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LabLinks

ISSUE 5 - Marine Sciences and The Deep Blue

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THIS MONTHS TOPIC (A BREIF OVERVIEW)

Delving into marine sciences reveals a realm of precipitous change and revolutionary advancements, offering a multifaceted perspective on an environment we know less about than outer space. From the intricacies of coral reefs to the fascinating procsses underlying bioluminescence, and the urgency of ocean conservation, this field blends cutting-edge technology with sustainability. It inspires a deeper understanding of Earth's final frontier— to protect and illuminate the depths of our blue planet.

A MESSAGE FROM THE FOUNDERS

Welcome to the sixth edition of LabLinks – The Newsletter! We cover the world of marine sciences, exploring the uncharted waters of our planet. From conservation efforts to technological innovations beneath the waves, this edition highlights how science and sustainability intersect to protect our oceans and inspire change.
Have questions or feedback? Drop us a line at lablinksofficial@gmail.com — we'd love to hear from you!

Regards, Nitya Kashyap, Tara Pratapa

OUR PODCAST

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HOW IS TECHNOLOGY TRANSFORMING MARINE SCIENCE?

BY SAANVI PARIGE

To put it literally, the ocean is a continuous body of saltwater. Mysterious and largely unexplored, the ocean holds secrets that can change our entire understanding of life here on Earth. But for centuries, studying these ecosystems has been an uphill battle—one that we haven't been able to tackle. So how do we track deep-sea creatures? How are we able to monitor marine biodiversity changing at a rapid pace? The answer? Digital technology — an advent that has ushered in a new era of discovery in marine science, offering state-of-the-art insights into underwater realms.

One of the most groundbreaking applications of this shift into digital technology lies in Autonomous Underwater Vehicles (AUVs) — unmanned, untethered robots that explore and collect data in real time without constant inputs from a human operator. Equipped with advanced sensors and imaging systems, AUVs collect high-resolution data on marine ecosystems, thereby enabling scientists to analyze initially inaccessible terrains and gain an enhanced understanding of deep-sea biodiversity.

Next in this digital revolution are refinements in Artificial Intelligence (AI). AI algorithms are now able to process vast datasets through satellite imagery, sensory networks, and underwater recordings to identify anomalies or new patterns. This has become crucial for monitoring marine biodiversity, managing sustainable fisheries, and predicting climate-induced changes. Complementing these AI capabilities, developments in remote sensing technologies have further enhanced our ability to monitor oceans on a global scale. Satellites are now equipped with sophisticated sensors that provide constant data on sea surface temperatures, chlorophyll concentrations, and ocean currents. Information collected by these satellites is vital for understanding algal blooms, predicting weather patterns, and assessing climate change impacts.

These advancements in satellite monitoring have built the foundation for even more comprehensive and dynamic approaches to exploring and understanding oceans. One such innovation is the concept of "Digital Twin Ocean, " which involves creating high-resolution, multi-dimensional virtual representations of the ocean. These models are able to integrate data from various sources, like satellites or AUVs, to simulate oceanic processes in real time. Researchers utilize the digital twins to test scenarios and develop strategies for marine conservation.

Through digital platforms, marine scientists can collaborate from any part of the world. By providing centralised repositories for data, technological innovations, and research findings, these platforms enhance the accessibility of marine science resources. To give an example, the Ocean Science and Technology platform was designed to increase the visibility and accessibility of technological advancements within marine science.

To conclude, the interdisciplinary integration of digital technologies into marine science is slowly transforming our ability to explore, monitor, and protect ocean ecosystems. These advancements not only enhance our scientific understanding but also play an important role in acknowledging environmental challenges and promoting the sustainable use of marine resources.

THE ROLE OF RENEWABLE ENERGY IN OCEAN CONSERVATION: *HOW SUSTAINABLE ENERGY SOURCES IMPACT MARINE ECOSYSTEMS*

BY MAYA YADLAPALLI

Picture colorful coral reefs that were once the heart of the sea, now bleached and empty. The ocean, a vital source of our food, oxygen, medicine, and recreation, is under unprecedented threat. The sinister creep of ocean acidification, slowly dissolving the shells of susceptible organisms and bleaching coral reefs. The ruinous effect of oil spills, suffocating aquatic organisms and contaminating fragile ecosystems. Our dependence on non-renewable energy sources – like coal, oil, and gas – has taken a severe toll on marine ecosystems due to the enormous quantities of carbon dioxide emissions. But amidst these challenges, renewable energy is a solution that has the potential to mitigate this problem.

