

Tracking Marine Mammals: The Role of Technology in Understanding Ocean Health

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Abstract

Marine mammals are key indicators of ocean health and play vital roles in marine ecosystems. With advances in technology, tracking these species has become increasingly sophisticated, providing valuable insights into their behavior, migration patterns, and the environmental challenges they face. This article explores the various technological tools used for tracking marine mammals, including satellite telemetry, acoustic monitoring, and drone surveillance. It discusses how these technologies contribute to our understanding of ocean health, inform conservation efforts, and enhance management strategies. Furthermore, the implications of this research for marine biodiversity and ecosystem stability are examined. Ultimately, the integration of technology in marine mammal research represents a significant advancement in our ability to monitor and protect ocean environments.

Keywords: Marine mammals; Tracking technology; Ocean health; Conservation; Satellite telemetry; Acoustic monitoring; Drone surveillance

Introduction

Marine mammals, including whales, dolphins, and seals, are integral components of marine ecosystems. They serve as both predators and prey, contributing to the balance of marine food webs. Additionally, marine mammals are sensitive indicators of ocean health, reflecting changes in their environment due to factors such as climate change, pollution, and habitat degradation. Understanding their movements, behaviors, and interactions with their environment is crucial for assessing the health of marine ecosystems.

Recent advancements in technology have revolutionized the way researchers track and study marine mammals. Tools such as satellite telemetry, acoustic monitoring, and drones provide unprecedented opportunities to gather data on these elusive species. This article examines the role of technology in tracking marine mammals, discussing the methodologies employed, the insights gained, and the implications for ocean health and conservation [1].

Methodology

The importance of tracking marine mammals

Indicators of ocean health

Marine mammals are often referred to as “sentinels of the sea” due to their sensitivity to environmental changes. Their health and population dynamics can provide insights into broader ecological issues, such as the impacts of climate change, pollution, and overfishing. For example, changes in the distribution of marine mammal species can indicate shifts in prey availability, which may be a result of changing ocean temperatures or altered food web dynamics [2].

Conservation and management

Tracking marine mammals is essential for effective conservation and management strategies. By understanding their migration patterns, breeding behaviors, and habitat use, researchers can identify critical habitats and seasonal patterns that need protection. This information is vital for developing marine protected areas (MPAs) and mitigating human impacts, such as shipping traffic and fishing activities.

Technological tools for tracking marine mammals

Satellite telemetry

Satellite telemetry is one of the most powerful tools for tracking marine mammals over large distances. By attaching satellite tags to individuals, researchers can monitor their movements in real time. This technology has provided valuable data on migration patterns, foraging behavior, and habitat utilization [3].

Advantages: Satellite telemetry allows for long-term tracking of marine mammals across vast oceanic expanses. Data can be collected remotely, minimizing disturbance to the animals and allowing for continuous monitoring.

Case studies: Studies utilizing satellite telemetry have revealed critical migration routes for species like humpback whales and gray whales. For instance, research on gray whales has shown their migration from feeding grounds in the Arctic to breeding grounds in warm lagoons along the Pacific coast of Mexico, highlighting the need for protection along this migratory path (Mate et al., 2015) [4].

Acoustic monitoring

Acoustic monitoring involves the use of underwater microphones (hydrophones) to detect and record the sounds made by marine mammals. This technology is particularly useful for studying vocal species such as dolphins and whales.

Advantages: Acoustic monitoring enables researchers to gather data on marine mammal presence, behavior, and communication without the need for visual observation. It is particularly valuable in areas where visual surveys are challenging due to depth or weather conditions [5].

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Applications: Acoustic data can be used to assess the impacts of noise pollution from shipping and industrial activities on marine mammals. For example, studies have shown that increased shipping noise can disrupt communication among whale populations, affecting their ability to find mates and locate prey (Holt et al., 2009).

Drone surveillance

Drones are increasingly being used to monitor marine mammals from the air. Equipped with high-resolution cameras, drones can capture images and videos of marine mammals, providing valuable data on their behavior and population dynamics [6].

Advantages: Drones offer a non-invasive method for observing marine mammals, minimizing human disturbance while allowing researchers to cover large areas quickly and efficiently.

Case studies: Drones have been employed to monitor seal populations and their breeding behaviors in remote areas. Research conducted on elephant seals demonstrated how drones could accurately estimate population size and assess habitat use without the need for direct human interaction (Hammill et al., 2017).

Environmental DNA (eDNA) analysis

Environmental DNA (eDNA) refers to genetic material obtained from environmental samples, such as seawater or sediment. This innovative approach allows researchers to detect the presence of marine mammals and other species without direct observation [7].

Advantages: eDNA analysis can provide information about species presence, diversity, and distribution, making it a powerful tool for biodiversity assessments in marine environments.

