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Marine Fisheries Information Service Technical & Extension Series

The Marine Fisheries Information Service, Technical & Extension Series (MFIS) is a quarterly publication of ICAR-Central Marine Fisheries Research Institute disseminating latest research information on marine fisheries and mariculture in India. Research based technical articles, reporting significant new information, knowledge and understanding of marine fisheries and ecosystems as well as new concepts/technologies in marine fish nutrition, hatchery and larval rearing, fish pathology, fish health management, application of genetics in fish conservation and farming, sea farming technologies, seafood trade and fisheries governance are published. To see all issues since 1978, visit:

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Harvest of Silver pompano from the indigenous land-based, super-intensive RAS
Photo credit: Anil, M.K

Marine Fisheries Information Service Technical and Extension Series envisages dissemination of information on marine fishery resources based on research results to the planners, industry and fish farmers and transfer of technology from laboratory to the field.

MFIS

Marine Fisheries Information Service
Technical & Extension Series

From the Editorial Board

Warm greetings to all our esteemed readers

Mariculture or fish farming in sea water, either in the open sea or land-based systems is an important component of the global aquaculture sector. With an estimated production of 33 million tonnes of marine farmed fish production constituting 27% of the total food fish through aquaculture in 2020, technology development plays a key role in taking mariculture to new heights. Globally, land-based Recirculatory Aquaculture Systems (RAS) for high value finfish production is being favored for maximizing production, enhancing productivity and more precise management of this particular intensive to super-intensive culture system. ICAR-CMFRI is in the forefront of indigenously developing such challenging technologies that is also sustainable and bio-secure, for the mariculture sector in India. Another important milestone has been the development of immortal marine fish cell lines which are invaluable tools in advanced research in environmental monitoring, biotechnology applications especially in immunology and genetic aspects as well as marine fish biodiversity conservation. This issue of MFIS presents interesting research findings across the broad spectrum of marine fisheries of India, to its valued readers.

Marine Fisheries Information Service
Technical & Extension Series

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Brief Communication

Development of super-Intensive land-based RAS for marine finfish farming

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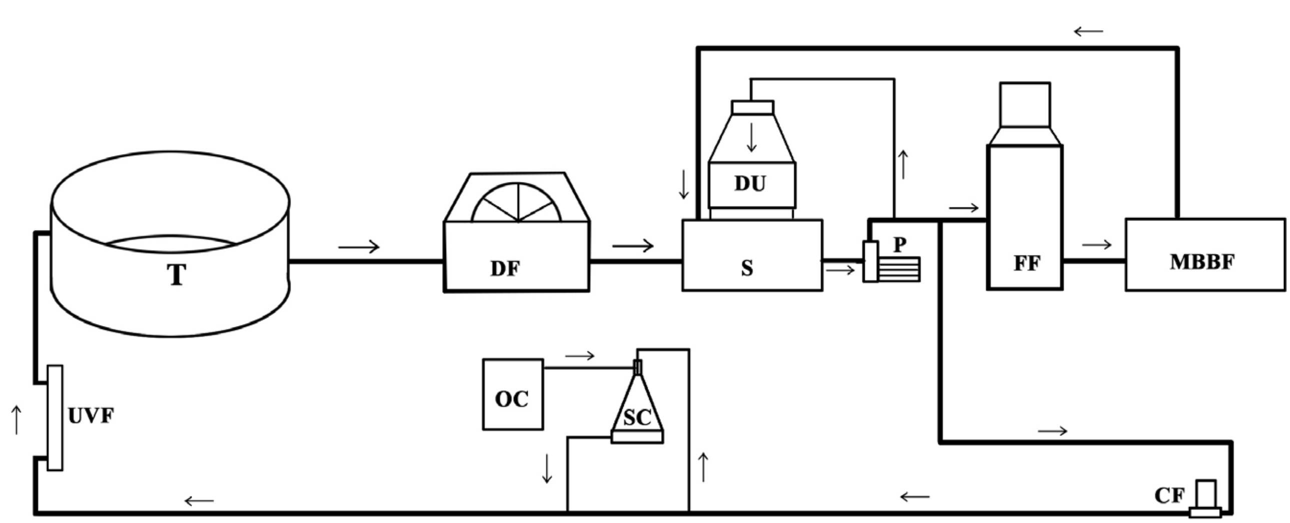
Around the world, most finfish mariculture production occurs within net cages. However, coastal net cage farming presents several significant drawbacks. More than 70% of the nitrogen provided as feed in these cages is lost into the open water, leading to environmental pollution. The widespread adoption of cage culture in coastal waters, particularly in backwaters and bays, inevitably results in substantial self-pollution. Cage farming also faces challenges related to parasitic and viral diseases and its vulnerability to natural disasters like high waves, strong winds, and floods, resulting in substantial crop losses. Globally, land-based Recirculating Aquaculture Systems (RAS) are gaining importance as an alternative method of mariculture, particularly for high-value finfish production. Land-based RAS offers numerous advantages, including the precise control of critical water quality parameters, efficient land and water utilisation, and maximised production. This production method is sustainable, environmentally friendly, and bio-secure. It provides flexibility in site selection and species cultivation, facilitates easy and complete harvesting, and allows year-round production planning. However, it is important to note that the high capital cost is a major obstacle to the widespread adoption of land-based RAS, which can only be overcome through intensive farming practices.

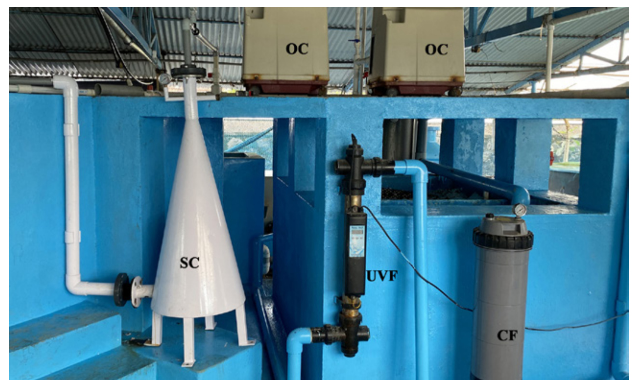
The Vizhinjam Regional Centre of the ICAR-CMFRI has established a dedicated facility to address this challenge and develop land-based super-intensive farming technology. This system comprises a 30-ton dual-drain tank with a balancing tank (T), a drum filter (DF), a foam fractionator (FF), a moving bed biofilter (MBBF), a degassing unit (DU), SUMP (S) a cartridge filter (CF), a UV filter (UVF), an oxygen concentrator (OC) and Speece cones (SC) or (down-flow bubble contactor). The flow of water from the



Flow Diagram of Super Intensive RAS Unit (T-tank, DF-drum filter, S-sump, P-pump, FF-foam fractionator, MBBF-moving bed biofilter, DU-degassing unit, CF-cartridge filter, OC-oxygen concentrator, SC-speece cone), UVF-UV filter.

Fish rearing tank of 35 t capacity

Filtration system



UV and O_2 injection

tank to the drum filter, as well as from the moving bed biofilter (MBBF) to the sump, is driven by gravity. All the equipment for the system was sourced locally. The dual-drain system removes concentrated waste through the central drain, while the side drain eliminates surface film and a portion of the circulating water. The balancing tank regulates the water flow through these drains. The drum filter effectively removes particles larger than 60 microns from the circulating water, and the foam fractionator targets dissolved and colloidal organic matter as well as particles smaller than 60 microns. The biological filter helps in the removal of ammonia through nitrification, and the degassing unit eliminates CO2 and other harmful gases. Subsequently, the cartridge filter removes any remaining particulate matter before the water enters the UV filter, efficiently eliminating parasites, bacteria, and viruses. The oxygen concentrator-Speece cone assembly maximises the dissolution of pure oxygen into the system water, sustaining high stocking densities. This system will be instrumental in developing and fine-tuning the super-intensive production mode, with the first trial's results being presented and discussed. The main component of the system, the rearing tank, had a diameter of 5 meters and a depth of 1.83 meters, with a total volume of 35 tons. During the culture period, the water level was maintained at 1.6 meters, resulting in a volume of 30 tons. A total of 1212 fingerlings of Silver pompano (*Trachinotus blochii*) with an average length of 85.33 mm (9.7 g) were stocked in the RAS. At the time of stocking, the water parameters were as follows: salinity 27 ppt, pH 8.18, temperature 28.6°C, and dissolved oxygen (DO) 5.04 mg/L.

The fish were fed with a feed (Nutrila) containing 40-42% protein, 6-10% crude fat, 3% fibre, and 12% moisture. During the first two months, the fingerlings were fed with a 1.8 mm pellet size. As the fish grew, the pellet size gradually increased to 2.5 mm during the third and fourth months, 3 mm during the fifth and sixth months, and 4 mm in the seventh month. This progression ensured the feed remained suitable for the fish at each growth stage. Initially, the fish were fed at 10% of their biomass, which was gradually reduced to 7% during the second month and further to 4.5% in the third month. During the third month, a technical issue occurred with the drum filter, resulting in the death of 12 fish due to waste accumulation, increased turbidity, and elevated ammonia (NH_3, 0.256 ppm) and nitrite (NO_2, 2.0 ppm) levels. Despite repairs, any increase in feed quantity led to high turbidity, indicating inadequate particulate matter removal by the filtration system, particularly the drum filter. Consequently, the feed quantity remained below


Harvesting pompano from the land-based super-intensive RAS

4 kg, even as biomass increased. This resulted in the feed percentage dropping from 4.5% in the third month to 1.7% in the seventh month.

