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APPLICATION OF ARTIFICIAL INTELLIGENCE ON FISHING CRAFTS AND GEARS FOR FISH POPULATION STUDIES-A REVIEW

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Abstract
Artificial intelligence (AI) in the fisheries industry is transforming conventional approaches that have been used to estimate fish populations, fishing operations, and fisheries management because of the development of efficient, accurate, and data-driven decision-making. The paper gives an overview of some recent developments in the application of artificial intelligence technology in fishing craft, fishing gear, and fish population. According to the literature, the application of artificial intelligence technologies such as machine learning, deep learning, computer vision, autonomous sensors, and real-time catch analysis has enhanced vessel navigation, fish identification, fish stock estimation, fish habitat monitoring, fish behavior analysis, electronic catch reporting, and fisheries surveillance. This development enhances fisheries resource monitoring, improves fishing gear selectivity, ensures data-driven decision-making, and sustainable exploitation of fishery resources. Various factors limit the application of artificial intelligence technology in fishing, including low-quality fisheries data, high cost of adoption, inadequate technical expertise, lack of proper data governance, and improper policies, especially in the developing world. Nevertheless, in spite of all these challenges, the advancement of AI technology along with some other aspects such as data exchange, multidisciplinary collaboration, capacity building, and good governance is expected to contribute to the digital revolution in the field of fisheries. The literature review conducted revealed that there is tremendous potential for the application of AI in enhancing the effectiveness and precision of fishery management and making the use of fishery resources more sustainable and responsible.

Keywords: Artificial Intelligence, fishery science, autonomous underwater vehicles, sustainable fisheries management, sustainable harvesting practices.

1.0. Introduction

The Crisis in Global Fisheries and the Need for Innovation

Fisheries play an indispensable role in global food security and economic development, providing sustenance and livelihoods for millions of people worldwide. With fish accounting for nearly 20% of the animal protein intake for more than 3.3 billion people, the sector's importance is undeniable. As of 2022, the Food and Agriculture Organization (FAO) estimated that over 600 million people depend directly or indirectly on the fisheries and aquaculture sectors for their livelihoods. However, global fisheries are confronted with escalating pressures, including overfishing, habitat degradation, illegal unreported and unregulated (IUU) fishing, and climate change, all of which threaten marine biodiversity and the sustainability of aquatic ecosystems. These pressures have led to the depletion of critical fish stocks and a corresponding loss in marine biodiversity, with approximately 34% of global fish stocks being fished at biologically unsustainable levels (FAO, 2022). One of the primary issues in modern fisheries management is the lack of accurate and timely data on fish populations. Traditional fish stock assessment methods, such as manual trawl surveys, logbook data, and catch-per-unit-effort (CPUE) metrics, are often time-consuming, labour-intensive, and subject to significant uncertainty. These methods frequently fail to provide real-time data, making them less effective in rapidly changing environmental and ecological conditions. In the context of sustainable fisheries management, access to precise and timely information on fish population distribution, abundance, and behaviour is essential. Reliable data informs management decisions such as fishing quotas, seasonal closures, and marine spatial planning, thereby reducing the risk of over-exploitation and supporting long-term ecological sustainability (FAO 2022; Honarmand Ebrahimi et al. 2021)

The Rise of Artificial Intelligence in Fishing Gears and Crafts

Emerging advancements in Artificial Intelligence (AI) offer a paradigm shift in how fisheries are monitored, managed, and optimised. From machine learning algorithms and image analysis to autonomous craft and smart fishing gear, AI technologies are streamlining fish population studies and real time ecological assessments. These tools not only enhance the accuracy of data collection but also improve decision-making in areas such as fisheries management, bycatch reduction, and vessel surveillance have demonstrated great potential in automating fish detection, estimating biomass, and analysing spatial-temporal patterns in fish movement (Barbedo, 2022).

Furthermore, the application of AI in fisheries is increasingly evident in the design and deployment of modern fishing craft and gear. Traditional fishing equipment is often limited by human error and inefficiencies in targeting species, leading to unintended bycatch and ecosystem disruption. Recent advancements in smart fishing gear, such as AI-powered sonar, machine vision-enabled sorting systems (MVESS) and autonomous underwater vehicles (AUVs), allow for more selective and sustainable harvesting practices (Mandal *et al.,* 2025). These innovations are particularly significant for artisanal and small-scale fisheries, where resource constraints often limit access to traditional stock assessment technologies. AI-enhanced gear systems can identify species, estimate size and abundance, and adapt harvesting strategies in real time, thereby reducing bycatch and promoting ecological balance (Cheng *et al.,* 2023).

