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REVIEW

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Innovative Technologies in Fisheries Sector

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Conflict of Interest

The authors declare that the manuscript was formulated in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Authors Contribution

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

Abstract

The World's greatest confronting issue is the increment in population and the trouble of feeding them healthy food. Agriculture and fisheries play a crucial role in global fish production on land and within the ocean. But currently the sector is facing numerous issues due to the use of age-old traditional techniques, improper management, environmental pollution and expensive labour costs. Hence this sector has embraced use of automation and technologies to address these challenges. This article looks at how fisheries management has changed as a result of technological improvements. Aquaculture innovations as well as advancements in robotics, autonomous systems, automatic feeding devices, drones, electronic tracking and reporting, acoustic devices, remote sensing and satellite monitoring are all on display. With the help of technology, the production and trading of fisheries can undergo an emerging shift. Technology has also set its way to the fish markets and supply chains. This study focuses on how technology may increase the sustainability, efficacy and transparency of fisheries paving the way for a future in which ethical fishing practices and healthy marine ecosystems coexist.

KEYWORDS

Innovation, Technologies, Fisheries, Automation, Sensors, Robotic fish, Block chain

INTRODUCTION

Since we are all aware about the fact that Innovation is essential to the future. At present, Innovation needs to reconstruct our ecosystem as fisheries management. The movement toward this goal may represent the only stopgap for fisheries. Innovation is the deliberate process of exercising or adapting invention and bettered practices for practical use at an individual, organizational or public level. Practices that contribute to the research, development and design of new goods, procedures or to improve existing results and produce new technical skills are appertained to as technological Innovation. One of the most important points is that fish husbandry is one of the best lucrative businesses (Ullah and Kim, 2018).

There are different innovative technologies like GIS, GPS, Remote sensing, Radar, Sonar, Drones, Automatic feeding devices, Sensors, Robotic fish. Fisheries resource management is the exertion of guarding fishery resources sustainably. Innovation will play an essential part in meeting global challenges such as environmental conservation and sustainability of the fishery sector. Technology is playing a significant part in the growth and modernization of fishing industry. This traditional industry is facing serious economic and environmental pressures, as well as ever changing regulations. Examples of fisheries and aquaculture innovations include conservation technologies, aquaculture technologies, harvesting technologies, new products and institutional Innovation. The gap between Innovation and Technology is quite significant. Innovation leads to new ideas, methods, things, or restructuring, remodeling, creative thoughts and new imagination in a device or process. Technology is the application of scientific knowledge for practical purposes and manipulation of human environment. Innovative technologies have a high impact in that they contribute to a sustainable harvest of marine resources and fisheries operation.

UMITRON CELL (Smart feeder)

UMITRON CELL is a smart feeding system that aims to accelerate the sustainable development of oceans by combining technology with aquaculture. It is the first real-time ocean-based fish appetite detecting system in the world. It decides when and how much feed to provide to each fish cage based on real time observation of swimming behavior. The device can be remotely controlled from a smartphone or computer. It can also determine the appetite of fish and thus regulate the quantity and rate of feeding. Thus, by keeping uneaten feed out of the water, it can aid in labour savings, feeding optimization and the realization of environmentally friendly aquaculture.

Fig 1: Umitron Cell (Source: Online)

UMITRON LENS

Technology has automated fish measurements in aquaculture installations. Umitron has developed a fish body measuring system called UMITRON LENS. This lens uses the internet to measure fish size underwater and records the results in the cloud. The ability to track fish throughout their growth cycles is an essential part of fish farming. The current method of monitoring fish growth requires farmers to labour intensively sample an acceptable number of fishes on a regular basis which stresses the fish leading to injuries or even death. Lens measures fish size automatically by using artificial intelligence and small stereo cameras. In this way, the process of monitoring fish growth is made easier for farmers helping them to lessen their workload and ultimately boost their income.

