



FISH TECH DIGEST

An E-Fisheries Science Quarterly Magazine

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**Editor,
Fish Tech Digest**





From the Chief Editor's Desk...

Dear esteemed Authors and Readers,

Greetings from the DIFST

It is with great pride that we present the third issue of Fish Tech Digest (FTD), a beacon of knowledge and innovation in the field of fisheries and aquaculture. At the College of Fisheries Science, St. Devasahayam Institute of Fisheries Science & Technology (DIFST), we remain steadfast in our commitment to fostering scientific inquiry and technological advancements that drive sustainable development in the fisheries sector.

This edition showcases groundbreaking research and expert perspectives on diverse and pressing topics, including: Seaweed integration in shrimp farming for eco-friendly aquaculture, transformative potential of fish hydrolysate in agriculture, ecotoxicological impacts of microplastics, revolutionary role of drones in modern fishing technology, and microfinance interventions for rural poverty alleviation.

These contributions not only highlight the interdisciplinary nature of fisheries science but also underscore the importance of collaborative efforts in addressing global challenges. By bridging research with practical applications, this issue aims to inform policies, inspire innovation, and empower stakeholders across the fisheries value chain.

We extend our deepest gratitude to the authors, reviewers, and editorial team for their dedication and scholarly excellence. Their efforts have made this issue a valuable resource for academics, practitioners, and policymakers alike.

As we look ahead, we invite faculty, scientists, and researchers from fisheries colleges and institutes to contribute their insights to future editions. Together, let us continue to advance the frontiers of fisheries science and technology for a sustainable and prosperous future.

Best regards,

Prof. S. Felix

Chief Editor

Fish Tech Digest

Date : 07.07.2025

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Marine Life: A Potential Source of Drugs

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Abstract:

Terrestrial plant-based medicines possess a recorded history of over 5,000 years; and microbially-derived medicines have been in use for more than a century. On the other hand, the medicinally important compounds from marine biota have recently only been investigated. The discovery of marine natural products started only in the 1950s, and this led to the discovery of only two pharmaceuticals, viz. the anticancer drug, Ara-C, and the antiviral drug, Ara-A, derived from marine sponges. The marine biota producing compounds includes mainly microorganisms such as microalgae (including cyanobacteria), bacteria, and fungi; macroalgae (green, brown, and red seaweeds); mangrove plants and other intertidal plants like halophytes; and sponges, cnidarians, bryozoans, molluscs, tunicates, and echinoderms. This article deals with the medicinal compounds derived from the different components of the marine biota and their bioactivities. The status of the marine drug development in terms of approved marine drugs and the marine drug candidates in phase III, II, and I clinical trials are also presented.

Marine biota and its bioactive compounds

Among the different components of marine biota, the sponges (Phylum: Porifera) have been reported as a treasure house of marine drug candidates. Sponges, cnidarians and microbes are known to contribute more than

50% of the marine bioactive compounds. The percentage contribution of bioactive molecules of the different groups of marine biota is shown in Table 1.

Table 1. Percentage contribution of bioactive molecules of marine organisms

Group of marine organisms	% contribution
Bryozoans	1
Molluscs	2
Tunicates	6
Echinoderms	6
Seaweeds	9
Bacteria, fungi & other microorganisms	18
Cnidarians	21
Sponges	37

Source: Pereira, 2010

Status of the discovery of marine bioactive molecules

The number of marine biota-based compounds isolated has increased considerably over the last two decades. As of December 2020, a total of about 36,000 bioactive compounds have been derived from about 3,400 species of marine biota (Alves et al., 2018). The status of marine bioactive compounds derived from the marine biota from 1965 to 2020 is given in Table 2.

Table 2. Discovery of marine biota-derived molecules during 1965 – 2020

Period	No. of molecules
2017- 20	36,000
2006- 16	29,000
1996-05	18,000
1986-95	10,000
1976-85	3,000
1965-75	Nil

Source: Alves et al., 2018

Major therapeutic properties of marine bioactive compounds

The therapeutic properties of bioactive compounds derived from the different groups of marine biota are given below.

1. Anti-infective
 - i) Antibacterial,
 - ii) Antifungal,
 - iii) Antimalarial (antiplasmodial)
 - iv) Antiprotozoal (antileishmanial and anti-trypanosomal)
 - v) Antitubercular (antimycobacterial)
 - vi) Antiviral (anti-retroviral, anti-herpetic)
2. Anti-tumor (anticancer)
3. Anti-diabetic

4. Anthelmintic (anti-helminthic)
5. Anti-Alzheimer (anti-dementia)
6. Anti-asthmatic
7. Anti-hyperglycemic
8. Anti-hypertensive
9. Angiostatic
10. Anti-inflammatory
11. Antioxidant
12. Anti-cardiovascular
13. Antithrombotic
14. CNS disorders
15. Hepatoprotective
16. Wound healing

Source: Ramesh et al., 2024

Bioactivities of marine biota-derived molecules

Among the bioactive molecules so far described, the anticancer compounds ranked first (64%) followed by antibacterial (14%) and antimalarial (6%). The bioactivity-wise percentages of marine bioactive molecules are shown in Table 3.

Table 3. Bioactivity-wise percentages of marine bioactive molecules

Bioactivity	%
Antiviral	1
Antidiabetic	1
Antioxidant	2
Central Nervous System (CNS) disorders	3
Antifungal	3
Anti-inflammatory	3
Anti-inflammatory	3
Antimalarial	6
Antibacterial	14
Anticancer/Anti-tumor	64

Source: Palanisamy et al., 2017

Approved marine-biota-based drugs

As of 1 July 2025, a total of 16 marine biota-based pharmaceuticals have been clinically approved, and most of these drugs are for the treatment of cancer which is mainly due to the funding by the US National Cancer Institute from the 1960s. It is also worth mentioning

here that the compounds marketed as drugs or that are under drug development are, however, relatively few. That is for every 2000-2700 described bioactive compounds, only one drug is approved (Francesch et al., 2024; Alves et al., 2018). The marine biota-based FDA-approved drugs are listed in Table 4.

Table 4. Marine Biota- based FDA approved drugs. (as on 1 July 2025)

Trademark/ Prescription	Yr of FDA approval	Compound	Chemical class	Source species	Disease area
Cytosar-U®	1969	e (Ara-C)	Nucleoside	<i>Tectitethya crypta</i> (Fig.1) (Sponge)	Cancer: Leukemia
Arasena A®	1976	Vidarabine (Ara-A)	Nucleoside	<i>Tethya crypta</i> (Sponge)	HSV
Prialt®	2004	Ziconotide	Peptide	<i>Conus magus</i> (Fig.2) \ (Cone snail)	Pain
Lovaza®	2004	Omega-3-acid ethyl esters	Omega-3 fatty acids	Salmon, mackerel, herring, sardines, and anchovies. (Fish)	Hypertriglyceridemia
Halaven®	2010	Eribulin Mesylate (E7389)	Macrocyclic ketone	<i>Halichondria okadai</i> . (Fig.3) (Sponge)	Hypertriglyceridemia
Adcetris®	2011	ab vedotin (SGN-35)	ADC (MMAE)	<i>Dolabella auricularia</i> (Fig.4) (Mollusk)	Hypertriglyceridemia
Vascepa®	2012	Eicosapentaenoic acid ethyl ester	Omega-3 fatty acids	Salmon, mackerel, herring, tuna, and sardines (Fish)	Metastatic Breast Cancer
Epanova®	2014	Omega-3-carboxylic acid	Omega-3 fatty acids	Salmon, herring, mackerel, anchovies, and sardines (Fish)	Cancer: Hodgkin's disease, maglinant lymphoma
Yondelis®	2015	Trabectedin (ET-743)	Alkaloid	<i>Ecteinascidia turbinata</i> (Fig.5) (Tunicate)	Sarcoma and Ovarian Cancer
Aplidin®	2018	Plitidepsin	Depsipeptide	<i>Aplidium albicans</i> (Fig.6) (Tunicate)	Multiple Myeloma, Leukemia, Lymphoma
Polivy™	2019	Polatuzumab vedotin (DCDS-4501A)	ADC (MMAE)	<i>Dolabella auricularia</i> / <i>Symploca hynoides</i> (Fig.7) and <i>Lyngbya majuscula</i> (Fig.8) (Mollusk/ cyanobacterium)	Lymphoma, B-Cell lymphoma, Follicular , Non-Hodgkin lymphoma, Chronic lymphocytic leukemia
PADCEV™	2019	Enfortumab Vedotin-ejfv	ADC (MMAE)	<i>Dolabella auricularia</i> / <i>Symploca</i> (Mollusk/ cyanobacterium)	urothelial cancer
Zepzelca™	2020	Lurbinectedin	Alkaloid	<i>Ecteinascidia turbinata</i> . (Tunicate)	Small Cell Lung Cancer

Trademark/ Prescription	Yr of FDA approval	Compound	Chemical class	Source species	Disease area
Aidixi™	2021 (China)	ab Vedotin	ADC (MMAE)	<i>Dolabella auricularia</i> / <i>Caldora penicillata</i> . (Mollusk/ cyanobacterium)	Gastric Cancer, HER2 Overexpressing Gastric Carcinoma, Urothelial Carcinoma, Advanced Cancer, Advanced Breast Cancer, Solid Tumors
TIVDAK™	2021	Tisotumab vedotin-tftv	ADC (MMAE)	<i>Dolabella auricularia</i> / <i>Caldora</i> sp. (Mollusk/ cyanobacterium)	Metastatic cervical cancer
EMRELIS™	2025	Telisotuzumab vedotin (ABBV-399)	ADC (MMAE)	<i>Dolabella auricularia</i> . (Mollusk)	Solid tumors

Source: <https://www.marinepharmacology.org/approved>

ADC (MMAE) : Antibody Drug Conjugate (Monomethylauristatin E);

The species of marine organisms contributed to the development of FDA approved drugs are shown in Figs. 1-8



1



2



3



4



5



6



7



8

1. *Tectitethya crypta*. - Image credit: Dr. Sven Zea. <https://creativecommons.org/publicdomain/zero/1.0/deed.en>
2. *Conus magus* - Image credit: Richard Parker . <https://creativecommons.org/licenses/by/2.0/>
3. *Halichondria* sp. - <https://creativecommons.org/publicdomain/zero/1.0/>
4. *Dolabella auricularia* - Image credit: Philippe Bourjon. <https://creativecommons.org/publicdomain/zero/1.0/>
5. *Ecteinascidia turbinata* - Image credit: Davis, Alison <https://creativecommons.org/publicdomain/zero/1.0/>
6. *Aplidium* sp.-Image credit:jkirkhart35 <https://creativecommons.org/licenses/by/2.0/>
7. *Symploca hynoides* - Image credit: Philippe Bourjon. <https://creativecommons.org/licenses/by-sa/3.0/deed.fr>
8. *Lyngbya majuscula* - Image credit: Philippe Bourjon. <https://creativecommons.org/publicdomain/zero/1.0/>

Marine bioactive compounds in clinical trials

As of 1 July 2025, a total of 25 marine biota-derived compounds have been reported to undergo clinical trials, and the number of compounds in Phase III, II, and I is 5,11, and 9, respectively.