Every day, 5-10 % water exchange was given to maintain the water quality. However, due to the drum filter malfunctioning again during the 5th month, 80 fish died, with ammonia and nitrite levels rising to 0.414 ppm and 2.1 ppm, respectively. To manage the increased turbidity, daily washing and replacement of the cartridge were implemented. On June 6th, the drum filter stopped working entirely, necessitating emergency harvesting. Despite these instrumentation


Harvested pompano fishes

Table 1. Growth and feeding of Silver pompano *T. blochii*

	No. of fish	Average length(mm)	Average weight (g)	Feed %	Monthly feed consumption
Initial	1212	9.7	11.7564		
1st month	1212	29.75	36.057	10.00%	33
2nd month	1212	71.5	86.658	7.00%	73
3rd month	1200	189.1	140.38	4.50%	100
4th month	1120	201.5	183.8	2.90%	114
5th month	1120	237.1	224.9	2.20%	125
6th month	1120	251.3	240.7	1.80%	125
7th month	1120	279.5	303.5	1.70%	127

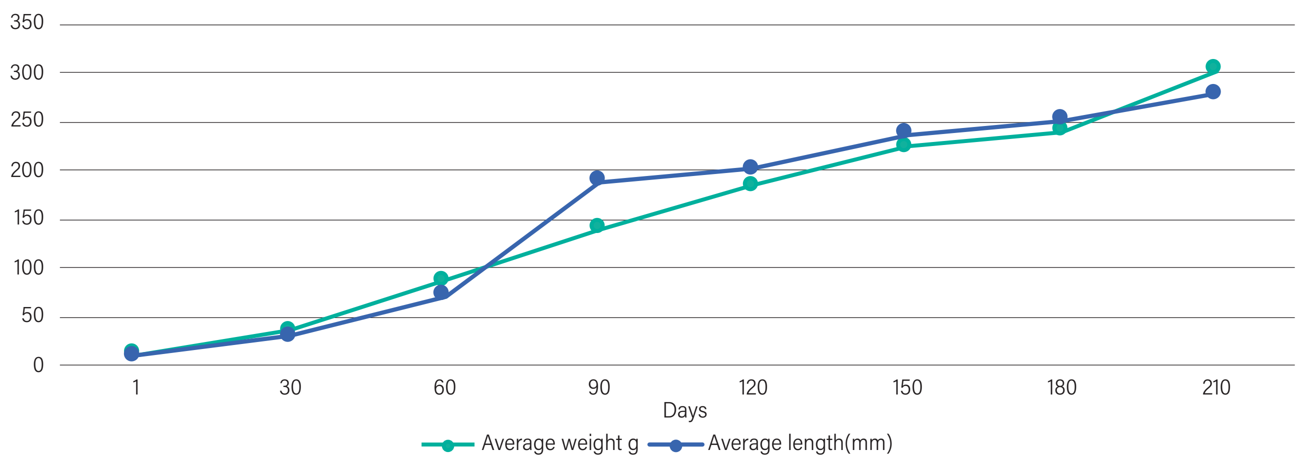


Fig. 1. Growth in length (mm) and weight (g) of Silver pompano over time in a super intensive RAS

challenges, we harvested 303 kg of fish with a survival rate of 92.40%. The average length and weight of the harvested fish were 279.5 mm and 303.5 g, respectively. The feed conversion ratio (FCR) calculated during the experiment was 2.4. The growth and feed are presented in Table 1 and Fig. 1.

Conclusion

The current production of 339 kg from a 30-ton tank, which is 11.3 kg/m^3 or equivalent to 172 tons per hectare, conclusively proves that production of more than 20-30 kg/m^3 is quite achievable with better equipment. The study highlights the importance of maintaining optimal water quality parameters and effectively managing organic waste in super-intensive RAS systems, as heavy organic load and consequent changes in water quality led to some mortality. Future research has to focus on improving waste management strategies, equipment selection, and system design to prevent similar issues. The development of super-intensive land-based RAS for marine finfish farming presents a promising alternative to traditional net cage mariculture. The experimental trial conducted at the Vizhinjam Regional Centre of ICAR-CMFRI demonstrates the potential for high-value finfish production with efficient resource utilization and sustainable practices. This study has yielded valuable data and insights into the operation of super-intensive land-based RAS. Despite challenges such as high capital costs and organic waste management, the benefits of land-based RAS make it a viable option for future mariculture development. Additionally, the importance of specially designed artificial feed in super-intensive systems cannot be overstated, as it plays a crucial role in optimizing fish growth, minimizing waste, and maintaining water quality. This research paves the way for more sustainable, productive, and economically viable marine aquaculture practices, promising a brighter future for the industry.

Establishment of immortal marine fish cell lines as *in vitro* tools for advancing research in environmental monitoring, biotechnology and biodiversity conservation

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Immortalized cell lines are invaluable to researchers as they can proliferate indefinitely, allowing them to be cultured across multiple generations. Unlike primary cells with a limited lifespan, immortal cell lines (also called as continuous cell lines) bypass challenges such as ethical concerns, difficulty in extraction, limited passage ability, and inconsistent results due to variations in cell sources. Most cells in laboratory conditions face the Hayflick limit, where telomeres shorten with each division, leading to senescence. Immortalized cell lines overcome these limitations, enabling stable, long-term studies while eliminating the need for repeated cell isolation and cultivation, thus saving both time and resources in research. Continuous cell lines can proliferate indefinitely *in vitro*, providing a sustainable and reproducible system for a wide range of research purposes. These cell lines offer a unique platform for investigating organisms at the cellular and molecular levels, providing insights that are not always possible with whole-organism models. It replicates the cellular and genetic homogeneity of the host, while minimising the variability inherent with *in vivo* systems. Consequently, there has been a growing focus on developing new cell lines to support a broader array of biological investigations.

The development of animal cell cultures was initially driven by the need for antiviral vaccine production and cancer research (Freshney, 2010). Similarly, fish cell cultures were initially established to support the growth of viruses for studying fish diseases. Fish cells possess unique traits such as tolerance to low oxygen, wide temperature adaptability, strong intracellular buffering, and high lactate dehydrogenase (LDH) activity, making them ideal for *in vitro* studies. The first permanent fish cell line, RTG-2, derived from rainbow trout gonadal tissue in 1960 (Wolf and Quimby, 1962), paved the way for development of a diverse range of species and tissue-specific fish cell lines. These have become invaluable tools in toxicology, immunology, virology, and genetics, facilitating research into cellular responses to environmental stress, pathogens, and pollutants, as well as for studying gene expression, protein synthesis, and metabolism.

The marine environment hosts a vast diversity of fish species that play vital roles in global biodiversity, fisheries, and mariculture. As research on marine fish species expands, there is a rising interest in developing *in vitro* tools, including marine fish cell lines, to explore their biology and responses to environmental shifts. For marine species that are difficult to access or maintain in the lab, cell lines provide a practical alternative to whole animal studies, enabling detailed investigations into how marine fish cells respond to stressors like climate change, pollution, and disease outbreaks.

Development of marine fish cell lines

The development of fish cell lines involves isolating cells from fish tissues, adapting them to artificial culture environments, as well as maintaining and passaging them over extended periods. Establishing a stable cell line requires careful optimization of both culture media and growth conditions. Typically, cell lines originate from primary cultures, which are derived directly from cells, tissues, or organs of an organism. Primary cultures of fish cell and tissues can be initiated by one of the two widely used methods viz., plating multiple explants (explantation) and trypsinisation (enzymatic digestion, using enzymes such as trypsin). Cell populations of primary cultures are usually heterogeneous than those of cell lines. At ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), we have successfully developed and characterized 16 continuous cell lines derived from commercially important marine fish species, including ornamental varieties, using either explant or trypsinization methods. These cell lines are derived from a variety of tissues spanning gill, fin, spleen, brain, heart, muscle, liver as well as embryonic tissue of various commercially important marine fish species.

Cell culture media and supplements

In *in vitro* cell cultures, growth media provide essential nutrients for cell proliferation, and a variety of complete media are commercially available. Media formulated for mammalian cells can also support fish cell growth when supplemented with foetal bovine serum (FBS). While antibiotics like penicillin and streptomycin are often added, fish cell lines can be maintained without them. Leibovitz's L-15 medium, which regulates pH through salts and high amino acid concentrations, is widely used for fish cell lines, especially with increased NaCl for marine species (Bols and Lee, 1994). FBS, though the most expensive component, is crucial for cell culture. For marine fish cell culture at ICAR-CMFRI, Leibovitz's L-15 medium supplemented with FBS is routinely used.

Subculture and passage

Monolayers initiated through explantation or enzymatic dissociation are subcultured once they reach confluency. This is done either by enzymatic or mechanical dispersion. We employ enzymatic dispersion, with trypsin-EDTA for subculture. With each subsequent subculture, cells with the fastest proliferation rate gradually dominate, while slower-growing or non-proliferating cells are diluted out. During early passages, 15-20% FBS is used, with 5% being sufficient in later stages.

Spontaneous immortalization of fish cell lines

Cell cultures derived from normal tissues undergo senescence after a set number of divisions due to the progressive shortening of telomeres, which prevents further replication. Exceptions include germ cells, tumour cells, and transformed cell lines, which produce telomerase, an enzyme that maintains telomere length, allowing indefinite division. All our marine fish cell lines are generated through spontaneous immortalization, where cells continued to proliferate without any addition of biological, chemical, or physical agents. Unlike mammalian cells, which show senescence markers like SA β-Gal, fish cells do not develop these markers with continued passaging. Spontaneous transformation of our cell lines generally happens between 50 to 80 passages, which is evidenced by an increase in plating efficiency and reduced FBS requirement. All our immortalised cell lines are adapted to grow in L!5 medium supplemented with 2% FBS.

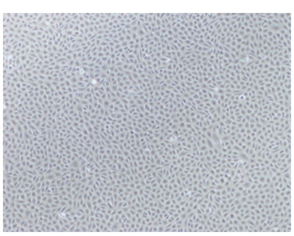
Cryopreservation

The freezing medium for fish cells typically includes 20% or more serum, along with a cryoprotectant, either glycerol or dimethyl sulfoxide (DMSO). We use DMSO at a final concentration of 10% as cryoprotectant and the cells are stored in liquid nitrogen at -196°C, which allows for indefinite preservation. The sixteen marine fish cell lines developed in ICAR-CMFRI have undergone *in vitro* passages ranging from 88 to 471, as outlined in Table 1. All these cell lines are anchorage dependent and grow adherent to the surfaces of tissue culture vessels. The cell lines have been cryopreserved in liquid nitrogen at different passage levels. The cell lines are predominantly fibroblast or epithelial in nature and have been thoroughly characterized. The immortalised cell lines are grown routinely in L-15 medium with 2% FBS at ambient temperature of 28±2°C. All the sixteen marine fish cell lines developed at CMFRI are being used for screening marine fish viruses, conducting gene transfection studies, performing cytotoxicity assessments on environmental contaminants and bacterial toxins, as well as for cell-based seafood research. Out of the 16 cell lines, 12 have been deposited in the National Repository of Fish Cell Lines (NRFC) in Lucknow, India, with their respective accession numbers provided (Table 1).