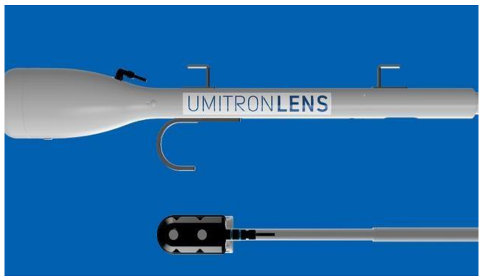

Fig 2: Umitron Lens (Source: Online)

ROBOTIC FISH CAGES

Robotic fish cages are the self-propelled spherical robotic cages also called ‘Aquapods’. The Aquapod is basically a cage in which growers put their fish and then leave it adrift in the ocean. They are made to accommodate a wide range of aquatic creatures and are appropriate for usage in rough ocean conditions. A free-floating fish farm called Aquapod has the capacity to hold several hundred thousand fish and can be remotely rotated in the water. The triangular panels are made out of fiberglass and reinforced plastic. The netting is made out of galvanized steel wire which acts as a predator repellent. When compared to other aquaculture techniques, these cages may appear pricely.

Fig 3: A fully assembled Aquapod (Source: Ocean Farm Technologies)

DRONES

One of the most common uses of new technology for sustainable fishing is the increasing usage of drones and fully or partially unmanned vehicles. Drones come in three primary types:

- Unmanned Aerial Vehicle (UAV)
- Unmanned Surface Vehicle (USV)

• Unmanned Underwater Vehicle (UUV)

When assessing fish stocks, drones can be utilized more affordably than naval vessels. Drones can be used to monitor and manage MPAs, giving MPA authorities more affordable and flexible options. Drone monitoring can provide fishery officers with enough information to suspect that an illegal act has occurred, that can aid in gaining prosecution. To exemplify, the French private business CLS in collaboration with European Maritime Safety Agency (EMSA) plans to introduce a multifunctional Unmanned Aerial Vehicle (UAV) to monitor and detect illicit fishing vessels and drug traffickers. Fishing vessels have also utilized drones to locate tuna aggregations illegally in the Pacific Ocean. Drones can be used to check underwater cages for any damage and to monitor offshore fish farms. They are also employed in fish movement tracking, algal bloom detection and water quality monitoring. One of the most common applications for sustainable fisheries is the employment of drones. The fact that international maritime regulations and conventions (such as SOLAS, UNCLOS) make no mention of autonomous (unmanned) vehicles present a barrier to the development of drone technology.

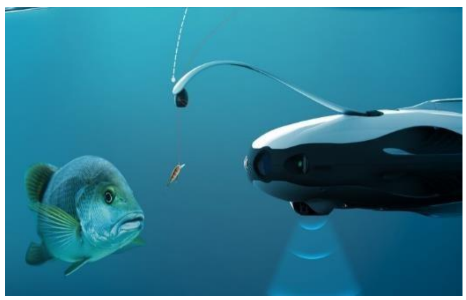

Fig 4: Underwater Drone (Source: Power Vision)

ROBOTIC FISH

The development of fish robots is one of the grueling exploration areas. Along with the designs and materials to be employed, the propulsion medium of the fish robot should imitate the natural movement of the real fish. The design of the robot, its movement pattern, hydrodynamics, control system, machine location, mechanical characteristics and material qualities are some of the factors that should be taken into account while developing robotic fish propulsion (Zhang et al., 2009 and Long et al., 1997). The majority of fish robots that are readily available are modeled after how fish actually move. Bluefin tuna served as a model for Robotuna, the first fish robot ever created (Triantafyllou and Triantafyllou, 1995; Triantafyllou et al., 2000) while yellowfin tuna served as the model for Vorticity Control Unmanned Undersea Vehicle (Anderson and Chhabra, 2002; Anderson and Kerrebrock, 1997). Robotic fish can swim autonomously like a real fish and provide a better perception of fish behavior. It is used to survey damage to underwater structures. The device is equipped with camera to record the resources present in depths of water and sensors to avoid obstructions.