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Traditional Fishing Crafts Operating along Dakshina Kannada Coast

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Abstract

The west coast of India, which includes states like Gujarat, Maharashtra, Goa, Karnataka and Kerala, out of which Karnataka has a long coastline of 343.30 km and abundant marine biodiversity and it offering fishing opportunities. The traditional fishing crafts of Karnataka state particularly Dakshina Kannada coast is essential part of the local fishing communities and represents cultural, economic, and environmental characteristics. These traditional fishing crafts are specifically built to meet the demands of coastal people and also the type of fishing they conduct. These fishing crafts vary in size, shape and design depending on which type of fishing they are conducting. The different types of fishing crafts which are being operated along Mangaluru coast are detailed in this article.

Introduction:

The West coast of India particularly Karnataka state, boasts a 343.30 km coastal length (Ministry of Ports, Shipping and Waterways, 2025). This coast is popularly known as 'Mackerel coast' because of the abundant mackerel (*Rastrelliger kanagurta*) found along this coast. Dakshina Kannada district is situated in Karnataka with the Arabian Sea in the west and the Western Ghats in the east. Mangaluru is one of the largest cities along the Karnataka coast which becoming economic importance due to urbanization and industrialization. It contributes more than 40% of total marine fish landings in Karnataka which making it one of the major landing centre. Various fish species are found along the Dakshina Kannada coast such as *Trichiurus lepturus*, *Sardinella longiceps*, *Rastrelliger kanagurta*, *Megalaspis*

cordyl, *Nemipterus japonicas*, *Mugilcephalus*, *Etroplussuratensis*, *Sphyrænaobtusata* etc. these species are captured using Traditional fishing crafts. According to FAO traditional fisheries involving fishing households (as opposed to commercial fishing), using relatively small amount of capital and energy, relatively small fishing vessels, making short fishing trips, close to shore. Traditional fishing not only contributes significantly to their economy and livelihoods, but also reflects their identity as well as social and cultural significance. In exercising such traditional fishing practices which often have traditional knowledge in managing resources, it plays an important role for conservation and sustainable management of fisheries resources. With this traditional knowledge different traditional fishing crafts are operated along the Dakshina Kannada



coast. These traditional fishing crafts are as follows:

Coracles:

Coracles are locally known as agarala boat. Typically, these coracles are operated in estuaries and rivers. These are small, rounded, lightweight and bowl-shaped made up of natural material like bamboo which can be made water proof by applying a thin layer of coal tar on the plastic sheets and tied properly on the surface of the coracle. The diameter is usually ranges from 6 to 7 feet and weight varies from 10 to 15 kg. The main fish species caught by using these crafts are *Mugilcephalus*, *Etroplussuratensis*, *Sphyraenaobtusata* etc. These traditional boats ensure sustainable fishing using eco-friendly fishing methods. Usually two fishermen can conduct fishing operating using coracle. The cost of coracles is roughly about Rs. 2500/-.



Fig.1. Coracle Operation by Fishermen

Dug-Out Canoe:

Dug-out canoes are locally known as 'Dhoni'. These fishing crafts are simple, made from a single wooden log. These fishing crafts are particularly constructed using mango and aini trees. The length of the craft generally varies from 1.5-4 metres. Slightly bigger craft size is about 7.3 m. These types of crafts are suitable

for estuary, backwaters, and rivers to carry and set fish traps, gill nets, cast nets, and lines. The main fish species caught by using these crafts are *Sardinellalongiceps*, *Rastrelliger kanagurta*, *Sphyraenaobtusata* etc.



Plank Built Canoe:

The boat is spindle shape in structure and made by joining good quality of wooden plank, generally teak wooden planks are joined with iron nails and screws. The size of the boat varies from area to area and respective fishing methods. Generally, two types are distinguished, larger one is about 12 meters and smaller one is about 7m in length. The bottom of the boat is coated with coal, neem oil and kerosene oil to preserve them from foulers and borers. The average life span of such boats is around 15 years. The main fish species caught by using these crafts are *Trichiurus lepturus*, *Rastrelliger kanagurta*, *Megalaspis cordyl*, *Nemipterus japonicas* etc.



Fig.3 Plank Built Canoe

Catamaran:

Catamaran is one of the most iconic and traditional fishing boats used along the coast of Dakshina Kannada. These boats have a

distinct design and are essential to the fishing, particularly in shallow coastal waters, estuaries, and backwaters. Two varieties of catamarans are mainly operated one is 'raft type' and the other one is 'boat type'. In Karnataka coast particularly along Dakshina Kannada coast raft type is commonly used. Raft type is a structure having flat top which floats on water. It is most basic design, characterized by the absence of hull. These types of Catamarans are consisting of 3-5 logs of wood tied with coir ropes. The length of raft catamaran is about 10 m. Mainly small fish species like *Trichiurus lepturus*, *Rastrelliger kanagurta*, *Megalaspis cordyl* etc. were captured by operating these types of crafts.



Fig.4. Raft Catamaran by Operating Fishermen

Rampani:

Rampani is the traditional fishing craft mainly operated along Dakshina Kannada. These types of fishing method started around 1910. These boats are shore seine boats. The length of these boats is more than 16 m. It is known for the operation of pelagic targeted fish species such as *Rastrelliger kanagurta*, *Megalaspis cordyl*, *Sardinella longiceps*, *Trichiurus lepturus*, etc. The term "Rampani" also refers to this particular method of casting nets, and the boats used are part of this traditional fishing method.



Fig.5. Rampani

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NSPAAD: A National Framework for Aquatic Animal Disease Surveillance

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Abstract

The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) is a flagship initiative by the Government of India aimed at safeguarding the country's rapidly growing aquaculture sector from devastating disease outbreaks. With aquaculture emerging as a vital component of India's blue economy, disease threats pose significant risks to productivity and farmer incomes, leading to substantial economic losses. Launched in 2013 and currently in its expanded Phase II under the Pradhan Mantri Matsya Sampada Yojana (PMMSY), NSPAAD employs a comprehensive surveillance system that integrates both passive and active disease monitoring across all States and Union Territories. Coordinated by the ICAR–National Bureau of Fish Genetic Resources, Lucknow, the programme has strengthened disease reporting, early warning mechanisms, and diagnostic networks, while incorporating digital tools such as the “Report Fish Disease” app to empower farmers. This article reviews NSPAAD's funding, achievements, and its pivotal role in enhancing India's aquatic animal health governance, supporting sustainable and resilient aquaculture growth nationwide.

Introduction

India's blue economy is powered by a strong engine: fisheries and aquaculture. However, as output expands and farming systems intensify, disease threats have emerged as the single biggest challenge to productivity and farmer incomes. Early detection remains one of the most effective strategies for combating aquatic animal diseases, and this is possible only through a structured surveillance system. Recognising this need, and to comply with international Sanitary and Phytosanitary (SPS) requirements, the Department of Fisheries,

Ministry of Fisheries, Animal Husbandry and Dairying, Government of India launched the National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) in 2013. Since its inception, NSPAAD has played a pivotal role in strengthening the country's aquatic animal health monitoring framework.

The programme has not only enhanced passive surveillance but also enabled the first-ever detection in India of several emerging pathogens, including Cyprinid herpesvirus-2, Carp edema virus, *Enterocytozoon hepatopenaei*, Infectious myonecrosis virus, *Candidatus*

Actinochlamydia pangasiae, and Tilapia Lake Virus. In essence, NSPAAD represents India's science-driven, nationwide answer to detecting, tracking, and managing aquatic animal diseases in real time.

Funding Sources for NSPAAD

The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) is primarily funded by the Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India.

- ▶ Phase I (2013–June 2020): The main funding came through the National Fisheries Development Board (NFDB), Hyderabad, under the Department of Fisheries.
- ▶ July 2020–March 2022: The programme was funded under the Pradhan Mantri Matsya Sampada Yojana (PMMSY).
- ▶ Phase II (since 2022): NSPAAD is fully supported as a central sector component under PMMSY, with funding allocated directly by the Department of Fisheries, Government of India. The total outlay for Phase II is ₹ 33.78 crores. The programme is coordinated by ICAR–National Bureau of Fish Genetic Resources (ICAR–NBFGR), Lucknow, in collaboration with partner institutions across India.

From Pilot to Pan-India: Advances in Phase II of NSPAAD

Since 2022, under the Pradhan Mantri Matsya Sampada Yojana (PMMSY), Phase II of the National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) has expanded its reach to cover all States and Union Territories. This phase integrates State

Fisheries Departments and strengthens both active and passive surveillance to facilitate timely detection and management of known, emerging, and exotic aquatic pathogens. Coordinated by the ICAR–National Bureau of Fish Genetic Resources (NBFGR), Lucknow, Phase II builds on Phase I's achievements in disease reporting, early warning systems, and laboratory diagnostics. It further introduces a national information management system and farmer-oriented digital tools.

With a total budget of ₹ 33.78 crore, the programme operates through a network of 54 partner institutions, including ICAR research bodies, fisheries colleges, universities, and state agencies, ensuring extensive field-to-laboratory coverage. Key objectives include rapid disease detection, creation of a comprehensive database for international reporting, nationwide surveillance, and broad farmer awareness initiatives.

Battling Aquaculture Diseases: NSPAAD's Mission to Safeguard India's Blue Revolution

Aquaculture has emerged as a cornerstone of India's food security and rural livelihoods, but its rapid growth is under constant threat from diseases that inflict staggering economic losses. Recent estimates reveal that disease outbreaks in shrimp farming alone account for nearly ₹ 7,100 crores in losses. Among these, infections caused by *Enterocytozoon hepatopenaei* (EHP) top the list, draining approximately ₹ 3,977 crores from the sector. The challenge isn't limited to shrimp culture. Freshwater aquaculture, too, bears the brunt of diseases such as argulosis and saprolegniosis, which routinely wipe out stock and reduce farmers' incomes. Clearly, disease management has become one of the most pressing concerns for the future of

aquaculture in India. This is where the National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) steps in. By recognising that *early detection* is the key to preventing the spread of pathogens, the programme strengthens both passive surveillance—based on farmer reporting—and active surveillance, which is carried out whenever needed.

NSPAAD: Strengthening Aquatic Disease Surveillance in India

India's vast size and diverse fisheries made coordinated disease surveillance a major challenge, with no international model to follow. The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) addressed this gap through a strong blend of policy support and scientific expertise. Launched with NFDB funding and led by ICAR–NBFGR, Lucknow, NSPAAD began in 14 states and has now expanded to 19 states, 2 Union Territories, and 31 centres. In just six years, it has built national capacity to detect, monitor, and report aquatic diseases, while providing the Department of Fisheries with evidence-based inputs on exotic species, trade, and emerging health issues (Sood et al., 2021).

Digital Bridge to Farmers: “Report Fish Disease” App

In a significant move to enhance aquatic animal health management in India, Union Minister for Fisheries, Animal Husbandry and Dairying, Shri Parshottam Rupala, launched the “**Report Fish Disease**” mobile application on June 28, 2023. Developed by the ICAR–National Bureau of Fish Genetic Resources (NBFGR), Lucknow, this farmer-friendly app is part of the National Surveillance Programme for Aquatic Animal

Diseases (NSPAAD). It enables fish and shrimp farmers to swiftly report unusual mortality or suspected disease outbreaks on their farms. With just a few taps, farmers can share real-time information—including photos and precise location data—directly with relevant authorities. This digital tool strengthens early warning systems, facilitates rapid response, and helps contain disease outbreaks that otherwise cause significant economic losses in aquaculture.

Working of NSPAAD

The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) is India's flagship initiative for monitoring and managing aquatic animal health. It works through a structured system that combines both passive and active disease surveillance:

1. Passive Surveillance

- ▶ Relies on disease reporting by farmers and hatcheries.
- ▶ Farmers can now use tools like the “*Report Fish Disease*” mobile app to submit information, images, and location data on suspected outbreaks.
- ▶ This helps generate an early-warning system and timely response to prevent disease spread.