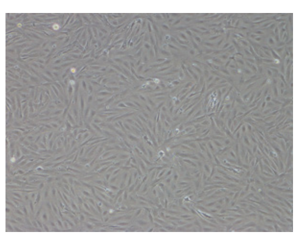
Table 1. List of Marine fish cell lines developed in ICAR-CMFRI

Cell line code	Species and tissue of origin	Number of passages crossed *in vitro*	NRFC (Lucknow) Accession number	NCBI GenBank Accession number
EM3GEx	*Epinephelus malabaricus,* Gill explant	391	NRFC032	MK165214
EM4SpEx	*Epinephelus malabaricus,* Spleen explant	471	NRFC033	MK165217
EM2HTr	*Epinephelus malabaricus,*Trypsinised Heart	298	NRFC030	MK165216
EM2GEx	*Epinephelus malabaricus,* Gill explant	340	NRFC031	MK165215
DT1CPEx	*Dascyllus trimaculatus,* Caudal peduncle muscle explant	419	NRFC024	KP791798
DT1F4Ex	*Dascyllus trimaculatus,* Fin explant	359	NRFC025	KP791797
DT1CPTr	*Dascyllus trimaculatus,* Trypsinised Caudal peduncle muscle	434	NRFC026	KP791799
PC1CpTr	*Pomacentrus caeruleus* Trypsinised Caudal peduncle muscle	318	NRFC035	KY982626
PC1F1Ex	*Pomacentrus caeruleus,* Fin explant	324	NRFC036	KY982627
PC1L1Tr	*Pomacentrus caeruleus,* Trypsinised Liver	311	NRFC037	KY982628
RC4H1Tr	*Rachycentron canadum,* Trypsinised Heart	290	NRFC027	MH559419
EB2SpEx	*Epinephelus bleekeri,* Spleen explant	333	NRFC038	MK165218
CA1F3Ex	*Cromileptes altivelis,* Fin explant	161	Not deposited	OM131589
CA1F4Tr	*Cromileptes altivelis,* Trypsinised Fin	88	"	OM131590
PB1BrTr	*Premnas biaculeatus,* Trypsinised Brain	108	"	OR290980
AP7EF1	*Amphiprion percula,* Embryo	99	"	OM127852

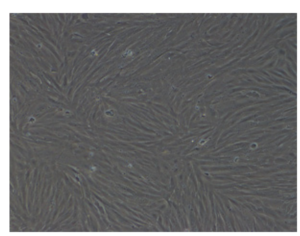
Phase contrast photomicrographs of marine fish cell lines developed at ICAR-CMFRI



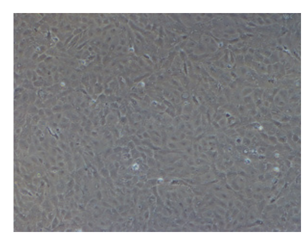
EM3GEx



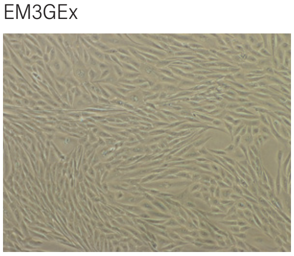
EM4SpEx



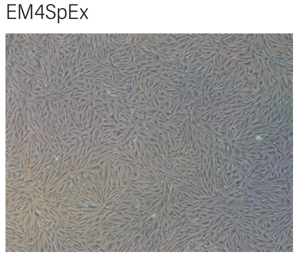
EM2HTr



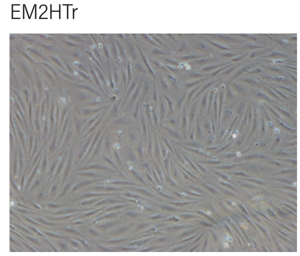
EM2GEx



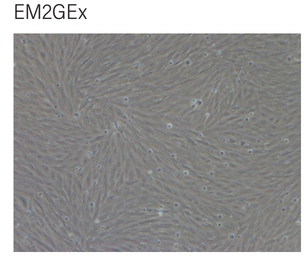
DT1CPEx



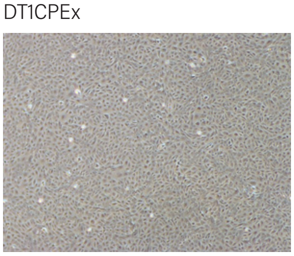
DT1F4Ex



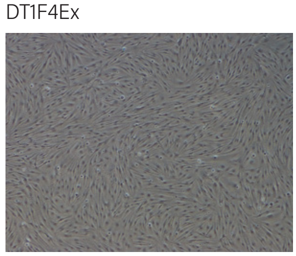
DT1CPTr



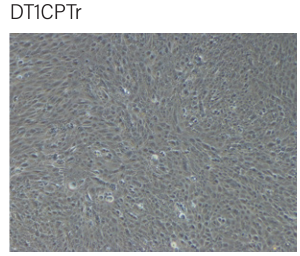
PC1CpTr



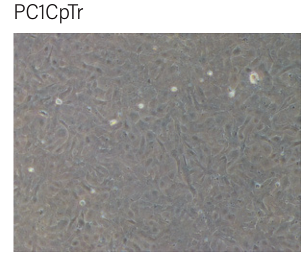
PC1F1Ex



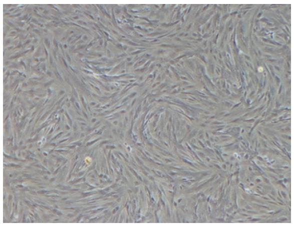
PC1L1Tr



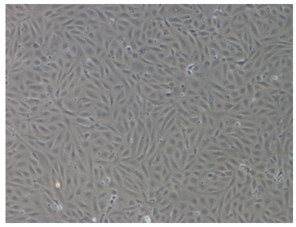
RC4H1Tr



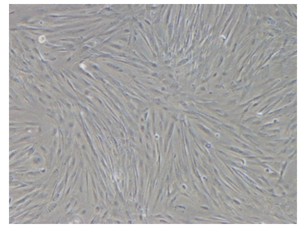
EB2SpEx



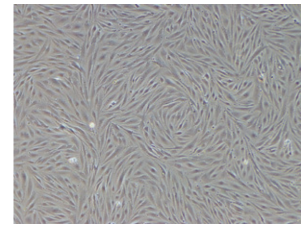
CA1F3Ex



CA1F4Tr



PB1BrTr



AP7EF1

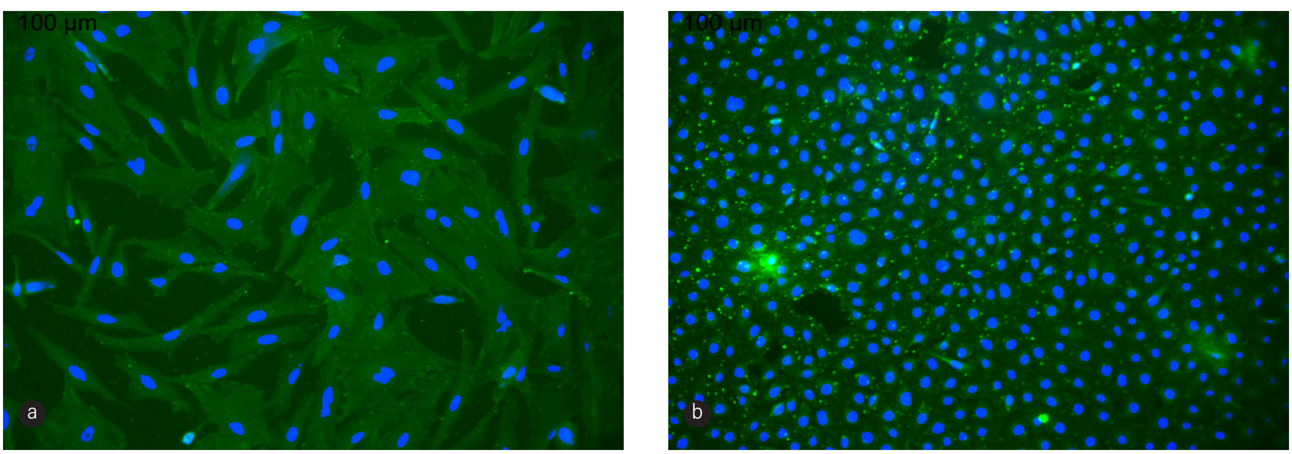
Characterisation of cell lines

Optimisation of growth conditions

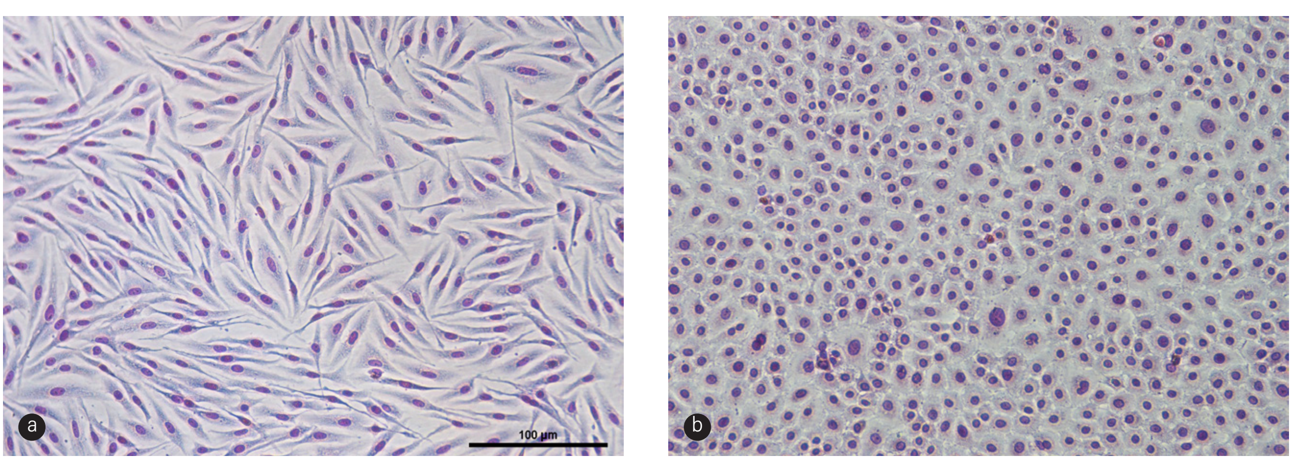
By systematically assessing and optimizing growth conditions, we can better understand the specific requirements of each cell line, ultimately enhancing their performance in experimental settings. All the cell lines developed have been optimised for key parameters such as temperature, and FBS concentration, along with the determination of plating and seeding efficiencies, which are critical for successful cell culture.

Cell morphology and ultrastructure

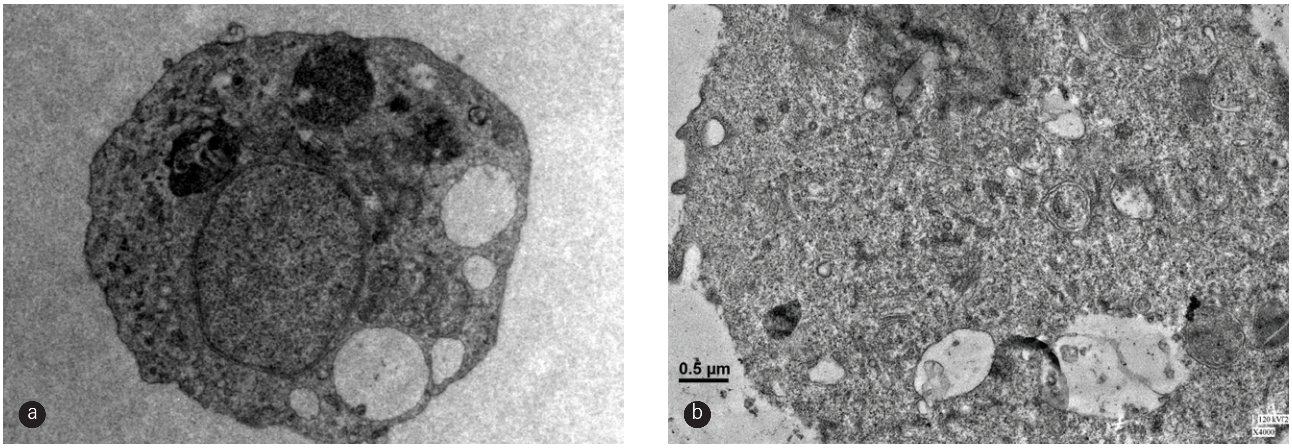
In fish cell cultures, the predominant cell shapes are typically epithelial-like or fibroblast-like, which may indicate their origin from epithelial or connective tissue. Fibroblast-like cells are bipolar, elongated, and often align in parallel as they reach confluency. In contrast, epithelial-like cells are flat with irregular to cobblestone outlines, and their shape can be variable. To correlate the epithelial and fibroblast shapes with cytoskeletal component expression, we have employed immunofluorescence staining using commercial antibodies against cytoskeletal proteins such as Vimentin and Pancytokeratin. Additionally, Giemsa staining and ultrastructural



Immunofluorescence staining of (a) Fibroblast and (b) Epithelial markers



Photomicrographs of Giemsa stained (a) Fibroblast and (b) Epithelial cells



TEM images of cells revealing (a) cell structure and (b) organelles

studies *via* transmission electron microscopy (TEM) were also employed to further assess cell morphology and structure.

