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BLEACHED

CONSERVATION EFFORTS AND TOURISM PRESSURES
IN RAJA AMPAT



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A black and white photograph of an offshore wind farm. Several wind turbines are visible, scattered across the dark sea. The sky is filled with horizontal cloud layers, creating a dramatic, layered effect. The overall tone is somber and industrial.

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Editor's Letter

"How do we not love it to death? That's the challenge now."

In Raja Ampat, at the heart of the coral triangle,

biodiversity is booming. An incredible 36% of the world's reef fishes and 76% of the world's known coral species can be found here in the 1,500-island, 4,000km² archipelago off the coast of Indonesia's West Papua. A single reef in Raja Ampat is said to contain more species than the entire Caribbean. And this, of course, attracts more tourists to the remote dive destination; while in 2007, 998 people travelled to Raja Ampat annually, that number increased to 29,653 by 2016. The impact of the relatively new tourism industry on its coral reefs and ecosystems is being seen: coral disease and mild coral bleaching have recently been reported. How will the region balance increasing tourism with the conservation of the natural beauty it has become so famous for?

Moving on from our cover feature, we travel to New Zealand where we join an expedition to the Auckland Islands. Here, a team of researchers gained access to one of the most remote breeding grounds of Southern right whales.

In a world-first, Marine Megafauna Foundation founder Andrea Marshall recently tagged the world's largest ocean stingray. In this issue, she exclusively writes about her experience meeting the elusive smalleye stingray.

In Portugal, a simple solution to kelp restoration might hold crucial insights into how to combat climate change and habitat degradation.

Finally, we learn more about the efforts of rearing the next generation of lobsters through their early stages, giving them a greater chance of survival in the wild.

Nane Steinhoff
Editor

 @nane_steinhoff

 @oceanomag

 Oceanographicmag

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A juvenile Clark's anemonefish in a bleached bubble-tip anemone in Misool, Raja Ampat. Photograph by Brooke Pyke.

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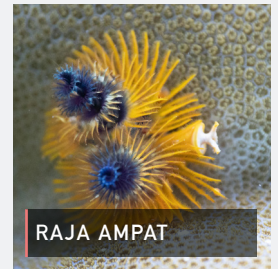


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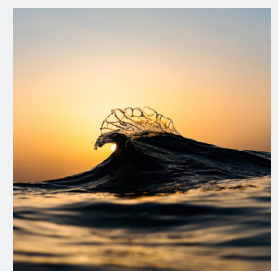
FEATURES



While increasing numbers of tourists explore Raja Ampat, parts of the region have seen mild coral bleaching in recent months. Is this paradise suffering from its own success?

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YOUR OCEAN IMAGES



A collection of some of the most captivating ocean photography shared on social media, both beautiful and arresting. Tag #MYOCEAN for the opportunity to be featured within these pages.

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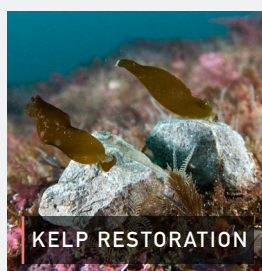
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WHALE ISLANDS

In New Zealand, a team of researchers gained rare access to one of the most remote breeding grounds of Southern right whales to reveal more about the species by collecting skin samples and tracking data.

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In Portugal, a simple, low-cost solution to restore underwater forests might hold some crucial answers to combat the effects of climate change.

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WORLD-FIRST

Smalleye stingrays are rare, elusive, and likely to be endangered. Off Mozambique, Marine Megafauna Foundation founder Andrea Marshall recently tagged the world's largest ocean stingray for the first time ever.

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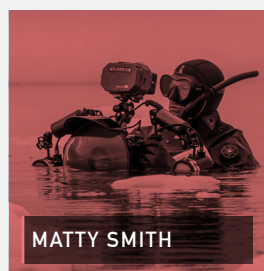


SMALL CLAWS

The National Lobster Hatchery in Padstow, UK, rears the next generations of Cornish lobsters through their early stages, giving this commercially exploited species a greater chance of survival in the wild.

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MATTY SMITH

Each issue, we chat with one of the world's leading ocean photographers and showcase a selection of their work. In this edition, we speak with renowned underwater photographer and expedition leader Matty Smith.

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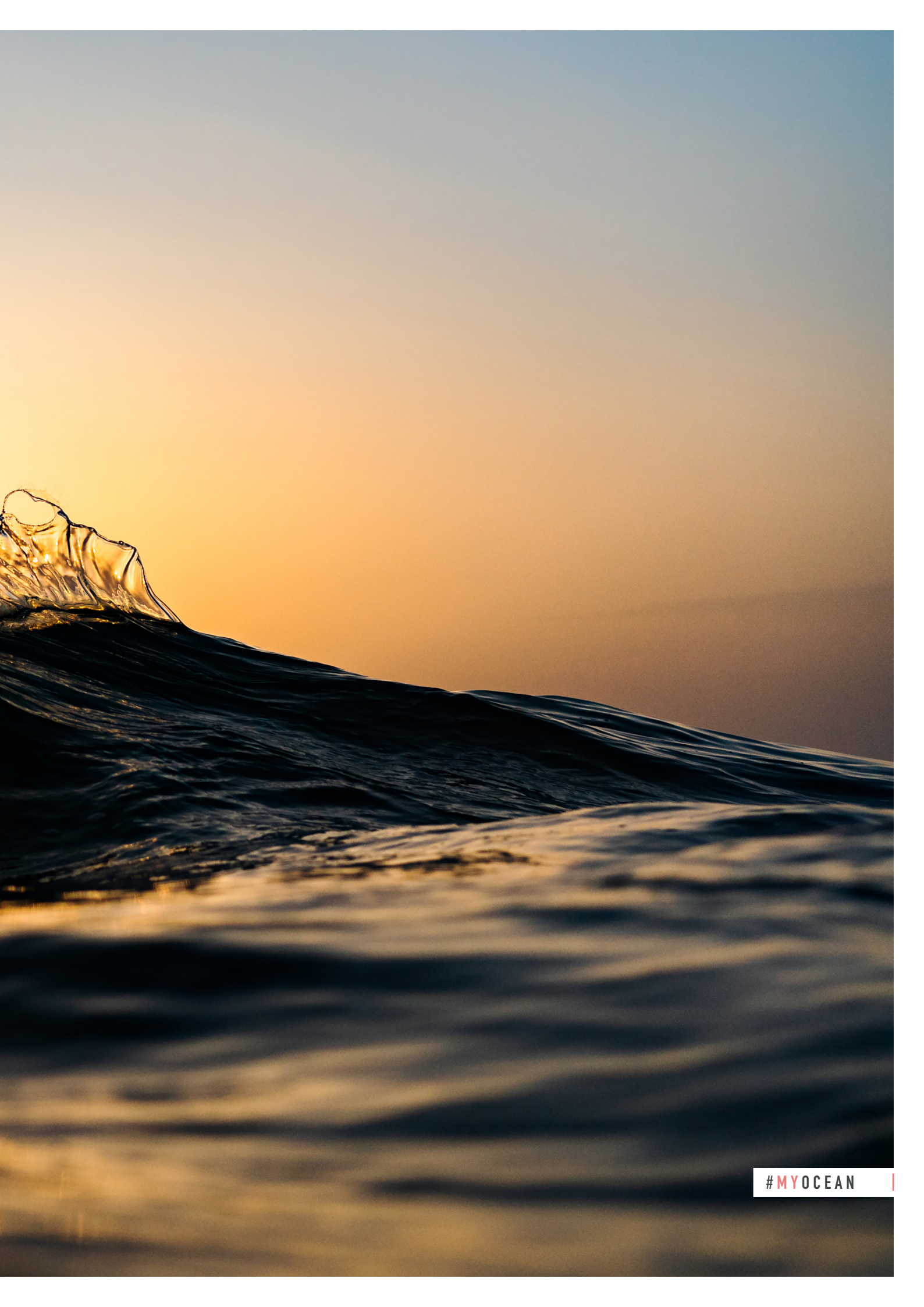
Alex Postigo

📍 **Ibiza**

“I shot this in summer off Ibiza’s North West coastline. In this image, the remnants of a short period swell created by thermal wind patterns break over a shallow rocky ledge.”

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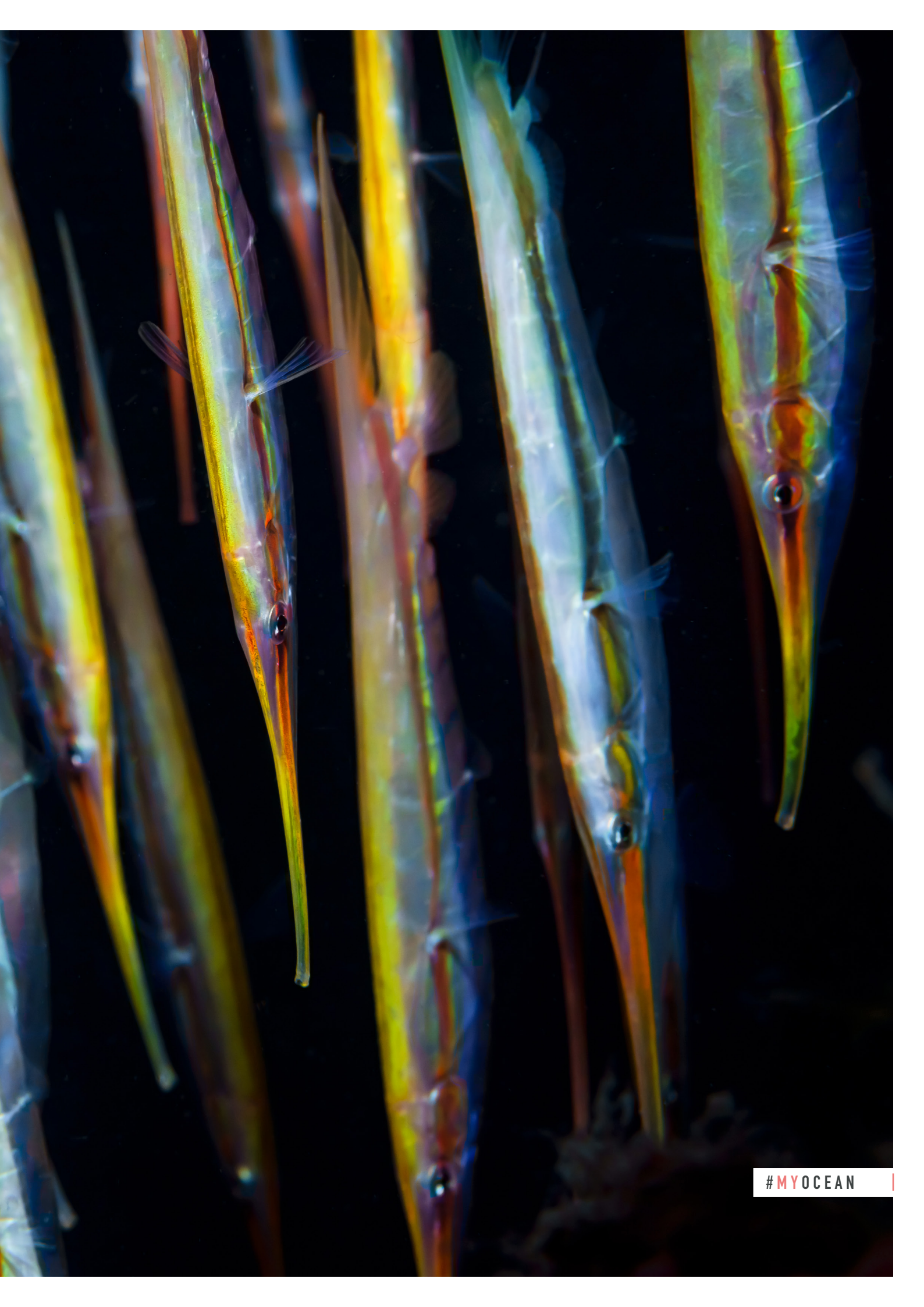
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📍 **Philippines**

"I almost always dive alone and love to dive at night. It's my favourite time to shoot. On one of these dives, I was lucky to spot a school of razorfish in the darkness."

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Henry Bliss

📍 **Florida**

“The most intelligent species you will ever meet! I found this common octopus on the sand flats of Southern Florida. It appeared to walk across the sand to find a new home. It was very curious about me.”

