrast to the vivid, chaotic underwater city that was Sipadan. His memories of the South Pacific's Marshall Islands in 2001 were full of sharks, reef fish, and colossal clams and oysters. Sipadan, however, had an abundance of reef fish unmatched in density. His simple narrative was that ecosystems, when left undisturbed, possess the remarkable ability to rebound naturally, something I would hear again and again. Sharks glimpsed from afar, giant schools of batfish, and thriving corals painted a colorful picture of hope. What he told me about Sipadan left a lasting mark, a testament to nature's resilience.

A family of sea gypsies with fish to sell to tourists. Photo: Marina De León

I planned our next dive in response to seeing the consequences of development and tourism from our initial dive, and from what I had learned from the woman at the first dive center. A 45-minute motorboat ride away from the mainland brought us to a small, remote island Mataking, and the nearby site Timba-Timba. Here, we sought the elusive promise of pristine reefs, clear water and

unclouded visions. There was some tourism there, a stilt bungalow development, but much less than Semporna and Mabul, and it showed in the health of the corals. The natural coral reefs were clean, colorful and full of large, perfectly camouflaged Broadclub cuttlefish, stingrays with bright blue spots, goliath Amberfish sea cucumbers and elegant Blackspotted sea cucumbers. It approached the looks of Kapalai in volume of corals and fishes, and approached Sipadan in health and overall appearance. During a surface interval, our guide, an established local diver, told me about the government's initiatives to combat plastic pollution. Cash-in incentives encourage locals to collect and dispose of beach and waterborne trash. He mentioned that a non-governmental organization (NGO) branch of PADI called Project Aware had been present in the past with efforts to clean up trash in the water. Project AWARE supports cleanups and reef protection through local partnerships, but seemed absent from Semporna for a long time. I spoke with a dive shop employee connected to Project AWARE, and she wasn't too hopeful about environmental progress in Semporna. Trash is a complex issue, and while some local dive shops run their own cleanups and small coral restoration efforts, working with the government has been tough due to a lack of motivation. She mentioned small wins like nightly garbage collection by boat and more public bins, but the real challenge is monitoring litter from stilt shanties over the water, which would require relocating residents. "There would also need to be a huge shift in attitude as at the moment people are not concerned about the environment nor the impact of throwing things into the ocean or river, it is not so long ago that Europe was the same, the only difference now is the huge amount of plastic available, which we introduced to them", she said. Though water filtration exists elsewhere in Sabah, bottled water is still the norm in Semporna, likely due to affordability and convenience. Single-use plastics dominate, and meaningful change seems unlikely without serious social media pressure on the government.

My final dive on Borneo would be from Selakan island, a government wildlife refuge that required specific permitting to dive there. Although it's not extremely far from other islands or stilt bungalows in the area, Selakan Island is not a widely known tourist destination, and like many islands in Southeast Asia, it is the home of indigenous communities referred to as "sea gypsies" or "sea nomads." These communities are known for their traditional, maritime-based lifestyles. Many sea gypsies live on boats, but others build their homes on stilts above the water, not having access to owning or renting land. A portion of Selakan island was purchased from the natives through a business deal that allowed the new owner to build a humble stilt bungalow with nine rooms. Some of the natives are now employed by the bungalow resort as cooks and cleaners. It rained on the day a transport boat picked us up from mainland Semporna and brought us 30 minutes North East to the remote island. We arrived as the only guests, spooking the flying fish that skipped on top of the water to escape our docking boat. Our tiny room over the water had a ladder that allowed me to climb down from the balcony into the seaweed village below. I immediately investigated the water around the bungalows by snorkeling. Trash from the mainland drifted continuously towards the island, and my view was tainted by floating bottles, bags and other single-use waste, all eventually coming to rest along the shoreline. But life below the surface persisted. I was met in the shallows by tiny fluorescent darters, skeptical pufferfish, anemonefish living out generations inside a single brown anemone, long, silver needlefish coasting along the surface, and a variety of sea stars lining the sandy bottom, including the glorious blue sea star. Snorkeling day after day exposed small Areolate groupers (or similar species), small green eels,

adorable, round tangs, colorful oysters, snails, various reef fishes, gobies, blennies, seaweed, sea grasses, and large flat corals resembling sunken tires. Each morning hundreds of tiny, transparent ctenophores floated gracefully beneath the bungalow. High tide revealed an impressive underwater world teeming with clams, fish, and miniature lobsters diligently tending to their tiny burrows.

The tide came in and washed a landfill of plastic onto shore just behind the bungalows, but by evening when the tide receded, staff members had raked the shore area, doing what little they could to mitigate the perpetual influx of floating garbage. They burn the garbage to get rid of it. Diving off Selakan Island, I was immersed in a dense thicket of soft corals, hard corals, bubble corals, brain corals, and every kind of coral imaginable, along with the ubiquitous crinoids. The terrain sloped down, and the corals adorned the hillside. Reef fish were present but not in the impressive abundance of Sipadan or Mataking. Selakan is renowned among locals for its stunning micros, and micros we found. My local guide, Nathan, another chain smoking young man in his 20's, explained that an abundance of worms was a good indicator of healthy reefs. He mentioned his reluctance for night diving due to worms being attracted to the flashlights, swarming hands with their curious antics. I carefully looked out for these underwater sentinels, and indeed, worms were there. A gracefully flying Persian rug flatworm caught my eye, and I mistook a long, purple and white Whiteline sea cucumber for a worm, given. Amidst this thriving ecosystem, a gargantuan moray eel peeked out from a coral hideaway. The reef boasted such vitality that even a family of pygmy seahorses had taken residence within a single sea fan, holding on tightly with their miniature tails. Large, gummy nudibranchs were all over the landscape, including several "holy grail" species in the *Phyllodesmium* genus, characterized by their large, frilly branched gill appendages. While Nathan and I retrieved a couple of plastic bags from the sea floor, remnants of the many drifting above, the ocean floor and hillside, for the most part, remained pristine and teeming with life. We surfaced on the boat and Nathan had fat white worms suctioned to his wetsuit, again evidence of how healthy the reef was. He gently flicked them back into the water.