Renewable energy is a strong counterpart in ocean preservation. Offshore wind turbines, utilizing the unrelenting force of the wind, provide a pollution-free alternative to fossil fuel plants. These massive turbines, when optimally located, occupy minimal land and substantially decrease carbon emissions. Tidal and wave energy, utilizing the ocean currents, generate steady and reliable power without interfering much with the environment. Though generally land-based, solar energy is essential to minimize the overall demand for fossil fuels. Ocean Thermal Energy Conversion (OTEC), though still in development, could harness the ocean temperature gradient to generate energy.

However, the shift to renewables is not free of its costs. The construction and operation of offshore wind farms and other renewable energy systems has the potential to upset marine ecosystems. Planning with the assistance of political support and funding is vital to mitigating the impact. Ensuring wise development, complete with rigorous environmental assessments and consultation with local populations is the highest priority. Instances like the offshore wind farms in Denmark and Scotland's tidal power schemes show the real advantages of renewable energy for ocean protection. Denmark has emerged as the global ideal for green energy, lowering carbon emissions and enhancing marine biodiversity while Scotland is proving the viability of tapping into strong sea currents.

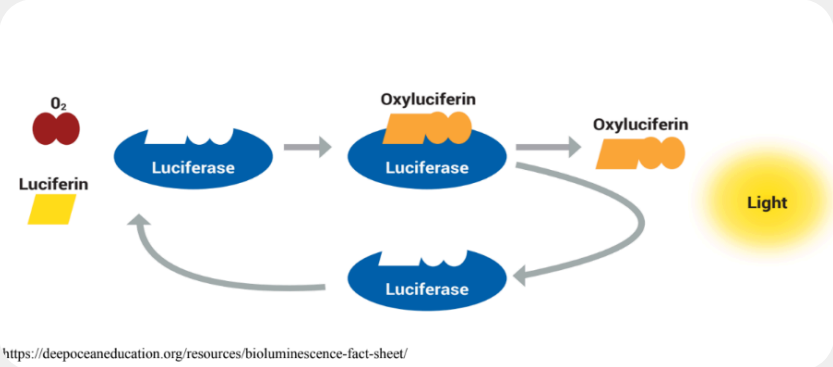
The future of our oceans relies on our capacity to adopt such sustainable energy solutions. Breakthroughs in wave and tidal power, combined with wave-catching offshore wind technology, promise to transform the energy landscape. Governments, industries, and research centers must collaborate to drive the shift towards a clean energy future. The future of our oceans is in our hands. By adopting renewable energy, we can create a better future for marine life and a healthy world for future generations. Let us promote sustainable energy solutions, facilitate responsible development to protect the lifeblood of our world – the ocean.

LIGHT FROM LIFE: BIOLUMINESCENCE

BY AMOGH REDDY BADIKOL

It is ironic that the lightbulb, the universal symbol for a bright idea, isn't actually very bright. In fact, 90% of the energy input is emitted as heat (infrared) while only a small fraction is emitted as light. However, where humanity failed, nature succeeded. Bioluminescence or cold light emits nearly 100% of its energy as light while only a negligible amount is released as heat.

Many organisms use this to their advantage, one such example being fireflies that exhibit yellow flashes of bioluminescence as a method of communication and mating. Apart from this, marineorganisms like the anglerfish, squid and even algae exhibit bioluminescence to deter predators, attract prey and find mates.



[1]https://deepoceaneducation.org/resources/bioluminescence-fact-sheet/

Bioluminescence occurs through an enzyme catalyzed chemical reaction. The enzyme luciferase allows the luciferin to react with oxygen (oxidation) to become an excited state molecule called oxyluciferin. When the oxyluciferin de-excites it emits visible light. **Hence, bioluminescence.**

Notably, marine organisms like algae, squid and the anglerfish use bioluminescence to their advantage to deter predators and attract mates or prey. The best part? It's completely environmentally friendly and biodegradable.