Impacts, Opportunities, and Future Outlook

Artificial intelligence (AI) is increasingly recognized as a transformative technology with the potential to reshape fisheries by improving the efficiency, accuracy, and sustainability of fishing operations and fisheries management. Advances in machine learning, deep learning, computer vision, autonomous sensing, and data analytics have expanded the capacity to monitor fish populations, support fishing activities, and generate reliable information for evidence-based decision-making. These technological developments offer opportunities to improve resource utilization, reduce operational inefficiencies, strengthen fisheries monitoring, and promote ecosystem conservation.

Despite its considerable potential, the successful integration of AI into fisheries depends on addressing challenges related to data availability, technological infrastructure, implementation costs, technical expertise, and governance. Consequently, understanding both the opportunities and limitations of AI is essential for its effective application in sustainable fisheries management. This review therefore examines current advances in AI applications in fishing crafts, fishing gears, and fish population studies, evaluates their contributions to sustainable fishing practices, identifies existing challenges, and discusses future research directions for enhancing the sustainability and resilience of fisheries.

2.0. Methodology

Literature regarding the study topic was found through an exhaustive search of database sources like Scopus, Web of Science, ScienceDirect, IEEE Xplore, SpringerLink, MDPI, Frontiers, and Google Scholar. The search identified relevant journal articles, review papers, conference proceedings, and other scholarly publications related to the application of artificial intelligence in fisheries like Fishes, Sustainability, Frontiers in Marine Science, Expert Systems with Applications, PLOS ONE, and SoftwareX, and in conferences such as IEEE International Joint Conference on Neural Networks (IJCNN), IEEE International Conference on Omni-layer Intelligent Systems (COINS) and Springer Lecture Notes in Computer Science (LNCS).

The literature searches employed combinations of predefined keywords, using the terms "AND" and "OR" to broaden and refine the search, thereby maximising the retrieval of relevant studies. Some of the key terms involved in the search are “artificial intelligence,” “machine learning,” “deep learning,” “computer vision,” “convolutional neural networks,” “neural networks,” “smart fisheries,” “sustainable fisheries,” “fisheries management,” “fish stock assessment,” “fish stock estimation,” “fish population monitoring,” “fish abundance estimation,” “fish species identification,” “fish behaviour recognition,” “fishing vessel behaviour,” “fishing gear selectivity,” “underwater imaging,” “electronic monitoring,” “real-time catch analysis,” “autonomous underwater vehicles,” “fish habitat monitoring,” "PeskAAS," and "Peskas.”

This paper was mainly concerned with literature from the years 2018 to 2025; however, other earlier literatures which contained a methodological contribution was considered. The criteria of inclusion involved journals and proceedings as well as review papers that looked at how artificial intelligence (machine learning, deep learning, computer vision, and intelligent monitoring systems) was applied to fisheries management, fishing craft, fishing gears, fish population estimation, fish behavior analysis, and sustainable fishing. Literature that was not relevant to fisheries, lacked an application of AI technologies, duplicated papers, literature not written in English, editorials, and opinions were excluded.

From the literature found, critical analysis and synthesis were done using the major themes of the study, which involved the application of artificial intelligence in fishing craft, fishing gear, fish population monitoring and estimation, sustainable fisheries management, challenges in the implementation process, and future research directions, among others.

3.0 The Role of Artificial Intelligence in Enhancing Fishing Gear and Craft Technologies

Transition from Traditional to Smart Fishing Technologies

Fishing gear and craft have long formed the structural backbone of marine resource extraction. Historically, tools such as trawlers, gillnets, longlines, and purse seines have dominated commercial and artisanal fisheries alike. However, despite their widespread use, these systems are often plagued by inefficiencies such as low species selectivity, high bycatch ratios, and the dependence on human judgement for monitoring and data collection. Manual catch documentation, in particular, contributes to delays in reporting and errors in stock evaluation, undermining conservation and quota management efforts (Mandal et al., 2025).

The emergence of artificial intelligence (AI) has prompted a paradigm shift from analogue operations to digital, adaptive fishing systems. AI-enhanced fishing gear, such as sensor-integrated nets and smart hooks, now uses real-time data and predictive modeling to improve catch efficiency while minimizing ecological damage. Notably, nets embedded with underwater cameras and trained image-recognition algorithms can now distinguish between target and non-target species, releasing bycatch almost instantaneously, indicating that AI-assisted selective fishing gears have demonstrated substantial potential to reduce bycatch by improving species recognition and gear selectivity. (Mandal et al., 2025). These improvements reduce human error and enhance transparency, making fisheries more accountable and aligned with ecosystem-based management goals. Figure 1 present artificial intelligence application in fish detection and harvesting offering improvements in accuracy, efficiency and scalability compared to traditional harvesting methods. The deep learning algorithms can identify and classify fish species in under water images and videos, thereby assisting in marine biodiversity monitoring, fisheries management and ecological research. AI uses automated fish detection and classification models such as:

1. Deep learning models: this model uses YOLO (You Only Look Once) for object detection enabling accurate identification of fish species in under water imagery.
2. Real time analysis: AI can process large data from under water cameras and sonar system in real time, thereby detecting fish and their behaviour.