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» This way up

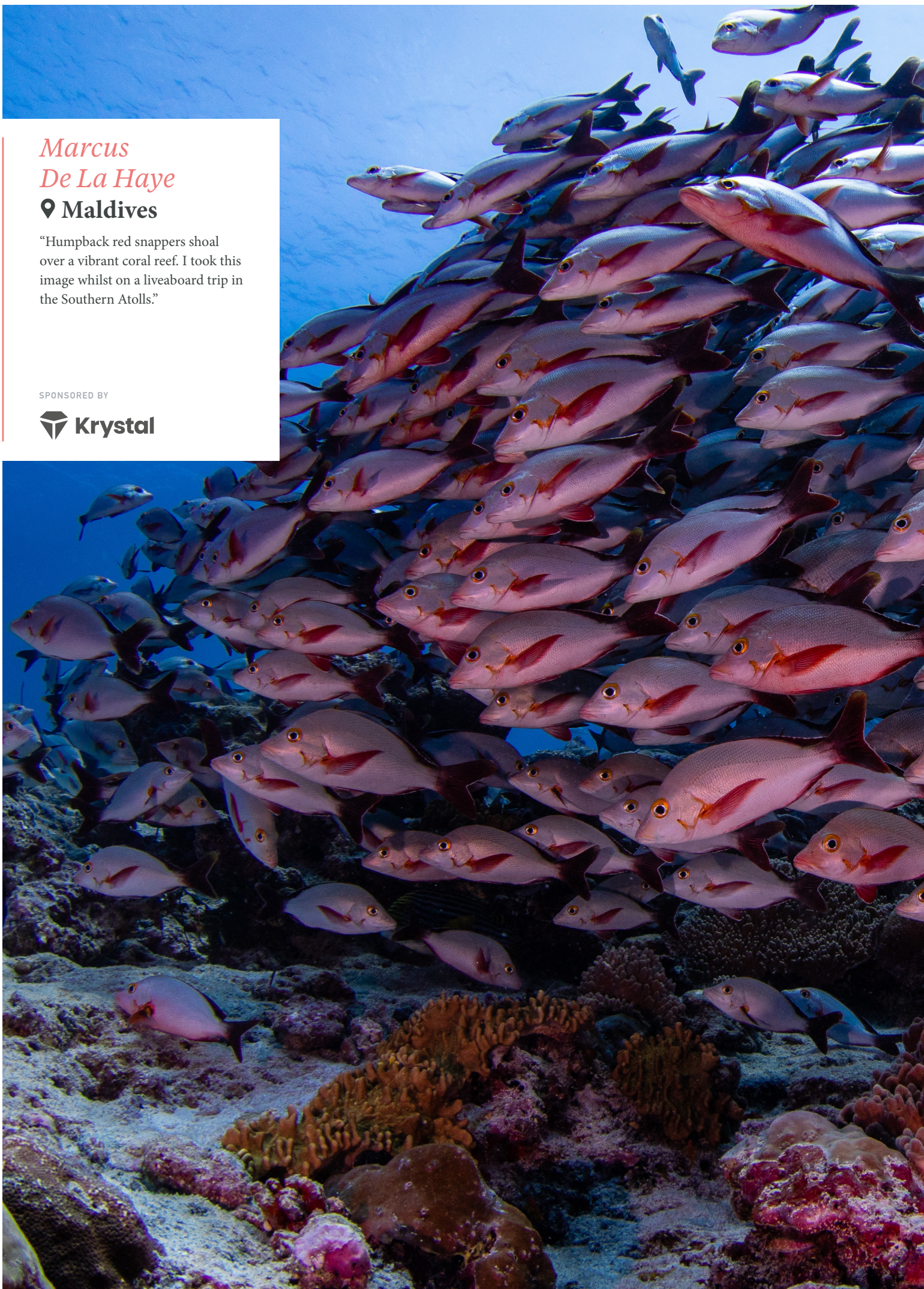
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*Marcus
De La Haye*

📍 **Maldives**

“Humpback red snappers shoal over a vibrant coral reef. I took this image whilst on a liveaboard trip in the Southern Atolls.”

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Bleached

PARADISE IN PERIL?

West Papua's Raja Ampat is one of the most biodiverse places on the planet. While increasing numbers of tourists explore the remote location, parts of the region have seen mild coral bleaching in recent months. Is the paradise suffering from its own success?

Words by Nane Steinhoff

Photographs by Brooke Pyke and Nane Steinhoff





I'm floating motionless amidst brilliantly hued soft corals. Different species, shapes, sizes, and colours as far as the eye can see. I float past a wide toadstool leather coral, a pulsating xenid mesmerises me with its pink tentacles that rhythmically dance in the water column, endless shoals of tiny fish swirl around this fascinating coral garden laden with sponges, sea fans, tunicates, hard corals and crinoids, while a peculiar-looking school of razorfish moves from coral to coral, resembling a grazing herd of cows. In the shallower end of the reef, long mangrove roots extend into the coral garden and high above my head, two eagles are circling.

Here in Raja Ampat, at the heart of the coral triangle, biodiversity is booming. An incredible 36% of the world's reef fishes and 76% of the world's known coral species can be found here. Manta rays, numerous shark species, whales and other megafauna are frequent visitors to the 1,500-island, 4,000km² archipelago off the coast of Indonesia's West Papua. A single reef in Raja Ampat is said to contain more species than the entire Caribbean. The reasons for the region's high biodiversity are complex. Its remoteness has kept development at bay, while its sheltered location within the path of the Indonesian Throughflow, a strong current that flows from the Pacific through to the Indian Ocean, brings nutrients, eggs and larvae to the region. According to research conducted by the non-profit Conservation International, another reason for its biodiversity are temperature fluctuations in the water due to currents. As reefs in Raja Ampat are exposed to a wide variation in temperatures - some reefs experience a 6 to 12 degrees Celsius variation within 24 hours - they are believed to be better equipped to deal with fluctuating temperatures and climate change.

Despite this positive outlook, the more time I spend in Raja Ampat, the more signs of human-induced pressures I come across. Brooke Pyke, an underwater photographer, and expedition leader who travelled to Raja Ampat at the beginning of 2023, remembers: "I visited Raja Ampat in both 2019 and 2020. I have vivid memories of the reefs being beautiful and abundant. I went back this year, post-Covid, and I was shocked to see how things had changed. Shallow reef sections at some of the dive sites I visited were showing signs of bleaching and many anemones were completely white. Some of the large sea fans in certain areas had algal growth on them." On social media and numerous dive blogs, I come across the same story: certain dive sites across Raja Ampat have experienced bleaching events in recent months.

To find out more about these events, I speak to Vincent Chalias, founder of Ocean Gardener, an Indonesia-based NGO that is dedicated to coral reef education and coral restoration. He explains that recent bleachings can be attributed, for the most part, to this year's La Niña climate phenomenon, a natural weather pattern that transports

| PREVIOUS PAGE: A common clownfish sits in a bleached anemone.

| LEFT: A vibrant coral reef with soft corals and sea fans in central Raja Ampat.





| ABOVE: Raja Ampat comprises more than 1,500 islands.
 | LEFT: A mangrove forest meets the edge of a shallow coral reef.

warm water at the ocean surface from South America to Indonesia. While it does so, it swirls up cold water from the deep near South America's coast and brings warmer-than-normal sea surface temperatures to the southern Pacific Ocean around northern Australia, New Guinea, and Indonesia. "Through this year's La Niña event, we experienced particularly bad weather, all due to warm water surfaces. We had dry weather on South America's west coast and extremely warm and wet weather on this side of the Pacific," says Chalias. "Luckily, this event was not a major one. While the water temperature wasn't over 32 degrees Celsius for a long time, which is considered extremely high for Indonesia, it was in the 29-30 degrees Celsius range for a very long time. That explains the mild bleaching event. Coral bleaching is all about the combination of high temperature and the time frame."

Shawn Heinrichs, founder of Only One and an underwater filmmaker and photographer who has worked on projects in Raja Ampat for many years, agrees that the bleaching events have been transient, for the most part: "There seems to be a resilience within the corals in Raja Ampat that aren't necessarily witnessed in other corals. I've seen entire reefs white and thought it's over. Then I return a year or two later and the coral coverage is beautiful. I don't think it's an 'alarm bell situation' yet. If we see multi-year bleaching, if we see entire large structures collapsing, then we might have something on our hands."

Other, more pressing threats facing Raja Ampat should be taken more seriously, urges Heinrichs: "I think a greater threat is coral disease. It is having a significant

impact on certain sites that used to be pristine." The issue is not entirely separate from bleaching; bleached corals are stressed which makes them more vulnerable to allergies and diseases. According to the study *The abundance of coral diseases and compromise health in marine protected areas on Dampier waters, Raja Ampat*, published in IOP Conference Series: Earth and Environmental Science in January 2023, coral diseases currently present in Raja Ampat are black band disease, which is caused by a blue-green algae, dark spots disease, as well as skeleton-eroding band disease. Chalias points out that these diseases could well be related to the influx of tourists to the region in recent years: "Hundreds of liveaboards, with an undetermined number releasing their sewage tanks into the water currently tour the region, while numerous resorts and homestays don't have proper sewage treatment facilities." Heinrichs agrees: "There are other concerns around the corals that we need to have a serious look at: the runoff from boats, the runoff from land, sewage, and other types of nitrates – all the other things that are being dropped into the water."

In 2007, 998 people travelled to Raja Ampat per year. By 2016, the number had increased to 29,653, according to the aforementioned study. This number is likely to have become even higher in recent years. Tourism in Raja Ampat only started to develop in the 2000s, making it a new industry in the region. "Given the massive increase in tourism in such a short period of time, understandably it has been hard for the government to keep up from an infrastructure and a staffing point of view - and this has been made even more challenging by the impacts of the

*“There seems to be
a resilience within
the corals in Raja
Ampat that aren’t
necessarily witnessed
in other corals.”*





| MAIN IMAGE: A Christmas tree
worm on a coral.
| RIGHT (ALL): Close-ups of
branching hard corals. Some
showing their extending polyps.

A full-page underwater photograph showing a diver in a black wetsuit and scuba gear swimming horizontally. The diver is holding a professional video camera with a large lens and is pointing it towards a large, dense coral reef on the right side of the frame. The coral is a mix of brown and white, indicating it is partially bleached. The water is a deep, clear blue, and the surface is visible at the top of the image with some ripples and light reflections. A semi-transparent grey box is overlaid on the left side of the image, containing a quote.

*“Coral disease is having a **significant impact** on certain sites that used to be pristine.”*

Photographing partially bleached staghorn corals in central Raja Ampat.





*A bleached anemone on a seamount
in Misool, Raja Ampat.*



*“How do we not love
it to death? That’s
the challenge now.”*

*“In 2007, 998 people travelled to Raja Ampat per year. By 2016, the number had **increased to 29,653.**”*

A coral shows signs of bleaching.





*A skunk clownfish in its
bleached host anemone.*

Covid pandemic. Procedure and policies are struggling to keep up. Before the 2000s, the region didn't have a tourism economy or tourism infrastructure," explains Heinrichs.

An agreement, at local government level, was established to limit the number of liveaboards operating in the region. This has never been properly managed. "The number of liveaboards operating in Raja Ampat is in the hundreds. The number is probably at least five times what it was meant to be," adds Heinrichs. "While there are, of course, incredibly responsible liveaboard operators, I've seen a number of vessels not operate the way they're meant to. I've seen lines of trash come out the back of boats. I've seen bilges being flushed adjacent to reefs. There's now an excessive number of liveaboards operating in the region that don't have any sense of responsibility."

In addition to the large number of liveaboards touring the region, numerous mid- to low-end homestays and larger developments are being built on land. These also flush different types of nitrates and other contaminants into the ocean and the region's deep channels and basins. Much like the liveaboards at sea, this building boom is a consequence of poor regulation management. Loopholes have been used to workaround rules designed to limit the number of resorts built, or where they were built. Homestays are a case in point. Designed to offer opportunities for locals to benefit from tourism by opening up their homes to visitors, mini-resorts have sprung up in villages instead.

"It's a legitimate political issue," says Heinrichs. "There needs to be a greater level of discernment and qualification about what it means to be a homestay and resort. If you're actually a resort, run by someone from somewhere else, or even someone from within but it's not a homestay, then it needs to be under the same regulations as the other resorts, properly managed and subject to the same quality standards."

To combat the overcrowding of dive sites, some NGOs collaborate with local operators and resorts to establish standards in tourism, bring mooring systems to the region, and to better distribute the liveaboards operating across Raja Ampat at any given time. Chalias, for example, urges visitors to opt for liveaboards, resorts and homestays with proper waste-water management facilities, as well as verified ecotourism ratings. Another step he sees as vital for Raja Ampat to flourish is the implementation of tourist quotas: "We need to disperse the liveaboard industry to other areas outside the popular dive sites of Raja Ampat. The only immediate solution is dilution." Heinrichs agrees: "There was a study, *Carrying Capacity of Diving Tourism in Dampier Strait Marine Conservation Area – District of Raja Ampat*. Those numbers need to be implemented. And that means restrictions on the volume of traffic, specifically on the more prominent sites."

The good news, Heinrichs adds, is that the government of Raja Ampat is "receptive and committed" to protecting Raja Ampat and making it what it is purported to be – a sanctuary. He says: "The good side is the government is pro-conservation and pro-tourism. There's a lot of potential for the current situation to get resolved. The challenge is resources and managing the different stakeholder groups."