Expanding on this, various companies have already began using this property. An example being the biotechnology company Nyoka Labs, whose aim is to create an eco friendly alternative for the conventional glowstick. Nyoka Labs CEO Paige Whitehead states current glowsticks are made of toxic chemicals that cause cell death. Moreover, the plastics from which these glowsticks are made use the strongest petrochemical-derived plastics that take hundreds of years to degrade. Bioluminescent glowsticks however are made using just luciferase and luciferin, you could even drink the mixture if you wanted to. Moreover, bioluminescent glowsticks are reusable and hence prevent excess wastage of glowsticks. The company also takes pride in selling these glowsticks with sustainable packing, making it fully biodegradable.

Overall, companies all over the world like Glowee and Light Bio are using bioluminescence to create sustainable alternatives to everyday products. As biotechnology improves the cost-effectiveness of these products only gets better. It is without doubt that very soon we will be able to live in a world where light is powered by life.

AI-DRIVEN AQUACULTURE IN NORWAY

BY SANKEETH DARA

Norway is a global leader in aquaculture, leveraging AI and cutting-edge technology to enhance efficiency, sustainability, and the welfare of the ocean. Norwegian fish farms are increasingly integrating artificial intelligence, automation, and machine learning to optimize monitoring, feeding routines, and disease prevention in water bodies — all while minimizing environmental impact.

How has AI transformed Norwegian Aquaculture?

Norwegian Aquaculture is being constantly developed through the implementation and elevated integration of Artificial Intelligence and Large Language Models (LLMs) to monitor the behavioral characteristics of fish in the ocean. This innovation is driven by three core AI applications: AI-powered Monitoring and Smart Feeding Systems, AI-driven Disease Detection and Protection, and the integration of Automated Robotics in Aquaculture operations.

More about AI-powered Monitoring & Smart Feeding Systems.

Monopolistic Norwegian Aquaculture companies such as Cermaq, Grieg Seafood, and SalMar utilize AI-powered cameras and sensors to obtain real-time analytics on fish health and behaviour. Underwater footage and sensor data are then processed through AI algorithms to detect signs of stress, evaluate potential health risks, and monitor growth rates. This information enables Norwegian Aquaculture companies to assess fish needs — such as feeding requirements — and respond promptly, drastically reducing the need for human intervention. Furthermore, the insights from the AI-powered monitoring are directly transferred to smart feeding systems that use AI to determine when fish are full and disperse feed accordingly. This prevents overfeeding and minimizes feed waste, both of which are primary ocean pollutants.

Using AI for Disease Detection and Protection.

Artificial Intelligence also plays a significant role in Norway's Agriculture by detecting early signs of disease in fish. AI models, usually LLMs, are trained to recognize different patterns in fish behavior, movement, and appearance. One such Norwegian startup, "Manolin," incorporates these AI models to analyze historical data and predict potential disease outbreaks, suggesting aquaculture farmers take necessary preventive actions. By integrating AI for disease detection and protection, aquaculture companies rely on antibiotics and explore different methods of improving overall fish health and making aquaculture more sustainable.

Automated Robotics in Aquaculture.

Additionally, Norwegian fish farms deploy underwater drones and robotic cleaners to remove algae, parasites, and unwanted debris that pose a threat to fish health within pens. These underwater drones are equipped with AI-powered systems, including "Fish Facial Technology," which enables the identification and tracking of individual fish. This ensures that only healthy fish are harvested, promoting sustainability and animal welfare.

The Future of Norwegian Aquaculture.

The democratic constitutional monarchy of Norway is actively investing in AI to develop fully automated, low-impact, and high-efficiency fish farms in order to ensure the global sustainability of Aquaculture. However, the future of Norwegian aquaculture is being directed towards more advanced solutions — specifically the ntegration of AI with blockchain for seafood traceability. This will guarantee transparency in sourcing fish ethically. Additionally, ongoing studies are investigating how to further integrate artificial intelligence and exploring how to reduce carbon emissions due to the aquaculture procedures while optimizing energy use.