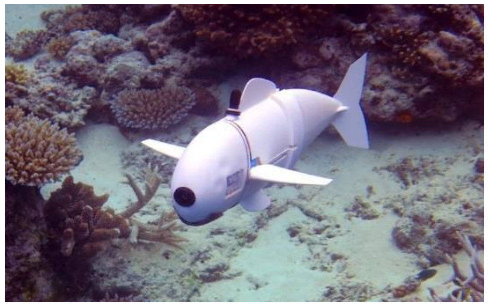

Fig 5: Robotic Fish (Source: Joseph Delpreto, MIT CSAIL)

AUTOMATIC FEEDING SYSTEM

The highest operating expense in aquaculture systems is feed. According to estimates, particulate matter makes up more than 60% of the feed fed to aquaculture systems (Masser, 1992). As sediments break down, oxygen levels drop and harmful substances like nitrogen and ammonia are released, endangering marine life. Applying feed in an aquaculture system requires careful consideration of the feeding schedule. Accordingly, feeding patterns have an impact on fish flesh's proximate composition and feed conversion rates (FCR) as well (Greenland et al., 1979). Yeoh et al. (2010) created an automated fish feeder that can be utilized in commercial aquaculture systems. This device was created to solve the aquaculture industry's labour shortage by introducing a semi-automated method. An automated fish feeder that is affordable and power-free is not available in India. However, Baldwin worked at the Hawaii Institute of Marine Biology to create an automated feed dispenser. Its construction is simple and it doesn't need electricity (Baldwin, 1983).

The following benefits could make this mechanical fish feeder popular in India and other developing nations: The distribution of feed won't be hampered by a manpower shortage; it might be less expensive than alternative methods; fish feed can be added to the pond system at appropriate times by correctly adjusting the feeder; it won't require any expensive or sophisticated components; and it should be fairly easy to build and maintain.

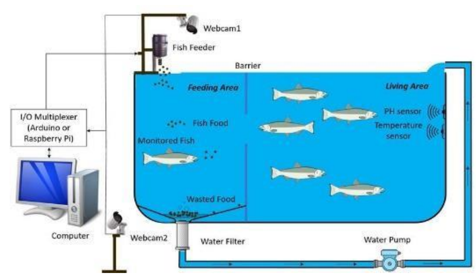

Fig 6: Automatic Fish Feeding System (Source: Mohammed Mastoor Alammar)

iFarm

Cermaq, a Norway-based fish farming giant is making waves in the area of technology with their novel iFarm project. iFarm refers to Individual-based fish farming system which aims to achieve unprecedented levels of fish health and wellbeing. It is predicated on fish photo identification. The objective of this project is to use AI technology to monitor individual fish as well as complete fish cages. It is possible to recognize, record and track individual fishes. This makes it possible to keep an eye on variables that impact fish's health and well-being such as weight, growth rate, sea lice, disease, sores and other conditions. Separating the fish that requires treatment is another option, for example to combat sea lice. Fishes are sort on the basis of weight and the fish which is ready for harvest is separated using sensors.

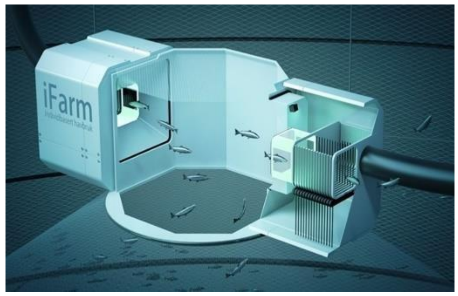

Fig 7: iFarm (Source: Cermaq)