2. Active Surveillance

- ▶ Conducted by trained personnel and laboratories across states, focusing on high-risk areas or when unusual mortality is reported.
- ▶ Includes collection of fish/shrimp samples, pathogen detection, and confirmation of emerging or transboundary diseases.



3. Laboratory Network & Diagnostics

- ▶ NSPAAD has established a nationwide network of laboratories linked to ICAR-NBFGR (Lucknow) as the national referral laboratory.
- ▶ These labs are responsible for diagnostic support, standardization of detection methods, and confirmation of pathogens.

4. Capacity Building & Farmer Awareness

- ▶ Regular training, workshops, and awareness campaigns are conducted to sensitize farmers, extension workers, and hatchery operators about disease prevention and reporting.

5. Data Management & Policy Support

- ▶ Surveillance data is consolidated and analyzed to track trends in disease occurrence.
- ▶ Provides evidence-based inputs for policy decisions on aquatic animal health and supports India's compliance with OIE (**World Organisation for Animal Health**) guidelines.

Through this multi-tier system, NSPAAD ensures **early detection, rapid response, and long-term capacity building** to safeguard India's aquaculture sector from devastating economic losses due to diseases.

Some important achievements of NSPAAD include providing farmers with scientific advice based on disease investigations and detecting nine pathogens for the first time in the country. The programme has also established mechanisms for the initial confirmation of exotic and emerging diseases, issued timely advisories to stakeholders upon suspicion of

new diseases, and developed a robust network of aquatic animal health laboratories across the nation.

The Challenge Map: What Needs Solving Next

- ▶ **Emerging and exotic threats:** Climate variability, intensification, and trade dynamics will keep evolving the pathogen landscape, demanding continual upgrades in molecular diagnostics and genomic surveillance.
- ▶ **Data fusion and analytics:** Expanding the national disease information system with AI/ML risk models and geospatial layers can sharpen hotspot predictions and pre-emptive advisories.
- ▶ **Inclusion of overlooked sub-sectors:** Scaling surveillance for freshwater finfish, ornamental trade, and smallholder clusters will further close blind spots in the national picture.
- ▶ **One Health alignment:** Integrating aquatic animal health with environmental and food safety frameworks will future-proof disease governance across the value chain.

Conclusion

NSPAAD represents a crucial pillar in India's efforts to protect and promote sustainable aquaculture amid escalating disease challenges. By combining robust surveillance systems with farmer-centric digital innovations, the programme has significantly enhanced early detection, timely reporting, and effective management of aquatic animal diseases. Its expansion under PMMSY to cover every State and Union Territory demonstrates a strong commitment towards building a resilient aquaculture ecosystem that safeguards

livelihoods and strengthens food security. As India continues to scale up its aquaculture ambitions, NSPAAD's science-driven, nationwide network will remain indispensable in mitigating disease risks, supporting farmer welfare, and sustaining the growth of the blue economy.

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Plankton as Biomonitoring agents in Aquatic Ecosystems

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ABSTRACT

Plankton as biomonitoring agents in assessing the health and quality of aquatic ecosystems and serve as sensitive indicators of environmental changes, such as nutrient enrichment and pollution. It discusses the methodology of aquatic biomonitoring, emphasizing its advantages over traditional chemical analyses by providing comprehensive insights and the cumulative impacts of multiple stressors. Various case studies show evaluating ecological conditions, limitations, future prospectus and pollution levels of diverse aquatic habitats including the development of early warning systems, climate change assessments, and advancements in ecotoxicology.

INTRODUCTION

Aquatic ecosystems are dynamic and complex environments that are highly susceptible to natural and anthropogenic changes. Monitoring the health and quality of these systems is crucial for sustainable management and conservation efforts. One of the most effective and widely used biological tools for assessing water quality and ecosystem health is the use of **plankton as biomonitoring agents**.

Plankton, including phytoplankton (microscopic algae) and zooplankton (small animal organisms), are sensitive indicators of environmental changes such as nutrient enrichment, pollution, and climate variations (Reynolds, 2006). Phytoplankton respond quickly to changes in nutrient levels and light availability, often showing shifts in species composition and abundance in response to eutrophication or toxic contaminants (Katsiapi *et al.*, 2012). Similarly, zooplanktons are influenced by changes in both their food

sources and predation pressures, making them reliable indicators of trophic interactions and ecological imbalances (Jeppesen *et al.*, 2011).

AQUATIC BIOMONITORING

In general, monitoring is a process of repetitive observation, for a defined purpose, of one or more elements of the environment, according to prearranged schedules in space and time, and using comparable methods for environmental sensing and data collection (Oertel and Salánki, 2003). Aquatic biomonitoring is the science of studying the ecological condition of rivers, lakes, streams, and wetlands by examining the organisms that live there. The organisms which are used in biomonitoring are called as biomonitors. These biomonitors provide the means for regular surveillance and to quantify the amount of pollutant present in the environment (Bonada *et al.*, 2006).

The goal of aquatic biological monitoring is to give reliable and proper information on the possible effects of chemicals present in

the water due to human activities, to enable the protection of the aquatic ecosystems, and particularly to provide scientific guidance for legislation and enforcement (Oertel and Salánki, 2003).

Importance: Biomonitoring plays a critical role in the assessment and management of aquatic ecosystems. It offers a more comprehensive and ecologically relevant evaluation of water quality compared to traditional chemical analyses, which often provide only a snapshot of conditions at a given time (Rosenberg & Resh, 1993). Biomonitoring organisms such as plankton, benthic macroinvertebrates, fish, and periphyton respond to both short-term and long-term environmental changes, allowing for early detection of ecological degradation (Bonada *et al.*, 2006). One of the key advantages of biomonitoring is its ability to reflect the cumulative impacts of multiple stressors, such as nutrient pollution, industrial discharge, pesticide runoff, and habitat alteration (Barbour *et al.*, 1999). Biological communities integrate the effects of these stressors over time, thereby providing a more reliable indicator of ecosystem health than chemical measurements alone. In an era of climate change and increasing anthropogenic pressures, biomonitoring is essential not only for detecting pollution but also for understanding biodiversity patterns, resilience, and ecosystem functioning (Baird *et al.*, 2011).

Role of Biomonitoring: Biomonitoring serves as a vital tool for assessing the health and sustainability of aquatic ecosystems. It involves the use of biological responses to evaluate changes in the environment, particularly those caused by pollution, habitat destruction, and climate change. By examining

the composition, abundance, and diversity of aquatic organisms, biomonitoring provides insights into the ecological integrity of water bodies over time (Rosenberg & Resh, 1993). A key role of biomonitoring is in **early detection** of environmental stressors. Organisms such as phytoplankton, zooplankton, benthic macroinvertebrates, and fish show measurable responses to contaminants, eutrophication, and changes in oxygen levels or pH. These bioindicators help identify disturbances that may not be apparent through physical or chemical analysis alone (Cairns & Pratt, 1993). In addition, biomonitoring supports **biodiversity conservation**, tracks long-term ecological trends, and aids in the assessment of ecosystem services. It enables cost-effective and non-invasive monitoring over large spatial and temporal scales (Bonada *et al.*, 2006). With advances in technology such as molecular biomonitoring (e.g., DNA barcoding and environmental DNA), the role of biomonitoring is evolving to become more precise, faster, and applicable to a wider range of aquatic habitats (Baird & Hajibabaei, 2012).

CASE STUDIES IN INDIA

- ▶ Pore *et al.* (2020) observed that a total of 29 phytoplankton taxa belonging to Chlorophyceae (13), Cyanophyceae (9), Bacillariophyceae (5) and Euglenophyceae (2) were observed. As examples, *Coelastrum microporum*, *Pandorina morum* and *Euglena viridis* indicate high levels of organic pollution in Krishnasayar Lake, Burdwan, and west Bengal, India.
- ▶ Kumari *et al.* (2008) observed that a total of 57 genera belonging to 7 groups of phytoplankton and 10 genera belonging to 3 groups of zooplankton were identified

from the lakes. Different patterns of dominance and subdominance of indicator plankton community and species along with physico-chemical quality observed confirms the pollution status of the lakes in Nagpur, Maharashtra.

- ▶ Panigrahy *et. al.* (2007) studied in Chilika Lagoon, Orissa used plankton as indicators to evaluate salinity gradients and pollution effects. Seasonal changes in phytoplankton (e.g., dominance of *Skeletonema* during saline periods and *Microcystis* in freshwater zones) reflected both natural fluctuations and anthropogenic influences such as aquaculture effluents.
- ▶ Madhu *et. al.* (2007) studied in Vembanad Lake, Kerala, and found that changes in zooplankton community structure (increased rotifer abundance and reduced copepod diversity) reflected elevated organic pollution and altered salinity due to human activity and climate variability. This highlighted the use of zooplankton as indicators of ecological stress in tropical estuarine systems.
- ▶ Anjana & Rao, (2006) observed that regular monitoring of phytoplankton in Hussainsagar Lake (Telangana) revealed periodic blooms of cyanobacteria (*Microcystis aeruginosa*), indicating heavy eutrophication from urban runoff and sewage discharge. Chlorophyll-a and species shifts were used as indicators of declining water quality
- ▶ Trivedi & Goel, (1986) studied in phytoplankton community analysis in the Yamuna River (Delhi region) showed low diversity and dominance of pollution-tolerant species such as *Oscillatoria* and

Microcystis. These cyanobacteria indicated high nutrient loads and organic pollution from untreated sewage and industrial effluents.

LIMITATIONS OF BIOMONITORING IN AQUATIC ECOSYSTEMS

- ▶ Seasonal variations may affect consistency.
- ▶ Requires trained taxonomists.
- ▶ Influenced by non – pollution factors (light, temperature, and salinity)
- ▶ Reliance on accurate species identification

FUTURE PROSPECTS

Early Warning Systems: Detect water quality degradation early, predict harmful algal blooms (HABs), Helps protect aquatic life and human health.

Climate Change Assessment: Long-term tracking of plankton shifts, Measure impacts of warming, acidification, and Key to understanding ecosystem resilience.

Ecotoxicology: Detect effects of microplastics, chemicals, sensitive indicators for emerging pollutants, monitor aquatic ecosystem risks.

Biotic Indices: Develop new plankton-based indices, quantify ecosystem health, and similar to benthic or fish indices.

Aquaculture & Water Supply: Monitor harmful plankton in fish farms, Ensure safe drinking water sources, and early detection of contamination.

CONCLUSION

Water resources are being polluted day by day, due to the increased human population, industrialization uses of fertilizers in agriculture and other man-made activity is one

of the reasons for the pollution of water bodies. The water bodies provide valuable ecosystem services, such as water supply, production recreation and aesthetics. Having it available in sufficient quantity and quality contributes to the maintenance of health. Meanwhile an anthropogenic activity deteriorates surface waters. Plankton plays a crucial role in aquatic biomonitoring. Their community structure is a natural indicator of ecosystem health. Integrating plankton-based assessments with physical and chemical water quality analyses offers a holistic approach to environmental monitoring. Integration of technology, data science, and policy needed toward sustainable and responsive aquatic management.

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Smart Fishing: How Technology is Transforming Fisheries Management

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Abstract:

The traditional practices in fisheries are evolving rapidly with the introduction of smart technologies. From satellite-based fish tracking to AI-driven stock assessment, technology is reshaping how we manage, monitor and sustain fishery resources. This article explores how modern innovations are helping fishermen, researchers and policymakers make data-informed decisions to ensure sustainable fishing practices.

