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THE EVERYTHING OCEAN
DIGITAL MAGAZINE

FEATURE

SAMUDRA - AI Global Ocean Emulator for Climate

INSIGHT

Evolution of the Hammer





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Editor's Letter

Dear readers,

September has been a pivotal month for our world's oceans. The High Seas treaty, a crucial agreement between the nations of the world has finally crossed the finish line. The High seas Treaty is a landmark international treaty to conserve and sustainably use marine biodiversity in international waters. It has taken 20 years to cross the line, and the number of people and organizations that have worked tirelessly to make this happen are beyond count. With Morocco's ratification of the treaty in the end of September, the 60 country threshold has been passed, and will come into legal effect from the 1st of January 2026. While this is a historic step towards meeting the 30x30 goal, the challenges we face going further cannot be underestimated. We are at a tipping point, with marine heatwaves becoming more frequent and more intense, while studies suggesting that warm water coral reefs may have already passed critical thresholds. Australia's great barrier reef has once again witnessed a widespread bleaching event. Super trawlers in the Atlantic fish for krill - the lifeline of our seas next to ocean giants.

Efforts to protect 30% of oceans by 2030 (the "30x30" target) continue to be emphasized in policies and campaigns, but what happens in reality will be the key differentiator. New governance strategies, new supporting frameworks, and new technologies lead from the front on the fight to safeguard our planet everyday, but this is just one of the thousand battles that need to be fought in an ever-changing, ever growing world and the needs of humans.



In our feature article in this edition of 70%, we bring to focus one of the recent advances in the use of AI driven technology for studying ocean parameters and to support climate scale simulations and testing.

As creators and ocean film makers, we appreciate films that weave story telling and critical topics into an enjoyable watch. Discover our list of some of the top ocean films every scuba diver must watch.

We will conclude with the third part of our Insight article on the extraordinary Hammerhead shark and its evolutionary brilliance.

And not to forget, we love underwater photography, and we reproduce a selection of shots from our contributors and in house photographers. If you want to submit, just send us a DM with the #myoceanphoto and we will feature it on the next edition of 70%.

That's it for now, and I hope you enjoy the magazine!

On behalf of the 70% editorial team,
Suhas





Cover photo:
Reef art

@oceanbluecollective



The moment when wildlife allows you to observe and appreciate from close quarters. [@oceanblueimaging](#)

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FEATURE

***SAMUDRA* - An AI Global Ocean
Emulator for Climate**

70%

The ocean is Earth's largest, least understood frontier—covering over 70% of our planet yet remaining largely unexplored due to the various challenges of time, scale, and depth. As we enter the phase of an ever warming world, science is on the forefront of understanding and preparing for the challenges that will be faced by people and planet.

With an increased frequency and intensity of climate change driven events, the use of data and technologies is becoming a vital ally to navigate through the challenges - foreseen and unexpected.

Today, artificial intelligence (AI) is transforming how we observe, understand, and protect this vast blue world. From deep-learning models that forecast ocean currents in real time to neural networks that decode decades of climate data, AI is giving scientists a clearer, faster, and more connected view of the sea than ever before.

Using machine learning, satellite imagery, and autonomous sensors, AI can detect marine heatwaves, track coral bleaching, map the seafloor, and even predict ecosystem shifts with remarkable accuracy. New AI powered models are revolutionizing climate and ocean forecasting—reducing simulation times from weeks to hours while maintaining physical realism.

While using AI brings with it its own set of challenges and concerns, there is no doubt that AI enabled technologies are leading from the front, and will continue to do so for the foreseeable future.



Artificial intelligence — humanity's most powerful creation yet — is diving into the unknown. From satellites orbiting high above the Earth to autonomous robots gliding through the abyss, AI is listening to the pulse of the planet from the billions of terabytes of data that are gleaned every single day. It reads patterns in waves and winds, maps invisible currents, and reveals how heat, carbon, and life move through the deep. Today's technologies no longer just model the ocean, or read historical data for context, but they understand it, learning from the billions of data points to predict the future of our blue planet; Storms, tides, coral reefs, and climate — all seen through a new digital lens.

In this merging of code and current, scientists are building the clearest vision yet of the ocean's story — a story of motion, memory, and survival. One such technology is SAMUDRA, a machine learning emulator that is trained to reproduce several key ocean state variables over the full ocean depth. While previous models could only look at the surface data, Samudra has been adapted to handle multi-depth levels - up to 6000m - providing a much closer, and accurate look at the state of the ocean.



Named after the Sanskrit term for “ocean”, Samudra is an AI / machine-learning (ML) system built to emulate the ocean component of a state-of-the-art climate model (OM4). Samudra can replicate key ocean model outputs (sea surface height, currents, temperature, salinity) throughout depth, but much faster and at lower computational cost than standard methods. The idea is not to replace full physics models but to accelerate simulations / projections, reduce computational expense, and allow long-term runs or larger ensembles.



It predicts key oceanic variables globally (i.e. across all ocean basins), through the full depth (from surface down to ~6000 m) rather than only near surface. The variables include:

Temperature (potential temperature)

- Salinity
- Sea Surface Height (SSH)
- Horizontal velocities (zonal, meridional)

Trained on historical data over a 65 year period (1958-2022) from the OM4 model, Samudra can simulate the key ocean state variables mentioned above through the full depth of the ocean.