Cell line authentication and confirmation of species of origin

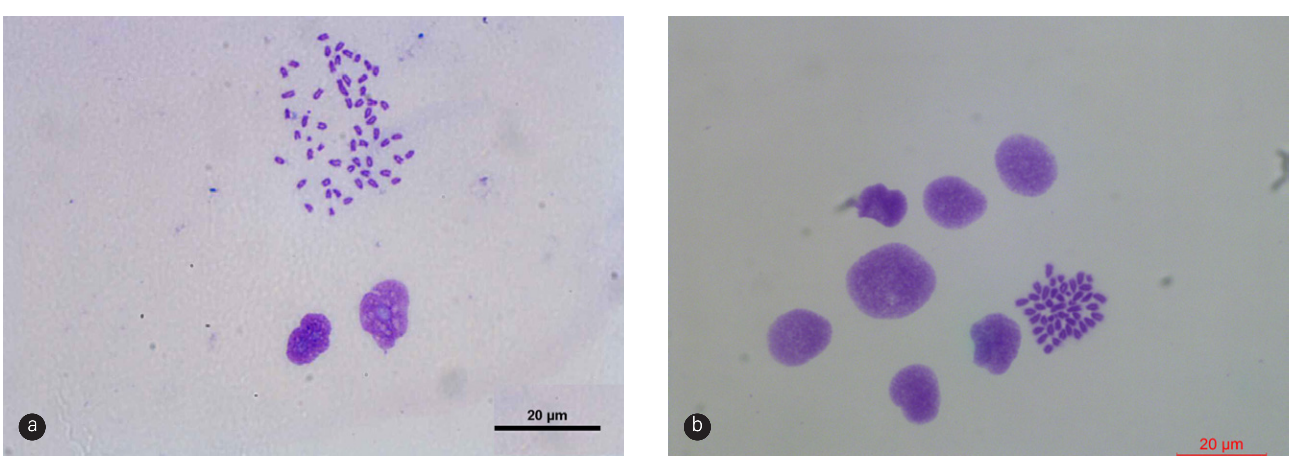
Cell lines are authenticated to confirm their species of origin and ensure the absence of cross-contamination, often using mitochondrial CO1 gene sequence analysis. Amplification and sequencing of a 653 bp region of the mitochondrial CO1 gene is effective for unambiguously identifying fish species (Ward *et al*., 2009). This DNA barcoding technique is widely used to authenticate species identity of fish cell lines. We have confirmed the species of origin for all cell lines through partial sequencing of the mitochondrial CO1 gene, with the sequences deposited in NCBI GenBank.

Chromosome analysis

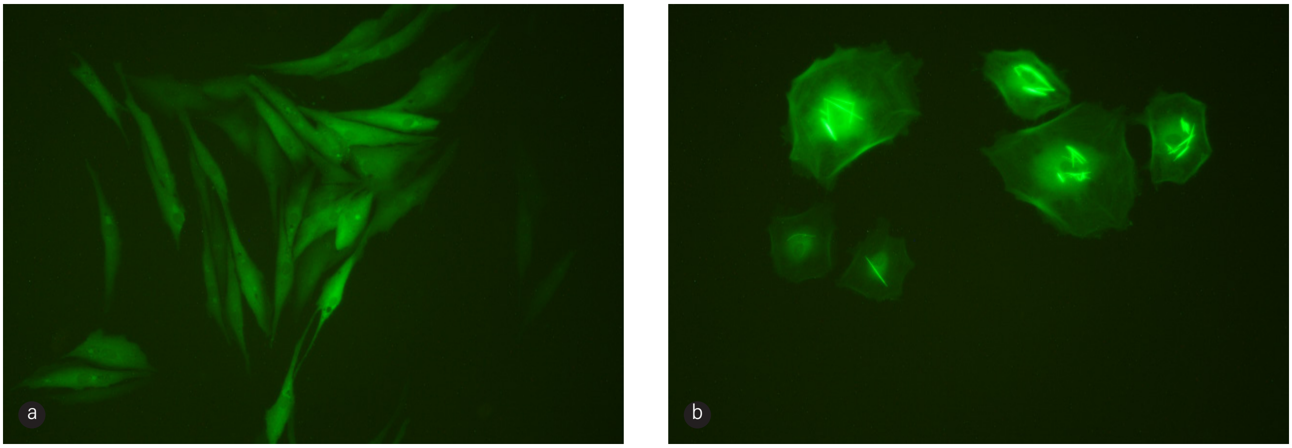
Continuous cell lines often become aneuploid, where one or more chromosomes are missing or present in excess. Determining whether fish cell lines are aneuploid could provide insights into different mechanisms of spontaneous immortalization. Chromosome analyses of a minimum of 100 metaphase spreads per cell line indicated that all our immortalised cell lines display chromosomal aneuploidy, indicative of spontaneous transformation.

Gene expression studies

Fish cell lines expressing exogenous genes have promising applications in producing recombinant proteins, gene-function studies, and creating transgenic fish. Transfection with plasmids encoding a gene of interest linked to a reporter, such as green fluorescent protein (GFP), is a key method for studying gene expression and localization. Gene expression studies using GFP reporter vectors, like pcDNA3-EGFP and pMAX-GFP, showed high transgene expression in most of our cell lines which confirm that our cell lines are effective *in vitro* systems for evaluating promoter efficiency, intracellular signaling and gene expression.



Metaphase spreads from cell lines showing chromosome numbers



Expression of GFP reporter gene after transfection by Nucleofection in (a) Fibroblast and (b) Epithelial cells

Screening for mycoplasma

Mycoplasma testing is an essential part of cell line quality control. Mycoplasma comprises various species with in the Mollicutes, and cell culture laboratories have long been vigilant about mycoplasma contamination due to its ability to infiltrate cultures without causing visible changes. Over the years, several detection methods for mycoplasma in animal cell lines have been established including culture tests, polymerase chain reaction (PCR), and fluorescent DNA staining. All our cell lines have been confirmed to be mycoplasma-free by screening using the MycoFluor™ Mycoplasma Detection Kit.

Applications of marine fish cell lines in research

Toxicology and environmental monitoring

Marine fish cell lines are an ideal model for toxicity studies since they provide a controlled environment for assessing the effects of environmental pollutants. By exposing these cell lines to contaminants, researchers can determine cytotoxicity, genotoxicity, and mutagenic effects at the cellular level. This data can then be used to gauge the impact on the overall marine ecosystem and guide environmental policies.

Fish disease research

Fish diseases, particularly in aquaculture, pose significant challenges to marine farming operations. Viral and bacterial infections can lead to mass mortality and economic losses. Cell lines derived from fish serve as crucial models for studying the pathogenesis of infectious agents. These *in vitro* studies help in understanding host-pathogen interactions and developing vaccines and therapeutics, significantly advancing fish health management. The establishment of robust and susceptible fish cell lines is essential for isolating and propagating infectious viruses from fish. Cell lines facilitate *in vitro* studies on viral replication and host-pathogen interactions to viral infections under controlled conditions. This knowledge is crucial for developing effective viral vaccines

Genetic engineering and functional genomics

Marine fish cell lines have become indispensable tools in the field of genetic engineering, offering researchers the ability to study gene function, expression, and regulation in a controlled environment. These cell lines enable the manipulation of genes to investigate their roles in growth, stress responses, and immune function, which are critical areas of focus for the advancement of aquaculture. Through techniques like transfection, CRISPR-Cas9, and gene editing, marine fish cell lines provide the foundation for developing transgenic fish, improving disease resistance, and enhancing environmental tolerance, all of which hold great promise for the future of sustainable aquaculture and marine conservation efforts.

Biodiversity conservation

Cryopreservation of marine fish cell lines offers a valuable approach to preserving the genetic diversity of fish species, particularly those at risk due to overfishing, habitat degradation, or climate change. Establishing a "cell bank" allows researchers to store genetic material for future research or potential repopulation initiatives. These preserved cell lines serve as a critical resource for conserving biodiversity and could play important role in reviving species or populations.

Cell based seafood research

The concept of producing laboratory-grown seafood through fish cell and tissue cultures is gaining importance as a solution to the challenges posed by industrial aquaculture and marine capture fisheries. Cell based seafood offers a sustainable alternative to traditional seafood production, addressing key challenges in food security, environmental sustainability, and ethical consumption. This approach would reduce reliance on wild-caught fish, contributing to the conservation of marine ecosystems and biodiversity, especially as global fish stocks decline due to overfishing and climate change. To advance cell-based seafood, more research is needed on fish muscle cultivation, serum-free media formulations, biocompatible edible scaffolds, and bioreactor designs for large-scale production. Although cultivated meat science is still emerging, with the first lab-grown hamburger debuted in 2013, cost remains a significant barrier. In 2020, Eat Just Inc. made a breakthrough with regulatory approval for lab-grown chicken nuggets in Singapore, the first cultivated meat approved for human consumption. However, solid research is crucial for informed decisions based on science rather than speculation.

Conclusion

Marine fish cell lines have proven to be invaluable in addressing a variety of scientific and industrial challenges. In environmental toxicology, for example, these cell lines are used to assess the impact of pollutants, such as heavy metals, pesticides, and oil spills, on marine life. They enable researchers to study the cytotoxic and genotoxic effects of these substances at the cellular level, providing data that can be used to protect marine ecosystems and ensure the sustainability of marine resources. In aquaculture, cell lines help in understanding disease mechanisms, improving fish health management, and developing vaccines and therapeutics to control pathogens that threaten farmed fish populations. Marine fish cell lines are also key to unlocking the potential of marine biotechnology. With the application of advanced technologies like CRISPR-Cas9 for gene editing and omics approaches (genomics, proteomics), the depth of knowledge that can be gathered from these cell lines is rapidly increasing. From environmental monitoring to disease management and biodiversity conservation, they also offer a controlled, reproducible, and ethical method of studying marine life.