The figure below shows detection of fish using under water imagery, figure 1 a and b show location and direction of fish movement. Detection of fish in schools as in b help in rapid fish harvesting thereby reducing time wasting by the crew and increasing catch per unit efforts

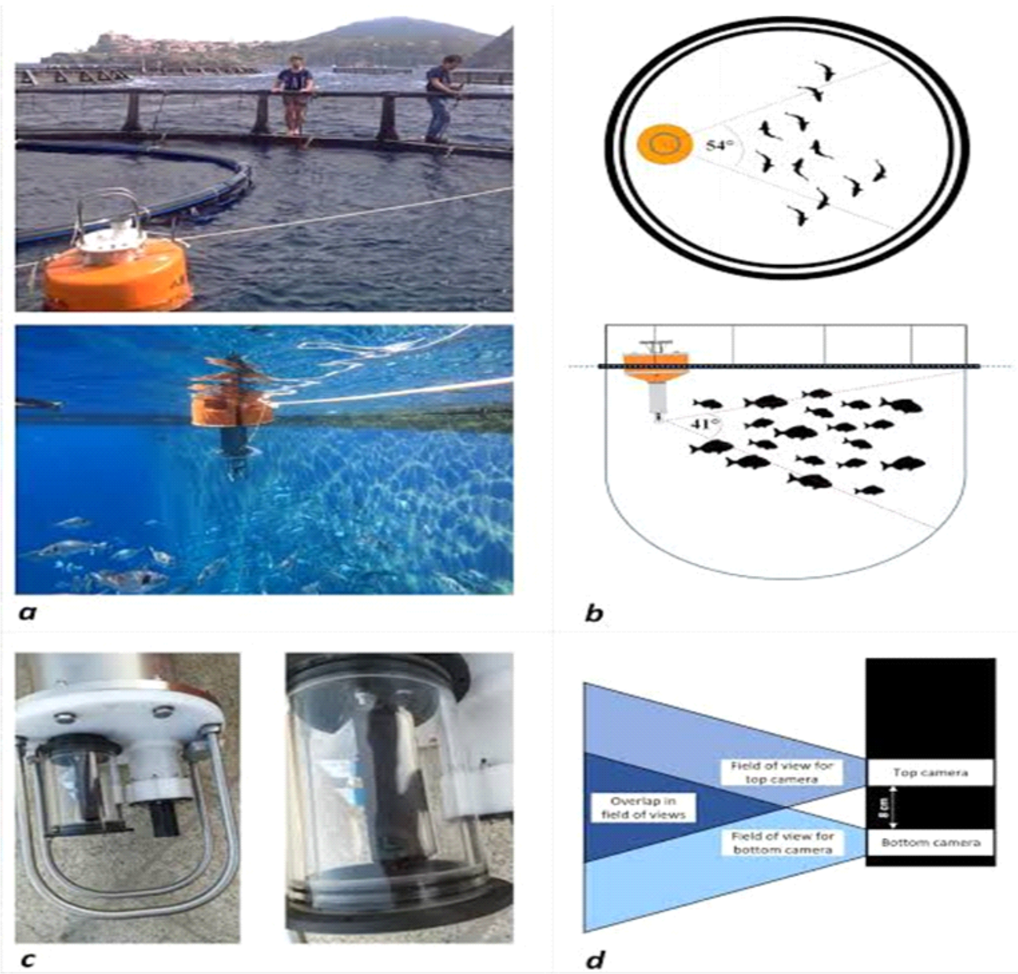

Figure 1: Artificial Intelligence Application in Fish Detection and Harvesting

AI-Powered Monitoring, Acoustic Intelligence, and Gear Optimization

Advanced fishing vessels are now being equipped with AI-driven onboard systems like Remote Catch Analysis Systems (AI-RCAS), which employ convolutional neural networks to recognize species, estimate biomass, and count catch volumes in real time. This streamlines regulatory compliance, minimizes illegal or underreported fishing, and allows skippers to make informed decisions at sea (Kim et al., 2024). Moreover, stereo vision cameras and automated data logging tools enable near-instant verification of size and maturity, improving selectivity and supporting juvenile conservation efforts. Using convolutional neural networks and transformer-based deep learning models, researchers can automatically analyse underwater video to determine how fish respond to fishing gears under different conditions. This information can be used to improve gear design, increase gear selectivity, and reduce the capture of non-target species **(Guðfinnsson et al., 2023).**