Introduction

Fisheries have played a vital role in supporting livelihoods, ensuring food security and contributing to the global economy for centuries. In countries like India, where a large population depends on fishing and aquaculture, the sector contributes significantly to rural employment and nutrition. However, in recent decades, the growing challenges of overfishing, illegal fishing practices, habitat degradation and climate change have severely threatened the sustainability of marine and inland fishery resources.

As these challenges intensify, there is an urgent need to move beyond traditional, manual methods of fisheries management. Enter the era of **Smart Fishing**—a new approach that integrates advanced technologies such as satellite imaging, artificial intelligence (AI), the Internet of Things (IoT), drones and data analytics into fisheries science. These tools enable better monitoring, resource planning and decision-making, which can lead to more efficient, equitable and sustainable fisheries.

The transformation is not just scientific but social and economic as well. Technology is

helping bridge the gap between policymakers and local fishers, giving them real-time access to information, weather updates, market prices and catch data. Mobile applications, digital fish markets and smart aquaculture systems are becoming everyday tools for many fishing communities.

Modern technologies are revolutionizing fisheries management and operations in unprecedented ways. With improved access to real-time data, smarter decision-making tools and innovative methods for monitoring and planning, both small-scale and commercial fishers are better equipped to navigate today's challenges. From oceans to inland waters and from fishers to consumers, smart tools are building a more connected, efficient and environmentally responsible fisheries sector.

1. Satellite and GPS Tracking in Fishing

Satellite imaging and GPS tools are revolutionizing how fishers operate. With **real-time ocean data**, such as sea surface temperatures and chlorophyll levels, fishers can locate fish-rich zones more accurately and reduce fuel usage and search time.



Example: The Indian National Centre for Ocean Information Services (INCOIS) provides **Potential Fishing Zone (PFZ)** forecasts using satellite data.

2. Mobile Apps and e-Diary Tools for Fishers

Mobile apps allow fishers to log catches, monitor weather and even check market prices instantly. These tools are particularly valuable in empowering small-scale fishers who may lack access to formal data systems.

Example: Apps like **FishLog** and **Fisher Friend Mobile App** (developed by MSSRF) support safe and informed fishing.

3. Artificial Intelligence (AI) for Stock Assessment

AI and machine learning algorithms can analyse large datasets from trawlers, sensors and remote devices to predict fish population dynamics. This aids in setting sustainable fishing quotas and avoiding overfishing.

Example: AI models are used to process underwater video footage to estimate species composition and abundance automatically.

4. Drones and Underwater Robots

Drones are used to monitor fish farms and coastal waters, while **underwater robots (ROVs)** inspect deep-sea habitats, collect samples and record videos. This non-invasive surveillance is key to ecosystem conservation.

5. Blockchain for Transparent Supply Chains

Blockchain technology ensures traceability of fish from sea to plate. Consumers can now know where their seafood comes from,

how it was caught and whether it's from a sustainable source. This enhances **consumer trust** and ensures **fair trade practices** across the value chain.

6. Smart Sensors in Aquaculture

Smart sensors are becoming increasingly common in aquaculture systems. These devices can monitor **water temperature, dissolved oxygen, pH, ammonia levels** and feed usage in real time. The data collected helps farmers maintain optimum water quality, reduce fish stress and increase productivity.

For example, **IoT-based smart cages** are being used in shrimp and tilapia farming to send alerts when water parameters cross safe limits, allowing timely interventions.

7. Data-Driven Fisheries Policies

Reliable data is the backbone of effective fisheries management. Governments and research institutes are now using data analytics and geographic information systems (GIS) to map fish habitats, assess stock health and predict seasonal migration patterns.

This leads to more informed policies such as **closed seasons, marine protected areas (MPAs)** and **species-specific quotas** aimed at conserving fish populations.

8. Eco-friendly Innovations and Bycatch Reduction

Smart fishing gears, such as **selective trawls** and **LED light traps**, help reduce **bycatch**—the unintentional capture of non-target species. These tools not only protect endangered marine life but also ensure compliance with environmental regulations.

In many countries, innovations like turtle excluder devices (TEDs) and fish size selectors are now mandatory in large-scale operations.

9. Training and Digital Literacy for Fishers

For technology to be truly transformative, it must reach the hands of those who need it most. Many organizations are working to train fishers in using mobile apps, digital maps and electronic logbooks.

Initiatives by NGOs and government bodies are helping improve **digital literacy**, enabling fishers to make better business decisions and reduce risks at sea.

Advantages of Smart Fishing Technologies

The integration of smart technologies into fisheries and aquaculture offers a wide range of benefits. These advantages not only improve operational efficiency but also contribute to ecological balance and socio-economic development.

1. Improved Fish Catch Efficiency

Smart tools like GPS, sonar and satellite-based forecasts help fishers locate fish-rich areas more accurately. This reduces time spent searching and increases the quantity and quality of catch.

2. Sustainable Resource Management

Technologies such as AI-based stock assessments and GIS mapping support evidence-based decision-making. This ensures fishing limits are set appropriately, preventing overexploitation of fish populations.

3. Better Monitoring of Water Quality

In aquaculture, real-time sensors help maintain ideal water conditions. This leads to healthier fish, reduced disease outbreaks and less environmental impact from excess feed and waste.

4. Reduced Fuel and Operational Costs

With precise fishing zone forecasts and route optimization, fishers can cut down on fuel usage and labour costs, making operations more economical and eco-friendlier.

5. Transparency and Traceability

Blockchain and digital traceability systems help track fish products from catch to consumer. This builds trust, ensures food safety and opens up new export markets that require proof of sustainability.

6. Early Warning and Risk Reduction

Smart weather forecasting tools and alert systems allow fishers to avoid dangerous conditions, reducing risks to life and property at sea.

7. Empowerment of Fishers

Digital tools, mobile apps and e-learning platforms help small-scale fishers access market information, government schemes and training resources—strengthening their role in the fisheries value chain.

Conclusion

Smart technologies are not replacing traditional fishing wisdom—they are enhancing it. By combining data, innovation, and local knowledge, the fisheries sector can

achieve sustainability, profitability, and food security. However, accessibility, training, and infrastructure remain crucial for inclusive tech adoption. As we navigate climate uncertainty and resource limitations, **Smart Fishing is not just a trend—it's the future.**

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Fish, Folk, and Future: Life and Livelihoods at Chinnamuttom Fishing Harbour, Kanniyakumari

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1. Introduction

Chinnamuttom Fishing Harbor, located on the eastern coast of Kanniyakumari district in Tamil Nadu, represents a vital intersection of economic activity, community tradition, and ecological significance for the southernmost tip of the Indian subcontinent. Since its establishment, the harbor has functioned as the sole designated commercial fishing center in the district, supporting mechanized boat operations and serving as a central hub for regional marine fisheries (Bierhuizen, 2000; Bay of Bengal Programme, 1997). The daily routines of local fishers, guided by generational knowledge and a deep connection to the ocean, underscore the harbor's role as both a source of livelihood and communal identity. As articulated by members of the fishing community, the sea imparts lessons of resilience and collective hope, shaping social and economic dynamics along the coast (Bierhuizen, 2000). Moreover, the significance of Chinnamuttom extends beyond local boundaries, facilitating fisheries integration and resource distribution across the broader Kanniyakumari region, while remaining closely interlinked with ecological stewardship and cultural continuity (BOBP, 1997).

2. Location and Significance

Chinnamuttom is situated on the eastern side of Kanniyakumari district, Tamil

Nadu, and holds the distinction of being the only fishing harbour in the district. It serves as the primary base for mechanised fishing operations across this southernmost stretch of India. While only 24 mechanised boats are registered locally, the harbour functions as an important regional hub, with the majority of vessels operating here owned by fishermen from other coastal villages (Bierhuizen, 2000; Bay of Bengal Programme, 1997).

3. Historical Background

The foundation of Chinnamuttom Fishing Harbor dates back to the early 1980s, conceived to support the developing fleet of mechanized boats in Kanyakumari district, which previously lacked adequate facilities. Construction was completed in 1994, with shared funding from the Government of India, and the total cost amounted to ₹ 684.70 lakhs over a decade (BOBP, 1997). With its completion, the harbour brought much-needed stability and development to the region's fisheries sector.

4. Overcoming the 2004 Tsunami

The devastating Indian Ocean tsunami of December 26, 2004, struck Tamil Nadu's coast with massive waves that damaged or destroyed much of Chinnamuttom Harbor's infrastructure. Boats were washed away, critical facilities were ruined, and many

lives and livelihoods were tragically lost (MPEDA, 2021). Nevertheless, the spirit of the community was not broken.

In the result, robust support arrived from a mix of government agencies, NGOs, and international organizations. Recognizing the harbour's significance, state authorities undertook a thorough reconstruction project, partly funded by the World Bank under the Emergency Tsunami Reconstruction Project (ETRP). The harbour was strengthened through the extension of the old eastern breakwater and the addition of a western breakwater, providing much-needed protection from future natural disasters. Furthermore, new facilities such as landing structures, auction halls, net mending and gear locker sheds, and upgraded waste management systems brought the harbour up to modern standards. Expanded capacity allowed for 150 more motorized boats, benefitting approximately 1,500 fishermen, while additional environmental safeguards helped ensure the harbour's sustainability. The large-scale renovation, costing around ₹70.97 crore, became a beacon of resilience and renewal for the local community (Tamil Nadu SCZMA, 2012).

5. Fish Production and Fishing Operations

Chinnamuttom Harbour plays a pivotal role in Kanniyakumari district's marine fisheries, acting as the main landing site for the majority of the district's catch. In the late 1990s, marine fish production reached approximately 42,125 tonnes, centered around Chinnamuttom (BOBP, 1997). More recently, the harbour continues to contribute significantly to Tamil Nadu's overall marine

fish output, and ongoing investment in infrastructure continues (Tamil Nadu Agricultural University [TNAU], 2014).



Fig 1: Major captured fish sorted on a boat.

5.1 Fishing Activity and Fleet

Fleet Composition: Only 24 mechanised boats are registered locally, but the harbour services about 370 boats, with nearly 280 boats going out to sea daily (Bierhuizen, 2000).

Boat crews typically consist of 20 workers, of whom about 15 are migrant workers hailing from West Bengal, Odisha, Bihar, and Andhra Pradesh—summing to an estimated 2,500–3,000 migrant workers at the harbour. Local fishers also participate from nearby areas such as Tuticorin, Tharuvaikulam, and Chettikulam.

Daily wages are ₹1,000 for workers and ₹3,000 for the pilot/operator, regardless of fishing season.

5.2 Fishing Practices and Gear

Fishing trips extend up to 30 nautical miles and last 3–4 hours. Total operational costs per trip are around ₹120,000, with ₹90,000 allotted for diesel.

The main gears used are longlines for shark and grouper, handlines for rockcod and squid/cuttlefish, drift nets for tuna and seer fish, and bottom/mid-water trawls for squid/cuttlefish and shrimp (Bierhuizen, 2000).

The average yield is 4 tonnes per trip, with about 650kg as bycatch. In more recent years, Chinnamuttom continues to be a significant contributor to Tamil Nadu's overall marine fish output, which was estimated at around 432,000 tonnes in 2013–14 and The Government has granted administrative approval for the expansion of the Fishing Harbour at Chinnamuttom in Kanniyakumari District, with an estimated project cost of ₹73.52 crore (Tamil Nadu Agricultural University, 2014). Ongoing investment in harbour infrastructure and fish handling facilities is further enhancing the region's fish production capacity.