What is OM4?

OM4 stands for Ocean Model version 4, and it's basically a giant computer simulation of the ocean. Scientists use it to understand how the ocean moves, how it stores heat, and how it interacts with Earth's climate.

To understand how it works, let's imagine cutting the ocean into millions of tiny 3D boxes - each one holding real data about Temperature, salinity, currents, and sea level height. Then, powerful supercomputers use physics equations to calculate how water flows between those boxes — every few minutes, for hundreds of years of simulated time. Check out the next page for a visual representation of OM4.

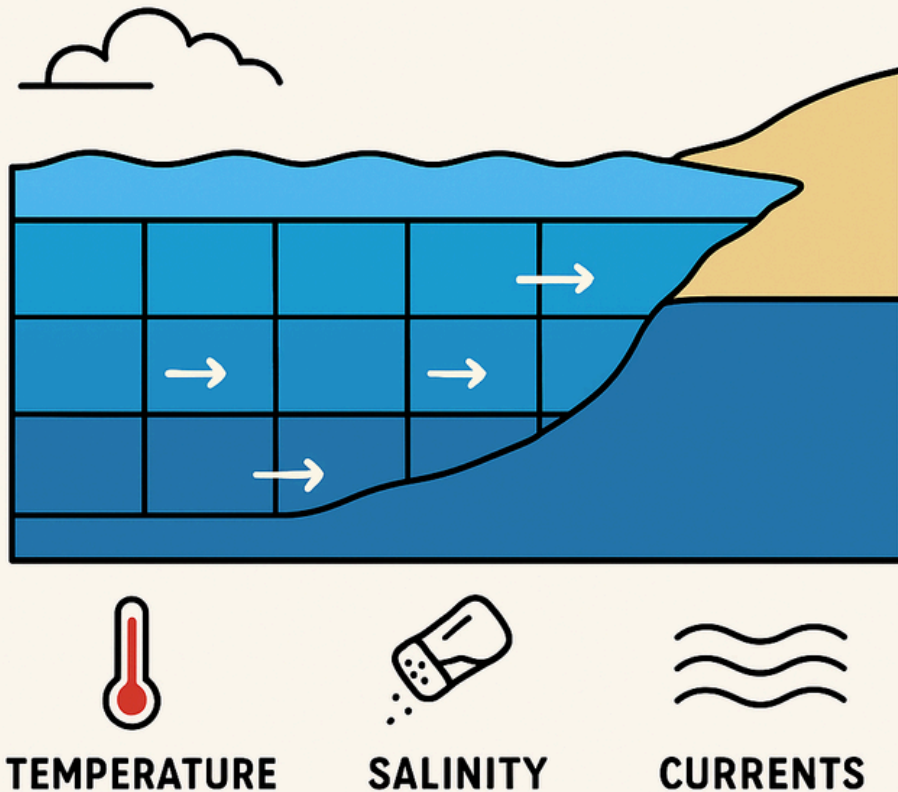
In a nutshell, OM4 is the ocean's twin in digital format. A *digital twin*. OM4 is part of a bigger climate model called GFDL CM4 (from NOAA's Geophysical Fluid Dynamics Lab).

Scientists use it to:

- Predict climate change and sea level rise
- Study heat and carbon storage in the ocean
- Understand events like El Niño or melting polar ice



OM4: OCEAN MODEL



Visual representation of how a OM4 model interprets data.

OM4 is super accurate, but also super slow — it needs huge computing power and time. That's why newer AI models like Samudra are trained to emulate OM4, running the same ocean simulations hundreds of times faster.

While OM4 takes many CPU-cores and days to simulate long runs, Samudra can do a 100-year control run in ~1.3 hours on a single A100 GPU, offering roughly a 150× speed-up in simulated years per day, with high accuracy. This is a massive benefit to running calculations with billions of data points. However, this is not without its own challenges and limitations.

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Samudra tends to under-represent the magnitude of climate change trends (e.g. warming) while keeping stability, and performs less well in forced scenarios where trends are large.

While there are challenges and limitations to Samudra, there are also many benefits to be gained which will further accelerate our understanding of the ocean and its behavior due to external influences. Some of the key benefits are outlined below:

- **Massive speedups in simulation time**

Samudra can run centuries-long simulations much more quickly than conventional ocean models. For example, what takes many CPU cores and days in OM4 can be done with Samudra in ~1.3 hours on a single high-end GPU. This allows more experiments, larger ensembles, sensitivity tests, scenario explorations etc.

- **Full depth, global ocean emulation**

Unlike many models/emulators that focus on surface variables, Samudra emulates temperature, salinity, sea surface height, and horizontal velocities through the full ocean depth. This gives more complete understanding of subsurface structures, deep ocean heat content, thermocline behaviour etc.

- **Long-term stability**

The emulator remains stable for very long integrations (century to multi-century control simulations) without drifting away, under repeating or realistic forcing. That makes it suitable for climate-scale experiments.

- **Reproduction of climatology & variability**

Samudra captures key large-scale features: the mean depth profiles of temperature & salinity, interannual variability (e.g. ENSO phases) with correct timing/structure. It reproduces the “shape” of many phenomena quite well.