Beneath the surface, artificial intelligence is revolutionizing sonar-based monitoring systems. Acoustic data from side-scan and multibeam sonar can now be processed using AI algorithms trained to detect fish aggregations, map benthic terrain, and profile marine habitats. Parallel developments in AI-guided beamforming and real-time gear control mechanisms allow dynamic adjustments based on water temperature, fish movement, and bathymetric features. These feedback-enabled systems ensure that gear deployment is not static but reactive adjusting haul timing, location, and gear tension in synchrony with environmental cues. Such responsiveness reduces energy waste, avoids sensitive habitats, and enhances catch precision (Cheng et al., 2023).

Real-World Applications, Sustainability Outcomes, and Future Implications

The integration of AI into fishing gear and craft technologies goes beyond efficiency, it represents a foundational change in fisheries governance, economics, and ecological accountability. Systems like Scantrol Deep Vision, equipped with stereo-video and AI object recognition software, can automatically identify and measure fish during retrieval, ensuring that undersized or non-target species are released unharmed (Barbedo, 2022). In doing so, these systems help protect population structures and sustain fisheries for future generations. Furthermore, real-time and high-resolution data from AI systems dramatically improve the quality of fisheries stock assessments and ecosystem modeling, supporting adaptive management and evidence-based policymaking. Ultimately, artificial intelligence is not just modernizing fishing technologies; it is transforming the philosophy of marine exploitation from extraction-centric to data-driven sustainability. By embedding intelligence into gears and vessels, fisheries are evolving into responsive systems capable of balancing yield with stewardship. In this sense, AI serves as both a technological tool, equipping the industry to meet the challenges of a changing ocean while safeguarding its biodiversity and economic future.

The Impact of AI Tools in Monitoring and Estimating Fish Populations

Application of artificial intelligence (AI) in detecting and quantifying fish stocks has emerged to be an innovative approach compared to some conventional methods used in fisheries stock assessment. Earlier, fisheries management involved manual fish counting, fishing nets, and direct observations which proved to be tedious and time-consuming and were affected by human and environment-related errors (Honarmand Ebrahimi et al., 2021). Recent advances in AI technologies including computer vision, machine learning, deep learning, and autonomous sensing, have made fish species identification, stock assessment, habitat monitoring and behavior studies easier in marine and freshwater ecosystems (Barbedo, 2022; Saleh et al., 2023).

Among the most innovative AI technologies is the emergence of AI imaging technology in automated fish monitoring. High-resolution underwater cameras along with the use of computer vision and deep learning models can help in detecting, recognizing, classifying and counting fish based on underwater video/images with great accuracy. According to Mandal et al. (2018), deep neural networks could be effectively used for processing underwater videos for fish abundance estimation. Similarly, Barbedo (2022) highlighted the growing application of computer vision techniques in recognition, monitoring, and management of the fisheries, whereas Saleh et al. (2023) demonstrated the potential of applying deep learning approaches for underwater imaging and habitat monitoring. Machine learning algorithms have widely been applied in analysis of large data sets in fisheries providing the possibility of stock and ecosystem assessment (Honarmand Ebrahimi et al., 2021; Barbedo, 2022). Moreover, the application of artificial intelligence technology has improved abilities in analysis of fish behavior around fishing gear utilizing computer vision and deep learning approaches. Guðfinnsson et al. (2023) developed the convolutional neural network and attention-based models capable of classifying herding behavior of fish in the trawling gear, thus giving the information about gear selectivity and fish-gear interactions. In addition, Cheng et al. (2023) have demonstrated that classification of the fishing vessels behavior utilizing artificial intelligence algorithms improves efficiency of fisheries monitoring by detecting fishing activities from vessel behavior.

In contrast to conventional monitoring methods, AI technologies have been found to be considerably faster when processing large volumes of imagery data, as well as more accurate, less prone to the bias of an individual observer, and more capable of continuous monitoring of fisheries. The application of computer vision and machine learning allows fishery managers to obtain better-quality data that can contribute to their better decision-making aimed at the sustainable management of fishery resources (Barbedo, 2022; Honarmand Ebrahimi et al., 2021).