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Brief Communication

Coastal pond farming of Orange spotted grouper (*Epinephelus coioides*): A package of practice for effective technology dissemination

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Introduction

Groupers are classified in 14 genera of the subfamily Epinephelinae, which comprises at least half the approximately 449 species in the family Serranidae. Throughout most warm and temperate marine regions, serranids are highly valued for food in different countries. In the Indo-Pacific and Middle Eastern regions, several grouper species are farmed in cages, ponds, and tanks, but mostly they are raised from wild juveniles and are fed trash fish. Groupers are popular fish in the global Live Reef Food Fish (LRFF) trade in most of the southeast Asian countries. Among different species of groupers, Orange spotted grouper, *Epinephelus coioides* is one of the important farmed grouper species and has the potential to become an important aquaculture species because of high market price and other cultivable characteristics. Captive seed production technology for the species was developed and followed by the coastal pond farming method was developed by the Visakhapatnam Regional centre of ICAR – Central Marine Research Institute. Under the National Fisheries Development Board (NFDB) sponsored project, the coastal pond culture technology was disseminated in Krishna, West Godavari and East Godavari districts of Andhra Pradesh using hatchery-produced seeds. With the result obtained from the technology dissemination in different coastal pond ecosystem, the package of the practice for the coastal farming of the fish is well developed.

Pond preparation and water quality

Existing shrimp/fish pond or newly excavated ponds of rectangular shape with 1-2 m water depth is suggested for the culture. For ease of management, the preferred pond size of 500 m^2 to 1 ha water area is recommended. The pond site should have adequate water sources with salinity ranging from 15 to 35 ppt. After filling the pond with seawater/brackish water, fertilization is to be done by applying either organic or inorganic fertilizers to enhance the growth of natural food in the pond. Organic fertilizers like cow dung or chicken manure are applied at the rate of 1 ton/ha. Inorganic fertilizers like urea and di-ammonium phosphate are applied at the rate of 50 Kg/ha. However, the dose may be increased or decreased depending on the pond's fertility. Stocking of adult tilapia at 2500 to 5000/acre is recommended in the grouper culture pond before stocking the grouper. Once the stocked tilapia starts reproducing; they will serve as natural food or prey for the grouper

Nursery culture in coastal pond-based hapa

The optimum stocking size for the species in the grow-out culture is 25 to 30 g, and if the available size is small (1-2 inches), then nursing of the fry should be done before stocking in the grow-out pond to achieve better survival and reduce the grow-out culture period. Nursery rearing

Nursery rearing of Orange spotted grouper in hapa based nursery in pond

should be in the vicinity of the pond culture site, to reduce the transportation stress fingerlings. Thus, pond-based nursery culture in hapa/cage is recommended in the same grow-out pond or a separate nursery culture pond near the grow-out culture pond. For pond-based nursery, a rectangular hapa made of nylon net is to be used with the support of bamboo or casuarina poles. The sizes of the hapa can vary from 4 x 2 x 1.5 m to x 3 x 1.5 m with mesh sizes of 0.5 mm. The stocking density varies from 200 to 250/m^3. The grading of stocked fry is to be followed every week, to minimize cannibalism.

Feed with higher nutrient content (45% Crude Protein & 10% Crude Fat) is suggested, although chopped or minced trash fish is the most preferred by the fish. The recommended feeding rate in the nursery is 8% to 7% and 15% to 13% for pelleted feed and trash fish, respectively. The fish fry stocked at 2 to 3 g usually takes 60 days to reach 25 to 30 g in size. Adequate aeration should be provided in the nursery pond as the fish fry is stocked at high densities in the hapa. Maintaining a dissolved oxygen level of 4 to 6 ppm is recommended through the use of paddle wheel aerators.

Grow-out culture range spotted grouper in coastal ponds

The grow-out culture phase involves the rearing of grouper juveniles from 25-30 g to a marketable size of 800 to 1500 g in weight. The ideal stocking density for the grouper juveniles is 3500/acre. In grow-out culture system, feeding the fish with the formulated feed and live tilapia perform better growth. Thus, nursery reared grouper fingerlings to be transferred to the grow-out pond, a month after tilapia brooders have been stocked in the grow-out pond. This ensures abundant availability of tilapia seeds when grouper fingerlings are stocked in the pond. Apart from the live tilapia available in the pond, the fingerlings should also be fed with either dead chopped fish at the rate of 5% of biomass or pelleted feed at the rate of 1% of the biomass.

The feeding rate should be 50% of the usual feeding rate for the fish fed with pelleted feed alone (Table.1). If the grow-out pond is stocked with sufficient number of tilapias, then the feeding rate of formulated feed should be reduced 50% than the regular feeding mentioned in the table 1. Whereas, instead of formulated feed, if dead tilapia given as feed, then the feeding rate should be 3-4 times higher than the regular feeding rate given in the table 1. The total feed should be divided and given at the feeding frequency of 2-3 times per day and feeding should be done at the same place to acclimatize the fish for feeding. When chopped fish are provided as feed, adequate care should

Table 1. Growth and feeding of Orange spotted grouper in grow-out farming with formulated feed

Days of Culture (DoC)	Fish size (g)	Feed size (mm)	Feeding rate	Feeding f requency (times/day)
0-60	25-75	1.8 to 3.0	8%	4
60-120	75-150	3.0 to 5.0	6-5%	4
120-180	150-275	5.0 to 6.0	5-4%	3
180-240	275-450	6.0 to 1.0	4%	3
240-300	450-650	1.0 to 1.5	3-2.5%	2
300-360	650-850	1.0 to 1.5	2%	2

(Note: When live tilapia are available in the pond, the feeding could be reduced 50%)

be taken to avoid the deterioration of water quality parameters. Determining the feeding rate depends on the fortnight growth. Based on the weight gain, subsequent feeding should be determined. Though the fish accepts formulated pelleted feed well, it needs a bigger pellet size since the fish has a bigger mouth size. For the fish being demersal, the use of aggregating substratum is recommended during grow-out culture, where the fish can hide and can also be fed at a particular location. However, at times, it may lead to an increase in cannibalism if a size difference exists. The fish growth, feeding frequency, and feed used are given below. While in the sampling, the fish can be collected from the regular feeding site using cast net. It is observed that the size variation in the grow-out culture is more prominent in the fish pond fed with formulated feed than the fish fed with dead tilapia.

Harvesting of Orange spotted grouper cultured in coastal ponds

Water quality and disease management in coastal ponds

Maintaining good water quality parameters determine healthy culture operation. Use of paddle wheel aerators of 2 numbers/ acre is recommended to maintain required dissolved oxygen content in the pond. Water salinity of 15-30 ppt is recommended for optimum fish growth. Maintaining grow-out pond with small weed fishes/crustacean is highly recommended to enhance the fish growth and reduce the feed cost, and thus frequent pond fertilization with organic or inorganic fertilizer is advisable. Three major disease-causing agents such as parasites, bacteria and virus are mostly responsible for disease in Orange spotted grouper. All diseases are associated with stress and the stressed fish are easily affected by the pathogens. Therefore, stress during culture should be minimized by maintaining good water quality, optimum feeding and stocking density. Among all, the virus infection can occur from hatchery produced larvae itself, so selecting active seed is an important measure to control the infection. Bacterial infection in the grouper culture can be managed by medicated feeds with admissible antibiotics or use of probiotics in the culture. Fish colouration decides market demand for the fish, and the fish with pale white with prominent orange colour spot fetched premium price. The coloration achieved for the fish reared in stress free environment. Thus, maintaining conducive water quality condition by with appropriate management strategy may help to maintain better fish coloration.

Fish harvest and marketing

Orange spotted grouper is demersal fish, and mostly remains in the bottom and thus entire pond should be drained for complete harvest. However, as size variation in the fish is more prominent, phased manned fish harvest would be ideal to achieve better economic returns. If an entire pond is planned for harvest, then the majority are harvested with help of a dragnet and the remaining in the pond bottom, by draining out the entire pond. For phased harvest, hideouts made of PVC pipes or small branches are used. The hideouts are placed usually where feed is given, and the fish congregates in the hideout, then, through the use of cast net or lift net, the fish is harvested. While in the phased harvest, the bigger fishes are collected and smaller fishes are released back for further culture. A type of production net cage of 6 x 3 x 1.5 m size can be installed in the pond, and the bigger fish collected through the cast net can be stocked in the net cage and fed till marketing. To maintain the freshness and quality of harvested fish, washing in clean water and chill killing is suggested. Harvested fishes are stocked in plastic trays or thermocole boxes by adding layers of ice in equal quantities, both below and above the fish. It is suggested to harvest in the morning hours to maintain the freshness of the fish which is highly popular in live and chilled conditions in South East Asian countries and United Arab Emirates, who are the major buyers. The live fish fetches premium price of 3-4 time higher than the dead fish trade, and chilled fish is another major form of export to other countries. All time retail price for the fish in the international live trade ranged between ₹ 1300 to 1600/kg.

Economics

The total operational expenditure and profit for culture of the fish in 1 acre water spread area is given in Table 2. Culturing the fish for one year at the stocking density of 3500 numbers per acre will support the farmer with net profit of approximately ₹1.5 lakhs with a price realization of ₹285 per kg. For the calculation, cost of production is calculated with the maximum price and selling price considered for the minimum price based on the earlier experience. Thus, the net profit can be increased by employing appropriate husbandry practices.

Table 2. Economics of coastal pond culture of Orange spotted grouper

Inputs	Cost (₹)
Pond preparation and water treatment	40,000
Seed cost–3500 nos @ ₹15/seed	52,500
Nursery rearing (hapa)	25,000
Expenditure towards live tilapia culture	25,000
Feed @ FCR 1:1 (for 2.4 tonnes of fish, approx. 2.5 tonnes of feed @ ₹ 110/kg is required)	2,75,000
Electricity	50,000
Miscellaneous expenditure (labour for grading)	50,000
Expenditure	517,500
Production: 2400 kg @ 80% survival with selling price @ ₹280/kg (Average harvest siz: 850 g)	6,72,000
Net profit	1,54, 500

Best Management Practices (BPM) for pond culture of Orange spotted grouper

The following steps are recommended for the coastal pond farming of Orange spotted grouper for better management with economic returns

- Seed transportation in the polythene bag should be avoided if the seed /fingerlings size exceeds more than 10 g. The dorsal spine for the fingerlings at the particular size is strong and prominent, thus, it may damage the polythene bags while in transport.
- Seed stocking during winter season should be avoided: The fish at initial stage (1-2 g) is easily stressed with the low temperature (< 27°C). Thus, fry staged fish transported at low temperature may stressed easily due to translocation.
- Grading in nursery is essential for reducing cannibalism: The species is highly carnivorous at the initial stage (<50 g). Thus, to enhance the survival, fish to be graded in the nursery phase.
- Use of hide outs: Hide-out should be used in grow-out culture pond for better feeding and ease of harvest
- Mixed feeding (artificial and low value fish) helps for better growth: Use of only trash fish deteriorate water quality and exclusive use of formulated feed increases size variation. Therefore, mixed feeding is recommended.
- Stocking of live tilapia: Stocking of the tilapia brooders before stocking the grouper in grow –out pond is highly recommended to make tilapia larvae readily available for the fish stocked in grow-out ponds. This practice will reduce feed cost in the culture operation.
- Good water quality: Maintaining good water quality with proper water exchange and appropriate fertilization at regular interval is recommended for to increase the natural food in the pond and also to maintain proper coloration of the fish for fetching premium price.