Raja Ampat managed to move away from being a place dominated by extractive industries, rampant with shark finning, bomb fishing, turtle poaching, gillnetting, and longlining. It is a conservation success story. It established a ray and shark sanctuary in a way that no other place had before. It put no-take zones in place that benefit both marine biodiversity and local villages. It shut down illegal logging activities, removed bomb fishermen and introduced sustainable dive tourism. In Raja Ampat's south, for example, one can find the island resort of Misool, a privately managed marine protected area that now covers 300,000 acres (1,220km²). According to research conducted by The Nature Conservancy, the worldwide annual economic value of coral reefs is calculated at \$36 billion. Misool is identified as a 'million-dollar reef' – a reef that generates over one million dollars per square kilometre per year. Since its opening, the resort has transformed from a former shark finning hotspot into a marine ecosystem where shark populations now thrive. A 2012 study suggested there were 25 times more sharks inside the Misool Private Marine Reserve than directly outside of it. Fish biomass has increased dramatically - by up to 600% in some sites, according to surveys conducted across a six-year period by Mark Allen from Murdoch University in Australia. Misool is the perfect example of how sustainable tourism can benefit nature conservation and local communities.

Raja Ampat is at a crossroads. As a place known for its pristine marine ecosystem, it has become popular with divers and snorkelers, and has suffered from its own success along the way. While we know that climate change is affecting coral reefs around the world, corals in Raja Ampat have proven, so far, resilient. But with the overarching danger of warming ocean temperatures, it is vital for us to rethink our relationship with the last wild places on earth. The next few years will determine whether Raja Ampat's biodiversity can be safeguarded for future generations. Will the region continue to take the path of conservation and long-term view? Or will it go on a journey towards mass tourism and short-term profit?

"Raja Ampat is a beautiful place that now thrives on a tourism-based economy," says Heinrichs. "But how do we not love it to death? That's the challenge now."

The *outlaw ocean reporter*

REIMAGINING THE REALM

Two-thirds of the planet is covered by water, and much of that space is ungoverned. Human rights and environmental crimes occur often and with impunity because the ocean is sprawling and what laws exist are difficult to enforce. Part of the problem, though, is in our heads. The ocean is typically and correctly viewed as a marine habitat. But it is much more than that. It is a workplace, a metaphor, an escape, a prison, a grocery store, a trash can, a cemetery, a bonanza, an organ, a highway, a depot, and, above all, an opportunity. Unless we reckon with this truth, unless we reimagine this domain more broadly, we will continue falling short in governing, protecting, and understanding the ocean.

The ocean is a workplace. More than 50 million people work offshore and many of these people work in fishing, which is the world's most dangerous profession, resulting in more than 100,000 fatalities per year – more than 300 a day.

The ocean is a metaphor. This place offshore has long connoted infinity, sui generis abundance, tireless plenty – where fish will regenerate and replenish themselves indefinitely. This perception is part of why the ocean has been taken for granted for centuries. If the ocean is so vast and indestructible, if it can replenish itself so boundlessly, why bother restraining ourselves in what we take from it or dump into it?

The ocean is an escape. For centuries, life at sea has been romanticised as the ultimate expression of freedom – a refuge from landlocked life, distinctly removed from government meddling, a chance to explore, to reinvent. From *Moby Dick* to *Twenty Thousand Leagues Under the Sea*, hunters, adventurers and explorers have chased this dream.

The ocean is a prison. Far from escape or recourse, ships at sea are for many workers a jail without bars. Every year tens of thousands of men and boys are bought and sold like chattel, and then find themselves stuck in bondage, sometimes for years – and even in shackles – on distant water fishing ships.

The ocean is a grocery story. More than 50% of the animal protein people consume in some parts of the developing world comes from seafood, which is the largest globally traded food commodity by value in the world. Industrial fishing has now advanced technologically so much that it has become less an

art than a science, more a harvest than a hunt. The consequence is that more than a third of the world's stocks are overfished.

The ocean is a trash can. For centuries, humanity has seen the seas as so vast as to have a limitless ability to absorb and metabolise all, a perception that has given us licence to dump virtually anything offshore. Oil, sewage, corpses, chemical effluvium, garbage, military ordnance, and even at-sea superstructures like oil rigs disappear into the ocean, as if swallowed up by a black hole, never to be seen again.

The ocean is a cemetery. Thousands of migrants disappear offshore each year – many of them in the Mediterranean Sea, for example, as they try desperately to cross over to Europe from launching points in Libya, Morocco, and Tunisia. When rough seas or human traffickers or the Libyan Coast Guard overturn these crowded rafts, their passengers don't just drown. Their bodies disappear into a blackness that conceals world notice. And so the sinister cycle continues.

The ocean is a bonanza. Is it thievery to take unchecked amounts of something from an area that belongs to everyone? No, it's called unregulated fishing, which happens to be the norm in international waters. And there is far more on offer at sea than food. Oil and gas drillers, miners, treasure hunters, wreck thieves, and biomedical prospectors know this all too well.

The ocean is an organ. The lungs of the globe, the ocean produces at least half of the oxygen we breathe. But as we burn more fossil fuels and release more carbon into the air, much of it dissolves and suffocates the water, thus killing the planet. The ocean has also already absorbed 90 percent of the excess heat from global warming, and today is 30 percent more acidic than it was before the Industrial Revolution.

The ocean is a highway. The high seas are the expressway of world commerce. In today's globalised economy, part of the reason that more than 70 percent of the products we consume travel by ship is that the high seas are distinctly less encumbered with borders and bureaucracies.

The ocean is a weapons depot. Plied by more ships than ever before, the ocean is also more armed and dangerous. Starting in 2008, as pirates began operating across larger swaths of the ocean, many merchant vessels hired private security, and their forces soon

“Can governments find common good above self-interest and cooperate toward managing the high seas?”

outstripped governments’ policing abilities.

The ocean is an opportunity. Not just a gritty netherworld, the ocean also represents a chance for salvation. Can governments find common good above self-interest and cooperate toward managing the high seas? The recent UN treaty on biodiversity was a step in this direction. The next test is whether governments can use the ocean as an opportunity to collaborate in mitigating the climate crisis.

A first and essential step to countering these many problems is to broaden our thinking about the ocean. Dispatches from the Outlaw Ocean is a documentary series that offers a sober tour through this untamed frontier. Its goal is to stoke urgency and to help the global public reimagine the ocean not as a thing that we take for granted, a bottomless trash can, a forever self-replenishing resource that we use to fill our stomachs or line our wallets, but instead as a vast habitat that we should leave alone, a workplace needing regulation, less a grocery store than a library or a cathedral, a protected common. **IU**

About Ian

Ian Urbina is the director of *The Outlaw Ocean Project*, a non-profit journalism organization based in Washington D.C. that produces investigative stories about human rights, environment and labour concerns on the two thirds of the planet covered by water. Before founding *The Outlaw Ocean Project*, Urbina spent roughly 17 years as a staff reporter for The New York Times. He has received various journalism awards, including a Pulitzer Prize, two George Polk Awards and an Emmy. Several of his investigations have also been converted into major motion pictures.

*Ulleung Island beyond vast blue sea.
Photograph by Fábio Nascimento/
The Outlaw Ocean Project*



| SOUTHERN *sanctuary*

Southern right whales were almost hunted to extinction at the beginning of the century. They have since made an impressive recovery. In New Zealand, a team of researchers gained access to one of the species' most remote breeding grounds off the Auckland Islands to reveal more about the species by collecting skin samples and tracking data.

Words and photographs by Julie Chandelier



The raging storm has finally eased and the sky is clearing. “Come to the upper deck,” I shout to my partner Scott, as we drop anchor in Erebus Cove in Port Ross. I gaze at the bay bathed in a timid morning light. Everywhere I look I can see and hear spouts. Whales everywhere, as far as the eyes can see.

It is June 2021, in the middle of New Zealand winter, and together with a team of nine, we have spent the last 36 hours crossing the infamous stretch of water between Bluff, the bottom of Aotearoa New Zealand’s South island, and Maungahuka, the Auckland Islands, in the Subantarctic. I am taking part in a three-week scientific expedition, documenting the hard work of Dr Emma Carroll, the onboard scientist and associate professor from the University of Auckland Waipapa Taumata Rau, who has been studying Southern right whales for 15 years.

Southern right whales are a critical species for conservation efforts in New Zealand. Historically, the population was hunted to near extinction during the late 1800s by commercial whaling, and their slow reproductive rates made them particularly vulnerable to annihilation. Southern right whales were the perfect quarry for whalers; the species was considered the ‘right’ whale to hunt due to its slow speed and ability to float after being killed.

Today, the whales continue to face threats from climate change, entanglement in fishing gear or vessel collisions. But in recognition of the importance of protecting these whales, New Zealand has established a number of conservation measures. For example, the Auckland Islands - Motu Maha Marine Reserve, created in 1993, is the only known breeding ground in New Zealand for this species. The whales gather here annually from May or June to September to mate and give birth. The government has further instituted regulations to limit the speed and proximity of boats in areas where the whales are known to congregate.

The remote Auckland Islands are located in the southern Pacific Ocean about 465 kilometres south of New Zealand. They are part of New Zealand’s subantarctic archipelago, which also includes the Campbell Island group, the Antipodes Islands, and the Bounty Islands. They encompass a total area of 57,000 hectares and are a UNESCO World Heritage Site due to their unique ecology and biodiversity. They are home to a significant number of subantarctic invertebrates and some of the rarest birds on earth. The sanctuary spans approximately 12 nautical miles around the archipelago. Entry is heavily regulated by governmental permits, and visitor numbers are limited. During the winter season, these islands are strictly closed to all tourism, allowing just a handful of research vessels. In 2021, our 78-foot-vessel Strannik is one of the only two allowed.

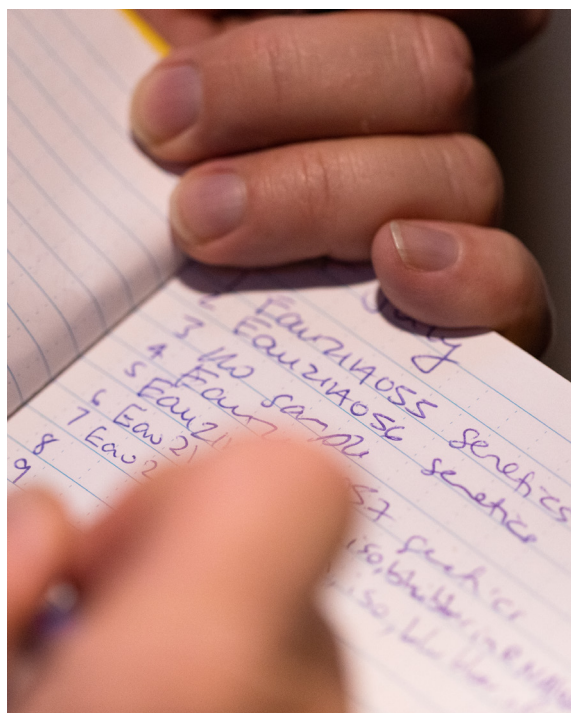
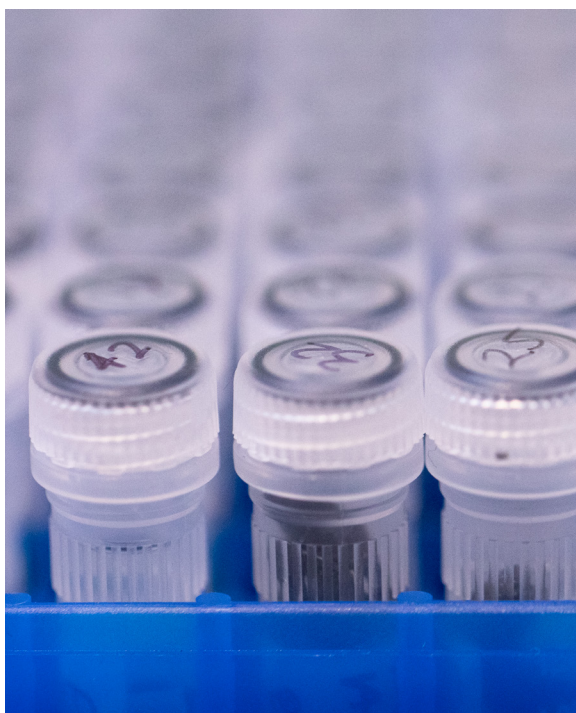
Our moorage is in a safe and sheltered spot, in this rugged bay that is Port Ross. Beautiful vistas surround us with

“Southern right whales have distinctive callosities which are irregular patches of thickened and keratinized tissue usually found around their heads or jaws.”

| PREVIOUS: A Southern right whale calf tail-flapping alongside its mum, in Port Ross at sunrise.

| THIS PAGE: Close-up of a Southern right whale’s iconic callosities, hosting three species of amphipod crustaceans.





TOP LEFT: Dr Emma Carroll sorts through her daily Southern right whale skin biopsies.

TOP RIGHT: Southern right whale skin.

BOTTOM LEFT: Collected and labelled skin biopsies in tubes.

BOTTOM RIGHT: Collecting data.

subantarctic vegetation, including tussock grasslands and low shrublands. I am in awe of the dense rātā forests that line the shores of these islands, ancient trees that have been shaped and beaten by the prevailing westerlies. They form a dense canopy that usually does not exceed a height of 20 metres.