The new developments in AI-fisheries include the PeskAAS (automated analytics system) designed by Worldfish. This is an open-source software system whose purpose is to monitor and analyze small-scale fisheries. The system includes fishery catch data, vessel trajectory data, fish species data, and automated analytical capacity through an interactive dashboard which helps in fish stock assessment, catch statistics, and fisheries management (Tilley et al., 2020). PeskAAS has since been developed into Peskas and has been implemented in some countries including those in Africa. The near real-time catch composition, fishing effort, catch per unit effort (CPUE), and fishing patterns data are provided by Peskas and have helped in improving fishery monitoring and sustainable exploitation of fisheries (Longobardi et al., 2025).

4.0. Effectiveness of AI in Promoting Sustainable Fishing Practices

The integration of Artificial Intelligence (AI) into the global fishing industry is revolutionising how marine resources are exploited, offering significant pathways to achieving sustainability. With growing concerns over overfishing, habitat degradation, and the challenges of enforcing fishing regulations in distant waters, AI-driven technologies provide tools that can mitigate environmental harm while optimising fishing efficiency. According to Honarmand Ebrahimi *et al.* (2021), AI-based systems are capable of supporting sustainable fisheries management by automating decision-making, reducing waste, and improving ecosystem health.

Role of AI in reducing bycatch and overfishing

One of the most detrimental consequences of industrial fishing is bycatch, the unintentional capture of non-target species such as dolphins, turtles, and juvenile fish. Traditionally, mitigating bycatch relied heavily on fisher discretion or manual observation, which is both inconsistent and insufficient. With the advent of AI, machine learning algorithms and computer vision tools can now identify target species with greater accuracy. The use of AI in sensors incorporated in fishing gears together with computer vision and machine learning algorithms makes it possible to identify, in real-time, both target and non-target species. It improves the selectivity of fishing gears and helps cut down the amount of bycatch and provide timely information for fishermen for sustainable fishing. The new achievements in AI fish behaviour recognition have proved to be effective in improving the selectivity of fishing gears through the automatic detection of fish responses to fishing gears (Abangan et al., 2023).

Additionally, the new technologies of deep learning have made it possible to use smart camera systems for the electronic monitoring of the catches onboard. At present, computer vision systems make it possible to automatically detect, enumerate and classify fish species based on images or video recorded under water. Compared to traditional monitoring methods, the process is much more effective, takes less time and provides accurate results (Barbedo, 2022; Mandal et al., 2018). Furthermore, AI-powered acoustic sensors and sonar mapping tools also help in identifying fish school compositions beneath the surface, allowing fishers to avoid endangered or juvenile populations.

Enhancing decision-making in quota allocation and seasonal restrictions

Sustainable fishing requires dynamic and data-informed regulation of fish catch limits. Traditionally, decisions on quota allocations have been based on historical data and manual assessments, which are often delayed and less responsive to real-time changes. With AI, there is a marked improvement in forecasting fish populations and adjusting quotas based on predictive analytics. Cheng *et al.* (2023) discussed how AI models analysing satellite and sonar data can generate accurate estimates of fish stocks, which inform more precise and adaptable quota systems.

The incorporation of AI into government and international regulatory frameworks has been instrumental in enforcing seasonal restrictions more efficiently. AI models can process real-time environmental data, such as water temperature, salinity, and migration patterns, to predict optimal breeding times for various species. This enables authorities to implement closed seasons that align more closely with ecological realities. Kim, *et al*. (2024) developed an AI-based real-time Catch Analysis System (AI-RCAS), which assists in adjusting catch limits dynamically to preserve stock health.

Additionally, compliance with fisheries management regulations is enhanced by artificial intelligence (AI) due to improved monitoring, analyzing and interpreting of the fishing vessels' actions. As reported by Cheng et al. (2023), use of machine learning algorithms for processing of vessel monitoring data may enable fisheries to detect patterns of fishing and classify the fishing vessels' actions, which would be beneficial for fisheries monitoring and management. AI-based real-time catch analysis systems are more effective as far as the rapid processing of fisheries data and provision of useful information for management decision-making is concerned. Together with AIS data, VMS data, satellite imagery and other remote sensing data, AI may be applied for detection of suspicious behavior of fishing vessels and prevention of IUU fishing (Kim et al. 2024).

Promoting eco-friendly harvesting techniques

Eco-friendly fishing involves minimal destruction of the marine environment coupled with efficient fish production. AI plays an integral role in attaining the set goal through monitoring of fisheries and fish species recognition as well as making decisions that are based on data which promotes selective and sustainable fishing (Barbedo, 2022; Honarmand Ebrahimi et al., 2021). The application of AI technology has led to an innovative development regarding fish detection, recognition, and monitoring from underwater images and videos (Barbedo, 2022). Also, the application of deep learning has resulted in huge potential in underwater images and habitat monitoring that enhance eco-friendly harvesting practices (Saleh et al., 2023).