Fig 2: Fishers sorting fresh catch on the boat.

6. Environmental and Seasonal Dynamics

During the southwest monsoon, fishing is restricted due to high waves. July to September is the peak fishing season, yielding about 40% of landings, while activity weakens in October–November. Main coastal catch species include squid, cuttlefish, carangids, ribbon fishes,

sardines, sharks, rock cods, and breams (BOBP, 1997).

6.1 Ecological Significance: Phytoplankton Diversity

Between June 2015 and May 2016, researchers found 74 species of phytoplankton in open waters and 59 on ship hulls, dominated by diatoms. Phytoplankton peaks in summer at 34,000 cells per liter and declines during the monsoon. These communities are crucial to the marine food web and support fisheries productivity (Nithya et al., 2023).



Fig 3: Fishers sorting fresh catch on a boat at night.

6.2 Water Quality and Harbor Management

Seasonal monitoring from October 2019 to February 2020 highlighted significant fluctuations in Chinnamuttom Harbor's water quality. For instance, total dissolved solids (TDS) ranged from 3,500 to 3,720 mg/L, peaking in February, reflecting changes in salinity and runoff. Hardness levels consistently remained above 520 mg/L, driven by elevated calcium and magnesium concentrations, while alkalinity reached up to 456 mg/L, providing stability against sudden pH changes. The pH value itself stayed neutral to slightly basic, suitable for marine life.

Heavy rains during the monsoon season resulted in increased chloride and sulphate levels due to runoff from surrounding areas. Temporary spikes in ammonia and iron were observed, coinciding with periods of ship repair and inadequate waste disposal. These changing parameters illustrate the impact of urban and harbour-related activities, such as fuel spills and unmanaged waste, on local water quality. This underscores the need for regular water quality monitoring and better waste management to safeguard marine resources and community livelihoods (Asha & Thusnavis, 2021).

7. Primary Fish Landings

Chinnamuttom Harbor is renowned for its diverse and abundant fish catches, making it

a critical hub for both local consumption and trade. Local surveys and official landing data indicate that shrimp are the most frequently caught species, with roughly three-quarters of fishing groups listing them among their top catches. Squid and cuttlefish also feature prominently, especially due to their high demand both in India and abroad. Seer fish (Spanish mackerel), skipjack tuna, and grouper are other major contributors to the harbor's daily landings. Additionally, a variety of other fish fill the nets, such as sharks, carangids (jacks), ribbon fish, sardines, rock cods, and breams. These species support a dynamic seafood market and contribute to the livelihoods of fishermen, traders, and exporters (Table 1) (BOBP, 1997; MPEDA, 2021).

Table 1: List of commercial fish

S.No	Common Name	Scientific Name
1	Shrimp	<i>Penaeus monodon, Parapenaeopsisstylifera</i>
2	Squid	<i>Loligoduvaucelii</i>
3	Cuttlefish	<i>Sepia aculeata</i>
4	Seer fish (Spanish mackerel)	<i>Scomberomorus commerson</i>
5	Tuna	<i>Thunnus albacares, Euthynnusaffinis</i>
6	Grouper	<i>Epinephelus malabaricus, Epinephelus tauvina</i>
7	Shark	<i>Carcharhinus</i> spp. (Blacktip, Milk shark, etc.)
8	Mackerel	<i>Rastrelligerkanagurta</i>
9	Rock cod	<i>Epinephelus areolatus</i>
10	Sardines	<i>Sardinella longiceps</i>
11	Carangids (trevally, scad)	<i>Caranx</i> spp., <i>Decapterusrusselli</i>
12	Ribbon fish	<i>Trichiuruslepturus</i>
13	Breams	<i>Nemipterus japonicus, Lethrinus</i> spp.
14	Pomfret	<i>Pampus argenteus, Pampus chinensis</i>
15	Anchovy	<i>Stolephorus indicus</i>
16	Barracuda	<i>Sphyraena barracuda</i>
17	Lobster	<i>Panulirushomarus, Panuliruspolyphagus</i>
18	Lizard fish	<i>Sauridatumbil</i>

7.1 On-field Observations & Prices

The price table highlights the relative market value of key commercial species landed at Chinnamuttom Harbour. High-value species such as squid, seer fish, breams, and certain pelagic fishes are in greater demand and fetch premium prices, particularly in export markets. Mid-range prices are observed for commonly landed species like mackerel, carangids, and lizard fish, reflecting their steady local and regional consumption. Bycatch species yield comparatively lower prices, indicating their lesser commercial priority. Overall, the table reflects how species type, market demand, and intended use (local consumption vs. export) influence the economic returns for fishers (Table 2).

Table 2: Prices of the commercial fishes

S.No	Fish	Price (₹ / 25 kg)
1	Squid	3,000–7,000
2	Seer fish	1,500–3,000
3	Mackerel	1,200–2,000
4	Carangids	1,200–3,000
5	Breams	1,400–6,000
6	Lizard fish	1,500–2,000
7	Bycatch	600

8. Fish Handling, Storage, and Transport



Fig 4: Fish being auctioned for sale.

Catches from Chinnamuttom are transported to multiple destinations, including Chennai, Namakkal, Tiruchirappalli, and other interior towns. Ice availability is high, with 71 ice plants situated near the harbour, enabling effective cold chain maintenance from catch to market.

9. Daily Life and Coastal Narratives in Chinnamuttom

The daily life of a Chinnamuttom fisherman is a testament to hard work and adaptability. Most fishermen leave home before sunrise, some as early as 3:30 AM, spending long hours on the water before returning late in the evening timing their activities by the tides and seasonal fish movements. Once landed, the day's catch is quickly auctioned off. Auctions at the harbour are lively events, attracting not just local buyers but also traders from Kerala, especially during periods when fishing bans or seasonal shortages occur there. This arrival creates high demand and occasionally drives up prices, particularly for export-grade species like squid.

Preserving these fresh catches is a logistical challenge, handled by local cooperatives and mobile vendors who transport ice from nearby towns such as Madhavapuram and Osaravillai. Maintaining a reliable cold chain ensures that fish reach markets in prime condition.

Recent improvements in harbour infrastructure, including upgraded transport access, better maintenance, and active traffic management by police, have considerably streamlined daily operations and reduced congestion at busy times. These enhancements reflect the government's ongoing commitment to supporting the local fishing industry.

Despite such progress, fishermen express concerns about declining fish stocks. Whereas past generations regularly returned with overflowing containers of fish, today's landings are smaller, attributed to overfishing and environmental changes. During the enforced closed season, meant to protect marine breeding cycles, the Tamil Nadu government offers the "Fishing Ban Period Relief Fund, providing ₹6,000 in financial support to each eligible fisherman. While this amount is modest, it is a vital lifeline during periods without income.

The harbour remains closely tied to the Roman Catholic Paravar community, whose fishing heritage spans centuries. In the poetic words of a local fisherman: "In those nights with hardly anyone else, I have marvelled at her beauty under the moon's company."

Daily harbour operation depends heavily on migrant labour, reflecting Chinnamuttom's role as a regional fishing hub rather than just a local landing site. Workers come from multiple states, forming a diverse, multi-lingual workforce that mirrors broader patterns across Tamil Nadu's mechanised fishing sector.

Conclusion

Chinnamuttom Harbor is more than just a harbour it is the soul of a tough and tradition-rich community. Having risen stronger from the devastation of the 2004 tsunami, it continues to adapt to new environmental and economic challenges. The harbour's future depends on maintaining its ecological balance, improving infrastructure, and supporting its proud fishing heritage, ensuring hope and opportunity for generations to come.

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Mud Crabs as Vectors: Cross-Species and Human Health Implications of Open Pond Culture in West Bengal

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Abstract:

Open-system mud crab (*Scylla* spp.) farming in West Bengal has rapidly expanded as an alternative livelihood for small scale farmers, yet it poses substantial pathogenic and zoonotic risks due to limited biosecurity and reliance on wild-caught seed. This review examines the major bacterial, fungal, and protozoan pathogens prevalent in non-captive crab culture systems and analyzes their role as potential vectors to other commercially important crustaceans such as shrimp and prawns, and the possibility of zoonotic transmission to humans through handling and consumption. The open exchange with natural waterways, coupled with poor management practices, may leads to disease outbreaks, resulting in significant economic losses, export rejections, and health hazards for farmers and local consumers. Socio-economic impacts are particularly severe on small-scale and traditional farming households, who face higher occupational exposure and limited access to modern hatcheries or healthcare. The article highlights the urgent need for farmer education, regulatory oversight, and hatchery development, and calls for “One Health” approaches integrating aquaculture, environment, and public health objectives for a sustainable and safe mud crab sector in West Bengal.

Introduction:

Mud crab farming in West Bengal is practiced by a small fraction (less than 5%) of the state’s aquaculture farmers, primarily through short-cycle fattening. Despite its small scale, it contributes a disproportionately high value to the state’s aquaculture sector due to export demand and high price, delivering vital supplementary income to thousands of vulnerable coastal households—particularly in the Sundarbans and surrounding districts. Estimates from the Ministry of Commerce and Industry reported India’s total seafood exports at 1,618,700 tons in 2021-22, valued at ₹57,586.48 crore (about \$7.8 billion) and west

Bengal achieved an annual production of 6,938 tons of farmed and fattened mud crab, with strong export orientation (MCI,2024)(Saha and Dash, 2021) when compared to its potential it was too low. This 5% of the total aquaculture production contributes between 7–10% of the harvest value, reflecting crab’s high market price and export orientation.

Export earnings from mud crab are estimated at ₹250–300 crore per year from the state alone (Raj, et al.,2025) (Dana, et al.,2023). It is an emerging sector in West Bengal’s aquaculture with *Scylla serrata* (green mud crab) being the most preferred choice due to its high growth potential (>1kg) compared to other species like

S. olivacea, *S. tranquebarica*, and *S. paramamosain*. The major crab-producing blocks (North & South 24-Parganas, Purba, Medinipur) are directly engaged in mud crab cultivation or fattening due to the access to water from the Hoogly and Matla rivers. Most of these operate as a supplementary occupation alongside shrimp, finfish, or traditional capture fisheries. They usually follow the 3 culture methods: Grow-out systems (juvenile to adult in 5-6 months), Fattening operations (Water crab to meat crab in 15 – 20 days), Soft-shell crab production. Out of these fattening operations (90%) are the most profitable (7-8 cycles/year), making it highly profitable for small-scale farmers than grow out culture (10%) (Lalramchhani, et al., 2019). Due to their resilience and ability to endure extended periods out of water (approx 4 days) in low temperatures, they are well suited for export to both foreign and domestic markets. Furthermore, mud crabs are less prone to diseases than other commercially farmed crustaceans like shrimp, relatively easy to farm, but with a longer growing period (Salam, et al., 2012) (Saha, et al., 2023). The majority of their commercial production is delivered live to market, making them one of the most trustworthy freshly caught crustaceans available in the native market (Saha, et al, 2021).

Recent efforts have shifted towards cultivating meaty crabs (over 300 g) by vertical RAS system and box culture (the act of culturing crab in a box to avoid cannibalism), yet most farmers still rely on open aquaculture systems such as happa, ponds, for their culture. Crab culture methods in the region rely primarily on wild seed collection rather than hatchery-produced juveniles (Dana, et al., 2023). The implementation cost of an RAS system constrains the small-

scale farmers from adopting the new effective technologies. Due to the lack of crab hatcheries in West Bengal, farmers rely on the wild-caught seed stocks (crab instar and crablets) for stocking (Saha, et al., 2023).