Brilliant Blue sea star. Photo: Erik Laurenceau

Nathan told me that dense healthy corals exist here because fish bombing has been outlawed and is heavily prevented by law authorities. Fish bombing is a destructive fishing method that has had a significant impact on Malaysia's marine ecosystems. Fish bombers have historically been from local communities. It was initially used to catch fish for sustenance, but the desire for a quick catch to sell to tourists has been one of the primary motivations for ongoing fish bombing. Fish bombing involves homemade bombs or dynamite detonated underwater. The explosion stuns or kills fish, making them easy to collect, but it also destroys coral reefs and marine habitats. The practice causes extensive damage to coral reefs, which are critical breeding grounds and shelters for fish and invertebrates. The use of explosives for fishing was officially banned in Malaysia through the Fisheries (Prohibited Fishing Gear and Methods) Regulations in 1985. This ban marked a significant step toward curbing fish bombing. To prevent illegal fish bombing, authorities have implemented surveillance and patrols in vulnerable areas. New technologies such as underwater sensors, when triggered, send an alert and dispatch a boat to the area. However, according to Nathan, people continue to bomb and get away with it today.

Zebra Mantis shrimp being sold for food outside of a restaurant. Photo: Marina De León

That afternoon, I hiked the circumference of the small island, and just outside our solar-powered bungalow oasis was a stilt shanty town where natives lived. In the forest, I came across a site with food canisters, trash, and tattered clothing. What startled me were the giant clam shells, each about ⅔ of a meter in diameter. Surprisingly, we hadn’t encountered these giant clams at any of the dive sites. While there were plenty of small and medium sized clams with beautifully colored interiors, these enormous ones were conspicuously absent. Nathan told me that their absence was likely due to harvesting by locals, depleting their numbers.

Recalling a few days earlier when we were sitting on our boat during a surface interval at Mabul Island, local families paddled their small canoes toward us, attempting to sell their catches. An elderly man had two rainbow lobsters and a pile of crabs, each displaying the entire visible light spectrum in their shells, speckled and iridescent. These crustaceans were slowly succumbing, barely clinging to life long enough to become someone's dinner. Children offered tiny clams they had gathered that morning along with smaller marine creatures kept in water bottles. They weren't just fishing for sustenance; they were fishing to sell their own food source to tourists.

By the time I left Selakan Island, I understood the challenges facing the reefs in the Semporna area. Overfishing was just one of these challenges, and it wasn't the fault of the natives or the tourists specifically. The insatiable human appetite for animal products transcends cultures. It isn't reasonable to expect tourists to self-regulate their fish consumption, as they often lack information on sustainable levels. This responsibility falls on the government's shoulders. The problem of excessive animal consumption extends beyond natives, tourists, and people worldwide. It's as if some believe animals are an unlimited resource, a notion that has led to restaurants in Semporna filled with tourists devouring massive platters of crustaceans, fish, and mollusks each night, driven by affordability and apparent abundance, often with plates full of uneaten portions being left to waste. Fishing bans only work if they’re enforced and supported by local communities, and success depends on compliance, monitoring, and real signs of ecosystem recovery.

Most of the tourists are affluent foreigners, while the inhabitants of the Selakan Island stilt shanty town and Semporna live in poverty. I watched a little girl with messy black hair playing on the volcanic rocky beach, her pretend kitchen set crafted from single-use plastic garbage. She filled her plastic cupcake tray with rocks while her brothers (or cousins, or neighbors) splashed in the water behind her, naked. The plastic waste that the staff at our bungalow cleaned also accumulated around the shantytown, but with no means to address it, it amassed on the shoreline. What could they do with it? It wasn't all their trash, and they lacked the resources to dispose of it. So, it remains, posing a dilemma of responsibility and duration.

By now, it’s clear that coral reef decline is not caused solely by tourist bungalows, the real issue is a lack of government regulation on plastic use and disposal. With little infrastructure or education on single-use plastics, the problem stems from governmental neglect, not tourism. The solution is clearly to ban single-use plastics and enforce strict fishing regulations, letting the market adapt naturally to these regulations. In 2017, Kenya implemented a strict plastic bag ban with heavy fines and prison sentences, reducing pollution, drainage blockages, and harm to wildlife. In 2018, Vanuatu banned single-use plastic bags and straws to fight marine pollution, enforcing the ban through legal measures and awareness campaigns. Plastic bans can be successfully implemented anywhere in the world. Diving in Borneo and the Caribbean showed me that the causes for ocean biodiversity loss differs across oceans. The Caribbean sea is victim to development pollution, while the Celebes sea suffers from the weight of single use plastic. But in all cases, real conservation can only be made by people pushing governments to step up, regulate, and enforce real policies.

Selekan island. Photo: Marina De León