Artificial intelligence has greatly contributed towards fisheries management by fish population assessment and monitoring. Besides, artificial intelligence technology may aid in integration of fisheries and environmental data to improve fishery resource monitoring, forecasting and management (Honarmand Ebrahimi et al., 2021). In addition, through the fish population assessment and monitoring as well as labour-intensive traditional monitoring methods reduction, AI plays an instrumental role in eco-friendly harvesting practices (Barbedo, 2022; Honarmand Ebrahimi et al., 2021). Figure 2 shows modern fish harvesting machine that can be used in both aquaculture and capture systems. They are often equipped with seine nets and reels, trawl nets, automated grading and sorting system and integrated monitoring system that employs sensors, under water cameras and software to monitor fish growth, water quality and behavior. Automated grading and sorting machines sort fish by size using a combination of conveyor belts and rollers which are more efficient than manual setting. Seine net and reels are used to pull large seine net through the water capturing fish as the net is drawn towards the shore.

Figure 2: Modern Fish Harvesting Machine

Use of AI in ecosystem-based management

Ecosystem-based fishery management (EBFM) considers the interdependencies among species, habitats, and human activities. This holistic approach requires extensive, high-frequency data inputs, which are well-handled by AI systems. AI models can assimilate vast datasets from oceanographic sensors, satellite imagery, and vessel logs to offer insights into ecosystem health and resilience. As noted by Kim *et al.* (2024), integrating AI into EBFM allows managers to simulate future scenarios and assess the ecological consequences of various fishing strategies.

Machine learning algorithms also play a crucial role in identifying ecosystem stress signals early. For example, shifts in species distribution due to ocean warming or pollution can be detected using AI-powered predictive modelling. Barbedo (2022) highlighted how AI tools trained on historical and environmental datasets can forecast ecosystem disruptions and recommend adaptive interventions. This timely insight enables policy makers to implement proactive conservation measures rather than reactive ones.

In addition, AI supports stakeholder engagement by making data more accessible and actionable. Real-time dashboards powered by AI visualise ecosystem trends in a user-friendly manner, allowing both policymakers and local fishers to make informed decisions. When local communities are equipped with AI-informed tools, they are more likely to adhere to sustainable practices, fostering cooperative stewardship of marine resources (Mandal *et al.* 2025). Ultimately, the integration of AI into ecosystem-based management not only enhances conservation efforts but also ensures that marine biodiversity continues to support human livelihoods for generations. Figure 3 show use of AI in monitoring and fish population estimation using the approaches of eDNA, Commputer Vision, and Acoustic based methods that is equipped with fish detection and recognition, fish biomass estimation, fish behaviour classification and fish health analysis.