Cultural practice in West Bengal

In West Bengal, Mud crabs have been cultured in various ways, from very extensive to intensive, monoculture to polyculture; and farm sites that range from mangrove forests to well-built aquaculture ponds or fattening cages, seed stock gathered from the wild as



Figure 1: Grow-out pond setup

Source: (Jithendran, et al., 2010)

well as produced in a hatchery (Saha, et al, 2021). Most of the farmers around the North 24 Parganas, South 24 Parganas, and Purba Medinipur depend on their brackish water resources for their livelihood. They collect wild seed from brackish water mangrove estuaries, and a high portion of the population is doing the extensive and semi-intensive farming, with as little as 3.33 percent of the population doing the intensive farming (Rahman, et al., 2020). Only 16.67 percent of the farmers cultivate the mud crab throughout the year, and the peak culture period is mentioned to be November to January (Saha, et al, 2021). Almost the majority of the seeds are collected from the wild, with most of the seeds from the South 24 Parganas district collected by seed

collectors(middlemen) (Salam, et al., 2012). Among farmers, a substantial proportion of women play a critical role in seed collection, nursery operations, and post-harvest handling, with the activity providing valuable alternative or supplementary income—up to 25–50% higher annual household earnings compared to fishing or conventional aquaculture alone (Raj, et al.,2025). The dominant fattening method involves collecting post-molt wild crabs, often undersized (water crab), then rearing them in pens, bamboo cages, or earthen ponds for 20–45 days using trash fish (usually fish offal,



Figure 2: Polyculture with shrimp(*p.monodon*) and sea bass(*L.calcarifer*)

bycatch, or mollusks) until they reach the desired market weight and conditions. This approach provides for multiple crab cycles and rapid income turnover. This provides them with financial flexibility and allows them to participate in the high market area. Since the initial establishment of the box culture of crab is very high, most of the farmers are doing polyculture practices of mud crab with other species like *L.calcarifer*, *P.monodon*, and *P.vannamei*. In this practice, mud crab is not a major target species of culture due to its cannibalistic nature, and keeping it only serves as an additional income booster.

Pathogen profile of mud carb in West Bengal

The ecosystem of West Bengal's Sundarbans offers ideal nursery and grow-out grounds;

here, mud crabs benefit from abundant natural feed and brackish water conditions, but these same characteristics also present challenges relating to the sustainability of seed supply, disease management, and the mitigation of environmental impacts arising from



Figure 3: Chitinolytic bacterial infection by *vibrio* species Source: (Jithendran, et al., 2010)

Most mud crab farming is low-tech and heavily reliant on wild-caught seed—juveniles and sub-adult crabs are harvested from natural tidal creeks, estuarine mudflats, and mangrove swamps before being transferred to enclosures and ponds for grow-out and fattening, respectively. This practice, while lucrative due to the quick turnover and high live-crab market value, exerts pressure on wild crab populations



Figure 4 : *S. tranquebarica* baby crabs with algal mass and *Zoothamnium* sp. on exoskeleton.

Source: (Jithendran, et al., 2010)

and raises ecosystem sustainability concerns (Jithendran, et al., 2010) (Coates, et al., 2022). Little attention was given to disease control in cultured crab populations and seed production facilities (Raj, et al., 2025). Discharged untreated effluents from industry, households, the agricultural and aquacultural fields directly or indirectly mingle with water bodies (river, sea, estuary, mudflat), making them susceptible to pathogens and causing a steady decline in immunological health (Saha, et al., 2021).

Mud crabs are susceptible to a number of diseases that are brought on by viruses, bacteria, fungi, and protozoa, including the deadly white spot syndrome, shell disease, sleeping disease, and baculovirus infection. In general, pathogenic infections are characterized by shell decoloration, incomplete moulting, and blackened ovaries. The infections may occur at each stage of the mud crab, but it is difficult to diagnose by morphological characteristics. Most naturally occurring viral infections, such as the white spot syndrome in mud crab, are 5% while in cultured farms, it is as high as 30% due to the increasing stocking technique and extensive polyculture technique followed by the farmers. The three most common fungi (Lagenidium, Atkinsiella, Haliphthoros) have been reported for fungal diseases in mud crabs.

Such fungal diseases generally cause loss of the egg mass and problems in hatching, affecting the wild seeds. Zoothamnium, Vorticella, and Epistylis are the ciliate protozoans present in gills. Such protozoans create problems during the hatchery phase of mudcrab culture, mainly on the egg and larval stages, resulting in a reduction in the feeding rate (Saha, et al., 2023). In various cases, mass mortality of farmed mud crab stocks has been reported frequently (Poornima, et al., 2011). Case study from the (Saha, et al, 2021) indicates the occurrence of the muscle necrosis virus (MNRV) in the semi-intensive crab farming in West Bengal villages, and they are more susceptible to the fungal infection as they are benthic in nature. Muscle necrosis reovirus (MNRV) is a major causative agent for sleeping disease in crab, which can cause 80 to 100% mortality. (Liew, et al., 2023) reported that the disease outbreak of mud crab was one of the major constraints. The climate changes in climate and environmental conditions, and less predictable monsoon seasons also contribute to it. From (Saha, et al, 2021) observation, we can interpret that the farmers didn't use any commercially available medication; they mostly depended on traditional treatments like lime or KMnO₄ for every pathogenic infection.

Table 1: comparison of pathogen with their primary target stage in crustaceans.

Pathogen / Disease	Primary Host Stage(Crab)
<i>Vibrio parahaemolyticus</i> , <i>V. vulnificus</i> , <i>V. alginolyticus</i>	Larvae & adults
<i>Hematodinium</i> spp. (parasitic dinoflagellate)	Juveniles & adults
<i>Spiroplasma eriocheiris</i> ("tremor disease")	Mitten crab; <i>Scylla</i> susceptibility suspected
<i>Photobacterium damsela</i> subsp. <i>damselae</i>	Mud crab & shrimp
Microsporidia (<i>Hepatospora</i> sp.)	Hepatopancreas of mangrove crabs
Shell-erosion complex (mixed chitinolytic bacteria & fungi)	Exoskeleton
Lagenidium, Atkinsiella, Haliphthoros (fungi)	Eggs and larvae of crabs, shrimp
Zoothamnium, Vorticella, Epistylis	Gills of Crabs, shrimp, prawns

Source : Saha, et al., 2023

How crabs become pathogen “taxi drivers” an occupational risk

An open aquaculture system is always associated with the pathogenic contamination of water bodies and the spread of zoonotic diseases. Zoonoses are infectious diseases that are transmitted from animals to human beings through direct or indirect contact with several causative agents like bacteria, viruses, protozoa, and fungi. It can be transmitted through different channels, such as wounds, ingestion, animal bites, vector bites, etc. Zoonoses are a dangerous threat to the health of the entire world, cause too much damage worldwide, and are present to a high or low degree in certain populations. It has a high impact not only on human or public health and livelihood but also on the environment and ecosystem. It is reported that more than 200 diseases occur through transmission from animal to human as zoonotic diseases, and over 60% of human infectious diseases are shared with wild animals or domestic animals (Saha, et al, 2021). Open-cage crab aquaculture, which solely functions on the workforce with less involvement of equipment, results in the easy transmission of zoonotic diseases. Furthermore, the pathogenic carrier nature of a crab species



Figure 5 : Handling of crab with bare hand in south parganas

and bare-hand handling of the species increases the chance of the spread of zoonotic diseases to humans. Generally, occupational hazards in aquaculture are three types: physical hazards, chemical hazards, and water-borne disease-based hazards. Physical hazards are caused during the handling of crab species or nets.



Figure 6 : Working on culturing pond water in south parganas

Without proper handling, crab chelipeds can cause severe injuries and facilitate the easy transmission of zoonotic diseases. In villages of West Bengal, the cultured pond water is used for other human activities like bathing and washing cattle. This further adds fuel to the chance of spread of zoonotic diseases through water-borne diseases. Even diseased crabs have the capacity to spread diseases to different farms nearby, adjacent farms, and even to natural ecosystems and contaminated wild seed, and decline the population of wild seed available for culture (Saha and Ray, 2014). Water bodies are polluted by pathogens, and occupational hazards can spread communicable human infections. Without proper safety concerns, it may increase the risk to the entire public health (Saha and Ray., 2014). There is a high chance of the occurrence of bioremediation in a crab species due to the entry of unregulated chemical compounds into the water system. Gram-

positive bacteria (Mycobacteria, Streptococcus, etc.) and gram-negative bacteria (Aeromonas, Vibrio, etc.) are the most common zoonotic bacteria and parasites (cestodes, trematodes, nematodes) that are harmful to fish and humans (public health) (Saha, et al., 2023). The few Vibrio pathogens notably *V. Alginolyticus*, *V. Vulnificus*, *V. Fluvialis*, *V. Mimicus*, *V. Cholerae*, *V. Parahaemolyticus*, and *Aeromonas sp.*, responsible for the shell disease in the crab, are reported to cause illness among humans. Chemical hazards

caused by the unregulated use of unauthorized chemicals in crab treatment. This will further damage their water bodies and other sensitive species cultured in the water bodies, which are not as tolerant as the mud crab.

Surveys in three coastal districts (North & South 24-Parganas, Purba Medinipur) found that >10% of human bacterial isolates near crab ponds matched waterborne strains from the ponds (Saha, et al., 2023).

Table 2.1: Disease caused by pathogenic zoonotic bacteria in Mud crab and human

No.	Pathogenic Bacteria	Disease in Mud Crab	Symptoms on human
1	<i>Vibrio alginolyticus</i>	Septicemia, Bacteremia (adult), Shell disease (juvenile and adult), wound infection	Gastroenteritis, wound skin infection
2	<i>Vibrio anguillarum</i>	Vibriosis, Shell disease (juvenile and adult)	Food poisoning
3	<i>Vibrio vulnificus</i>	Bacteremia (adult), Shell disease (juvenile and adult), wound infection, cutaneous lesions	Watery diarrhea, abdominal cramping
4	<i>Vibrio harveyi</i>	Luminescent vibriosis (eggs and larvae), Shell disease (juvenile and adult), high mortality	Nausea, vomiting
5	<i>Vibrio fluvialis</i>	Shell disease (juvenile and adult)	Fever
6	<i>Vibrio mimicus</i>	Shell disease (juvenile and adult)	Chills
7	<i>Vibrio cholerae</i>	Vibriosis, Bacteremia (adult)	Cholera
8	<i>Vibrio parahaemolyticus</i>	Septicemia, Bacteremia (adult), Shell disease (juvenile and adult)	Gastrointestinal infection
9	<i>Aeromonas sp.</i>	Wound infection, Septicemia	Gastrointestinal disease, wound infection

Source: (Saha, et al., 2023)

Table 2.2: Table comparing the pathway, zoonotic pathway and their preventive hints

Pathway	Zoonotic pathway	Preventive Hint
Cutaneous exposure	Sorting crabs bare-handed; dorsal spines puncture skin; <i>V. vulnificus</i> enters bloodstream causing necrotizing fasciitis.	Rubber gloves + iodine wash for cuts
Ingestion (food-borne)	Festival dish "Kakra Jhal" prepared from crab; <i>V. parahaemolyticus</i> survives	Steam ≥ 100 °C for 10 min; avoid "half-done" dishes
Drinking/brackish water	Coastal households using pond water; <i>Aeromonas</i> spp. pass from crab faeces to shallow wells during floods	Simple chlorine or UV community treatment

Source: (Saha, et al., 2023)

Socio-economic impact on farmers

Fisher families often treat their wound infections privately without relying on the proper medical support from recognized doctors. In addition to the degradation of the farmers' health, it also affects their future incomes by reducing the wild seeds and other commercially important crops. The degradation of the environment will affect the future possibility of culturing other species and the use of water for drinking and household purposes. The viral infection, like white spot syndrome, generally reduces molting frequency, resulting in lower weight gain. The price of *Scylla* ranges from 250 to 800 rupees/kg, depending on the weight, from 400 grams to 800 grams. Above 500 grams are sold for around 400 to 600 rupees/kg. And less than 500 grams are sold around 150 to 350 rupees/kg (Saha, et al., 2023). These disease outbreaks have led to a sharp decline in productivity and significant financial loss (Ding, et al., 2016). Disease-induced mortality of 15–40% during fattening cycles reduces net income by up to ₹35,000 per crop for a 0.2-ha farm (Saha, et al., 2023). There will be a high chance of rejection during the live crab export tagged for EU/US markets due to *Vibrio* counts (Ding, et al., 2016). The rejected crab will be sold in the local market anonymously, affecting the local population.