BOILING WATERS: COUSTEAU AND CONSERVATION

BY SHREYANK ENUGU

Exactly 69 years ago, a man named Jacques Cousteau created a short film called The Silent World. The New York Times said that it “takes the audience beneath the surface of the sea”. The Washington Post said it “is a revelation of nature's secrets”. In reality, Jacque had only one mission. To preserve the beauty of the ocean for generations to come. To advance from the industrial detriment we cause. To lay a foundation for thousands of researchers after him to work upon.

Cousteau was born in Gironde, in 1910 in a small town named after the meander of a river. As a child he swam the rivers and seas that surrounded his town, growing up he joined the French Navy, traveling the seas through his reconnaissance. Then he returned home to the sea. He co–invented the Aqualung, the world's first underwater breathing gear (scuba gear) with Emile Gagnan in 1943. Yet, he was inspired to dive deeper.

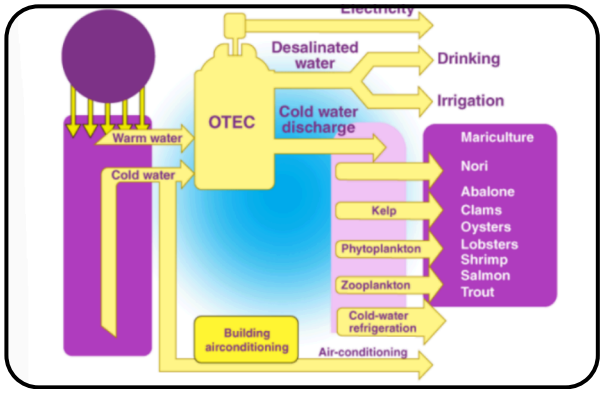
Improving on his aqua-lung designs, pioneers developed the equipment to last far longer underwater - inspiring documentation on his underwater views. He founded the French Oceanographic Campaigns (FOC), and leased a ship called the Calypso to transform it into a mobile laboratory. By this time it was the early 1950’s, but his nine years so far had inspired the world to look at the seas with a different lens. His subsequent films and discoveries in echolocation only proved him as a worthy marine biologist.

However, decades have passed and Cousteau’s name has still not been swept away by the tides; instead it fuels the hearts of present explorators. His advocacy for marine life and valuation lead to the creation of the vita MPAs - Marine Protected Areas. The creation of these areas has allowed for numerous organisms to thrive underwater, away from the toxic, polluted and harmful waters we create. Adding on to this, in 2021 Ascension Island in the atlantic ocean was created, spanning 445,000 square kilometers: making it one of the largest MPAs in the world.

In conclusion, the history that makes up our conservationist past should never cease to inspire us. Today, researchers are working hard to create sustainable solutions to prevent ocean pollution. Jacque Cousteu’s breath still seems to pulsate through the tidal winds, prompting us to see the truth. The truth of how our home waters are Boiling.

OCEAN THERMAL ENERGY CONVERSION - THE FUTURE OF RENEWABLE ENERGY

BY AAGAM JAIN



The oceans account for over seventy percent of our planet. These untapped bodies of water have the capacity to supply renewable energy on a massive scale. The potential of renewable sources that utilize the ocean to provide clean, renewable energy such as offshore wind and wave energy are often overlooked. Another example of such technology is the Ocean Thermal Energy Conversion process (OTEC). A process that is based on the thermal gradient existing in the ocean water, it generates electricity from the temperature difference between the surface and deep waters of the ocean. This is possible as the surface of the ocean is significantly hotter than its depths, by almost more than 20°C (36°F). However, unlike wind and solar energy, OTEC provides consistent solar energy throughout the day and night.