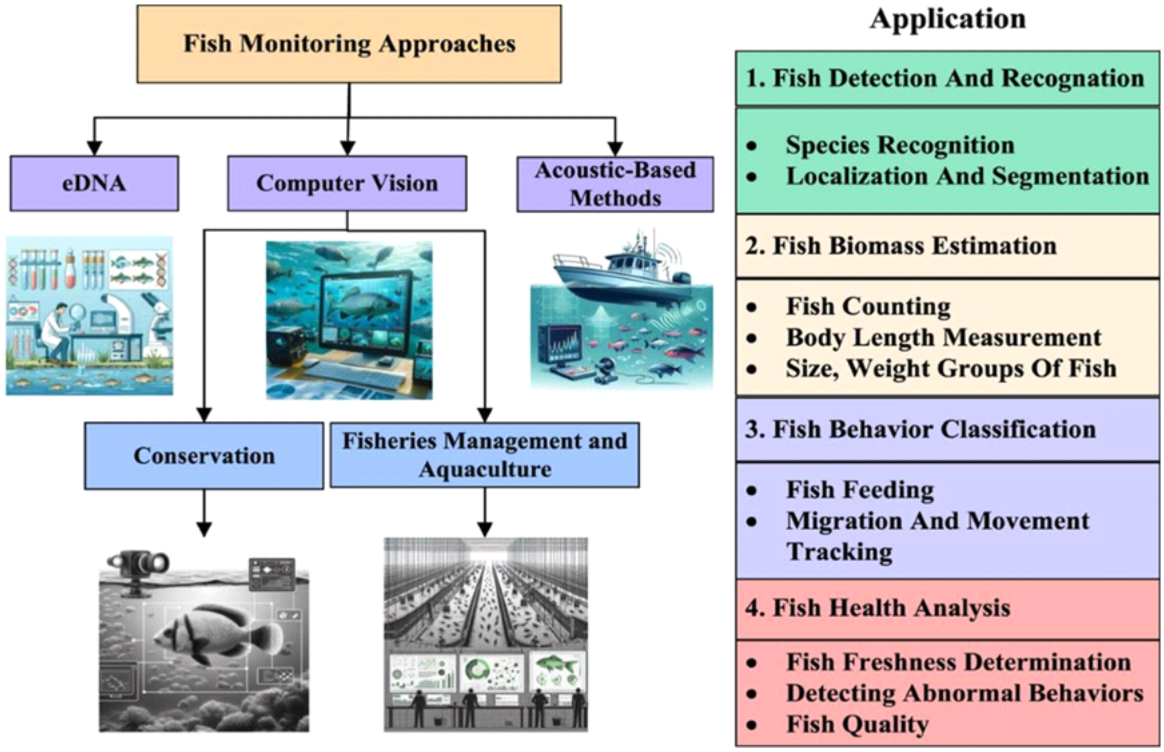

Figure 3: Tools in Monitoring and Estimating Fish Population

5.0 Challenges of Applying AI in Fish Population Studies

Artificial Intelligence (AI) has gained significant ground in modern fisheries science, particularly in fish population studies, due to its potential to enhance data collection, processing, and interpretation. However, despite its promise, there remain critical challenges that hinder the full implementation and impact of AI-driven solutions in aquatic ecosystems. These challenges are multifaceted, encompassing technical, infrastructural, financial, environmental, and regulatory dimensions. Understanding these issues is vital to improving the integration and sustainability of AI applications in fisheries monitoring and management.

Data quality and availability

One of the major problems that appear in the application of AI for fish population research is the issue of data availability. In order to ensure accurate results in machine learning and CNN models, it is essential to have large amounts of appropriately labeled data that include underwater pictures, acoustic data, and other ecological information (Barbedo, 2022). However, gathering data in aquatic environments is challenging because of such aspects as different water quality, lighting, fish behavior, and diversity.

In addition, there is a problem of inconsistent datasets since the sampling protocols and monitoring systems vary (Honarmand Ebrahimi et al., 2021). The inconsistency of the datasets, combined with the imbalance in the samples and conditions, can contribute to low accuracy and introduce bias into AI algorithms when they are used in a different fishery or ecosystem. The absence of standardized datasets and the mentioned problems might result in poor AI performance under different environmental conditions (Barbedo, 2022; Honarmand Ebrahimi et al., 2021). Additionally, the shortage of fisheries data which have been gathered for a very long time with high quality can be cited as another limitation, particularly in many developing countries, where the application of digital technology in monitoring fisheries data is at an early stage of development. Shortage of historical data hinders the training, validation, and improvement of the AI model.

High cost of implementation and maintenance

Another critical barrier to widespread AI adoption in fish population studies is the high cost associated with acquiring, deploying, and maintaining AI infrastructure. Advanced AI tools such as underwater drones, AI-enabled sonar systems, and cloud-based analytics platforms require significant capital investment (Kim *et al.,* 2024). These costs are often prohibitive for small-scale fisheries and low-income countries where budget constraints and competing priorities limit technological upgrades.

In addition to the cost of equipment, there are ongoing expenses for software licensing, data storage, system maintenance, and personnel training. AI systems must be regularly updated to adapt to changing environmental patterns and to integrate new scientific knowledge. Moreover, skilled data scientists, marine biologists, and technicians are needed to interpret AI outputs and ensure the accuracy of results. The shortage of such interdisciplinary expertise further escalates the long-term costs and reduces scalability.

Despite the promise of automation, initial setup and calibration often require extensive manual effort. For instance, Saleh *et al*. (2023) observed that deploying underwater imaging systems for habitat monitoring demands both technical support and fieldwork expertise, creating a financial and logistical burden for research teams. Until the cost of AI tools becomes more affordable or subsidised, their use in global fish population studies will remain uneven and limited.

Technical complexity and interdisciplinary integration

AI systems in fish population studies are highly technical and demand expertise across multiple disciplines, including marine biology, computer vision, software engineering, and statistics. Bridging these diverse fields to create robust, accurate, and scalable AI solutions is a complex task that often hampers progress (Cheng *et al.,* 2023). Many AI researchers lack a comprehensive understanding of ecological dynamics, while marine scientists may not be well-versed in data analytics or AI algorithms.

This skills gap complicates the design, validation, and interpretation of AI models. For example, understanding how fish respond to environmental stimuli is essential for building accurate behavioural prediction models, yet this information is not always available to AI developers (Guðfinnsson *et al.,* 2023). Likewise, fish detection systems may misinterpret noise or movement in murky waters as false positives, requiring biological expertise to calibrate correctly.