Applications: eDNA has been used to detect elusive marine mammals, such as the endangered vaquita porpoise, in areas where traditional survey methods are challenging. This technology offers a complementary approach to tracking and monitoring marine mammal populations.

Contributions to understanding ocean health

Assessing habitat use and critical areas

Tracking technologies have revealed important insights into marine mammal habitat use and critical areas that require protection. By analyzing movement data, researchers can identify regions that serve as feeding grounds, breeding sites, or migratory corridors.

Impact on conservation: Understanding the spatial and temporal patterns of marine mammal habitats can inform the designation of marine protected areas. For example, the identification of critical feeding grounds for baleen whales has led to increased protections in specific regions, safeguarding these areas from shipping traffic and fishing activities [8].

Monitoring climate change impacts

As climate change alters ocean conditions, tracking marine mammals can provide valuable information on how these species respond to environmental changes. Shifts in distribution, changes in migratory patterns, and alterations in breeding behaviors can all signal the effects of climate change on marine ecosystems.

Case studies: Research on narwhals in the Arctic has shown how rising sea temperatures are impacting their migration patterns and habitat use. As sea ice diminishes, narwhals are forced to adapt their

foraging strategies, which can have cascading effects on the entire ecosystem (Laidre et al., 2015).

Understanding prey dynamics

Tracking marine mammals also aids in understanding prey dynamics and the relationships between predators and their food sources. By correlating marine mammal movements with environmental data, researchers can assess how changes in prey availability impact marine mammal populations [9].

Implications for fisheries management: Insights gained from tracking marine mammals can inform fisheries management practices. For instance, understanding the foraging behavior of marine mammals can help identify areas where fish populations are being depleted, allowing for more sustainable fishing practices.

Challenges and limitations

While technological advancements have greatly enhanced our ability to track marine mammals, several challenges and limitations persist:

Technological constraints

Tracking technologies, while powerful, are not without limitations. Satellite tags can be expensive and may have limited battery life, restricting the duration of data collection. Acoustic monitoring relies on the presence of vocalizations, which may not capture non-vocal species or individuals that do not call frequently.

Environmental factors

Environmental conditions can also affect the effectiveness of tracking technologies. For example, poor weather conditions can hinder drone operations, while underwater noise pollution can interfere with acoustic monitoring.

Ethical considerations

The deployment of tracking devices on marine mammals raises ethical considerations regarding animal welfare. Researchers must ensure that tagging procedures are conducted with minimal stress and disturbance to the animals. Long-term monitoring is also essential to assess the potential impacts of tracking devices on individual health and behavior [10].

The future of marine mammal tracking

As technology continues to advance, the future of marine mammal tracking holds great promise. Emerging technologies such as artificial intelligence, machine learning, and big data analytics will enhance our ability to analyze and interpret the vast amounts of data collected from tracking efforts.

Integrating data sources

The integration of various data sources, including satellite telemetry, acoustic monitoring, and eDNA analysis, will provide a more comprehensive understanding of marine mammal populations and their interactions with the environment. This holistic approach can lead to more effective conservation strategies and better-informed management decisions.

Community engagement and citizen science

Engaging local communities and citizen scientists in marine mammal tracking efforts can enhance data collection and promote

awareness of marine conservation. Initiatives that involve the public in monitoring efforts can foster a sense of stewardship and responsibility for marine environments.

Policy and conservation implications

The insights gained from tracking marine mammals will have significant implications for conservation policies and marine resource management. By providing data-driven evidence of the ecological roles of marine mammals, researchers can advocate for stronger protections and sustainable practices in marine environments.

Discussion

The role of technology in tracking marine mammals is transforming our understanding of ocean health and the dynamics of marine ecosystems. By employing innovative tools and methodologies, researchers can gather valuable data that informs conservation efforts and enhances our ability to protect these vulnerable species.

Marine mammals serve as essential indicators of ocean health, and their tracking provides crucial insights into the impacts of human activities and environmental changes. The integration of various tracking technologies and data sources will enable a more comprehensive understanding of marine ecosystems and facilitate informed decision-making for conservation and management.

Conclusion

In conclusion, tracking marine mammals is crucial for understanding ocean health, and technology plays an invaluable role in this endeavor. Advanced tools such as satellite tagging, drone surveillance, and bioacoustic monitoring enable researchers to gather vital data on animal behavior, migration patterns, and habitat use. This information not only enhances our knowledge of marine ecosystems but also informs conservation efforts and policy decisions aimed at

protecting these species and their habitats. As technology continues to evolve, it will further empower us to safeguard the ocean's health, ensuring a sustainable future for both marine mammals and the biodiversity they represent.

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