As sea sickness fades from the rocky journey south, the next few days leave me speechless. From early morning to dawn, we observe dozens of whales feeding, socialising and breaching directly from our mooring. Being at anchor allows us to see individuals swim under our boat or circle us. Moms and calves often visit us in the early hours, while hot coffee is still brewing inside our floating home. On many occasions, I find myself putting on all of my warm layers and wet weather gear in a hurry, still wearing my pyjamas underneath. It is not uncommon to hear one of my comrades' voices shouting to everyone to come outside as whales approach us yet again. We can hear spouts directly from our cabins almost every day and night. At these moments, I am oblivious to the challenges I've overcome to be here. One evening before shutting our eyes, Scott tells me: "How lucky we are to be here, so few people get to visit the Subantarctic in the middle of winter, let alone share it with hundreds of whales."

Scott and I are glued to our cameras most of the day and are blessed by many special encounters. One morning, a calf breaches more than 20 times in a row, playing with sea birds at the surface. Groups of females roll around and rub against each other, showing us their pectoral fins and tails. On three occasions, we come across rare white calves that grow up to be grey morph adults: "The proportion of calves born white seems to vary from population to population," says Dr Carroll.

The Southern right whale is an impressive animal. It can reach a maximum length of 18m and weigh nearly 80 tonnes. Scientists are not sure how long they live but North Atlantic right whales have been documented to live into their 70s, and Southern right whales are believed to have a similar age range. Dr Carroll's ongoing research involves identifying feeding habitats of the various populations of Southern right whales. The overarching objective of her work is to grasp the recovery of these populations in relation to these foraging habitats over the last decade, which coincides with a period in which climate change has had the most profound influence on the ocean. She

"The population was hunted to near extinction during the late 1800s by commercial whaling."

builds on 25 years of research initiated by University of Auckland researchers C. Scott Baker and Nathalie J. Patenaude in 1995 by advancing genetic monitoring.

Everyday - hail or shine - Dr Carroll surveys the bay in one of the zodiacs with her team, observing and counting individuals. She also collects skin biopsies from as many individuals as possible by carefully using darts and a crossbow. The darts bounce off the chosen whales' backs without harming them, with the tip of the dart collecting a tiny skin sample about the size of a human fingernail. This small piece of blubber collected is full of information for her research. The DNA extracted is used to identify individual whales, their relatives and estimate the population size, including historical population size. Dr Carroll can also identify their diet and even give them a pregnancy test with this piece of blubber. One of my jobs throughout this expedition is to join Dr Carroll's team in the zodiacs and collect photo IDs to help her catalogue the whales.

Over the winters of 2020, 2021 and 2022, Dr Carroll and her team have successfully tagged 25 whales with satellite tags. The data allows her to map the migration paths of the whales, while putting them in relation to human activities such as shipping, and determining their feeding grounds. To this day, she can track whales that were tagged in 2021. While these satellite transmitters tell us about the present, the collected genetic data tells us about their past, she explains.

Dr Carroll's recent work has used microchemical markers in whale skin to identify their foraging



| THIS PAGE: A Southern right whale calf spy-hops.
| RIGHT: A breaching Southern right whale calf.

*“When a whale feeds
at a certain location, it
produces a characteristic
microchemical marker
in their skin, allowing
researchers to identify
where they were feeding.”*







An adult Southern right whale leaps into the air in Port Ross. The splash created an echo resonating in the whole bay.



| TOP: A tomtit (*miromiro*).
 | MIDDLE: A yellow-eyed penguin (*hoiho*).
 | BOTTOM: A sea lion (*whakahao - pakake*).

“Different populations of Southern right whales have responded differently to climate change.”

grounds on a circumpolar scale. Leading a collaboration of dozens of researchers from around the world, Dr Carroll compiled a dataset of over 1,000 skin samples from all the major wintering grounds. Recent advanced biogeochemical models then provided a map of how these microchemical markers vary across the Southern Ocean and through time. When a whale feeds at a certain location, it produces a characteristic microchemical marker in their skin, allowing researchers to identify where they were feeding approximately six months prior to sampling. This work shows that, over the past few decades, different populations of Southern right whales have responded differently to climate change, in a way consistent with how scientists think their ecosystems are changing. In the South Atlantic, scientists observed fewer whales around Antarctica, whereas the Southern right whales of New Zealand and Eastern Australia were recorded to travel south to Antarctica more often than their South Atlantic cousins. This could reflect the fact that parts of the South Atlantic are warming faster and are some of the most rapidly warming waters in the world, while the waters south of New Zealand and Antarctica are actually getting colder. Furthermore, the team compared data on where the whales currently feed to where they were killed by whalers between 1790 and 1970. This showed that, across four centuries, mid-latitudes have remained important feeding grounds. The researchers believe this may be due to the fact these areas are changing less, or have whale prey that are less sensitive to temperature changes than Antarctic krill.

On the expedition, from time to time, we recognise a few individuals, thanks to distinctive features on their heads or bodies. Southern right whales have distinctive callosities which are irregular patches of thickened and keratinized tissue usually found around their heads or jaws. Three species of amphipod crustaceans inhabit the tissues of these whales: *cyamis ovalis* and *cyamis gracilis* that are white and commonly found on healthy individuals' normal callosities, and *cyamis erraticus*, which is orange and primarily found in the wounds of sick or young whales. These small crustaceans, also known as whale lice or cyamids, feed on whale skin and can't survive in open water without a host. They survive by moving from one whale to another by direct contact.

The islands are also home to a wide range of exotic wildlife, including elephant and New Zealand fur seals, yellow-eyed penguins, and a great variety of seabirds. We even saw an Antarctic visitor one day, a leopard seal. Captain Russ has been lucky to visit these islands over 150 times in his lifetime, but never in winter. “On a scale from 1 to 10, this trip has definitely been a 15”, he says during our last dinner.

In the 1920s, only 30 to 40 Southern right whales were left in New Zealand. In 2009, 2,000 individuals were recorded. The species has made a strong recovery since the passing of the Marine Mammals Protection Act in 1978. However, these conservation efforts need continued vigilance and action. By protecting these marine mammals, not only are we preserving an important piece of New Zealand's natural heritage but also promoting the health and resilience of our marine ecosystems.

Witnessing hundreds of Southern right whales in their natural habitat was a humbling experience. Observing them thriving in peace will leave a lasting impression on me. Amidst climate change, species extinction, and biodiversity loss, the revival of a sizeable whale population offers a glimmer of hope. Their story is proof that when left alone, nature finds a way to recover.



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Behind the lens

IN ASSOCIATION WITH



MATTY SMITH

Behind the lens places a spotlight on the world's foremost ocean conservation photographers. Each edition focusses on the work of an individual who continues to shape global public opinion through powerful imagery and compelling storytelling.

Q&A

MATTY SMITH

Originally from the UK, Matty Smith is an internationally acclaimed underwater photographer, currently residing in New South Wales in Australia.

The aim behind his photography is to show the distinctive beauty of underwater landscapes and alien creatures he encounters. With his images, he seeks to show people the treasures of the ocean, how fragile they are and the importance of protecting them.

OCEANOGRAPHIC MAGAZINE (OM): MATTY, THANKS FOR TAKING TIME TO SPEAK TO US. DO YOU REMEMBER WHEN YOU FIRST CONNECTED WITH THE OCEAN?

Matty Smith (MS): As I'm originally from the UK, when I was younger, I was going on holidays down to Europe with my parents. One particular time, when we went to the Mediterranean coast of Spain, I went snorkelling and that was the first time I'd put my head under the water. I remember looking down and I saw a big school of fish below me just above the sand. I remember the way the sun was shining down and the beams of light were dancing around on the backs of the fish. I was instantly mesmerized and captivated. From that moment on, I just did everything I could to go back to the ocean. As soon as I was able to drive, I really got into surfing. I've pretty much been in the ocean ever since.

OM: HOW AND WHY DID YOU START TAKING PHOTOS UNDERWATER? HOW HAS THE LOVE FOR UNDERWATER PHOTOGRAPHY DEVELOPED?

MS: An ex-girlfriend's dad was a photographer. I was talking to him about it and I got interested in the whole SLR thing. This was in the mid '90s before digital cameras were a thing, of course. So, for my birthday I got an SLR camera with rolls of black and white film. I started shooting surf primarily. My camera has always been aimed at the ocean even from the first time I picked one up. I started taking photographs of my friends surfing. Then I built a darkroom in the cellar of the house I was living in at the time. I would go on surf trips and then develop and print all my own photographs. I also signed up to a night school. I did three years of college, learning how to print black and white to a certain standard. Photography has been under my skin ever since.

OM: HOW DID YOU TURN YOUR PASSION INTO YOUR PROFESSION? HOW DID YOU END UP AS AN UNDERWATER PHOTOGRAPHER?

MS: What many photographers testify to, once photography gets under your skin, it becomes a very expensive hobby. So for years I was just shooting as much as I could, trying to think of new ideas and angles. I guess my big break was in 2014. It was quite a good year for me. I had an idea to shoot some split-shots, or over-under photographs as people call them, of Portuguese man o' war or bluebottles as we call them in Australia which are basically a smaller species of man o' war. I shot a whole portfolio of split-shots of those at sunrise and I didn't do anything with them. I just sat on them and kept them close to my chest because I knew that they were quite nice pictures that could potentially do well in competitions. Then, in 2014, after I had been shooting the bluebottles for around a year or so, I had gotten a small portfolio of shots I was really happy with. I entered those into all the major competitions and in 2014, I placed in the Wildlife Photographer of the Year competition. I got to go to London and attend the ceremony that was presented by David Attenborough. I then won the Australian Geographic Nature Photographer

of the Year overall prize with another picture from the same portfolio. So, 2014 was a big year; I won many awards, met some influential people through those awards, picked up my Nikon sponsorship, as well as a sponsorship with Aquatica Digital. Loads of doors opened on the back of those few pictures.

OM: YOU'RE ORIGINALLY FROM THE UK. WHY DID YOU DECIDE TO MOVE TO AUSTRALIA? HOW DID THE MOVE IMPACT YOUR CAREER AS AN UNDERWATER PHOTOGRAPHER?

MS: I moved to Australia to become a better underwater photographer and a better surfer. I emigrated in 2007 so several years before my professional photography career took off. I was working as a mechanical engineer at the time. I first came to Australia in 1999 as a backpacker. I spent a year here to surf and take photos and I just absolutely fell in love with the place. In 2005, I did another three-month trip which really fortified my passion for the country and made me decide that this was where I wanted to live. I went home and did all my applications to get my permanent residency which I got granted in 2007. I was literally on the next plane over as soon as that got signed off. I've lived here ever since and became a citizen in 2012. It helped my photography career a lot because I live on the coastline. I get to see the ocean every morning. It's very inspirational.

OM: WHAT DO YOU LOVE ABOUT AUSTRALIA'S UNDERWATER LANDSCAPES? DO YOU HAVE ANY FAVOURITE SPECIES OR AGGREGATIONS?

MS: I just love the diversity of the creatures here. There are so many different species and unique things that you don't find anywhere else in the world. For instance, the weedy and leafy seadragons – they're firm favourites of mine because they're endemic to the area that I live in. You can fly all around the world and not quite see anything like it. They're abundant here. You can swim out on any given day and find some to photograph. And then I love the cold water of the South Coast of Australia too. I love the giant cuttlefish there which again are endemic to Australia. And then you can go over to Western Australia and there are different things again or up to the Great Barrier Reef and there are different things again. All within a short flight, you've got this whole range of water temperatures and diversity of life with, very often, clear, good conditions to dive in. There's a lot going on here and there's still so much more to explore. I've not really done very much of Western Australia, for example.

OM: WHAT DO YOU WANT TO ACHIEVE AND CONVEY WITH YOUR PHOTOGRAPHY? DO YOU HAVE A SPECIFIC AIM OR STYLE?

MS: I think anybody who enters the ocean with a camera, whether you like it or not, becomes a champion for the seas and a conservation photographer in some shape or form. My style has never really been to show the bad stuff. That's because I prefer to try and generate a love for the ocean, rather than show the negative. There are plenty of photographers out there showing the negative and that's very important. We need that. But on my side of the fence, I'm trying to share the beauty and show people what we've got. I think as a group of photographers, including myself and the people of all the other genres of underwater or conservation photography in general, we've got the whole spectrum covered by all the different styles and what people need to see to generate compassion for what we've got.

OM: HOW DO YOU PLAN YOUR IMAGES? WHAT THOUGHT PROCESS GOES INTO IT? WHAT'S IMPORTANT TO YOU IN YOUR PHOTOGRAPHIC APPROACH?

MS: I always go into the sea with a clear objective. I usually have a particular animal in mind, whether it might be a certain species like a nudibranch or a humpback whale. There's always a focus so when I'm in the water, I try to not get too distracted and remember the focus. My plans as far as camera settings and lighting setup go is all very pre-planned. I want to light something in a certain way or I want to depict it using camera settings in a certain way, so there's a lot of forethought that goes into a picture. Very few of them are opportunistic shots. I travel to a place to photograph certain things in a certain way. My signature shot is a kind of split-shot – I like to do a lot of over-under photography. For that, I build and make my own equipment. I make giant-sized dome ports to shoot through which makes the job easier. There are various bits and pieces I design from my engineering background and make in preparation to get one specific kind of shot. So, my photography is very planned and there's definitely a lot of forethought going into it.