- **Enabling more ensemble & scenario experiments**

Since running Samudra is cheaper/faster, climate researchers can run many more scenario variations, perturbed parameter studies, coupled forcing experiments, etc. This improves understanding of uncertainty in projections.

- **Lowering computational resource barrier**

Because high-fidelity ocean models are expensive in compute & infrastructure, Samudra helps reduce the barrier: institutions with less computing power (GPUs rather than large CPU clusters) can do meaningful ocean emulation work.

SAMUDRA in the real world

1. Climate Projection Acceleration

Samudra can emulate long-term ocean behavior at a fraction of the computational cost of full numerical models like OM4.

- Enables rapid testing of climate scenarios (e.g., future warming under different greenhouse gas trajectories).
- Supports ensembles of hundreds or thousands of simulations to explore uncertainty in ocean responses.
- Useful for Intergovernmental Panel on Climate Change (IPCC)-style studies where ensemble averaging is critical.

2. Coupling with Earth System Models (ESMs)

Because Samudra runs fast and stably over centuries, it can replace or augment the ocean component of ESMs.

- Allows hybrid AI-physics models that retain physical realism but save massive computation time.
- Facilitates real-time coupled experiments (e.g., atmosphere-ocean feedbacks, El Niño prediction).



3. Study of Ocean Heat and Carbon Uptake

By simulating temperature and salinity through the full ocean depth, Samudra can model heat transport, deep ocean warming, and carbon sequestration processes.

- Useful for estimating how much heat and CO₂ the ocean absorbs under different climate scenarios.
- Helps assess long-term energy imbalance and climate stabilization pathways.

4. Training Data for AI Forecasting Models

Samudra's fast emulations can produce massive synthetic datasets of ocean states, useful for training higher-resolution models like FuXi-Ocean or regional downscalers.

- Provides a physically consistent “foundation” for AI ocean twins or digital Earth projects.

5. Policy and Climate Risk Applications

Because it can be run many times with different forcing scenarios, Samudra enables probabilistic ocean risk analysis—for example, assessing regional sea-level changes, ocean circulation slowdown (AMOC), or deoxygenation impacts.

- Supports national climate services, blue economy planning, and long-term adaptation policies.

6. Educational and Research Accessibility

Samudra lowers the entry barrier for universities and research labs lacking supercomputing clusters.

- Students and early-career researchers can experiment with ocean-climate dynamics using only GPU resources.

In conclusion, AI-driven technology is transforming ocean science—turning data into discovery, speeding up forecasts, and revealing the ocean's hidden patterns. As machines learn the language of the sea, humanity gains the understanding to protect, predict, and better understand our blue planet.





Coral reefs are the lifeline of our world's oceans. With changing weather patterns, warming oceans, and acidification, coral reefs are facing a crisis of existence.

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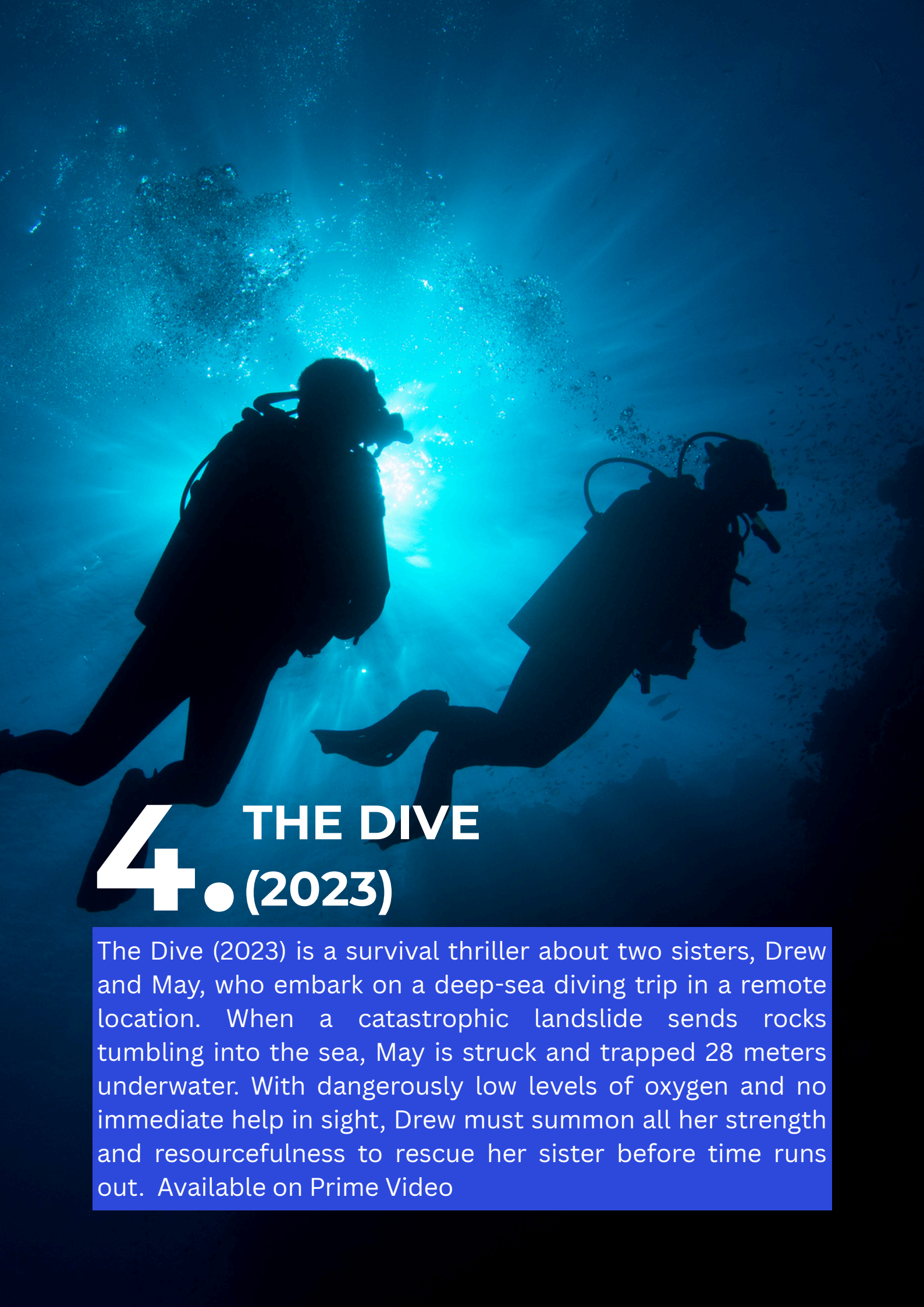
5 FILMS EVERY SCUBA DIVER MUST WATCH