Furthermore, AI outputs are often difficult for non-technical users, such as policy makers or community fishers, to understand and apply. The lack of user-friendly interfaces and transparent models contributes to scepticism and low adoption rates. Many AI applications fail in real-world scenarios due to poor alignment between algorithmic assumptions and the ecological or social realities of fishing communities (Mandal *et al.* 2025).

Ethical and regulatory concerns

The application of AI in fisheries science raises important ethical and legal issues that have yet to be fully addressed. Concerns around data ownership, privacy, consent, and ecological disruption are central to debates about the responsible use of AI in natural resource management (Honarmand Ebrahimi *et al.,* 2021). For example, the widespread deployment of AI-enabled drones or acoustic sensors in marine protected areas may unintentionally interfere with delicate ecosystems or infringe on indigenous fishing rights.

In many jurisdictions, regulatory frameworks have not caught up with the rapid development of AI technologies. This legal vacuum makes it difficult to standardise protocols for data collection, storage, and sharing. Furthermore, the lack of transparency in AI decision-making processes, often referred to as the "black box" problem, can complicate accountability in cases where AI-driven estimates lead to incorrect policy or quota decisions.

The integration of AI into fisheries governance also raises concerns about equity. Wealthier nations and commercial fishing fleets may have greater access to AI tools, thereby widening the technological gap between industrial and artisanal fisheries. The potential for AI to unintentionally centralise decision-making power or favour profit-driven management strategies could exacerbate social and economic inequalities in fisheries sectors (Kim *et al.* 2024).

Environmental variability and adaptability of AI systems

Lastly, the dynamic and unpredictable nature of aquatic environments poses significant challenges to AI applications. Fish populations are affected by a wide array of environmental factors, including temperature, salinity, oxygen levels, ocean currents, and climate change, all of which can vary temporally and spatially (Mandal *et al.,* 2018). AI systems trained in one set of conditions may perform poorly when deployed in a different context, reducing their reliability and utility.

Additionally, extreme weather events or climate-induced habitat changes may render historical data obsolete, requiring AI models to be constantly retrained and validated. This need for ongoing adaptability increases both computational demand and the risk of model failure. Models that do not incorporate real-time environmental feedback loops may generate inaccurate predictions, leading to ineffective or even harmful management decisions (Saleh *et al.* 2023).

Moreover, aquatic systems are characterised by a high degree of noise and signal interference. Underwater imagery, for instance, is often obstructed by turbidity, algae blooms, or shifting sediments, which complicate object detection and tracking (Barbedo, 2022). Acoustic sensors may also be disrupted by vessel noise or natural bioacoustics. These environmental complexities require AI systems that are not only technically advanced but also ecologically contextualized and resilient to unpredictable conditions.

Conclusion

The advent of artificial intelligence (AI) technology has been identified as an innovative technology that may help promote sustainable development in the field of fisheries through the optimization of monitoring, harvesting, and management of fisheries in terms of efficiency, accuracy, and speed. In this review, it has been shown that different AI technologies such as machine learning, deep learning, computer vision, autonomous sensing technology, and predictive analytics are being utilized in fishing vessels, smart fishing gear, and studies on fish populations. Therefore, the use of AI technologies makes fisheries management more efficient and helps to achieve sustainable development of aqua resources.

It should also be acknowledged that the use of AI technologies is crucial for implementing sustainable fishing practices, as it provides for the possibility to harvest fish populations selectively, control fisheries and make decisions based on facts. With the help of technologies such as underwater imagery, acoustic technologies, remote sensing, and environmental monitoring systems, fisheries managers get information about the condition of fish populations and ecosystems, which can be analyzed more quickly than with other methods. However, despite considerable success in this direction, there are still several barriers that hamper the use of AI in fisheries. Some of these barriers can be listed as poor availability of high-quality data sets, high cost of technologies and their maintenance, shortage of skills for AI implementation and maintenance, ethical problems arising from the use of such data and algorithms, and regulatory issues. In order to tackle all these barriers, it is necessary to cooperate between fisheries specialists, experts in artificial intelligence, government officials, representatives of the industry, and international organizations to create an affordable solution for the use of AI in the sector.

Thus, future research should involve the creation of models taking into account multi-source data that can be satellite imagery, underwater cameras and acoustics, environmental and fisheries databases, etc. Availability and low cost of AI technologies should be ensured to help small-scale fisheries, especially in developing countries, become sustainable due to efficient resource management. Thus, the use of artificial intelligence in fisheries science and management offers numerous opportunities for the sustainable and responsible exploitation of global fishery resources and protection of aquatic ecosystems.

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Data Availability Statement
This study is a review and does not contain original experimental data. All data and findings discussed are derived from previously published research articles, technical reports, and publicly accessible scientific databases, which are cited appropriately in the reference list.

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