Operational process of the OTEC

With OTEC, systems generally function via a closed cycle using ammonia as a working fluid. This method is preferred due to ammonia's low boiling point. Warm seawater is pulled into a heat exchanger, which then increases the temperature of ammonia, allowing it to evaporate and expand. The resultant vapor rotates a turbine coupled to a generator to produce electricity. Subsequently, cold seawater from deeper layers cools down the vapor, causing it to condense back into liquid form, completing the cycle. While this method requires relatively rare stable ocean temperatures for optimum performance, it not only generates electricity but achieves a multitude of things - cold water and fresh-desalinated water is produced, which can be used to shift air conditioning or aquaculture respectively.

Advantages of OTEC

One of the most powerful advantages presented with OTEC is the consistent power generation. In contrast with solar or wind energy, which is dependent on the weather, OTEC can function for the entire year. The possible energy output with OTEC systems is enormous, it is estimated that it can produce up to 10,000 terawatt-hours annually with no detrimental changes to the ocean's thermal structure.

Development and Challenges

While promising, OTEC is not without its issues, particularly when it comes to commercial viability. The high initial costs, coupled with its complex technology, have made it difficult to adopt on a wider scale. Nevertheless, advances in materials used for heat exchangers and innovation in deep-sea infrastructure is opening the door for large scale OTEC plants.

Future Outlook

With rising global energy consumption and the necessity for a sustainable solution, OTEC stands to be the most viable option for clean energy generation due to its unique approach. Its capacity to constantly generate power while offering additional services like desalination makes it useful for island and coastal communities. We can hope that further investments, OTEC will become one of the driving forces towards a more sustainable world. By harnessing the natural thermal gradients of our oceans, OTEC has the promising potential of boosting worldwide energy security while furthering environmental sustainability endeavours.

STUDENT SPOTLIGHT:

BY ANOUSHKA CHANDRA

SAMANTHA LYNN-MARTINEZ

Samantha Lynn-Martinez, an undergraduate student at the University of Washington, is currently making waves in the field of environmental science with her research in the Aleutian Islands. As a passionate advocate for marine biology, her interest sparked from a young age. Her interests lie in ocean conservation, filmmaking, and outreach to young minds about the issue of marine conservation. Her current work in one of the most critical and remote regions of the world emphasizes the need for ocean conservation and preservation.

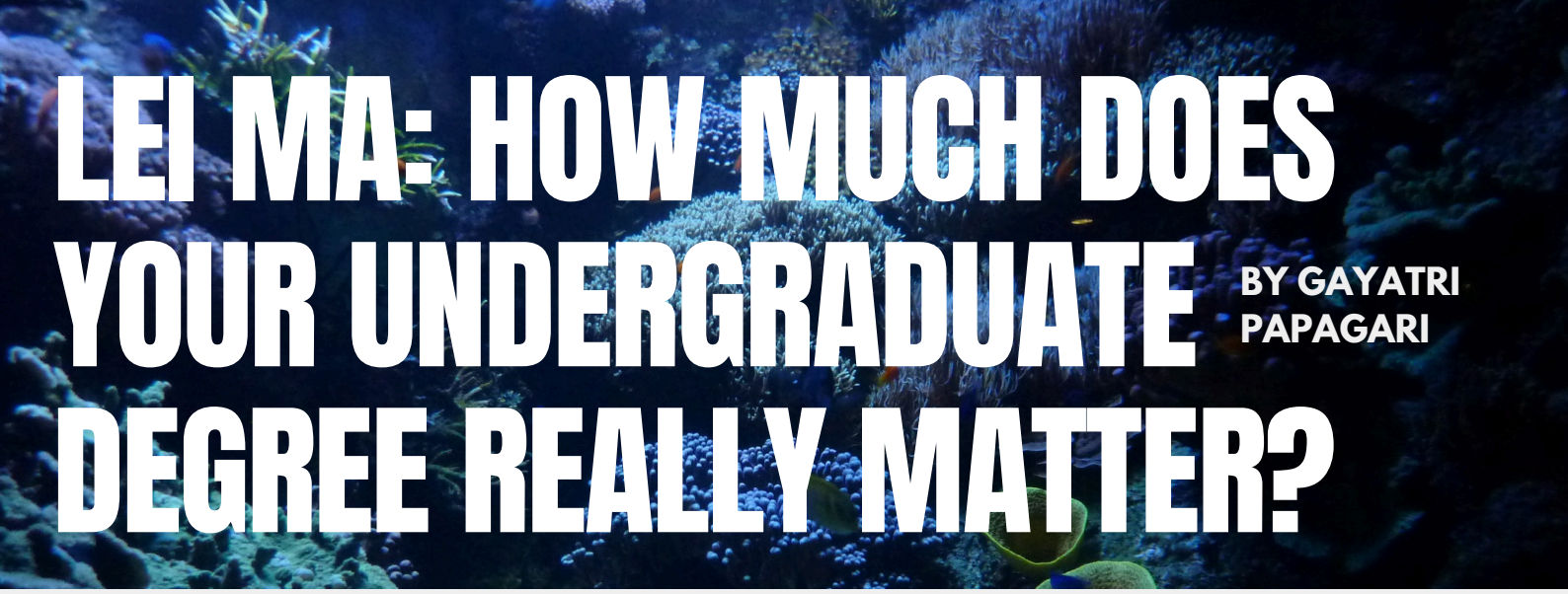
Martinez's interest in biology was influenced by her culture and her home: "I've always had an interest in the marine environment and being born in the Philippines and then moving to Seattle, this affinity for the marine environment was always there for me. Going to beaches, tracing the seafood I ate, stewardship principles – these things are all a big part of my culture."