Conclusion

Aquaculture supports the farmers of West Bengal with financial support, food security, especially with the low-cost, high-profit mud crab fattening. The water resources help them to sustain their daily life with various aqua-related farming activities. Due to the financial crisis, they have been following the traditional

culture system with a high risk of exposing themselves and other commercially important crustaceans like shrimp and freshwater prawn to various pathogenic infections. This affects the overall production and health of the farmers. The rapid decline of the green mud crab (*Scylla serrata*) will lead to a decline in wild-caught seed resources and will give a huge blow to the farmers who depend on it. Several reports of mangrove destruction and unregulated pollutant discharges will also contribute to it. This calls for the establishment of crab seed hatcheries and provides subsidies for the establishment of basic intensive farming infrastructure with training programs. Fishing is the riskiest and health hazardous occupation that involves physical hazards (Injury from spines, sting, bite, fracture in body parts, sunburns, acidification, mechanical accidents, environmental calamities, rise sea level, erosion etc.), chemical hazards (poisonous gas due to long storage, accumulation of pollutants, pollutants contamination) and biological hazards (work stress, allergy, parasite and pathogenic infection, skin and lip cancer). According to the ILO, nearly 24000 fishermen or fishery industry people are killed every year globally due to their occupational hazards (Coates, et al., 2022). Even though the polyculture technique of crab is not a viable approach in the open system, farmers are practicing this culture because of their financial constraints and lack of knowledge of optimal scientific approaches. Government and other research institutes should give more attention to the knowledge gap present between the farmers and scientific approaches. For proper economic development, concerted educational efforts are needed to educate the crab farmers regarding

the adoption of scientific crab culture practices, proper handling, and the knowledge about the chance of zoonosis diseases transmission from wild stocks. Necessary information should be provided on demand for the quality of crabs in the overseas market. The result of the research will help fishery extension personnel to know the lacuna of the crab cultural practices and the problems faced by the farmers during the culture practices.

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Harnessing Untapped Aquaculture Opportunities in Kanniyakumari District

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Introduction

Kanyakumari District, situated at India's southernmost point, has a 71 km coastline where the Arabian Sea, Bay of Bengal, and Indian Ocean converge. The region's tropical climate, plentiful freshwater sources, and rich marine biodiversity provide ideal conditions for diverse aquaculture activities. Key water bodies such as Pechiparai, Perunchani, and Mathur reservoirs are well-suited for cultivating freshwater species including *Labeo rohita*, *Catla catla*, *Ctenopharyngodon idella*, and *Oreochromis* spp. The district's coastal areas, featuring rocky shores, estuaries, and brackish water zones, are favorable for marine and brackish water aquaculture, encompassing finfish culture, shellfish farming, and seaweed production. Coastal waters with salinity levels of 30–35 ppt and temperatures ranging from 26–32°C support high-value species such as Seabass, Cobia, Pompano, and marine ornamental fishes. There is considerable potential for integrated multi-trophic aquaculture (IMTA), which combines fish, mollusks, and seaweed cultivation to optimize productivity and reduce ecological impact. The district's proximity to ports like Tuticorin and Thoothukudi enhances access to domestic and international markets, boosting the commercial viability of aquaculture ventures. By investing in modern aquaculture infrastructure, hatcheries, and skill development for local

communities, Kanyakumari can emerge as a leading hub for sustainable freshwater and marine aquaculture, supporting livelihoods, food security, and biodiversity conservation.

1. Seaweed Farming

Current Status

Seaweed farming is gaining traction in Kanyakumari, particularly in coastal villages like Arokiapuram, Colachel, Muttom, and Midalam. The region's warm waters and rocky intertidal zones provide ideal conditions for cultivating red seaweeds such as *Kappaphycus alvarezii*, *Gracilaria edulis*, *Sargassum*.sp., *Ulva* sp., etc. known for their use in pharmaceuticals, cosmetics, and food industries.

Opportunities

- ▶ There is significant potential to scale up seaweed farming on a commercial level by involving women's Self-Help Groups (SHGs) and Fishermen Cooperatives, thereby improving livelihood opportunities in coastal areas.
- ▶ Seaweed farming can be aligned with climate-resilient blue economy strategies, contributing to sustainable coastal development.
- ▶ Government initiatives, especially under the Pradhan Mantri Matsya Sampada Yojana (PMMSY), offer support for

essential activities such as seed stocking, installation of floating cultivation units, and infrastructure development.



Sargassum sp.

Ulva sp.

Seaweed Industry as a Source of Livelihood

The seaweed sector in India currently sustains the livelihoods of about 5,000 women, particularly in coastal villages. By improving resource utilization and expanding farming practices, this industry could create employment for nearly 20,000 more people with approximately 10,000 involved in harvesting and another 10,000 engaged in post-harvest operations, including processing and value addition.

Seaweed Growth and Harvesting

Seaweeds, being renewable marine biomass, grow naturally in shallow coastal waters where they can attach to suitable surfaces. In India, they are predominantly found along the southeast coast of Tamil Nadu from Mandapam to Kanyakumari and are also harvested from regions such as the Gujarat coastline, Lakshadweep, Andaman and Nicobar Islands, and brackish water bodies like Chilka and Pulicat lake. The collection and cultivation of seaweed provide steady employment and income generation for coastal fishing communities. Moreover, seaweed farming has emerged as a socio-economically empowering activity, particularly for women in

Kanyakumari district, driving both community development and local economic growth.



Student of DIFST at a seaweed (K. alvarezii) farming unit at Mandapam

Challenges

- ▶ Seasonal fluctuations affecting overall productivity.
- ▶ Requirement for sustainable cultivation methods to prevent ecological imbalance.

Seaweeds are an integral component of coastal ecosystems, contributing significantly to both ecological stability and socio-economic development. They provide essential ecosystem services and are a valuable source of vitamins, minerals, and various bioactive compounds with promising applications in the production of health supplements. Commercially important seaweeds are broadly classified into Agarophytes, Carrageenophytes, Alginophytes, and edible varieties. Among them, *Kappaphycus alvarezii* is the most widely cultivated species, contributing approximately 30% of total production, while other species such as *Ulva*, *Gracilaria*, *Gelidiella*, and *Sargassum* are also cultivated to a lesser extent. Despite its potential, the seaweed industry faces multiple challenges, including overharvesting of natural resources, inferior-quality seed stocks, and a shortage of skilled labour. Moreover, seaweeds are highly vulnerable to epiphytism, where they are colonized by bacteria, protozoans,

algae, and invertebrates, leading to reduced growth and quality. Adoption of innovative farming practices, coupled with the use of high-quality seed materials, can help overcome these obstacles. Such advancements would enable large-scale and sustainable seaweed cultivation, particularly in resource-rich regions like Kanyakumari district, unlocking significant potential for growth and livelihood generation.

2. Marine Cage Farming

Current Status

Marine cage farming is an emerging practice in Kanyakumari's coastal waters. Pilot projects supported by CMFRI, and the Department of Fisheries have demonstrated promising yields, especially for high-value species such as Cobia (*Rachycentron canadum*), Seabass (*Lateolabrax calcarifer*), and Pompano (*Trachinotus blochii*).

Surface-based cages are the dominant production technology for the marine finfish aquaculture industry. Submerged cages may reduce many of these problems and commercial interest in their use has increased. However, here, we review the current status of submerged fish farming worldwide, outline the biological challenges that fish with fundamentally different buoyancy control physiologies face in submerged culture, and discuss production benefits and problems that might arise from submerged fish farming. The recent addition of underwater air domes to submerged cages can alleviate this issue. Despite this advance, a greater understanding of how to couple advantageous environmental conditions with submerged culture to improve fish growth and welfare over the commercial production cycle is required if submerged cages are to become

a viable alternative to surface-based cage aquaculture such as salmonids, submergence is more complex as they require access to surface air to refill their swim bladders and maintain buoyancy. The above-mentioned Image is a real image as we went to a field visit of Mandapam CMFRI they build a cage for finfish culture near the seashore it gives a one of the good experiences to see the cage farming. And also it includes a few cage farming trials undertaken at Arokiapuram, Muttom, etc., which were successful. Department of State Fisheries and CMFRI are continuing their efforts on this line to promote marine cage farming in this district.



Marine Cage for Finfish Culture at Mandapam

Opportunities

- ▶ Strong domestic demand and export prospects for the culture of high-value marine finfish species.
- ▶ Favorable sea conditions with relatively stable and calm waters in certain regions make them ideal for cage farming operations.
- ▶ Possibility of adopting integrated multi-trophic aquaculture (IMTA) systems by combining cage fish culture with seaweed or mollusk farming, enhancing overall sustainability and productivity.

Challenges

- ▶ Requirement of high initial capital for the installation of cage structures and procurement of quality feeds.
- ▶ Management of biofouling and disease outbreaks, which can affect fish health and production efficiency.
- ▶ Skill development and technical training are essential for fisherfolk, along with the need for insurance coverage to reduce financial risks.

The marine fisheries sector plays a pivotal role in supporting the national economy, contributing through both capture fisheries and mariculture activities. Mariculture, which involves the farming of marine organisms in seawater, includes several fisherwomen-friendly technologies such as seaweed cultivation and marine ornamental fish culture. Among these, seaweed farming particularly the cultivation of *Kappaphycus alvarezii*, a red algal species is gaining prominence. This species produces carrageenan, a commercially valuable polysaccharide widely used as a raw material in the food, pharmaceutical, cosmetic, and mining industries.