Brief Communication

Inferences on distribution and movement of some pelagic seabirds in western India

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India, with its extensive coastline, is home to a diverse array of seabirds. The Arabian Sea, Lakshadweep Sea, Bay of Bengal, and the island groups of Lakshadweep and Andaman-Nicobar offer varied habitats for these birds. The estuaries and mangrove ecosystems along the coastlines, and the neritic and pelagic zones of the country's vast EEZ combine to form unhindered foraging grounds for a significant number of coastal and oceanic birds. India's tropical location attracts seabirds from both the Northern and Southern Hemispheres, as they migrate away from their breeding grounds in search of more favourable wintering conditions. The inferences presented are based on personal observations and other published records, including those available in the online global database eBird. The personal observations span a period of six years from 2018-2024 on south western coasts of India (Kerala) and the islands of Lakshadweep. Observations were made along the shorelines and shelf waters off Kerala at seasons of seabird activities and off seasons. On board surveys were conducted up to a distance of 40 nautical miles off Kochi and Ambalappuzha. On a few occasions, seabird occurrences were documented enroute Lakshadweep islands from Kochi in ships. Monitoring at Lakshadweep consisted of shoreline and onboard surveys

Red-footed booby off Kochi

around the immediate waters of the islands as well as oceanic zones. Whether due to increased, regular, and synchronized seabird monitoring efforts and increased cyclonic events in the Arabian Sea and Bay of Bengal, or a combination of these factors, the records and diversity of seabirds encountered in India, is steadily increasing. The monitoring efforts carried out primarily and largely by the general public include individual as well as well-organised group endeavours. Such citizen-led monitoring programs, often organized in conjunction with migratory patterns and key times annually, have significantly contributed to these findings. An example is the regular 'Sea watching' events, of which the first author is a participant, organised by a community of birdwatchers in Kerala at strategic observation points across Kerala coasts and similar initiatives in other coastal states. An analysis of such observational data points that the addition of new records as well as the sightings of irregular occurrences of many species along Kerala resulted from these attempts. For instance, the recent discovery of Arctic tern on India's west coast by a hobbyist ornithologist highlights the importance of citizen science contributions. Similarly, the sightings of Christmas Island frigatebirds and a lone Red-footed booby in locations along the west coast and near the Kochi estuary, respectively, are direct results of dedicated individual or group efforts. The occurrence and distribution of regular migrants from both the northern and southern high latitudes follow the general physical and biological oceanography of the region. Observations from onshore areas, oceanic waters, and the Lakshadweep Islands show that birds tend to converge in areas with high pelagic productivity. This pattern is evident during the monsoon period (mid-May to October), when major species in groups congregate on the coastal waters of western India. This oceanic province, known for its annual monsoon-induced coastal upwelling, can sustain a vast number of seabirds. They primarily forage in inshore waters, even near shorelines, specifically targeting anchovies, sardines, mackerel, and shrimps with minimal interaction with the local fishery. The two-month annual trawl ban in western Indian waters also provides favourable conditions for wintering birds.

Seabird movements along the west coast

Seabirds are drawn to Indian waters primarily by four factors. First, they migrate from breeding grounds in both hemispheres to escape colder climates. During austral and boreal winters, various species seek warmer temperatures and better feeding opportunities in subtropical and tropical latitudes. Second, some species move from nearby breeding grounds, such as from islands and continental margins in the Indian Ocean. These post-breeding dispersals are often species-specific and independent of seasonal climatic changes. Third, species might move intentionally or unintentionally to western Indian waters in the prevailing winds. This can be advantageous due to increased oceanic productivity, especially during

Flesh-footed shearwaters off Ambalapuzha

Wilson's Storm Petrel foraging at Kochi estuary

the annual monsoon season. Finally, occasional vagrant or nomadic species may arrive without a clear connection to climatic or oceanic processes. These individual behaviors are primarily driven by intrinsic factors.

High latitude migrants

The waters surrounding India see year-round regular occurrence of migratory species from both the Northern and Southern high latitudes. Southern high latitude migrants, such as Wilson's storm petrels and Flesh-footed shearwaters, arrive in Indian waters from April to May and remain until September. Conversely, the arrival of Arctic breeding species, like three species of jaegers, coincides with the autumn migration of northern hemisphere birds to tropical regions. Observation records demonstrate an increasing frequency of occurrence These species appear in Indian waters during the mid-summer monsoon and return to their breeding grounds by April or May. Observation records demonstrate an increasing frequency of occurrence of these species in Indian coastal waters which are crucial feeding and staging areas for these migratory populations.

However, many other species have been recorded only a few times or even just once, by way of nomadism, vagrancy or consequent to cyclonic storms. This includes the Tropical shearwater, Sooty shearwater, Cory's shearwater, Black-bellied storm petrel and Light-Mantled Albatross. These isolated and erratic records often occur during the exceptionally windy monsoon seasons. For instance, the single exceptional records of Light-Mantled and Grey-headed albatrosses from the Palk Bay region happened during the summer monsoon. Similarly, the Lesser frigatebird and Christmas Island frigatebird occasionally appear along Indian coastlines and sometimes venture inland due to prevailing winds. Masked boobies were occasionally observed along the western Indian coast, particularly during the monsoon season. Both adults and juveniles were documented, often in exhausted or stranded conditions due to stormy weather. These seabirds are widely distributed across the major oceans and have breeding colonies in the northern Indian Ocean islands, including a small number of pairs in the Chagos archipelago. As mentioned earlier, the highly productive waters off India's western coast, encompassing the eastern Arabian Sea and Lakshadweep Sea, experience regular movements or passage of migrants from both hemispheres. Several observations conducted along the coasts of Sri Lanka have revealed a consistent pattern of seasonal species movement in this oceanic region. Among these, Pomarine, Long-tailed, and, less frequently, Parasitic jaegers are observed migrating eastward across the southern tip of Sri Lanka and into the Bay of Bengal. The immediate origin of these passing flocks is the western waters of India where they have been reported annually. These Holarctic breeding birds are known for their continental habits during the breeding season. However, during the non-breeding period, they disperse widely across the major oceans, sometimes even traversing land. Typically, they follow coastal routes during migration. While Sri Lankan observations suggest a return journey to their breeding grounds via the Bay of Bengal, Malacca Strait, and the northern Pacific in the spring, their autumn migration route to southern wintering areas, including India's western coast, remains uncertain. Observation data from the northern Indian Ocean is insufficient to clarify whether these jaegers enter the Red Sea from the Mediterranean and then migrate south-eastward to India. Although there are records of them in southern African waters, no evidence exists for a migration path from the Atlantic to the western Indian Ocean, encompassing the

Parasitic jaegers in coastal waters off Ambalappuzha

entire eastern African coast and continuing into the eastern Indian Ocean region. The notable absence of any species of jaegers in the Lakshadweep waters also implies that they migrate along a more coastal route than crossing the oceanic waters. One of the primary factors contributing to India's higher oceanic productivity, particularly along the western coast, is the prevailing wind patterns that significantly influence the movement and distribution of seabirds. During the summer monsoon (May-September), trade winds blowing from the southeast equator turn towards the Indian subcontinent, creating extensive coastal upwelling zones. These conditions are ideal for seabirds, as they can conserve flight energy by riding the prevailing winds to areas with higher productivity. As a result, the western Indian coast witnesses numerous sightings of various tern species, including Saunders tern, Lesser and Great crested terns, Bridled tern, Sooty tern, Common tern, Lesser noddy, Brown noddy, Little tern, Caspian tern and others. The abundance of certain species suggests that they are driven to Indian shores by these trade winds. Many of these terns, which are primarily oceanic and have breeding grounds in the region such as Lakshadweep Islands (Sooty & Brown noddy terns), Maldives (Sooty tern, Great crested tern), Chagos (Lesser noddy, Brown noddy & Sooty terns), and Sri Lanka (Bridled tern, Common tern, Greater crested tern), are observed passing the Indian coast annually.

Sooty tern *Onychoprion fuscata* & Brown noddy *Anous stolidus*: Certain islets or small sandbars in some atolls of Lakshadweep historically host the breeding colonies of some oceanic terns, including Sooty and Brown noddy terns, etc. Over the last century, many of such known breeding locations have been lost or abandoned by the birds. This can be linked to the increased human inhabitation on many of the atolls as well as to the gradual rise of sea level, though with more pronounced seasonal effects, that has made some of them vulnerable to flooding. Their breeding has been studied by many over the last 150 years, including ourselves, yet a clear picture is not available regarding the exact seasonality of the breeding events. As highly oceanic, these two terns has generally been not observed across the mainland coast of India. However, on rare occasions, both of them had been observed in the western coastal waters. It is not clear whether they are intentional migrants or wind-blown individuals. The record of a few Brown noddies along the west coast in healthy condition during the current monsoon suggests an intentional movement from the nearby breeding colonies across the atoll system of Laccadive-Maldives-Chagos ridge. But in the case of Sooty tern, they are almost completely absent in the records along the coastal waters during any season. Even in the conditions of powerful trade winds blowing across their breeding colonies in Lakshadweep their general absence in the mainland coasts points to an ongoing breeding event in the Lakshadweep islands during the monsoon months as observed in some previous studies. Another inference that could explain this absence is that they complete their breeding by the time of the initial spell of monsoon and leave their breeding range to more southern or western oceanic regions. This could be substantiated if we consider the occurrence of a few wind-blown juveniles of sooty terns, though irregular, from various locations along the western coasts of India. Our observations made between 2016 and 2020 of the breeding colonies of Sooty terns and Brown noddies at Pitti Islet suggest that they may not have the same breeding time there. Instead, the Sooty terns breed earlier in the summer monsoon while the fledglings of Brown noddies were observed to be more numerous towards the end of the same season. However, there is also the possibility of a continuous breeding event of these species in the islet as suggested by some previous observations, or a synchronicity in breeding. Year-round monitoring of the islet is necessary to ascertain the same.

Lesser noddy *Anous tenuirostris:* In the summer monsoon, it is noticeable that a considerable number of Lesser noddies were sighted along the entire west coast of India during the months of July and August. This species is known to spend non-breeding time (December to April) in large numbers in Maldives and having large breeding colonies in Chagos and Seychelles. The occurrence of Lesser Noddy in India suggests the movement/dispersal of a population, probably a post-breeding one, along the prevailing monsoon wind regime from the above-mentioned breeding localities.