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An underwater scene featuring a diver in the upper center, surrounded by bubbles. Below the diver is a large, rusted, and partially submerged metal structure, possibly a shipwreck or a large container. The water is dark blue, and the lighting is dim, creating a somber and mysterious atmosphere.

5. **THE LAST BREATH** **(2025)**

The Last Breath is a gripping film following deep-sea diver Chris Lemons, trapped 100 meters underwater after a malfunction, showcasing human resilience, survival, and the relentless, unforgiving power of the ocean. The 2025 film also has a documentary on the same subject that came out in 2019. Available on Prime video.



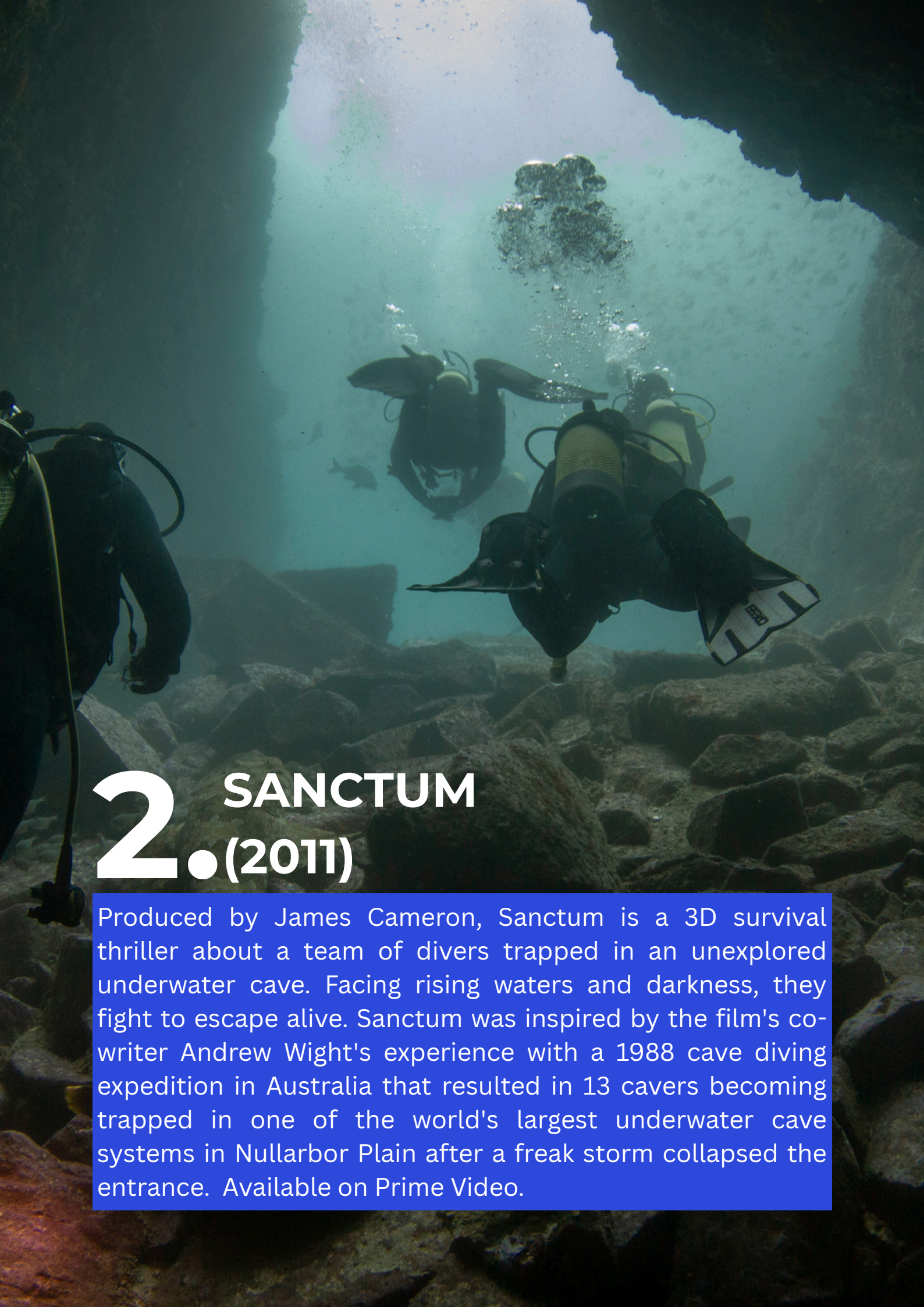
4 THE DIVE ● (2023)