Continued on p. 80...























































Continued...

OM: TELL US MORE ABOUT YOUR CUSTOM-BUILT OVERSIZED DOME PORTS.

MS: You can't buy dome ports the size that I make them. The biggest one you can commercially buy is around 10 inches or 250mm. They're great dome ports but to shoot split-shots in particular, if you're in rougher water in the open ocean to shoot a whale, for example, the bigger the dome port, the easier it is to manage the water in choppy conditions. It also gives you some focusing advantages and improved depth of field, a better focus, it pushes the waterline further away from the camera lens so you get a thinner, sharper waterline in the picture. So, there are a lot of optical and practical advantages of having large dome ports. As nobody commercially made them, I made the first one myself. As soon as I took it in the ocean, I was gobsmacked and so pleased with the results. It worked out exactly as I had hoped – super sharp pictures. Since then, I've published a number of shots that I've taken with those big dome ports and people love them. I've also build and sell these oversized dome ports to other ocean photographers.

OM: YOU ARE RENOWNED FOR THE OVER-UNDER SPLIT-SHOTS YOU'VE JUST MENTIONED. WHAT MAKES THIS TYPE OF IMAGE SO SPECIAL?

MS: This type of shot always takes me back to that moment I first put my head underwater as a child and seeing the comparison of the two worlds. When you do a split-shot, it generally turns into a fine art landscape shot. You're trying to tell a story that is both above the water and below the water so it's no good trying to do a split-shot just for the sake of it. If you've got something uninteresting on the underwater side or something uninteresting on the top side, then it's just a failure of a shot, it's a boring photograph. So, you have to have something special. I like dramatic skies, mountains or trees in the top side and underwater you have to be close to something interesting, whether that is a fur seal, a coral reef or a Portuguese man o'war. So, the whole picture has to tell a story.

OM: WHAT'S YOUR OPINION ON POST-PROCESSING AND PHOTOSHOPPING? WHAT ROLE DOES IT PLAY IN YOUR PHOTOGRAPHY?

MS: I'm kind of old school. It's a throwback from shooting film. I'm very used to trying to get everything right in camera and I've always carried that on through my digital forays as well. I build equipment, I go out of my way to keep everything in camera, so everything you see in my photographs really happened. There's nothing added on or taken away or collaged together or anything like that. Everything is as it was. Aside from global enhancements which are things like colour temperature, contrast and similar things that you can do globally to the picture, obviously I do that because you need to do that to RAW files and process them in some shape or form. But that's all stuff you could do in a dark room. When I used to shoot old school on different films, I would select a type of film – either a contrasty film or a more colour-saturated film or a flatter film or a black and white film. All these things that I do in post-processing are all things that you can do in a dark room. That's kind of how I judge whether I'm on the right path or not. I ask myself – could I do this in a dark room? If I could, then I do it.

OM: DO YOU HAVE ANY FAVOURITE SUBJECTS OR PLACES TO PHOTOGRAPH?

MS: I've just come back from Antarctica. I've had a month down there on a sailing boat. Leopard seals have become a new favourite of mine. They're intimidating but so beautiful at the same time. I'm now planning to go back there as often as I can and shoot more of them. But I've always loved shooting seals and sea lions. They're very playful creatures, they're very engaging. They like to come up right to your camera which is good from a photography point of view. I also love to shoot octopus or any cephalopods. They're amazing creatures because they're so intelligent.

OM: ARE THERE ANY MOMENTS THROUGHOUT YOUR CAREER THAT FILL YOU WITH A PARTICULAR SENSE OF PRIDE?

MS: I have a split-shot of a humpback whale calf that I shot in Tonga a few years ago. I remember it being a particularly bad day. We had a lot of days which were quite nice with clear, blue skies and calm seas. I was getting split-shots on those days but it wasn't making for a very interesting shot. It wasn't good enough on the top side for me. So, on that particular day, I got this whale split-shot, it was a real stormy, rainy and windy day. We were out on the water for six hours and had no opportunity to go in the water. On the way back, we came across this mother and her calf, really calm and just floating in the waves, allowing us to get in the water. The calf then approached and swam around me and the people I was with for maybe 15 minutes. I got this beautiful split-shot with this broody, dark, stormy sky and rough seas. And it was just the atmosphere I was looking for.

OM: YOUR FAVOURITE WILDLIFE ENCOUNTER TO DATE?

MS: There have been a few. I remember one that happened in 2015 over in Cuba. I was in the Gardens of the Queen, a mangrove system. They have their own species of American crocodiles there. That was the first time I got in the water with a crocodile and photographed them. I got very close to one and shot a split-shot which engrained itself in my mind forever. It's not very often you remember the exact moment of pressing the photograph on the frame but I remember everything about that moment of getting the shot and getting out of there as quickly as I could.

OM: YOU MENTIONED YOUR RECENT TRIP TO ANTARCTICA. TELL US A BIT MORE ABOUT THAT EXPERIENCE.

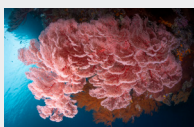
MS: It was my first time there. Myself and a few other photographers chartered a 60 foot sailing boat with two professional sailing crew. We sailed from Argentina down to Antarctica which took four to five days. Having such a small boat and no fixed agenda, we had the advantage over the big cruise ships. We spent a month down there, just going wherever we wanted, whenever we wanted. One day, we were all standing on deck watching six humpback whales bubble netting all around the boat, coming up in random places. Then it happened right next to the boat. We had all six whales erupt with mouthfuls of krill metres away from us! There were people crying and yelling; it was the most amazing moment.

OM: LAST YEAR, IN THE OCEAN PHOTOGRAPHER OF THE YEAR AWARDS, YOU WON THE OCEAN PORTFOLIO AWARD. WHAT ROLE DO COMPETITIONS PLAY IN YOUR CAREER AS AN OCEAN PHOTOGRAPHER?

MS: Entering underwater competitions and photography competitions in general was my route to success. It got me my credibility as an underwater photography teacher and instructor, and through it, I became a sponsored photographer and an ambassador for Nikon. That all came off the back of entering competitions. In this day and age where it's hard to get some limelight, competitions are, in my personal experience, the best way to do it. If you can produce a really strong body of work and place fairly regularly in a lot of the prestigious competitions like the Ocean Photographer of the Year, then this definitely gets your work under the nose of influential people. To place in competitions, for me, is key to staying relevant, and key to success and support from the companies that support me. I actively seek out and enter as many of the reputable competitions as I can.

OM: WITH NEGATIVE NEWS ABOUT THE STATE OF THE OCEAN COMING IN DAILY, HOW DO YOU STAY POSITIVE?

MS: You've got to keep the beauty of the ocean under peoples' noses. This is the drive for people to improve their lifestyles. You need to keep people interested and show them that it is still worth looking after and saving. If you stop, people will stop.



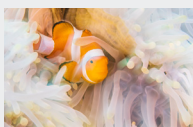
Raja Ampat, Indonesia

A large sea fan filter feeding in the nutrient rich waters of Raja Ampat. Sea fans provide vital habitat for many creatures such as seahorses, shrimp and fish.



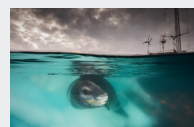
Raja Ampat, Indonesia

A whip coral goby and a coral shrimp on the same whip coral. "I had to approach very stealthily to get this shot as both species are prone to hide quickly if disturbed," says Smith.



Raja Ampat, Indonesia

The haunting beauty of a bleached anemone with its clown fish.



Antarctica

"This leopard seal approached our sailing boat as we entered Paradise Harbour," explains the photographer. "I shot until the sun slid below the horizon and it was too dark to carry on."



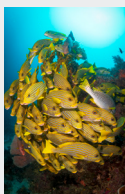
Cuba

An American crocodile in the Gardens of the Queen. "It's not often you remember the exact moment of pressing the shutter but I remember everything about this moment," says Smith.



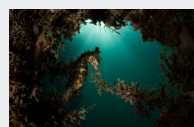
Tonga

A young whale shark in Vava'u pays Smith a surprise visit, while scouting for humpback whales.



Raja Ampat, Indonesia

Schooling sweetlips in Raja Ampat. "You have to dive to 40m to find them, leaving little bottom time to get the shot," explains Smith.



Sydney, Australia

A White's seahorse in Sydney Harbour, backlit by a sunset.



Jervis Bay, Australia

Bioluminescent plankton in Jervis Bay. The photographer says: "When I heard that there had been sightings of bioluminescence, I drove through the night to find it."



Antarctica

Whilst swimming through brash ice in Antarctica to shoot snow-capped mountains from the water, Smith came across this leopard seal asleep on the ice.



Tonga

A young humpback whale calf in a belly-up position just under the surface of the water.



Sydney, Australia

A male weedy sea dragon with bright pink eggs at the root of his tail where the female deposited them during courtship.



Wollongong, Australia

A bluebottle floats on the surface. "Every summer when the north-easterly winds blow, thousands of them get washed up on Australia's east coast," explains Smith.

Behind the lens

MATTY SMITH

Matty Smith is an internationally acclaimed underwater photographer who is best known for his signature over-under split-shots. His work has been published by The BBC's Blue Planet 2 Documentary, National Geographic, BBC Wildlife Magazine, and The Guardian amongst others. His work has been exhibited all around the world from London's Natural History Museum to Sydney's Australian Museum. He speaks publicly about his approach, conducts underwater photography classes, and sells custom-built dome ports. He is also a staff photographer for Ocean Geographic Magazine as well as a Nikon Australia and Aquatica Digital brand ambassador. He has won numerous photography awards including the National Geographic Nature Photographer of the Year People's Choice Award 2017.

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Model Gonzalo Manera





Gravel of hope

At a time when habitats are being degraded and destroyed across the world, a question arises: how can we stop this appetite for destruction? In Portugal, a simple, low-cost solution to restore underwater forests might hold answers.

Words and photographs by Nuno Vasco Rodrigues

“3, 2, 1... let's go!” shouts João Franco while rolling backwards from the boat and entering the water. The water temperature is 14 degrees Celsius and the visibility is poor - something that concerns Franco's dive partner, Álvaro Sánchez. “I hope we can see something down there,” he says before the pair start their descent. The duo dives down to 20m and starts exploring the luxuriant kelp forest. The environment is shady, largely due to the poor visibility, but marine life is rich and abundant. Small fish of different species abound in this habitat. Large sponges of different colours and shapes cling to the few rocks that are not covered by algae.

A few minutes later, one of the divers identifies the presence of sori (reproductive structures that contain and produce kelp spores) in one of the kelp blades. He cuts the section with a knife and places it in a container along with sea water. Hand signals are exchanged to end the dive and the team ascends to the surface. The dive represents the first phase in a process being developed that could help restore abundant kelp forests to the ocean.

Innovative solutions will play an important role in counteracting the ever-intensifying trend of habitat loss and destruction that the ocean is currently facing. One of the more effective land-based solutions being used to counteract deforestation is based on replanting trees. This restoration process recovers lost habitats and their associated biodiversity, and increases the absorption of greenhouse gases. The equivalent of terrestrial forests in the ocean are kelp forests. Kelp is the general name given to a group of brown algae species, some of which can grow to more than 60m tall. Kelp forests are found along 25% of the world's coastlines, generally in cold and nutrient rich water, in temperate and polar regions. These marine forests play a critical role in balancing the health of the ocean and the planet. They provide food and shelter for many marine species, create complex habitats, and are considered hotspots of biodiversity. According to some studies, kelp and other types of marine vegetation absorb up to 20 times more carbon dioxide per acre than terrestrial forests. But they also reduce the ocean's acidity, counteracting the worrying trend of acidification that is affecting species, habitats, and ecosystems. In short, these forests are an important weapon in the battle against climate change.

Despite this, the degradation and loss of these submerged forests is happening at an alarming rate. It is estimated that half of the world's kelp forests have been in decline in coastal areas for 50 years. Pollution, overexploitation, coastal development, marine heatwaves, and ocean warming are some of the factors causing the degradation. To counteract the loss of terrestrial forests, several reforestation initiatives have emerged worldwide, some of them having produced promising results. The



| PREVIOUS: João proudly looking at one of his 'babies'.

| RIGHT: During a dive, the team finds sori, the reproductive structure, on a kelp blade.