Saunders tern *Sternula saundersi:* The distribution of this species is mostly confined to the western Indian Ocean with widely scattered breeding localities. Sighting records during the summer monsoon show that non-breeding birds, including a few juveniles, frequent the western inshore waters of India and are generally absent during the remaining periods of a year. Since different populations in the western part of Arabian Sea (including Red Sea) are known as either resident breeders or migrants to southern Africa, those individuals moving to India could originate from the breeding colonies of Chagos or Seychelles along the monsoon winds.

Lesser-crested tern flock on Pallana coast, Alappuzha

Bridled tern *Onychoprion anaethetus:* This circumtropical species is one among the most common terns that visit western India during the mid-monsoon periods. The southward movement of Bridled terns (hereafter BTs) along the western coast of the Indian subcontinent (which also includes Sri Lanka) during the southwest monsoon season has been well documented by several observers from western India and Sri Lanka. Such observations of population movement towards the south along the inshore waters of India have been made from Mumbai to Kerala coasts during the August-September period. If we consider the timing at the known breeding locations of BTs in the Indian Ocean, it is highly probable that those that reach India originate from the eastern Indian Ocean breeding sites post breeding, by following the trade winds. Observers recorded the arrival of BTs at numerous breeding sites across the western Australian coasts by mid-October. Given the timing of mass movements of Bridled Terns (BTs) along the western coast of India and off southern Sri Lanka, it is plausible to infer that these birds undertake an annual round-trip migration primarily influenced by trade winds. After breeding in western Australia, they migrate to the productive upwelling waters of the western Indian shelf.

Great (*Thalasseus bergii*) and Lesser crested (*Thalasseus bengalensis*) tern: These are the two common species that can be seen regularly along the western waters of India irrespective of seasons, though large groups are seen towards the post monsoon periods. There are breeding sites of Great crested terns in Maldives and the population seen in India might emerge from there. In the case of Lesser crested terns there is no known breeding activity in Maldives and Chagos, but they are observed to move along western Indian waters from the Arabian regions during the end of summer monsoon. Large flocks of this species, sometimes mixed with the other conspecific, are recorded from various shorelines and estuarine regions of Kerala towards the second half of the boreal migratory period. Both the species forage across a wide area from the continental shelf to estuaries, backwaters as well as other coastal wetlands like paddy fields and marshes.

Seabird interactions with fishery

One of the finest interactions between fishery and seabirds can be seen in the Lakshadweep islands. As mentioned earlier, two species of oceanic tern breeds in this region and thus have a regular presence and movement in the sea surrounding the islands. The people of these islands are following a sustainable method of tuna fishing. Their efforts in finding a tuna shoal would be largely scaled down if they could find a few birds in surface feeding. We noticed such occasions where the fishers would follow the birds to their point of aggregation where shoals of skipjack or kawakawa would be detected. They could detect shoals of skipjacks or kawakawas. Usually, the birds feed on small fishes chased to the surface by large pelagic fishes such as the tunas and species like needle fishes, dolphin fishes, seer fish, barracudas, and billfishes. Thus, in a small-scale island fishery where subsistence-level pole and line fishing is prevalent by using small to medium-sized boats, minimizing fishing efforts through the use of a reliable biotic cue can significantly enhance both economic efficiency and time-saving. This cue, which directly indicates the presence of target resources, allows fishermen to concentrate their efforts on areas with higher potential yields, thereby optimizing their livelihood activities. Seabird bycatch and competition for the same resources by both humans and seabirds remains the primary fishery related impact on seabird populations in the ocean. In general, most species of migrant seabirds target the same fishery resource as humans as their food. These include seabirds which primarily target plankton feeders and the smaller pelagics such as sardines, flying fishes, anchovies, and the shrimps. Thus the interaction of seabirds with fishery becomes more evident during the productive summer monsoon period. However, the extent of bycatch mortality or injuries remains to be conclusively assessed. Current global estimates indicate about 700000 annual seabird mortalities occur through two major fishing gears, gill net and longline, with the former surpassing the later. Trawl and purse seine fisheries contribute to bycatch to much lesser extents. Mortality through gillnetting and longlining is not documented in India. No mortality of seabirds has been reported from the tuna fishery in India. Fishery discards can have both positive and negative effects on seabird populations, serving as a supplementary food source while also increasing the risk of bycatch.

While the lack of reports suggests that seabird bycatch in Indian seas might not be substantial, only dedicated monitoring through extensive surveys employing advanced technologies like electronic monitoring, remote sensing, big data, and artificial intelligence can provide an accurate assessment. As interest in and monitoring of seabirds grows, comprehensive information on these vital components of the marine ecosystem will become increasingly accessible.

Brief Communication

Protected guitarfish released by fishermen of Uttara Kannada District, Karnataka

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The Widenose guitarfish (*Glaucostegus obtusus*) is a small elasmobranch species that typically inhabits shallow coastal waters and estuaries. These fish are frequently caught as bycatch in various fishing practices, including gillnets, single-day trawlers, hook and line, and shore seine fisheries. The largest recorded specimen of this species, measuring 114 cm, was found off the coast of Goa. In March 2024, during routine visits to fish landing centers, researchers from the ICAR-Central Marine Fisheries Research Institute (CMFRI) observed two instances of incidental entanglement of the Widenose guitarfish, a species protected under Schedule I of the Indian Wildlife (Protection) Act. These incidents highlight the ongoing challenges in conserving this vulnerable species and underscore the importance of raising awareness among local fishing communities. The first incident was recorded at the Gokarna fish landing center, where Dr. Mahesh V., scientist from the Karwar Regional Station of ICAR-CMFRI, encountered a live mature male Widenose guitarfish measuring 65 cm caught in a gillnet. The fishermen, unaware of the species' protected status, were informed by Dr. Mahesh about the legal protections in place and the importance of releasing such specimens back into the sea. This intervention was crucial, as it led to the immediate release of the guitarfish and prompted the publication of an awareness article in the *Karavali Munjavu* newspaper. A week later, another accidental entanglement of a Widenose guitarfish occurred at Aligadda beach, Karwar. In this case, the fishermen, having been recently informed through the newspaper article, promptly identified the species and ensured its safe release. The specimen, a mature female measuring 74 cm, was reported to ICAR-CMFRI by the fishermen, who were motivated by their newfound awareness. Dr. Mahesh used this opportunity to reinforce the protection status of the species among other fishermen at the

Widenose guitarfish (*Glaucostegus obtusus*) entangled in gillnet

Release of Widenose guitarfish (*Glaucostegus obtusus*) by fisherman

beach, encouraging them to release any accidentally caught guitarfish in the future. The conservation of the Widenose guitarfish is part of a broader effort by ICAR-CMFRI to protect elasmobranchs along the Indian coastline. Previously, ten elasmobranch species, including four sharks (Gangetic Shark, Pondicherry Shark, Speartooth Shark, and Whale Shark), two rays (Ganges Stingray and Porcupine Whipray), three sawfishes (Green Sawfish, Largetooth Sawfish, and Knifetooth Sawfish), and one guitarfish (Giant Guitarfish), were listed under Schedule I of the Wildlife Protection Act of 1972. To enhance conservation efforts, ICAR-CMFRI has been actively creating awareness among coastal communities through a dedicated project titled "Developing management plans for sustainable exploitation and conservation of elasmobranchs in India." This initiative involves a diverse group of stakeholders, including fishermen engaged in mechanized and motorized fishing operations, fish trader associations, officials from the Department of Forests and Fisheries, coastal police, the Indian Navy, local government leaders, as well as professors and students from various educational institutions. The success of these awareness programs is evident in the rescue and release of numerous Whale sharks, an iconic elasmobranch species, that were accidentally entangled in fishing gear. The collective effort of local communities, informed and empowered by ICAR-CMFRI's initiatives, has been crucial in the conservation of these species. In response to the declining populations of several elasmobranch species, an amendment to the Wildlife Protection Act in 2022 added nine more elasmobranchs to Schedule I. The newly listed species include Bottlenose wedgefish, Smoothnose wedgefish, Bowmouth guitarfish, Clubnose guitarfish, Widenose guitarfish, Giant manta ray, Reef manta ray, Giant freshwater whipray, and Dwarf sawfish. ICAR-CMFRI scientists emphasize the importance of continuous collaboration with the Fisheries Department and Forest Department to broaden awareness programs, particularly concerning the newly listed species. Fishermen are urged to be vigilant about the incidental catch of these protected species and to release them back into the sea if they are alive. In cases where the fish is dead, it is essential to report the incident to the nearest Forest or State Fisheries Department. Trading of these specimens is strictly prohibited, even if the fish dies after being landed, as it would contravene conservation laws and undermine efforts to protect these endangered species. The conservation of the Widenose guitarfish and other elasmobranchs is critical to preserving marine biodiversity. Through research, education, and active engagement with local communities, ICAR-CMFRI is leading the way in promoting sustainable and responsible marine resource management. The positive response from local fishermen in recent incidents underscores the importance of awareness and the potential for collective action in safeguarding our marine ecosystems.

Brief Communication

A note on women entrepreneurs of Iduvanipalem's fishing village of Andhra Pradesh

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Fishing village of Iduvanipalem under Kaviti Mandal of Srikakulam District, Andhra Pradesh is witnessing a silent women empowerment process. In this coastal village, around 40 women self-help groups (SHGs) are transforming their lives and community through the age-old trade of fish drying. The residence of about 3,000 fishers, and approximately 16 inboard boats, 65 outboard engine boats, and 90 non-motorized fishing vessels available, the men catch the fish while the women have organized themselves into self-help groups, each comprising 10-15 members. These groups play a pivotal role in the procurement, processing, and selling of dried fish, creating a thriving local economy. The resulting dried fish like anchovies, sardines, and ribbon fish, find their way to nearby markets such as Berhampur and Sonepur in the neighboring state of Odisha. The peak months of October to January witness a flurry of activity, with an average daily production of around 3,000 kg of dried fish. The economic impact of these women entrepreneurs is substantial. Dried anchovies, with their high demand, fetch an average of ₹250 to ₹300 per kg. Meanwhile, a 20 kg bag of sardines commands prices ranging from ₹550 to ₹650, and ribbon fish, sold individually, brings in ₹1200 for 80 pieces. Each woman earns about ₹750 to ₹800 rupees per day after negotiating the input costs of labour, packing and transport to market. This steady income not only supports the livelihoods of the women involved but also contributes to the overall prosperity of the village.

Beyond the economic benefits, the self-help groups in Iduvanipalem are fostering a sense of community empowerment. A portion of the revenue is deposited in the Grama Vikas Bank through a female agent of the community. Through collective efforts, these women are challenging societal norms and proving that they can excel in traditionally male-dominated industries. The ripple effect is evident as education and healthcare initiatives gain momentum, creating a holistic transformation in the village. Thus, these women entrepreneurs stand as beacons of resilience and empowerment which is a testament to the transformative power of community-driven initiatives.