BIOSENSORS FOR THE ASSESSMENT OF FISH HEALTH

Currently, there is a strong push for the investigation and development of biosensors which use electronics and technology to assess the functioning of biological creatures. Technological developments enable the measurement and identification of certain materials even in intricate environments (Yogeswaran and Chen 2008; Windmiller and Wang 2013). To recognize target molecules, biosensors use the molecular components of natural processes such as enzymes and antibodies. By utilizing signal conversion components like electrodes and optical devices, which convert minute changes into electric signals, biosensors can detect these changes and analyze particular target compounds (Grieshaber et al., 2008). In order to assess fish health, biosensors are now being developed due to their high perceptivity and particularity. Over the past few decades, experiments have created and utilized biosensor technology to assess fish health and produce novel diagnostic techniques that have the potential to significantly improve it. Many biosensors for fish health checks have been developed in an attempt to ameliorate the safety of cultured fish in the market.

Likewise, in the contemporary aquaculture sector, it is critical to identify harmful bacteria in fish (Irianto and Austin 2002). Recently, fast detection techniques such as polymerase chain reaction (PCR) and flow cytometry (FCM) were created to identify and quantify harmful bacteria in fish (Chilmonczyk and Monge 1999; Gonzalez et al., 2004).

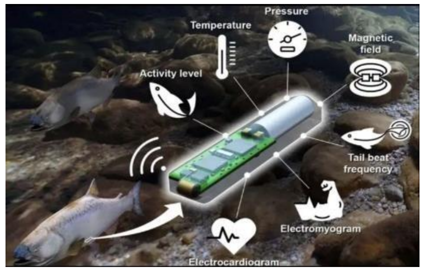

Fig 8: Fish Biosensors (Source: Pacific Northwest National Laboratory)

RAPID VIBRIO SENSOR

Farmers used to rely on lab-based methods to detect vibrio bacteria in their tanks. To help farmers better monitor the conditions of their farms, Institute of Material Research and Engineering (IMRE) team developed the portable Rapid Vibrio Sensor which is capable of detecting bacteria on-site within 30 min. First the water samples are filtered, then a solution containing ultrafine particles is added that binds to vibrio cells, then the sample is washed. The ultrafine particles that bind to the vibrio cells present a colour to the sample.

Fig 9: Rapid Vibrio Sensor (Source: AR BioTech/A*STAR)

BLOCKCHAIN TECHNOLOGIES

Blockchain technology is a distributed, decentralized digital ledger of deals that is duplicated on each network node. It is distributed because it is dispersed across multitudinous participants globally and decentralized because no single authority has complete control over the network. Since centralized ledgers are often held by a single entity, they may be vulnerable to manipulation. A sale is irreversible once it is registered on the blockchain, it cannot be altered without the consent of the majority of the blockchain network. By doing this, the network as a whole and the blockchain itself are guaranteed to protect the sale data. Aside from decentralization, other features of blockchains include persistency, which ensures data cannot be tampered with since it is recorded over all blockchain bumps. Other crucial features include auditability and transparency which refer to the fact that each and every transaction is documented on the blockchain and is auditable at a later time for permissionless blockchains where transactions are visible to everyone.

Because of these characteristics, blockchain technology is becoming an intriguing possibility for supply chain and tracking systems. In its introductory form, a smart contract is a piece of computer generated code that operates within a blockchain network and can take automated action when specific criteria are met without the need for intervention from a third party. Depending on the criteria programmed into it, the executed code in smart contracts can perform a range of functions such as automatically paying one or more parties and transferring ownership of a digital asset from one unit to other.

In 2017, the first use of blockchain technology in the seafood sector was started. The Earth Twine-Stratis Platform is the result of the collaboration of three businesses to develop the first blockchain-based tracking system for the global fish market. This platform targets illicit, mixed use fishing products within the legal product value chain by combining collaborative technologies and increasing fish product traceability.