3. Freshwater Ornamental fish culture

Current Status

In the inland regions of Kanyakumari district, particularly Nagercoil, Thuckalay, and Marthandam, there has been a notable increase in small-scale freshwater ornamental fish farming in recent years. Species such as guppies, platies, swordtails, mollies, goldfish, and bettas (fighter fish) are commonly reared in concrete tanks or backyard systems, contributing to local income generation and household-level aquaculture diversification.

a) Live Feed

The development of freshwater ornamental fish culture on an industrial scale has been limited by the inadequate availability of suitable live feed for various life stages of fish. Among the most important live feeds are freshwater rotifers (*Brachionus calyciflorus*), which serve as highly nutritious food for larvae. *Artemia*, available in forms such as nauplii, encapsulated cysts, and on-grown stages, is another widely used live feed source. Both rotifers and *Artemia* nauplii are particularly beneficial for raising *Discus* fry in the absence of parental care, thereby reducing the risk of larval predation by adult fish. Additionally, *Moina*, a small freshwater crustacean, is extensively utilized as live feed due to its high nutritional content and excellent digestibility. Live feeds like rotifers and *Moina* enhance growth, survival, and health of ornamental fish. Moreover, unlike farmed food fish, skin coloration is a critical quality trait in ornamental species. Thus, dietary carotenoid supplements are often included to intensify pigmentation, improving the visual appeal and market value of the fish.

b) Updated Checklist of Fish Species in Pechiparai Reservoir, Kanyakumari District, Tamil Nadu

A recent survey of the Pechiparai Reservoir in Kanyakumari district documented a diverse array of finfish species and their distribution. A total of 60 species, representing 8 orders, 17 families, and 37 genera, were identified. Of these, the order Cypriniformes was the most dominant, comprising 1 family, 14 genera, and 27 species, while Synbranchiformes was represented by the fewest species. This biodiversity highlights the potential of the reservoir as a source of native ornamental fish,



offering opportunities for sustainable collection, conservation, and commercialization.



A typical Freshwater Ornamental Aquaculture Farm

Opportunities

- ▶ Growing domestic and international demand for ornamental fish.
- ▶ Significant potential for employment generation, especially among youth and women
- ▶ Possibility of integration with homestead-level aquaculture and urban fish farming systems.

Challenges

- ▶ Absence of well-organized and efficient marketing networks.
- ▶ Restricted access to high-quality broodstock and advanced hatchery facilities.
- ▶ Urgent need for training programs in breeding techniques, larval rearing, and disease management.

4. Marine Ornamental Fish Culture

The range of marine ornamental species that can be commercially cultured in Kanyakumari district is still relatively small. However, the sector holds significant potential for growth similar to the trajectory seen in marine food fish farming. Many species of marine ornamental

fish and invertebrates are capable of being bred in captivity, but successful large-scale production depends on the consistent supply of viable eggs, successful larval rearing, and smooth transition from larval to juvenile stages.

Current Status

With its diverse rocky shore ecosystems and rich coastal biodiversity, Kanyakumari has substantial potential for the development of marine ornamental fish culture. Despite this, the industry remains in its early stages, with limited initiatives focused on species such as clownfish and damselfish, primarily driven by research institutions and private hobbyists.

The global marine ornamental trade is growing steadily, but it continues to rely heavily on wild-caught species from tropical coral reefs. Currently, captive-breeding techniques are established mainly for species like Anemonefish, Damselfish (Pomacentridae), Gobies (Gobiidae), cardinalfish (Apogonidae), Seahorses (Syngnathidae), Angelfish (Pomacanthidae), and dottybacks (Pseudochromidae).

Academic research is vital for advancing this sector, improving knowledge on breeding biology, larval rearing, nutrition, and growth optimization, which supports the transition from experimental setups to commercial-scale production.

The marine fisheries sector is an important contributor to the national economy, encompassing both capture fisheries and mariculture. Mariculture practices such as seaweed farming and ornamental fish culture are particularly suitable for fisherwomen-led enterprises. In particular, farming *Kappaphycus alvarezii*, a red algae rich in

carrageenan, provides raw materials for the food, pharmaceutical, cosmetic, and mining industries.

For sustainable development of the ornamental sector, integrated approaches covering collection, culture, preparation, and conservation are essential. Recent innovations focus on eco-friendly captive-breeding methods, including hatchery-scale production of clownfish and damselfish, and the use of recirculating aquaculture systems (RAS) to improve broodstock management and larval survival.

Opportunities

- ▶ Potential for integration with eco-tourism initiatives and development of public private partnerships
- ▶ Expansion into global marine aquarium markets through captive-bred species
- ▶ Creation of conservation-based livelihood opportunities for coastal communities

Challenges

- ▶ Regulatory restrictions concerning the collection and trade of marine ornamental species.
- ▶ Technical challenges associated with breeding and rearing marine fish species.
- ▶ Urgent need for specialized hatcheries, research facilities, and R&D support to scale up production.

Challenges and Future Prospects

Ornamental fish culture offers considerable opportunities, but several challenges need to be addressed. Disease management is a major concern, as high-density farming can lead to outbreaks that threaten entire fish populations.

To tackle this, the use of probiotics (beneficial bacteria that enhance gut health and immunity), immunostimulants (substances that boost the immune system), and vaccination techniques are being explored to improve disease resistance and reduce dependence on antibiotics.

Overharvesting for the ornamental fish trade can negatively impact wild populations. Sustainable practices, such as captive breeding in controlled environments and protection of natural habitats, are crucial to conserve biodiversity and reduce pressure on wild stocks. Research focused on genetic improvement, breeding efficiency, and development of resilient strains can further strengthen the industry by producing hardier ornamental species.

Technological advancements, including recirculating aquaculture systems (RAS), automated feeding, and the integration of artificial intelligence and data analytics, can enhance production efficiency, improve survival rates, and ensure better fish quality while minimizing environmental impact.

Other Emerging Opportunities in Kanyakumari District

- ▶ Shrimp and finfish hatcheries: Proximity to Kerala and Tamil Nadu markets provides potential to develop the district as a hub for hatchery production.
- ▶ Integrated aquaculture: Combining fish farming with agriculture, such as rice-fish systems, in lowland areas.
- ▶ Cold chain and processing units: Establishment of value-added processing and cold storage can improve marketability and price realization for aquaculture products.



Conclusion

Kanyakumari District possesses significant, yet largely untapped, potential for developing a diverse and sustainable aquaculture sector. With adequate policy support, investment in infrastructure, capacity building, and active involvement of stakeholders, the region can emerge as a leading aquaculture hub in South India. Emphasizing sustainable practices, technological innovation, and strong market linkages will be crucial for achieving long-term growth and improving the livelihoods of coastal and inland communities.

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Microeconomic and Macroeconomic Applications in Fisheries

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Abstract

The fisheries sector plays a pivotal role in national and global economies by contributing to food security, livelihoods, employment, and export earnings. The application of economic principles to fisheries allows for a comprehensive understanding of both the operational decisions made by individuals and the policy decisions made by governments. At the micro level, concepts such as price elasticity, resource allocation, production cost, and demand-supply dynamics govern the functioning of markets and individual actors within the fisheries sector. At the macro level, aggregate indicators such as GDP contribution, inflation, trade balance, and employment determine the broader impact of fisheries on national development. This article explores both microeconomic and macroeconomic applications in fisheries, emphasizing their relevance in managing fisheries sustainably, maximizing economic returns, and improving the livelihoods of fishing communities. Case examples from India and global trends are analyzed to illustrate how these economic dimensions interact and influence the sector. The paper concludes with recommendations for integrated economic strategies that bridge micro and macro considerations to optimize resource use and policy planning in fisheries management.

1. Introduction

Fisheries and aquaculture constitute a vital part of the global food system, particularly in developing nations where they provide employment, nutrition, and livelihood opportunities. According to FAO (2022), over 60 million people are directly employed in fisheries, and millions more depend on the sector indirectly. In India alone, the sector supports over 28 million fishers and fish farmers, contributing significantly to the economy through exports and domestic consumption. The growth of the blue economy has brought renewed attention to the economic potential of marine and inland fisheries. Economics offers

analytical tools to study the allocation of limited resources among competing uses. In fisheries, this includes decisions by fishers regarding gear, effort, and markets (microeconomics), as well as decisions by governments regarding investments, subsidies, and international trade (macroeconomics). Microeconomics deals with the behavior of individual units such as consumers and producers, while macroeconomics looks at aggregate outcomes like national income, employment levels, and fiscal policies. Understanding both perspectives is essential to ensure efficient, equitable, and sustainable management of fisheries resources. This article aims to explore the applications

of both microeconomic and macroeconomic frameworks in the fisheries sector, supported by empirical data and policy examples.

2. Microeconomic Applications in Fisheries

2.1 Demand and Supply in Fish Markets

Microeconomics helps analyze how price and quantity of fish are determined in markets. Fish demand is influenced by consumer income, price of substitutes (e.g., chicken, mutton), preferences, and seasonality. Supply depends on factors like fishing effort, technology, and biological stock availability. For instance, a rise in consumer income in urban India has increased the demand for high-value fish like pomfret and seer, shifting the demand curve rightward (CMFRI, 2022).

2.2 Price Elasticity

Price elasticity of demand is crucial in determining fish pricing strategies. Perishable fish species tend to have more elastic demand. Understanding elasticity helps producers and retailers maximize revenue and avoid price crashes in times of glut.

2.3 Production Functions and Cost Analysis

Fish production, particularly in aquaculture, follows a law of diminishing returns. Economic efficiency is assessed using production functions and cost-return analysis.

A shrimp farmer in Andhra Pradesh may analyze the marginal productivity of feed, labor, and capital to optimize yields and reduce unit costs.

2.4 Resource Allocation and Opportunity Cost

Fishermen allocate effort (time, labor, fuel) across species, fishing grounds, or gear types.

Opportunity cost analysis is crucial when choosing between wild catch and aquaculture or allocating funds for gear vs. pond improvements.

3. Macroeconomic Applications in Fisheries

3.1 GDP Contribution

Fisheries contribute around 1.07% to India's national GDP and approximately 6.86% to agricultural GDP (MoFPI, 2023). At the macro level, the sector is monitored for its impact on national income and rural development.

3.2 Trade and Foreign Exchange

India is a leading exporter of marine products, with export earnings exceeding USD 8.09 billion in 2023–24, driven primarily by frozen shrimp (MPEDA, 2024). Exchange rates, trade agreements, and tariffs significantly affect this trade.

3.3 Inflation and Input Prices

Macroeconomic variables like fuel prices, interest rates, and feed costs influence the cost of fish production and marketing. Inflation affects both producer profits and consumer access to fish protein.

3.4 Employment and Fiscal Policy

Government schemes like PMMSY (Pradhan Mantri Matsya Sampada Yojana) are examples of macroeconomic interventions promoting job creation and infrastructure development. Public investments and subsidies are often justified based on their multiplier effects.

4. Interplay Between Micro and Macro Economics in Fisheries

The microeconomic behavior of fishers and farmers is embedded in a macroeconomic

environment. For example, a prawn exporter's profitability is affected by individual cost decisions (micro) and exchange rate volatility (macro). Likewise, government support programs alter market incentives at the micro level.

Level	Example
Micro	Cost-benefit analysis for pond stocking
Macro	Trade policy impacting export volumes

5. Conclusion

The economic analysis of fisheries from both micro and macro perspectives reveals the sector's multifaceted role in national development. Microeconomic tools help understand producer behavior, market responses, and cost structures, thereby guiding fishers and aquaculture entrepreneurs in making informed decisions. Macroeconomic indicators highlight the sector's contribution to GDP, trade, employment, and inflation, which are critical for policy formulation. The interplay between these dimensions underscores the need for an integrated approach to fisheries development. Policymakers must align individual incentives with broader economic objectives by promoting efficient market structures, providing fiscal support, ensuring sustainable resource use, and strengthening infrastructure. As the fisheries sector continues to evolve under the pressures of globalization, climate change, and technological advancement, economics will play an increasingly central role in navigating trade-offs and prioritizing investments. Future strategies should incorporate both microeconomic insights—such as profit maximization, consumer

behavior, and pricing—and macroeconomic considerations—such as export performance, employment generation, and environmental sustainability. Bridging these scales can support the transformation of fisheries into a resilient, inclusive, and economically vibrant sector.

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