The Dive (2023) is a survival thriller about two sisters, Drew and May, who embark on a deep-sea diving trip in a remote location. When a catastrophic landslide sends rocks tumbling into the sea, May is struck and trapped 28 meters underwater. With dangerously low levels of oxygen and no immediate help in sight, Drew must summon all her strength and resourcefulness to rescue her sister before time runs out. Available on Prime Video

A photograph of a beach scene. In the foreground, a diving mask with a blue frame and clear lenses is attached to a blue snorkel. The mask is resting on a silver metal post. Below the mask, a pair of yellow and grey diving fins are also resting on the same post. The background shows a clear blue sky, a turquoise ocean, and a sandy beach.

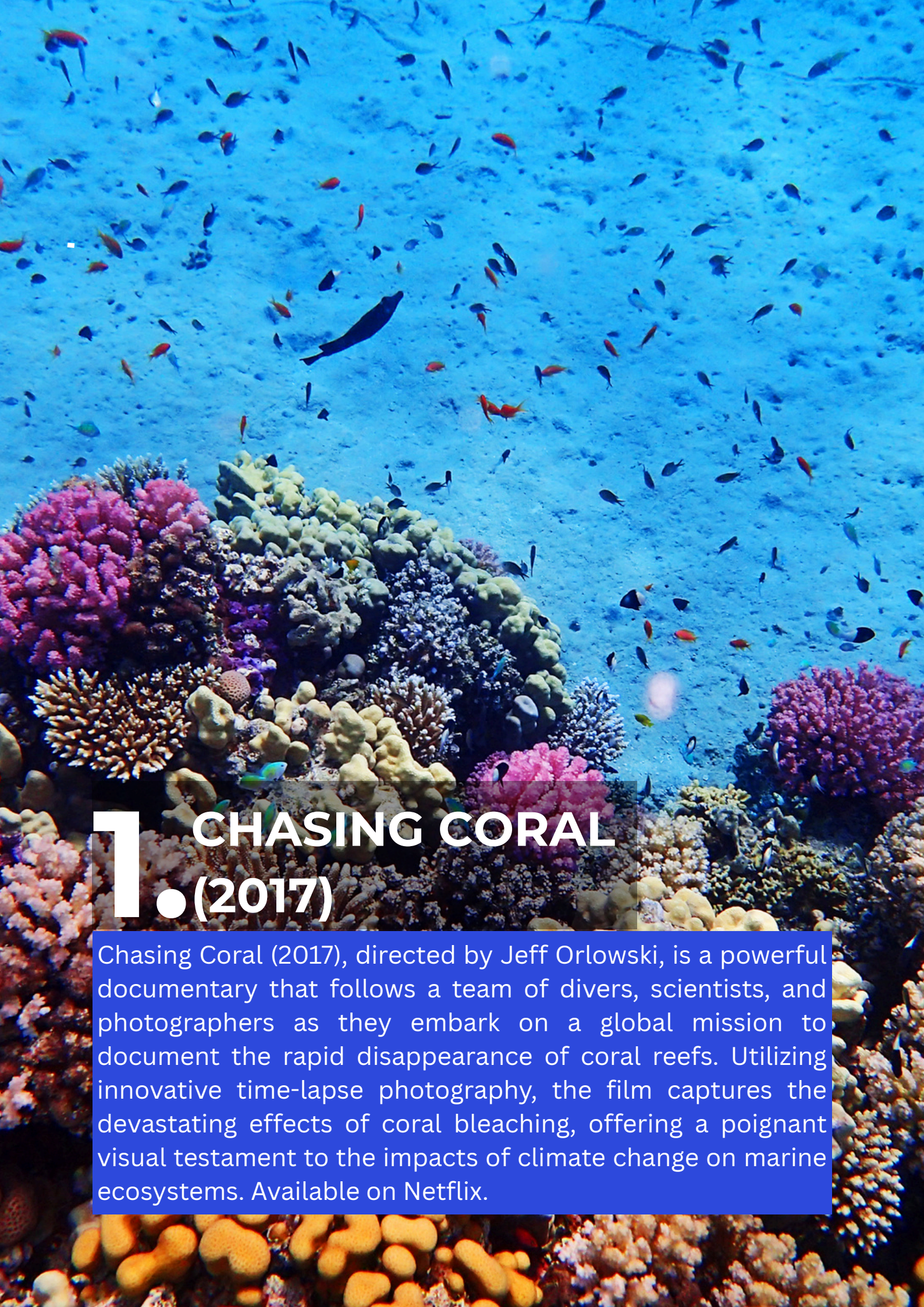
3. L'ODYSSÉE (2016)