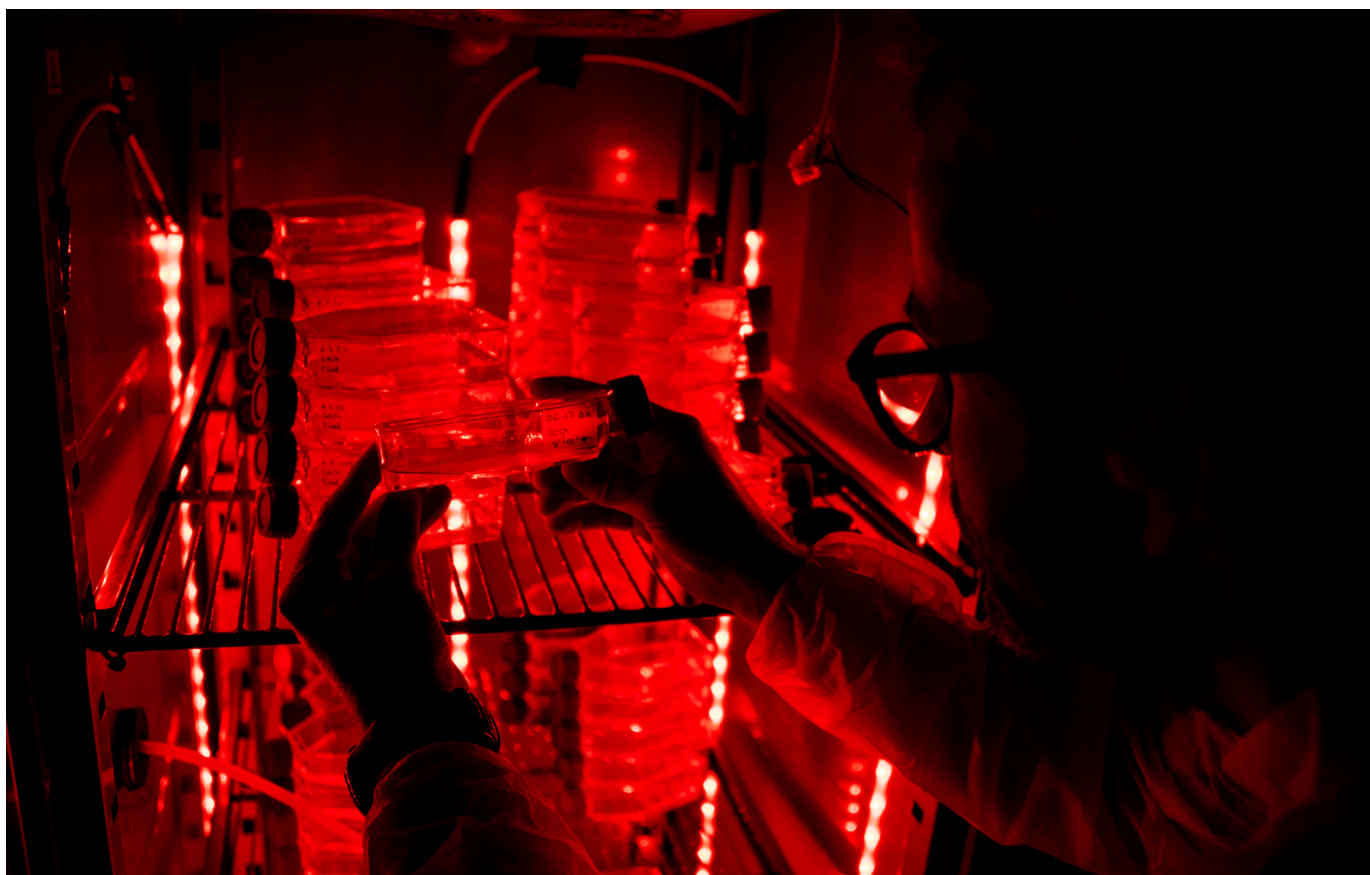
*“Half of the world’s coastal
kelp forests have been
in decline for the last
fifty years.”*

An underwater photograph showing a vibrant coral reef in the foreground, with various shades of red, orange, and brown. A large, flat, brownish-green kelp frond is attached to a grey rock on the right side. The background is a deep blue ocean with some blurred coral and kelp. A thin red vertical line is visible near the top center of the image.

*“Kelp and other types of
marine vegetation absorb
up to 20 times more carbon
dioxide per acre than
terrestrial forests.”*

Kelp recruits settling in the ocean.





| TOP: Maintenance of the kelp spores.
| BOTTOM: A researcher sprays kelp spores over the gravel.

question then arises: can we reforest underwater habitats too? The difficulties inherent to working underwater, the costs involved, and the complexity of the species' biology make ocean replanting significantly more challenging than the equivalent process on land. Considering these challenges, any prospective replanting process needs to be scalable, easy to deploy, and relatively low-cost. This 'accessibility' of deployment is ultimately what will enable meaningful restoration, and even the creation of new forests in locations with favourable conditions.

Of the many global initiatives working to overcome these challenges, the 'Green Gravel' technique being developed by Portugal-based Seaforester is particularly interesting. Developed by scientists in Norway and Australia, the Green Gravel methodology is simple: kelp spores are attached to small stones in a laboratory, where they germinate under controlled conditions. After that, the stones are dropped into the sea and, if the conditions are favourable, the small kelp plant that has attached itself to the stone will grow and further attach itself to the substrate, potentially contributing to a healthier kelp forest – or giving rise to a new kelp forest entirely.

Seaforester is part of the Green Gravel Action Group, a network of research centres working on the development of this special methodology. In the long-term, they think the process could play an important role in global kelp forest restoration given the limited barriers for people and organisations wanting to contribute to this mission. Thomas Wernberg, one of Seaforester's founders, a professor at the University of Western Australia and Researcher at the Institute of Marine Research in Norway, describes 'Green Gravel' as "a technique that should be adaptable for use with a variety of kelp species and deployable by community groups, institutions and conservation organisations alike".

In Portugal, Seaforester uses golden kelp, a species found in the North-East Atlantic between the United Kingdom and Morocco, to test the Green Gravel methodology. "We are testing the Green Gravel technique against the oceanographic and environmental conditions prevalent on the Portuguese coast," explains Franco, the researcher and development coordinator of Seaforester's reforestation actions, and a researcher at MARE IPLLeiria, a research group based in Peniche, in the west of Portugal. Franco has been working in this area for over a decade, and was involved in the first successful trial of marine reforestation using stones in Peniche. With regards to the current project, he further explains: "The work being developed aims to evaluate the performance and limitations inherent to this technique and to find solutions that allow us to optimise its efficiency".

A fundamental component of the process takes place in CETEMARES, the headquarters of MARE IPLLeiria. The dim ambient light of the laboratory allocated to the reforestation project is contrasted by intense LED lights that illuminate the trays arranged on several shelves that cover the walls. Each of the trays contains numerous small stones submerged in water, some of them bearing

small brown filamentous projections. "These are kelp recruits raised in our nursery system," says Sánchez, nursery assistant at Seaforester and also a researcher at MARE IPLLeiria. Sánchez spends much of his day in this lab. "This is the most important part of the whole process, the kelp culture," he explains. He then shows the details behind the nursery area: the water circulation system, the kelp culture's different maturation stages, the rigorous water quality monitoring, and the importance of keeping the lab temperature stable. But, as in any cultivation process, it all starts with seeds. These are collected underwater, in a golden kelp forest discovered by the team a few years earlier, off the Peniche peninsula. Here, the researchers regularly go on dives to extract sorus tissue in the kelp blades - cells that generate and contain the kelp spores. Once the 'seeds' are collected, spore release must be induced. For this, the kelp pieces are subjected to stress in the laboratory. "We temporarily expose the blades containing the spores to a process of dehydration, low temperature and darkness," explains Franco. "After 24 hours, we put them back in the water and the spores are released." Seawater and essential nutrients are added to the solution that now contains millions of spores. It gets divided into small containers and is stored in an infrared light chamber that is kept at 14 to 15 degrees Celsius. Here, the spores will remain stable and remain viable for weeks or even months.

After that, the cultivation stage begins. "To start a new culture, we dilute the spores in water from the system and spray that solution onto the stones," explains Catarina Abrantes, MARE IPLLeiria research intern. Once the seeds have been sown, the waiting begins. "The first shoots usually appear after three weeks," says Franco. "And once they reach a size of between three to eight centimetres, it's time to release them into the ocean."

After trialling various locations with favourable conditions around Peniche, the team has seen some promising results. "We monitor these sites regularly in order to assess the algae attachment rate to the seabed and their growth rate," Franco says. "The results make us feel optimistic. We've been testing the cultivation with different types of substrates, such as variations of stones, biodegradable fibres and different densities of spores to find the best possible solution for this species in this region." One of the great advantages of this process is that the transfer process from the lab to the natural environment doesn't require a specialised team. And herein lies an interesting opportunity. "We've done deployments with fishers' associations, surfers, government entities and schools which were memorable experiences. This also gives us an opportunity to explain the importance of kelp forests and the threats they face today. The feedback has been fantastic as people feel part of the solution," says Franco.

As each stone falls from palm to seafloor, it carries with it not only kelp, but also the spirit of innovation, academic endeavour, and citizen science.

New growth, fresh hope. ●

The ocean activist

WHAT IF?
WE NEED NEW STORIES OF HOPE AND
INSPIRATION TO LIGHT THE WAY.



What if we walked tidelines free of the kaleidoscope of multi-coloured plastic pollution? What if we saw the return of whales up and down our coasts? What if we saw fish populations rebound in size and scale? What if we could jump into a crystal-clear river and be carried seaward into a pristine estuary? What if waves peeled onto beaches free of sewage pollution? What if local fishers saw the return of abundance? What if properly protected Marine Protected Areas became the engines and generators of life across the global ocean? What if seabirds flocked in cliffside colonies nationwide? What if our seas were free from industrial factory fishing vessels? What if the only energy source we extracted from the sea was the infinite and abundant wind blowing across the seascape? What if we saw the end of Big Oil?

We must imagine and create the future we want to see for our ocean. All our actions will depend on a hopeful vision of the future. Our future seas will depend on visionary and hopeful ideas. Everything humankind has ever done started in the mind. An idea to be brought to life. We need to believe in what we can achieve. We need to develop radical hope for our ocean. **Think big. Deliver even bigger.** We must respond to the accelerating climate and biodiversity crisis with big ideas, new stories, new

visions, infectious hope, collective inspiration, and a blueprint for a future that people want to live in. A future we can all get excited about again. Protecting and restoring our ocean will be central to this. Blue hope will carry us all to a better future.

But we're not there yet. Whilst the world talks up the 'sustainable blue economy', it risks losing the only economy we all depend on. The economy of nature. The economy of a wild ocean. Left alone to do its thing. Given the space to thrive. Biodiversity loss is happening at an alarming rate, and a staggering number of species are at risk of extinction. According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), around 1 million animal and plant species are threatened with extinction, many within decades, primarily due to our activities. This is the toll of the current economic model and approach we have.

We need to be bold, progressive, radical, and rapid. We don't have time to waste. We need to create the future we want to see. A future where we live in harmony with nature. A future where we live within our limits. A future where less is more. This will take some radical shift in mindsets. We particularly need to give hope back to younger generations.

It is crucial to take urgent action to protect biodiversity and preserve the natural world for future



“Our world is changing, and we need to focus on inspiring people of what it can become rather than entering a doom spiral of news and dismay.”

A cliffside colony of seabirds.
Photograph by Juan Cuetos, OCEANA.

generations. This includes the need for Herculean efforts to reduce greenhouse gas emissions, protect and restore habitats, eliminate the industrial pillaging of wildlife and natural resources, and raise public awareness and support about the importance of biodiversity restoration. And, if we look around, there are many examples of where we have achieved huge results in the face of seeming doom, from the near extinction of whales to the global pandemic. Times when we have united people around an idea and action. We can do the same for our seas and the environment.

The International Whaling Commission (IWC) implemented the moratorium on commercial whaling in 1986, and even though some countries continued to engage in whaling under objection or with special permits, the success has been clear. Before the moratorium, an average of 38,000 whales were killed annually. Since the moratorium, this number has dropped to fewer than 2,000 per year. The number of countries engaged in commercial whaling has also decreased, from over 20 countries in the 1950s to just three countries in recent years - Japan, Norway, and Iceland.

We must create a similar story and vision for fish. The ecological recovery of our seas will depend on addressing overfishing. The fishing industry has been

About Hugo

Hugo Tagholm has previously led the ocean campaigning charity Surfers Against Sewage and is the executive director and vice president of Oceana in the UK. He was recognised as Environmentalist of the Year 2021 by the Save the Waves coalition and is a regular media commentator on environmental issues.

exploiting the ocean for far too long, resulting in the depletion of fish stocks and the disruption of marine ecosystems. It's time for a new story. It is time for governments to implement more sustainable fishing practices and protect marine biodiversity. This can be achieved through the establishment of Marine Protected Areas, the adoption of more selective fishing methods, and the strict enforcement of fishing quotas and restrictions.

And of course, it will also depend on addressing the climate crisis. The accelerating impact of climate change on the ocean cannot be ignored. Rising temperatures and ocean acidification are devastating marine ecosystems, including the bleaching of coral reefs and the disruption of food chains. We need to take colossal action to reduce our greenhouse gas emissions and limit global warming - through the rapid adoption of renewable energy sources, the promotion of energy efficiency, and the reduction of our carbon footprint.

