Technological innovations in fisheries data collection: From edna to AI.

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Introduction

Technological innovations are transforming fisheries data collection, providing unprecedented opportunities to monitor, manage, and conserve aquatic ecosystems [1]. From environmental DNA (eDNA) analysis to artificial intelligence (AI), these advancements enable more accurate, efficient, and comprehensive assessments of fish populations and their habitats. As fisheries face increasing pressures from overfishing, climate change, and habitat degradation, leveraging these technologies is crucial for sustainable management [2].

Environmental DNA, or eDNA, represents a revolutionary tool in fisheries science. Organisms release genetic material into their environment through skin cells, feces, or mucus, which can be collected from water samples. By analyzing eDNA, researchers can identify species present in an area without physically capturing them [3]. This non-invasive method is especially valuable for detecting rare or elusive species and monitoring biodiversity. eDNA sampling is also faster and more cost-effective than traditional survey techniques, such as trawling or visual dives, which often require significant time and resources. However, challenges remain in interpreting eDNA data, including accounting for factors like water currents and degradation rates that can affect the distribution and detectability of genetic material [4].

Remote sensing and satellite technologies are also playing a vital role in fisheries data collection. High-resolution satellite imagery can monitor oceanographic conditions such as sea surface temperature, chlorophyll concentrations, and habitat changes, providing insights into fish distribution and migration patterns. Coupled with vessel tracking systems like the Automatic Identification System (AIS), remote sensing enables real-time monitoring of fishing activities, helping to combat illegal, unreported, and unregulated (IUU) fishing. These tools are particularly beneficial for countries with limited resources for patrolling vast marine territories [5].

Artificial intelligence (AI) is another game-changer in fisheries science. AI algorithms can process vast amounts of data, identifying patterns and trends that might be missed by human analysts. For example, AI-powered image recognition software can analyze underwater videos or sonar data to identify fish species and estimate their abundance. This technology is not only faster than manual analysis but also reduces observer bias. AI applications extend to predicting fish stock dynamics and assessing the impacts of environmental changes, enabling proactive and adaptive management strategies [6].

Mobile technology and digital platforms are enhancing data collection at the community level. Apps designed for fishers allow real-time reporting of catches, including species, sizes, and locations. These tools empower small-scale fishers to contribute to data collection while providing valuable information for stock assessments and management. Integrating mobile technologies with blockchain systems further improves traceability and transparency in seafood supply chains, ensuring sustainable practices and fair market access for fishers [7].

Acoustic telemetry and underwater drones are advancing our ability to study fish behavior and habitat use. Tagged fish equipped with acoustic transmitters emit signals tracked by underwater receivers, revealing migration routes, spawning grounds, and habitat preferences. Underwater drones equipped with cameras and sensors offer an additional avenue for exploring areas that are challenging to access, such as deep-sea habitats or remote coral reefs [8].

Despite the promise of these technologies, their implementation faces challenges. High costs, technical expertise requirements, and data integration issues can limit their adoption, particularly in developing countries. Ensuring equitable access to these innovations and building local capacity are essential for maximizing their impact. Additionally, the ethical implications of data collection and privacy concerns must be addressed, particularly when monitoring human activities in fisheries [9].

Collaboration between governments, research institutions, the private sector, and local communities is vital for harnessing the full potential of technological advancements in fisheries. Investments in infrastructure, training, and policy development are necessary to support the widespread adoption of these tools. By integrating these innovations into fisheries management, it is possible to achieve more sustainable practices, improve livelihoods, and protect marine biodiversity [10].

Conclusion

Technological innovations such as eDNA, AI, and satellite monitoring represent a transformative shift in how fisheries data are collected and used. These tools offer solutions to longstanding challenges in fisheries management, enabling more informed decision-making and fostering resilience in the face of environmental and economic pressures. As these technologies continue to evolve, their integration into global fisheries systems will be a cornerstone of sustainable resource management.

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