



Advances in Deep-Sea Technologies and their Impact on Marine Biodiversity

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DESCRIPTION

The deep sea is one of the least explored environments on Earth, has long been shrouded in mystery due to its inaccessibility and the harsh conditions that define it. However, in recent years, advancements in technology have enabled scientists to penetrate the ocean's depths and uncover new species and ecosystems altering our understanding of marine biodiversity. These technological innovations have opened up new avenues of discovery and have provided understandings of the complex, hidden ecosystems that thrive far beneath the ocean's surface. Deep-sea exploration has traditionally been hampered by the extreme conditions of the ocean depths, including high pressure, low temperatures and complete darkness. These conditions require specialized equipment capable of withstanding the deep ocean's rigors. Over the past few decades, a range of technologies has been developed to meet these challenges, greatly expanding our ability to study these remote environments.

Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) have revolutionized deep-sea exploration. These unmanned submersible vehicles are equipped with cameras, sensors and sampling tools that allow them to operate at great depths for extended periods. Unlike manned submersibles, which are limited by human endurance and safety concerns, ROVs and AUVs can dive to depths of several thousand meters and explore areas previously unreachable. Their ability to capture high-resolution images and videos has been essential in documenting the existence of new species and ecosystems. Advances in sonar technology have significantly improved our ability to map the ocean floor. High-resolution multibeam sonar systems allow scientists to create detailed maps of deep-sea environments, revealing features such as underwater mountains, hydrothermal vents and trenches. These technologies have also aided in the discovery of new habitats and the identification of areas with high biodiversity, such as coral reefs and deep-sea vents.

One of the most important tools in marine biology is environmental DNA (eDNA) analysis. This technique involves collecting water samples and analyzing the DNA shed by organisms

into the environment. By using eDNA, scientists can detect the presence of species without the need for physical samples, which is particularly useful in the deep sea where sampling is logistically challenging. eDNA analysis has led to the discovery of new species and provided insights into the distribution of rare organisms. While ROVs and AUVs have become the primary tools for deep-sea exploration, human-occupied deep-sea submersibles, such as Alvin and Deepsea Challenger, have also played an essential role. These vessels have allowed scientists to explore the ocean's depths firsthand, providing invaluable opportunities for real-time observation and sample collection. These missions have contributed to the discovery of unique deep-sea organisms, such as giant tube worms and bioluminescent fish.

The application of these technologies has transformed our understanding of marine biodiversity, particularly in the deep sea, which was once thought to be sparsely populated and devoid of life. However, the discoveries made in recent years have shown that the deep sea is teeming with life, much of it previously unknown. Advancements in technology have led to the identification of hundreds of new species in deep-sea environments. For instance, hydrothermal vents, which were first discovered in the 1970s, have been found to host unique ecosystems that rely on chemosynthesis rather than photosynthesis. These ecosystems are home to a range of species, including giant clams, tube worms and extremophile bacteria, many of which were unknown to science. Additionally, the exploration of deep-sea coral reefs and underwater mountains has revealed an array of species that are highly adapted to the extreme conditions of their environment.

The discovery of new species has also provided insights into the complex connectivity of deep-sea ecosystems. Research has shown that many species in the deep sea play critical roles in nutrient cycling and carbon sequestration, contributing to the overall health of the planet's oceans. For example, deep-sea organisms like sea cucumbers and worms help recycle organic material, while certain microbial communities facilitate the breakdown of methane and other gases.

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