Whilst the scale of the task ahead is daunting, our society can rise to the challenge. We saw this through the pandemic, where rapid change across our global communities practically happened overnight. This was seemingly in some ways a dress rehearsal of what is to come. Rather than a gradual shift, I believe we will see some dramatic and sudden changes to how we live. But positive ones. Governments will be forced to mobilise funds, collaborate, and innovate in record time as new shocks come. Our world is changing, and we need to focus on inspiring people of what it can become rather than entering a doom spiral of news and dismay.

We still have so much to protect and restore.

Rather than Gross Domestic Product and endless financial growth, we should be thinking Great Dreams Produced and endless natural growth. As I write this, NGOs, businesses, and civil society are congregating in Westminster for a huge rally - 'The Big One' - to demand faster action to tackle the ecological crisis. This tide is rising and will be impossible for governments to ignore.

We all need an inspiring and hopeful new story of what our beautiful ocean planet will look like in 100 years. **HT**





| TAGGING A SMALLEYE: *a world-first*

Not much is known about smalleye stingrays. They are rare, elusive, and likely to be endangered. Off Mozambique, Marine Megafauna Foundation founder Andrea Marshall recently tagged the world's largest ocean stingray for the first time ever. Will tagging help protect the species?

Words by Andrea Marshall

Photographs by Andrea Marshall and Janneman Conradie



“With massive stingers the size of a human forearm and the tail musculature needed to deploy it mid-water into anything that presents a threat, these rays can certainly defend themselves.”

“As a bare minimum you are going to need an armoured breast plate to protect you,” one of my research associates said. I mulled the statement over for a minute. Perhaps, I thought. I was incredibly nervous about what we were proposing. The idea of tagging the world’s largest marine stingray, free-swimming in the wild, was intimidating to say the least. With massive stingers the size of a human forearm and the tail musculature needed to deploy it mid-water into anything that presents a threat, these rays can certainly defend themselves. As no one had ever tried to tag this species before, it was unclear how they would react.

I am a shark and ray expert. I have been researching different species in the field for more than 20 years. Along the way I have personally tagged more than 100 individual sharks and rays and I feel extremely comfortable doing so. I also have been working with this specific species of ray in the wild for years in Mozambique and have always found them to be docile, slow moving and relatively unperturbed of our presence.

Known commonly as the small-eye stingray, these rays can reach up to ten feet in length and have extremely small eyes relative to their body size. They give the impression they can’t see very well - we often see them bumping into soft coral sea whips or sponges as they track around the inshore reefs to visit cleaning stations. In fact, when another species accidentally bumps into them, it seems to elicit a disproportionately strong response, almost as if they had not seen the animal at all. These observations were worrying as I was unsure how these specific rays might respond to me prodding them with my tagging pole. Different species of sharks and rays have wildly different responses to tagging. Whale sharks barely react. However, given the fact that they have the thickest skin of any animal, they simply may not feel it. Giant oceanic manta rays, on the other hand, know I have done something to them, but they often act like they are not bothered by it. An animal that feels like tagging is a threat to them might react by trying to defend itself. In the case of the small-eye stingray, this kind of reaction could result in them deploying their stinger.

The development of sophisticated animal-borne tags has been a gamechanger for marine researchers, particularly those of us needing to track rare, elusive or highly mobile species. We have learned so much about manta rays, whale sharks and marine predators like bull sharks by tagging them. Tagging a small-eye might be our best and only opportunity to learn more about one of the world’s rarest and most elusive species of rays - a species that has never been studied before, and is likely to be endangered. Given all that, the potential reward outweighed the potential risk.

We only discovered we had small-eye stingrays in Africa in 2008. Dr Simon Pierce, the other co-founder of the Marine Megafauna Foundation (MMF), and I had been

regularly encountering a huge species of stingray that we were unfamiliar with on our deep reefs in southern Mozambique. After some sleuthing we determined it was an extremely rare species, occasionally seen in fisheries on the other side of the Indian Ocean. It was not known from Africa, and it turned out to be a whopping 5,000km range extension from the Maldives, the furthest west they had previously been seen in the Indian Ocean. We continued to encounter them regularly and it did not take us long to realise that we were sitting on the largest identified population in the world, and the only known location where they could be studied reliably.

Fast forward a decade and we were now faced with the daunting challenge of tagging some representative individuals in an attempt to learn more about their movement patterns, habitat preferences and daily habits. Even with the highest rates of encounters in the world, our researchers were not seeing them very often and interactions were limited to inshore cleaning stations. If we wanted to know more about this intriguing animal, tagging them with satellite and acoustic tags was the only way to find out more.

I had some theories. Seeing them only on deeper reefs led me to believe they might be a deep-water species, one that would only come up to shallower waters periodically for a clean. We also believed them to be pelagic or at least semi-pelagic, meaning that they may, like manta rays, be in constant motion - never resting on the sea floor like a typical stingray. We believed this because we had never come across one stationary on the seabed. Plus, their body shape is designed for swimming, with elongated wing-like pectoral fins that enable them to swim more efficiently than their more rounded counterparts. If they were highly mobile like mantas, they might travel far distances as well - another possible explanation for why we were not encountering them regularly on our reefs.

Then there were the impossibly tiny eyes. There had to be an explanation for those. Sharks and rays, or at least those that live in the shallows, typically rely heavily on vision and generally have good eyesight. This ray was different. Did it live in a deep-water environment where vision was not needed? Had its other senses heightened, making sight less important? What on earth could be the explanation for miniature eyes on such an enormous body and was the development of their super-sized stinger related? Poor vision resulting in the need for an over-the-top defensive system?

My preferred tagging tool is a Hawaiian sling, a simple pole with elastic on one end that, when pulled, launches the pole at speed toward its target with enough force to place a small anchor under the skin of the target animal. The tags themselves sit outside the animal and eventually come off. Some tags are programmed to release after a set amount of time, others simply work their way out of the animal over time like a splinter.



*“Double tagging
is the holy grail
for researchers as
each tag provides
different types of
information.”*



| TOP: Dr Andrea Marshall and her equipment.
| BOTTOM: A small-eye stingray.

Different types of tags provide researchers with different types of information. Acoustic tags work in conjunction with 'listening' receivers affixed to the seabed. They provide highly accurate information about how animals are using specific areas or habitats. The animal must be in close range to the receivers to log its presence at a site. It helps us to understand how often they visit these specific areas of interest, how long they spend once there and ultimately how important these environments are to them. Satellite tags are helpful in other ways. They collect data independently as the animal moves along, recording things like water temperature, depth, and the animal's physical location as it travels through time and space. The location data are often not precise, as GPS does not work underwater, but generally you still get a good idea of what the individual animal has been up to for up to a year.

As novel and exciting as this research seemingly was, it took us a long time to get support for the project and the necessary funding. Then, even after everything was secured and the necessary planning had taken place, I still had to find some individuals to tag. This turned out to be a lot harder than we had anticipated. While we encounter smallmouth stingrays here in Mozambique more than anywhere else in the world, we do not see them regularly. The first day I went out prepared to tag a smallmouth I was incredibly nervous. If I only had an indication of how the ray was going to react. Then it dawned on me - as a tester, I could try to genetically sample one first and see what happened. We use the same pole for this, just with a different modified tip which extracts tissue rather than placing a tag. I could sample the animal from the underside as it was swimming, well away from where it could deploy its stinger, and I could see how it reacted. After a few weeks I found one, tried it and was pleasantly surprised to see that while the ray did have a small reaction, it swam away from me without any retaliation.

It was a long time before I saw my next smallmouth. I waited almost six months before the first opportunity to deploy a tag presented itself. Then it came. I saw the familiar shape approaching me from across the reef. I knew instantly what it was. It was a mature male but not a particularly large individual, maybe with a 2-metre disc width. I needed to ditch the extraneous gear I was carrying - three tagging poles, my large underwater camera housing, and some tools to clean one of my listening stations. The smallmouth had finished cleaning and was now swimming across the reef to make its exit into the blue. There was no time to safely stow the rest of my gear, so I transferred it all to one hand and swam towards the ray. I knew I would get one shot before it disappeared into the depths. It was now or never.

Trying to maintain as much distance as I could from the tail, I stretched my arm out as far as I could. I used my camera and the other poles to block my torso as much as I could, on the off chance the ray would react defensively.

I cocked the spear and let go. The tag went in perfectly. Even better, the ray barely reacted. I was stunned. I stared dumbfounded as it slowly circled back around. Perhaps with its miniature eyes it wanted to look at what I was or figure out what I had done. I paused, watching it for a moment. Then I had an idea.

I had another tag with me - an acoustic tag. I had brought it along on the off chance I had an opportunity to tag a manta. Could I place a second tag on the smallmouth? Double tagging is the holy grail for researchers as each tag provides different types of information. Placed together they can help ground truth one another and when data are analysed together, they can provide robust information about the movements and habits of the tagged individual. I switched poles, swam over the top of the smallmouth, and placed the second tag, this time on the opposite side. The tag slid in easily. This time the ray moved off. I suppose he now realised I was up to something. As it started to swim off, I gasped for air. It was only at that moment that I realised that I had been holding my breath for quite some time. There was an extreme high from the adrenaline, an overwhelming sense of relief and, of course, a sense of accomplishment. We had done it.

As the ray swam out over the sand at the edge of the reef he slowed, almost beckoning us to follow. We obliged. The ray continued for a while. His leisurely pace had us huffing and puffing behind him. We were quickly running out of bottom time and air. Then something remarkable happened. He stopped swimming and parked himself on the sand - just like a normal stingray. He proceeded to bury himself, throwing sand over his body creating a large sandstorm in the process. Once settled in, he grew still and lay there. So, there it was, hypothesis #2 - disproved. Smallmouth stingrays are not pelagic like mantas. They do in fact rest and bury themselves.

It is a remarkable privilege to be able to study a species for the first time in the wild. Sometimes, however, I get frustrated with the fact that science is a slow road. Like most, I would prefer the answers 'right now', but I have come to appreciate that it simply does not work that way. After coming down from the initial high of my world-first tagging, I was giddy to find out more. Annoyingly, the satellite tag was programmed to release in only six months' time; the acoustic tag could stay on, providing data, for years. It would take a long time before we had the answers we sought.

We have now placed 11 tags on smallmouth rays. Of those, three individuals were double tagged. For the first time we are gaining insight into the extraordinary lives of these incredibly rare and enigmatic stingrays. Southern Mozambique may hold the largest remaining population of these giant rays in the ocean, and the Inhambane Seascape may be their most critical habitat in the country. Determining how we might best protect this key population is essential. **●**

The *adventurer*

OUT OF SIGHT

Two years ago, I nervously carried my enormous stand-up paddleboard and dry bags down a swan poo covered slipway in the centre of Glasgow towards the River Clyde. To my left was the Tall Ship, a tourist attraction moored on the Clyde's banks, and just further up lay the heart of the city centre. To my right were industrial yards, followed by increasingly green areas on the horizon. I couldn't yet see it, but two days' paddling would take me to the open ocean.

Over ten weeks I paddled day and night to cross to the Isle of Arran, through the stunning azure Argyll Hope Spot, around Scotland's most westerly point, the Ardnamurchan peninsula, up the rugged West coast via Skye, around the brutal Cape Wrath and along the indomitable North coast, weaving through Duncansby Stacks to the Moray Firth, down the East coast, past castles and seabird colonies, to the last harbour in Scotland. These 1200km incorporated every possible weather condition, time of day and snack you could imagine.

Why?

I wanted to show people what's out of sight and out of mind in our seas. Not somewhere exotic, with warm, crystal-clear waters (lest I make life easy for myself!) but right here in the UK, in Scotland's uninviting, peat-coloured, windswept, cold ocean. An ocean which is just as full as life as any tropical reef.

If you're reading this magazine, then you probably know how vitally important our seas are globally. But how we connect to them as individuals plays an important part in how we care for them. So, as I paddled, I met and interviewed individuals and communities along the way to understand how different people connect to the sea. I dived underwater and saw for myself what really is out of sight and out of mind to so many people. I learnt more than I even realised there was to learn about fishing, conservation and playing in Scotland's seas.

My aim has always been to bring this to life for as many people as possible, and so my partner and I set out to make a film series about the journey. The term "epic adventure" is so overused nowadays, but I can't find a better way to describe what unfolded over the two and a half months we were at sea together. Sights I would never have believed to see in Scotland, wildlife I could never have imagined being so close to, and situations I would never have thought I could get out of.

Filming added a new element to what was already a full-on time of planning and paddling and eating enough to keep going day after day. We had to work extremely hard to ensure we captured everything that might be relevant to the series, which was particularly challenging in the face of dangerous waters or wildlife encounters when we only had one shot at getting it right.