L'Odyssée (2016), is a French language film directed by Jérôme Salle, is a biographical drama that chronicles the life of French explorer Jacques-Yves Cousteau. It delves into Cousteau's pioneering underwater explorations aboard the Calypso, his innovations in marine conservation, and the personal dynamics within his family. The narrative highlights both his professional achievements and the complexities of his personal life. Available on Prime Video.

An underwater scene inside a cave. Three divers are visible. One diver is in the foreground on the left, partially cut off. Two other divers are further back, swimming towards a bright opening at the top of the cave. The water is dark and murky, with bubbles rising from the divers. The cave floor is covered in large, dark rocks.

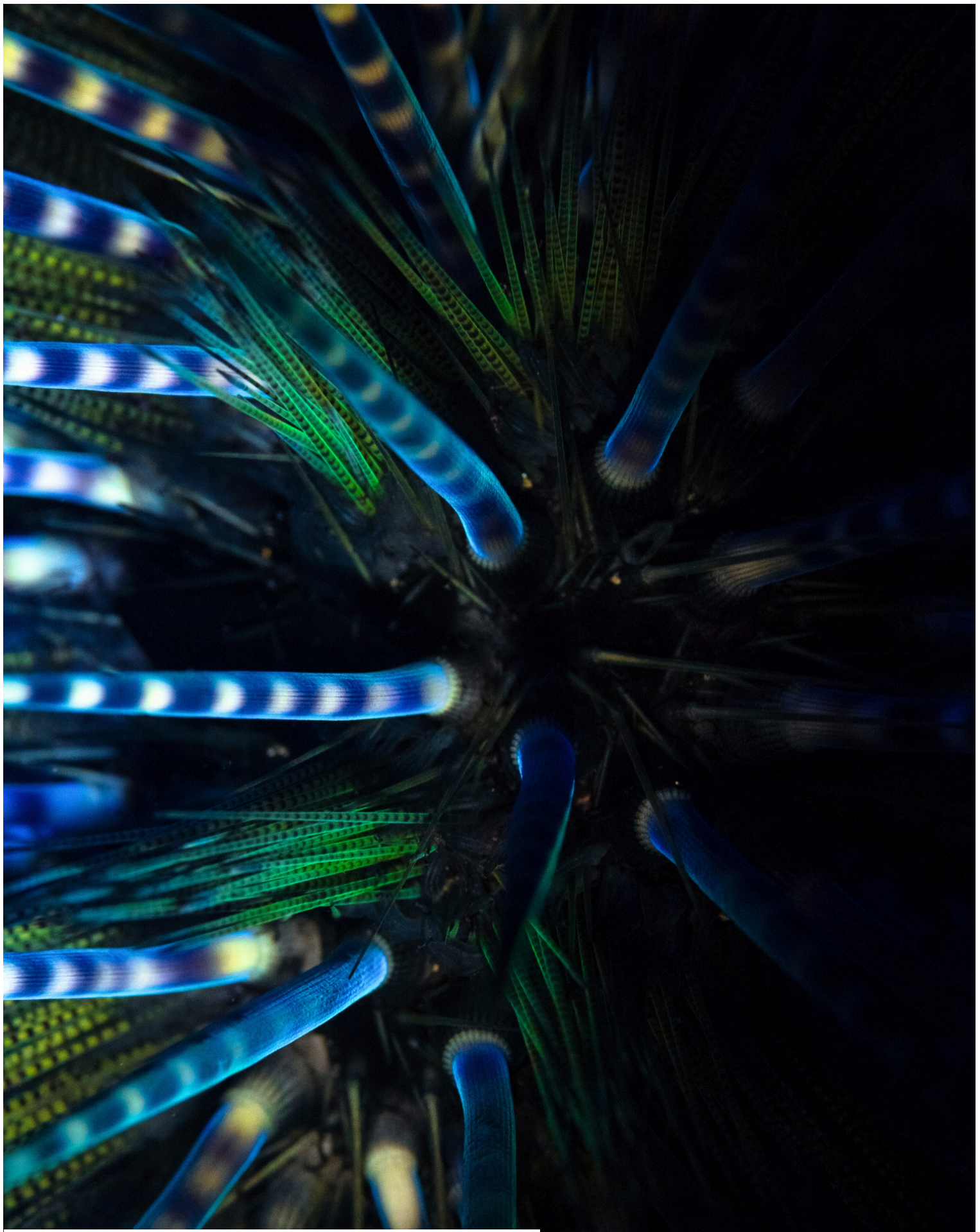
2. SANCTUM (2011)

Produced by James Cameron, Sanctum is a 3D survival thriller about a team of divers trapped in an unexplored underwater cave. Facing rising waters and darkness, they fight to escape alive. Sanctum was inspired by the film's co-writer Andrew Wight's experience with a 1988 cave diving expedition in Australia that resulted in 13 divers becoming trapped in one of the world's largest underwater cave systems in Nullarbor Plain after a freak storm collapsed the entrance. Available on Prime Video.