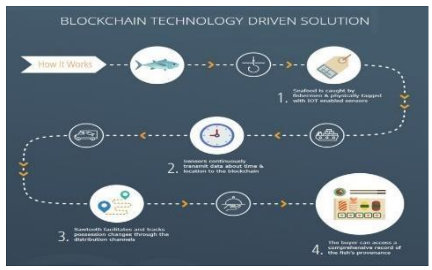

Fig 10: Blockchain Technology (Source: Online)

ReAL Craft (REGISTRATION AND LICENSING OF FISHING CRAFT)

'ReALCraft' is a web enabled work flow based online application system that provides fishing vessels operating along the Indian coast with license certificates under the MFR Act and vessel registration under the MS Act. Security agencies, civilians and other authorized Government machinery would be able to track the status of any Registered Vessel at anytime from anywhere, via the internet or SMS with the complete registration. Open source technology powers this web-enabled system (Department of Fisheries, Government of India, 2023).

Objectives

- To consolidate all the Indian fishing vessels into a single hub.
- To prepare National database for fishing vessels.
- To regulate the movements of fishing vessels.
- To strengthen coastal security and security of fishers in the ocean.
- To stop un-reported, unregistered and illegal vessels from entering territorial waters.
- To facilitate optimum utilization of the fisheries resource.
- Allocation of registration and license certificates electronically.

Fig 11: Real Craft (Source: National Informatics Centre)

GEOSPATIAL TECHNOLOGIES

The collection and management of position-specific Earth surface data is done via Geospatial technology. Three key geospatial technologies are the Global positioning system (GPS), Remote sensing and Geographic information system (GIS). Remote sensing and GPS are techniques for gathering data about the Earth's surface and GIS is a mapping application for data organization and analysis.

1. **Remote Sensing:** Branch of science that derives information about objects from measurements taken from a distance or without physically touching them. The term “Remote sensing” refers to relating earthly features (objects) by identifying the properties of electromagnetic radiation that the earth’s surface reflects. Everything, depending on its physical properties, reflects some of the electromagnetic radiation that is incident onto it. In addition, depending upon their temperature & emissivity, objects also release electromagnetic radiation. Each object has a unique reflectance pattern at different wavelengths. Such a collection of properties is known as the “spectral signature” of the object. An illustration of remote sensing is the Visual perception of objects (Cracknell, 2007).

2. **Global positioning system (GPS):** Global Positioning System calculates the position, course and speed from signals sent from the satellites. The United States department of defense created, operated and maintained the Navigation Satellite Timing and Ranging Global Positioning System or NAVSTAR GPS. The service is available to the public free of cost. The position is reckoned by getting the data from three or more satellites. The Global Positioning System (GPS) is a constellation of twenty-four satellites that makes possible the precise measurement of any place on or near the Earth's surface. Due to their small geolocation, at least four GPS satellites are always visible from any place on the Earth's surface. Every time a satellite sets below the horizon, another one always rises in a different location. GPS has only been extensively used since more reasonably priced GPS receivers were available in the early 1990s (Jules, 2002).

3. **Geographical Information system (GIS**): Geographical information system (GIS) may be defined as an assembly of computer hardware, software, personnel and data that is intended to gather, store, update, alter, analyze and present information. Operations management, decision making and science are supported by an integrated system of computer-based tools for end-to-end processing like data acquisition, storage, retrieval, analysis, display utilizing position on the Earth's surface for interrelation supports (Chang, 2016).

ACOUSTIC DEVICES

Sonar

Sonar or Sound navigation and ranging is a method for communicating, navigating or detecting things on or beneath the water surface by using sound propagation (generally underwater). The Sonar is used for navigation purposes, fish finding, wreck location and salvage, detecting, track and destroying enemy ships and submarines etc.