It was also challenging to really capture the magnificence of Scotland underwater. I've been fortunate enough to scuba dive in some truly stunning places around the world. But I can honestly say that I was most blown away when I snorkelled on the West coast of Scotland. Perhaps it's because looking out at the brown seaweed floating on the surface, I couldn't have imagined just how special it could be under the surface. But this particular spot was absolutely bursting with life - maerl, brittle stars, fish, algae, anemones... it's impossible to describe the scene. When I first watched the footage back, I was over the moon to think that I could translate some of what is out of sight and out of mind to viewers at home. I had a similar experience snorkelling amongst seagrass, one of the ocean's most important plants, and feeling a desperate desire to bring everyone I possibly could to see it for themselves. Nothing will replace seeing it for yourself, but the footage goes a long way to doing this verdant forest justice.

Our Scotland Ocean Nation series is launching in the UK on STV Player on April 1st, and after more than two years of working on the project, I'm incredibly delighted to be able to share with people back home just what is so wonderful about Scotland's seas, wildlife and people. To share its majesty and its plight, all wrapped up in one "epic adventure". To bring to life places and things that people might not see otherwise. What are Scottish waters really like? How can we protect them? What does an eight-week-old sea eagle chick look like? How would a human react when a 25-foot-long orca swims under her paddleboard? Let's find out together. **CM**

About Cal

Cal is a vet, ocean advocate and world-record stand up paddleboard adventurer who founded the UK charity Seaful to reconnect people to the ocean.

For more information or to get involved visit:
www.seaful.org.uk

*"I can honestly say that I
was most blown away when
I snorkelled on the West
coast of Scotland."*





Small claws

BIG IMPACT

Well into their third decade, The National Lobster Hatchery in Padstow, UK, rears the next generations of Cornish lobsters through their early stages, giving this commercially exploited species a greater chance of survival in the wild.

Words by Lewis Jefferies and Dr Carly Daniels

Photographs by Lewis Jefferies



*Lobster eggs around the
pleopods of a "berried hen".*



- | PREVIOUS: A planktonic juvenile lobster.
- | ABOVE: The European lobster is the UK's most valuable marine species.

Chris Weston holds out a berried lobster hen to show us the eggs around her pleopods, the feathery parts underneath her abdomen. The senior hatchery technician at The National Lobster Hatchery (NLH) in Padstow, Cornwall, UK, reveals that a single female can carry anywhere from 2,000 to 45,000 eggs depending on her size. However, only about one in 20,000 of these is expected to survive when laid in the wild. "When the hen is ready, she will do a headstand to release the eggs. They then naturally float to the surface. In the wild this usually happens at night for safety, so predators can't see the larvae," adds Dr Carly Daniels, head of production, science and development at NLH.

We travelled to Padstow to learn more about a unique approach to the conservation of European lobsters. Their ancestry dates to the Jurassic period when their relatives roamed the planet alongside dinosaurs. Believed to live up to 100 years in the wild, the largest European lobster ever landed weighed a staggering 9.3kg and measured 50 inches in length. European lobsters have an unmistakable appearance - dark blue armour with yellow, white, and red markings, large powerful claws and long, red antennae. Every time they moult - around once a year as adults - they may slightly change colour. The species' mating process is complex; the female must shed her shell before mating. She has a long incubation period lasting for around nine months. The species is one of the UK's most valuable marine species with many coastal

communities relying upon it to make their living. To help support the sustainability of wild European lobster stocks, the NLH opened in 2000 with a simple idea: To rear lobster hatchlings through their smallest stages in a bid to increase their chances of survival in the wild by up to 1,000 times.

With the global human population expected to rise to more than 9 billion in the coming decades, pressure on wild caught fisheries and aquaculture is increasing. Naturally, the demand for lobster has been rising too. These pressures have, according to the hatchery, seen other lobster populations in Scandinavia and the Mediterranean completely collapse. In the UK, the hatchery's work plays a vital role in making sure that UK stocks don't follow the same path. Currently, lobsters in the UK are classified as common, but are vulnerable to local overexploitation, according to the The Wildlife Trusts. Stock enhancement initiatives like the one from the NLH complement fisheries management measures to help conserve and sustain exploited commercial species such as the European lobster. With added pressures created by climate change, such as warmer seas, this is an important initiative - a study conducted in the Gulf of Maine found that lobsters had considerably lower survival rates when reared in waters 3 degrees Celsius warmer than normal.

Led by researchers and scientists, the NLH closely works with fishermen, local restaurants, and the





**“LOBSTERS HAD
CONSIDERABLY LOWER
SURVIVAL RATES WHEN
REARED IN WATERS
3 DEGREES CELSIUS
WARMER THAN NORMAL.”**

community to help maintain a sustainable fishery. When an egg-bearing female is landed, the responsible fisherman will phone the hatchery who will then send a technician out to collect the female lobster. “We usually take them into the hatchery at a later stage in the incubation, when they are ready to hatch their babies,” explains Dr Daniels, who has worked at the NLH since 2004. A female lobster carries her eggs for about nine months during which she constantly fans water over them to maintain oxygen supply and keep water quality stable. Due to the sheer number of eggs one female can carry, the NLH team seeks to extend the natural hatching season of the lobsters to ensure that the breeding tanks aren’t overcrowded. “In the brood system where we keep all our hens, we’ve got two cold water pools that are set to lower temperatures than the other tanks. This allows us to extend the natural hatching season and bring the eggs on when we are ready,” adds Dr Daniels. In the wild, the natural hatching season would normally fall between March and October. Cooling the females slows the development of the eggs and as the eggs are incubated for longer, it gives the hatchery a larger capacity and ability to hold hens at different stages of incubation.

Once the hatchlings emerge, which nearly always happens at night, hatchery staff collect the minuscule lobsters, classed as planktonic in the first two to four weeks of their life, and put them into a larval cone. It swirls them around in the water to imitate the surface of the sea where they are found as larvae. After three days of eating as much as they can, it’s time for their first moulting (they will burst out of their exoskeletons several times in the first few weeks of their lives to grow) and in only three weeks, they will look like perfect miniature lobsters with claws. The hatchery rears juveniles through their first four stages. They are kept in recirculating aquaculture systems which mimic conditions in the wild by keeping them floating. Once they reach their last larval stage, they are then transferred to the Aquahive® systems to separate individuals and prevent cannibalism. “Each Aquahive® can carry around 4,000 animals, and we have a capacity of over 24,000 in total,” says Dr Daniels. “At this stage, they become truly benthic. This means living in close relationship with the substrate bottom, so instead of floating around in the plankton the young lobsters would swim to the seabed and burrow into the sand or gravel where they would stay for two years,” explains Dr Daniels.

The hatchery-reared lobsters will continue to grow in the hatchery until they are released back into the wild. “The bigger they get, the better chance they have of survival in the wild,” says Dr Daniels. The hatchery process helps lobsters through the most vulnerable stages in their life. At roughly three months old, when they are destined for release, they remain relatively small but

A honeycomb container from the Aquahive® systems. They separate animals at later larval stages to prevent cannibalism.

“REARING LOBSTER
HATCHLINGS THROUGH
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SURVIVAL IN THE WILD
BY UP TO 1,000 TIMES.”



| *TOP: A lobster fishing boat moored at Padstow Harbour next to the hatchery.*
 | *BOTTOM: A wild adult lobster hides under a reef overhang off the south coast of Cornwall.*

possess the natural instincts they need to burrow and shelter amongst the seabed. Currently, the lobsters are released in Cornwall and the Isles of Scilly using three methods: dive release, where volunteer divers will take a small number and release them on a suitable reef during a dive; offshore, where fishermen can release larger numbers from their boats using a specialist lobster floom; and by shore release, where lobsters are released on spring low tides onto a shoreline with suitable cover.

Despite their natural instincts at this age, due to their size they may still be susceptible to predation. This led the NLH to trial a new technique in the wild: the Lobster Grower 2 project (LG2), which ran for three years concluding in 2019. The innovative project saw around 45,000 juvenile lobsters deployed in sea-based containers to determine whether survival rates were higher when they were reared, for longer, in this way, while also assessing the culture site's environmental impact. The project reared lobsters to larger sizes in containerised systems out at sea where they could feed on natural food sources during their development so that there would be no feed costs. The containers also became home for many other marine species benefiting the surrounding environment. For example, the NLH partnered with a local mussel company - Westcountry Mussels of Fowey (WCMOF) - who helped to install and maintain the containers out at sea, next to their mussel lines in St Austell Bay. This ensured the carbon footprint of the project was minimal and it had very little impact on the environment. In preliminary trials prior to Lobster Grower, the NLH found that lobsters in containers in more estuarine areas with higher silt levels didn't do as well as lobsters in containers situated in near-shore sites such as St Austell Bay. "The hope of rearing lobsters in protected environments out at sea is that this will act as a transition step between the hatchery and release into the wild, providing them with ecological conditioning that will improve their chance of survival post release," says Dr Daniels. If implemented on a permanent, long-term basis, this could ultimately provide better results for the fishing sector and could also benefit the marine environment in the process.

The trial has proven the potential in sustainably farming lobsters alongside other species. "This is perhaps one of the project's parts that excites me the most - it helps to reduce the costs of establishing a lobster-growing operation and shows the possibility of integrating the culture of numerous species," explains Dr Daniels. "The

farm could act like an artificial reef, supporting a diverse community - from sedentary species such as scallops to motile species of fish and crabs." Data will determine whether a new sustainable aquaculture industry could be developed in the UK.

European lobsters are a high value species of which approximately 3,000 tonnes are captured annually in the wild in the UK and Ireland. This prospective new industry could therefore have ecological benefits, help the conservation of wild lobsters, and prove valuable for producers and investors. Following the project's conclusion, the NLH continued to rear the lobsters for a further year out at sea before they were either released or transferred to the NLH to help with a study on ageing lobsters, conducted with the University of East Anglia. It is difficult for the hatchery to monitor success rates as it is nearly impossible to track one of the lobsters once released - at only an inch in length, physical tagging is not an option. "We have a lot of anecdotal evidence from fishermen in areas where they have done releases with the NLH. The fishermen have since reported many more lobsters of the size you would expect given the length of time they have had to grow post release, and they are not seeing such an increase in numbers in other areas," explains Dr Daniels. Although this observation is a good indicator of the NLH's success, along with extensive evidence for the success of stock enhancement across multiple species, it is hoped that growing lobsters for longer will also allow for physical tagging before release.

The ability to find and possibly track individuals post release would provide valuable scientific evidence of the NLH stock enhancement success and allow for quantification of success, which would in turn inform release practices. Another method of identifying lobsters post release is through their DNA. The NLH have been working with the University of Exeter to help develop a method that would allow this. Two DNA samples from each egg-bearing female over the last decade, have been taken to gather DNA from the mother, father and larvae. The DNA identification technique has now been developed and the NLH are currently looking for funding to help analyse their samples against wild lobsters to identify hatchery-reared animals about five to seven years after release. "We have been taking samples for around ten years now so we have an amazing resource of samples," says Dr Daniels. "Once we are in a position to analyse these, it may give us vital insight into the effectiveness of our work." 



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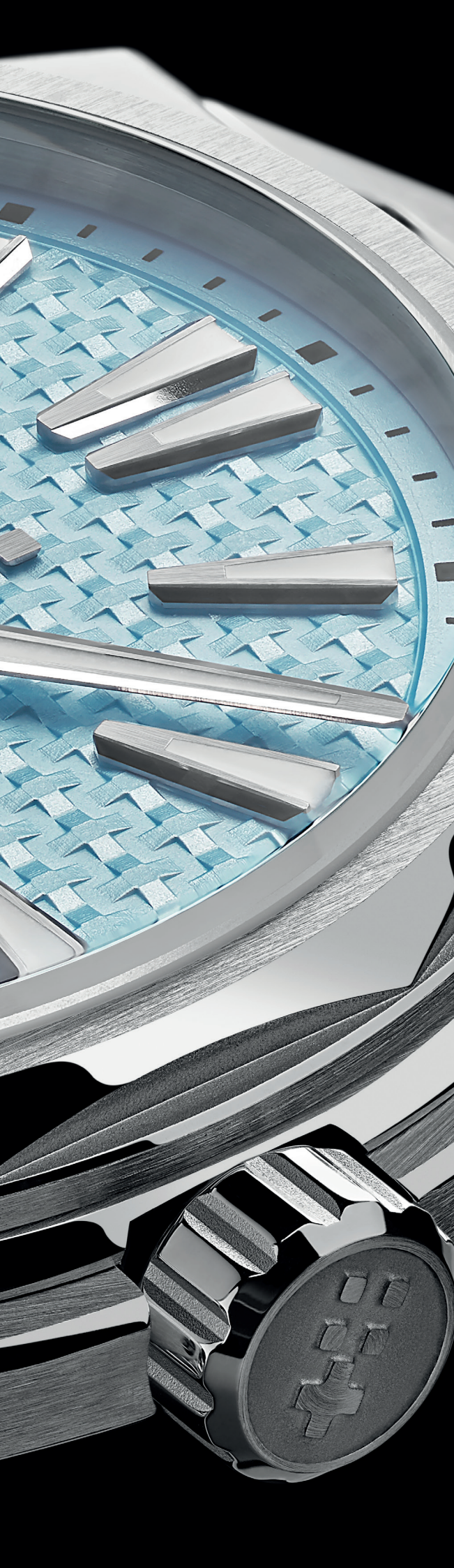
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