1 CHASING CORAL (2017)

Chasing Coral (2017), directed by Jeff Orlowski, is a powerful documentary that follows a team of divers, scientists, and photographers as they embark on a global mission to document the rapid disappearance of coral reefs. Utilizing innovative time-lapse photography, the film captures the devastating effects of coral bleaching, offering a poignant visual testament to the impacts of climate change on marine ecosystems. Available on Netflix.



A Sea Urchin shot under UV lights.
Fluorescence is a phenomenon that can be
observed in many marine creatures and
coral. [@oceanblueimaging](#)

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INSIGHT

Evolution of the Hammer - Part Three

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The cephalofoil, or the 'hammer' of the Hammerhead shark gives its many advantages over other sharks. - Their vision is unique and gives them extraordinary depth perception. The hammer also gives the shark unmatched agility while hunting.

But there is a third and final advantage that evolution has granted the hammerhead shark - the ability to detect electrical signals in the water - A 6th sense that is un-paralleled compared to other sharks.



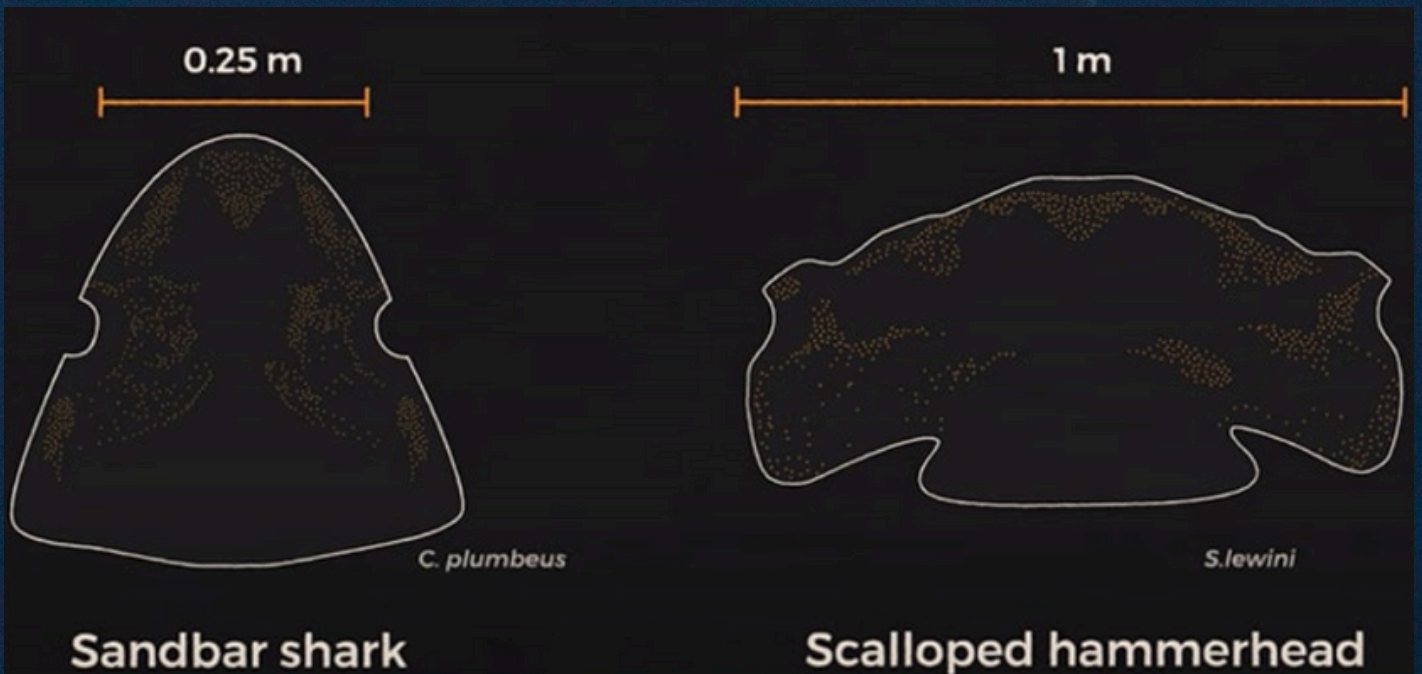
Electroreception is the ability to detect the electrical fields that permeate the water, giving navigational cues and information about the location of prey.



Electroreception is observed almost exclusively in aquatic animals since water is a much better conductor of electricity than air. But it is the sharks that have evolved this ability the most.

Sharks receive tiny electrical signals from their environment via a series of pores peppered over their heads. These pores are distributed in discrete patterns and are filled with an electrically conductive jelly within tiny bulbous cells called “Ampullae of Lorenzini”.





With a wider head, hammerheads have a greater number of electrosensory pores. The pores are also located over a broader area, which increases the surface area that the head can sample.