She spent a lot of time exploring the Pacific Northwest coastline, developing an interest for the delicate marine ecosystems and the ocean's balance. Her first legitimate interaction with the field was when she was a Seattle Aquarium volunteer in high school, where she was able to fully explore and learn. "Getting so much hands-on experience in talking and engaging with marine science, both with experts and the public, was eye-opening."

This, she said, was what inspired her to start her work in outreach in her undergraduate years– teaching young minds about fields she's passionate about, while making it engaging and accessible. She went on to pursue marine biology at the University of Washington, advocating for ocean conservation through filmmaking and research. Throughout her first few years as an undergrad student, she's been able to tackle documentary filmmaking, research projects, and introduce the topic of marine biology to many young minds like she had once been.

Her ongoing research project, based on an expedition to the Aleutian Islands in July 2023, allows her to work closely with the National Oceanic and Atmospheric Administration (NOAA) and monitor the Western Population of the endangered Steller sea lions. Martinez joined the team using multiple Unmanned Aircraft Systems (UAS), combining her love for both photography and marine biology. She also worked with the team to determine the impact of ocean acidification on local species such as kelp, sea otters, and native fish populations. Research such as this provides a critical role in delivering insights about crucial species while also informing and fueling conservation efforts.

In her later years, she intends to pursue something related to science communications–outreach, wildlife camera work, or natural history filmmaking. She hopes to be able to use all of her passions and skills for her career in the future, and educate young minds about the research she plans to do. Through her work, she aims to bridge the gap between marine conservation and public awareness, making marine sciences a well-known, passionate field for everyone.



LEI MA: HOW MUCH DOES YOUR UNDERGRADUATE DEGREE REALLY MATTER?

BY GAYATRI PAPAGARI

On the most basic level, most sciences require similar skills and understanding. Skills from mechanical engineering can be transposed into biomedical engineering, which explores valuable skill sets seen in drug development. Everything is interconnected, and the same is true for marine sciences. In our student spotlight, we will be focusing on Lei Ma, a student at the MIT-WHOI Joint Program for graduates pursuing her doctoral degree in marine science.

The MIT-WHOI Joint Program is a five-year doctoral degree combining MIT, a top research university with WHOI, the top oceanographic research institution. Their students pursue degrees in biological, chemical, physical oceanography, marine geology and geophysics, climate variability and impacts among other interdisciplinary studies. Due to the interdisciplinary nature, students come from a variety of backgrounds from microbiology to physics and mechanical engineering.

Lei got her undergraduate degree in biology at Brown University and trained as a general microbial ecologist. Even though she eventually switched to marine sciences, she learnt invaluable skills in her undergraduate studies, especially lab techniques from sterilization techniques to analysing genetic sequence data. Apart from practical understanding, her undergraduate experience also taught her how to understanding existing literature, essentially learning how to learn.