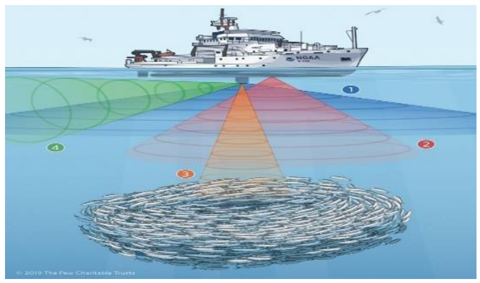

Fig 12: Sonar (Source: NOAA Fisheries)

Echosounder

Echo sounding is the process of determining the depth of water by means of sound pulses. The depth is determined using the known speed of sound propagation through the water and the interval between the emission of a pulse and receiving of its echo is recorded. Echosounder helps in navigation, measuring the depth of water and to find the fish beneath the vessel for fish biomass estimation. In addition to echo sounding, hydroacoustic "echo sounders" are underwater devices that produce active sound and are utilized in fish research. The difference between Echosounder and Sonar is the use of (high-frequency) sound to detect and range targets underwater. Usually, Sonar is used in connection with imaging targets while echosounder refers to just seeing the bottom and is used for body scans.

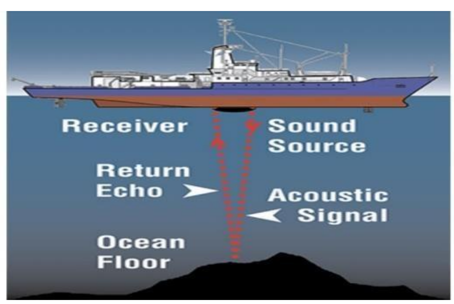

Fig 13: Echosounder (Source: DOSITS)

Hydrophones

A hydrophone is an underwater aquatic device that detects and records ocean sounds from all directions. They pick up sound from a particular direction and can be used to track fish movements. They can also be used to monitor aquatic ecosystems, study marine life, detect submarines or underwater excavation activities.

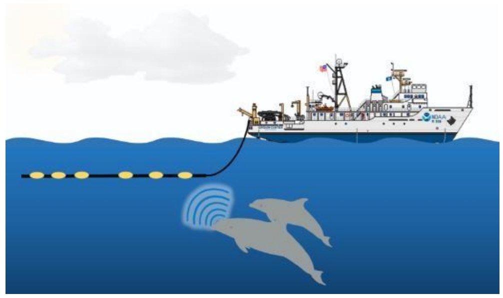

Fig 14: Hydrophones (Source: NOAA Fisheries/Amanda Debich)

TRACKING ENDANGERED SPECIES

Despite the numerous conservation efforts, it is challenging for humans to keep an eye on endangered species due to the wide sea. Tracking endangered marine species by sight is difficult as they are rare. Sound tracking is effective even in locations that are challenging to access. With the help of transmitters and drones, we can track movements of endangered species. This will make it easier for researchers to spot possible dangers and take preventive actions to keep them safe. This facilitates the study of creature behaviour and in conservation of aquatic resources.

Fig 15: An Acousonde TM tag attached to whale via suction cups (Source: NOAA Fisheries/MMPA Permit)

ADVANTAGES

- There is reduction in human errors.
- Automated tasks have almost zero risks.
- The technology is available 24×7.
- It leads to better management of resources.
- There is autonomous monitoring.
- It reduces the labour costs.
- It is possible to detect diseases at an early stage to prevent disease outbreaks.

DISADVANTAGES

- There is high cost.

- There is no creativity.
- New technologies create unemployment for the labours.
- There is no improvement
- Construction cost of automated systems is high.
- It requires more electric energy.

CONCLUSION

Fish farming is the fastest in the world food sector, but as our early-stage start-ups reveal, the industry is still trying to catch up in terms of innovation. By the use of technology great strides in mechanized fisheries are being made. Innovative technologies enable a more comprehensive learning process. For example, best practices can be integrated into insufficient programs for education, training and advice along the value chain. New technologies have also increased public awareness of fisheries, especially in isolated fishing communities. According to Innovation and Acceptance of New Technology, major obstacles have restricted support for new technologies in a large portion of the world's fisheries. But investing in technology can significantly produce more sea food to feed the growing population while reducing the cost. It can also reduce labour cost, increase the superiority of aquatic products and improve productivity. Through automation, aquaculture farms can be operated with approximately 95% accuracy and significantly easier maintenance and management.

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