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All animals generate electricity around them as their muscles contract in movement and their heartbeats, and this current radiates away from them in the water. When these electrical currents travel towards the shark, they stimulate the sensing cells and trigger neurotransmitters in the sharks' brains, which tells them they are close to something alive. It works in all conditions - turbulent water, darkness, or even when the prey is hidden beneath the sand.



The ability of electroreception works even when the conditions underwater render the five other common senses - sight, smell, taste, touch, hearing - useless.

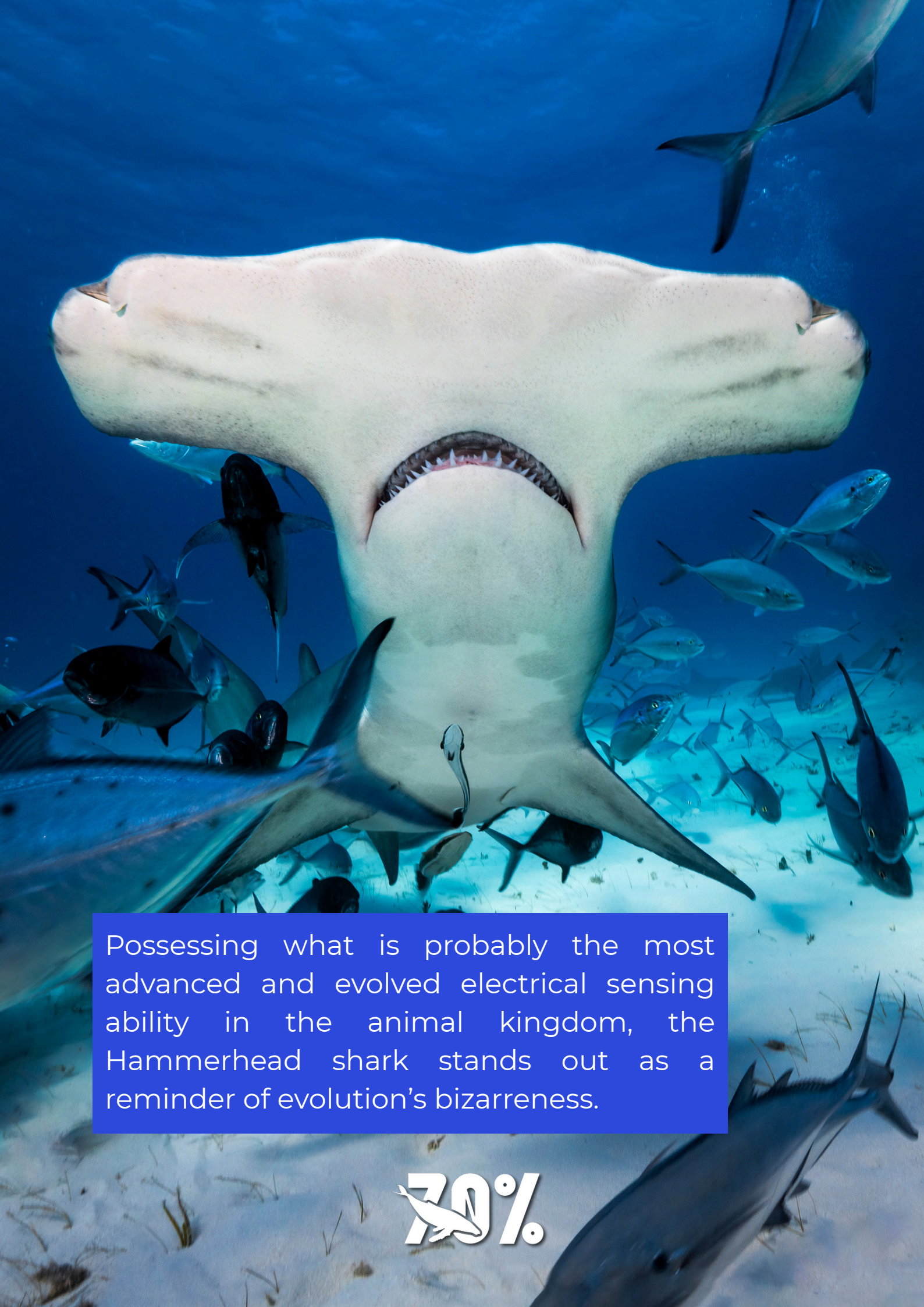


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The ability of hammerhead sharks to detect electric fields is profound. It has been found that newborn Bonnet head sharks can detect electric fields less than 1nanovolt/sq cm - the equivalent of an electric field intensity generated by connecting a 1.5v battery across a 1500km distance. This level of sensitivity is over 5 million times greater than anything we can ever feel.

And out best equipment is no match for the sensing capability of the hammerhead shark.





Possessing what is probably the most advanced and evolved electrical sensing ability in the animal kingdom, the Hammerhead shark stands out as a reminder of evolution's bizarreness.

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And with that, we conclude our insight series on the evolution of the hammerhead shark. To get the full insight into the unique evolutionary advantages of the hammerhead shark, check out the previous editions of the 70% magazine.

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A colorful Box Fish. The yellow body and black dots make it a very recognizable fish. [@oceanblueimaging](#)

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Sunlight reflects of the shallow sea bed in the Maldives. I always love these patterns due to the interaction of light and the waves. [@oceanblueimaging](#)

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