Using this understanding, Lei studied coral-reef associated seawater microbes at MIT-WHOI. These microbes reside inside corals and brackish-water fish called “killifish.” The main goal of her research is to understand how the microbial community composition affects their environment. For microbes in seawater, she is also investigating if they are unique to that reef/reef system. Her study, in collaboration with other individuals, is now published online. It investigates the seawater microbial communities in the Florida Reef Tract and the US Virgin Islands by collecting seawater samples regularly. The paper finds that there is a difference in community composition of reef seawater microbiomes even a few kilometres apart. Individual reefs within a reef system may also have different regional stressors. Her paper is linked at the bottom of the page.

To conclude, it becomes clear that the field of research is not clear cut in the least. Most times, it is the skills that matter more than the subject content. With access to such a wide range of academic resources, we, as students, can begin building on these skills now. Lei’s story demonstrates that there is no reason to wait until “we know enough” to begin exploring the fields we are interested in. We can simply start.

Link of Lei Ma’s paper: https://par.nsf.gov/servlets/purl/10342920

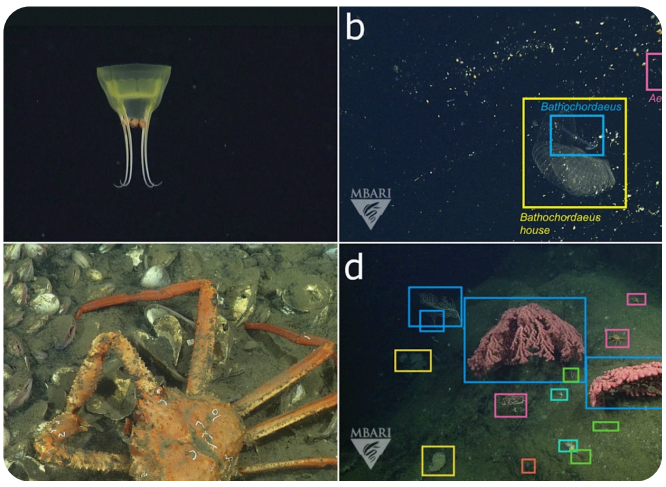
UNVEILING THE MYSTERIES OF THE DEEP THROUGH TECHNOLOGY

By Krishna Sriram

With the goal of going after the phrase, “we know more about space than we know about our oceans,” researchers and marine engineers have advanced in the field of marine sciences by developing new technology for in-depth marine exploration and new sea life discoveries.

Deep sea exploration vehicles, or autonomous underwater vehicles (AUVs), are an example of advancements in technology and engineering, as these new vehicles allow humans to explore hazardous areas autonomously. Humans can control these vehicles remotely, eliminating possible risks researchers would face by being physically present. Additionally, some innovations in technology, pecifically advancements in artificial intelligence, shave influenced researchers to create robots and other autonomous deep-sea vehicles that are controlled by AI. Implementing AI in these vehicles allows for autonomous decision-making when navigating complex underwater terrain, obstacle detection and avoidance, and adaptive route planning to optimize the vehicle’s energy and data collection. This technology has enabled the discovery of new species, such as the dumbo octopus (Grimpoteuthis), found in the Mariana Trench–the deepest oceanic trench on Earth with high-pressure conditions, dangerous for human exploration.

In addition to improving exploration capabilities, AI technologies have also revolutionized the way that researchers identify and classify marine species. Previously, identifying newly discovered species had to rely on optical pattern recognition, which highly limits the clarity of the recently identified species as it requires complex template creation and is a time-consuming and error-prone process. Now, these outdated methods have been replaced by advanced techniques such as image recognition and pattern definition to analyze a newly uncovered species. These innovations allow researchers to analyze and classify marine life more efficiently and connect them biologically with other existing species. Additionally, this method allows researchers to identify these species on the go, during deep sea exploration.



As technology continues to evolve, the mysteries of the deep are slowly being unraveled. With the help of AUVs, AI technologies, and further engineering advancements, future discoveries may bring the secrets of our oceans to light, redefining our understanding of marine life.

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