Women filling bags with sundried fish to be transported to the market

Brief Communication

A note on the fish species affected by the sea sparkle bloom in the coastal waters of the Gulf of Mannar

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A 6-kilometer stretch of coastal waters between Periyapatinam (9.250915 N, 78.909109 E) and Indira Nagar (9.265104 N, 78.923969 E) in the Gulf of Mannar witnessed a *Noctiluca* bloom from August 28th to September 2nd, 2022. The bloom of *Noctiluca scintillans* (Macartney), a bioluminescent dinoflagellate with a size range of 0.6 to 1.15mm that emerged on September 2nd, 2022, turned coastal waters green, affecting small pelagic fish and reef-associated fish, and

A. View of the *Noctiluca* cell under the microscope (4X); B. freshly dead fish sorted on the shore; C. scattered stranded fish on the shore; D. decayed stranded fish on the shore emitting a foul odour. We identified and quantified the species diversity of fish that perished during the bloom period. From an estimated 2.5 tonnes of fish washed up on the beach, 50% of the fish were from the family Clupeidae, followed by Gerridae and Leiognathidae. These stranded fish were collected by local fishermen. The 53 stranded fish species include 46 teleosts, 5 crabs, and one sea anemone and annelid species each. Since 2019, *Noctiluca* blooms have been a regular occurrence in the Gulf of Mannar during the brief period between the southwest and northeast monsoons. However, in 2022, the *Noctiluca* bloom started as early as the middle of August, and continued till October, during which we maintained bloom monitoring. The primary causes of fish death in Periyapatinam and Indira Nagar coastal waters were low dissolved oxygen and an increase in ammonia concentrations. The observations during the close monitoring of the algal bloom along the coast provided information of the species with size range, that died due to the algal bloom.

Table 1. Fish mortality caused by the algal bloom

Species	Family	Size range (cm)
Siganus canaliculatus	Siganidae	8-9
Sillago sihama	Sillaginidae	25.8
Gerres filamentosus	Gerreidae	11.2-14.2
Epinephelus merra	Serranidae	23.2
Ellochelon vaigiensis	Mugilidae	15.6-16.2
Thalassoma hardwicke	Labridae	11.8-14.2
Karalla dussumieri	Leiognathidae	8.5-9.0
Aurigequula fasciata	Leiognathidae	13.2
Terapon puta	Terapontidae	10.2-13.0
Saurida micropectoralis	Synodontidae	15.2-17.5
Lutjanus fulviflamma	Lutjanidae	13.5
Parupeneus indicus	Mullidae	10-10.6
Platycephalus indicus	Platycephalidae	9.2-20.0
Plotosus lineatus	Plotosidae	14.5
Sardinella albella	Clupeidae	12.5
Hemiramphus lutkei	Hemiramphidae	18.4-26.2
Alepes kleinii	Carangidae	13.5
Pomadasys furcatus	Haemulidae	18
Amphiprion sebae	Pomacentridae	9-10.5
Iniistius cyanifrons	Labridae	7.8
Lactoria cornuta	Ostraciidae	6.4-8.6
Ostracion cubicum	Ostraciidae	5.2
Zebrias synapturoides	Soleidae	12.2
Lethrinus lentjan	Lethrinidae	5-11
Jaydia queketti	Apogonidae	8.9-10.2
Syngnathoides biaculeatus	Syngnathidae	20.4-25
Uranoscopus marmoratus	Uranoscopidae	9-15

Species	Family	Size range (cm)
Lalmohania velutina	Monacanthidae	7.2-7.7
Parascorpaena picta	Scorpaenidae	9.6
Osteogeneiosus militaris	Ariidae	16.0
Sepia pharaonis	Sepiidae	17.5
Parapercis hexophtalma	Pinguipedidae	9.2
Oxyurichthys papuensis	Gobiidae	8.8
Strophidon sathete	Muraenidae	23.5
Ashtoret lunaris	Matutidae	6.2
Charybdis (Charybdis) annulata	Portunidae	3.5
Portunus pelagicus	Portunidae	7.5
Parapercis pulchella	Pinguipedidae	5.5
Hilsa kelee	Clupeidae	9-9.5
Nematalosa nasus	Clupeidae	8.5-9.5
Escualosa thoracata	Clupeidae	3-5
Stichodactyla haddoni	Stichodactylidae	
Diodon hystrix	Diodontidae	15-18
Epinephelus coioides	Serranidae	16-18
Uropterygius concolor	Muraenidae	75
Gymnothorax undulatus	Muraenidae	75-80
Thalamita crenata	Portunidae	3-4
Atergatis integerrimus	Xanthidae	4-4.5
Terapon jarbua	Terapontidae	13-15
Gymnothorax pictus	Muraenidae	77-85
Arothron hispidus	Tetraodontidae	9.5-12.5
Hemiramphus far	Hemiramphidae	18-22.5
Arenicola sp.	Arenicolidae	9-13.0

Brief Communication

Report on avian prey in the diet of sharks from the eastern Arabian Sea

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Studies on the food and feeding of the graceful shark *Carcharhinus amblyrhynchoides* and the tiger shark *Galeocerdo cuvier* from specimens collected from the landings at Cochin Fisheries Harbour, Kerala, on 13th February and 13th March 2024 respectively, showed surprising insights into the dietary habits of these shark species. The male *C. amblyrhynchoides* specimen, which measured 210 cm in total length and weighed 54 kg was caught by a hook and line operated in the Arabian Sea off the south-west coast of India. The gut length was 46 cm, with a weight of 880 grams. Notably, the content weight was found to be 358 grams, indicating substantial recent feeding activity. The state of the gut was observed to be three-fourth full, suggesting a well-fed condition. Among the dietary findings was the presence of a bird belonging to the Laridae family identified as *Chlidonias niger* (Black Tern) from its black and white plumage with a black bill and black eyes. It weighed 133 grams. The presence of this bird in the gut contents indicated the shark's opportunistic predatory behaviour. In addition to the bird, the gut contents also included 1 puffer fish, 2 crabs (*Charybdis smithii*) and beaks of the oceanic purpleback flying squid *Sthenoteuthis oualaniensis*, showing the wide diet spectrum of *C. amblyrhynchoides*.

C. amblyrhynchoides landed at Cochin Fisheries Harbour

Chlidonias niger obtained from the gut of *C. amblyrhynchoides*

The male tiger shark specimen, which measured 350 cm in total length and weighed 50 kg was caught by a hook and line operated in Gujarat waters of the Arabian Sea. The fishermen who brought the shark to the landing centre mentioned that they observed the shark catching a bird, prompting them to quickly deploy a hook-and-line operation. This observation underscores the dynamic interactions that occur within marine ecosystems, shedding light on the opportunistic and highly predatory nature of tiger sharks and their potential impact on avian populations. The gut measured 59 cm in length and weighed 11.47 kg. The content weight was found to be 4.37 kg, and the gut's condition was noted to be 3/4 full, indicating that the animal was well-fed. A bird belonging to the Laridae family *Larus fuscus*, also known as the Lesser Black-backed

G. cuvier landed at Cochin Fisheries Harbour

Larus fuscus obtained from the gut of *G. cuvier*

Gull, was identified in the diet contents. Its characteristics include a white head, white neck, dark grey back, longer, pointed black wings, and yellow legs. We also observed parts of a turtle in the shark's stomach, demonstrating the diverse feeding habits of *G. cuvier*.

Tiger sharks are among the most voracious predatory sharks and have been known to prey upon sea birds, with anecdotal instances of feeding upon terrestrial birds too. The first scientific evidence of tiger sharks feeding regularly on terrestrial birds was reported by Drymon *et al*. (2019). These findings challenge traditional notions of shark feeding behaviour and emphasize the species' role as an apex predator capable of preying on a variety of organisms. They also warrant the need for continuous monitoring and research efforts in our marine ecosystems to better understand the dynamics of marine food webs and the ecological roles played by apex predators like *C. amblyrhynchoides* and *G. cuvier*.

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Brief Communication

Emerging fishery of Unicorn leatherjacket along Chennai coast

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Unicorn leatherjackets (*Aluterus monoceros*) (Family Monacanthidae) are locally known as "Seruppumeen" in Tamil due to their highly compressed body, rough, thick sandpaper like skin and human footwear like appearance. In Kasimedu landing centre (Chennai) the unicorn leatherjackets were usually landed in negligible quantity along with other fishes. They had least importance in the fishery, considered unpalatable and thrown away as trash fish.

Unicorn leatherjacket *Aluterus monoceros* (Linnaeus, 1758)

Recently, during the months of August – September 2023, an unusually heavy landing of leatherjackets was observed in Kasimedu fish landing centre. On an average each trawler brought 4 to 5 tonnes of leatherjacket fish every day which amounted to a total 150 to 180 tonnes of fish per day. The fishes were exported and about one lakh tonnes obtained from 700 trawlers fetched an export value of ₹30 crores (Ref: Tamil newspaper "Dinathanthi" dated September 17, 2023).

Each fish weighed 0.8 to 1.2 kg. The minimum export size was 300 g. The exporter said that the fish skin was peeled, head cut off and the body alone was exported. The exporters were of the opinion that, this fish is extremely tasty, much tastier than pomfret and seer fish. It is much sought-after fish in South-East Asian countries for preparing delicacies like fried rice, soups, salads etc. After seeing the export market, the locals also have started buying this fish at the rate of ₹250 to 280 per kg. The meat quality is white and firm and the taste is assessed on par with pomfrets and seerfishes by consumers of these fishes. The length and weight range of the fish were from 420 mm to 500 mm and 782 g to 1181 g respectively. Three fourth of the visceral cavity was occupied by the liver and weight of each liver ranged from 60 g to 80 g. A study to assess the utility of this liver to extract oil or consumption is needed. All the specimens were either immature or in maturing condition and fishes with gonads in mature state were not recorded. Male: Female ratio was 1:1.1. While the males were entirely immature (100%), among the females 50% were immature and rest in maturing condition. Male gonads were light cream in colour and female gonads were pink in colour. Gut analysis showed that empty gut was dominant (84.2%) and full stomachs (5.2%) only. Silverbellies, threadfin breams, elvers, prawns and *Acetes* were the major food items. Conversation with fishermen indicated that initially large quantities of leatherjackets emerged off Guntur, Andhra Pradesh in August 2023. The shoal later moved towards south and was spread from along Pazhaverkadu (Pulicat) to Chennai coast. From Pazhaverkadu, the fishery reversed to Guntur. The fish shoal appears to move about 10 km every day and forms fishery at corresponding location. The fishermen co-relate the occurrence to "Vandal thanneer" (upwelling-like phenomenon) that usually occurs along Chennai coast during September-October. According to information in FishBase, this is a benthopelagic fish with adults mostly in deeper waters, and juveniles travel with jellyfish close to the shore. Further investigation on the resource are required to assess the fishery.

Landing of leatherjackets from trawlers in Kasimedu Landing Centre

Brief Communication

STI-Hub at ICAR-CMFRI for advanced scientific collaboration and innovation

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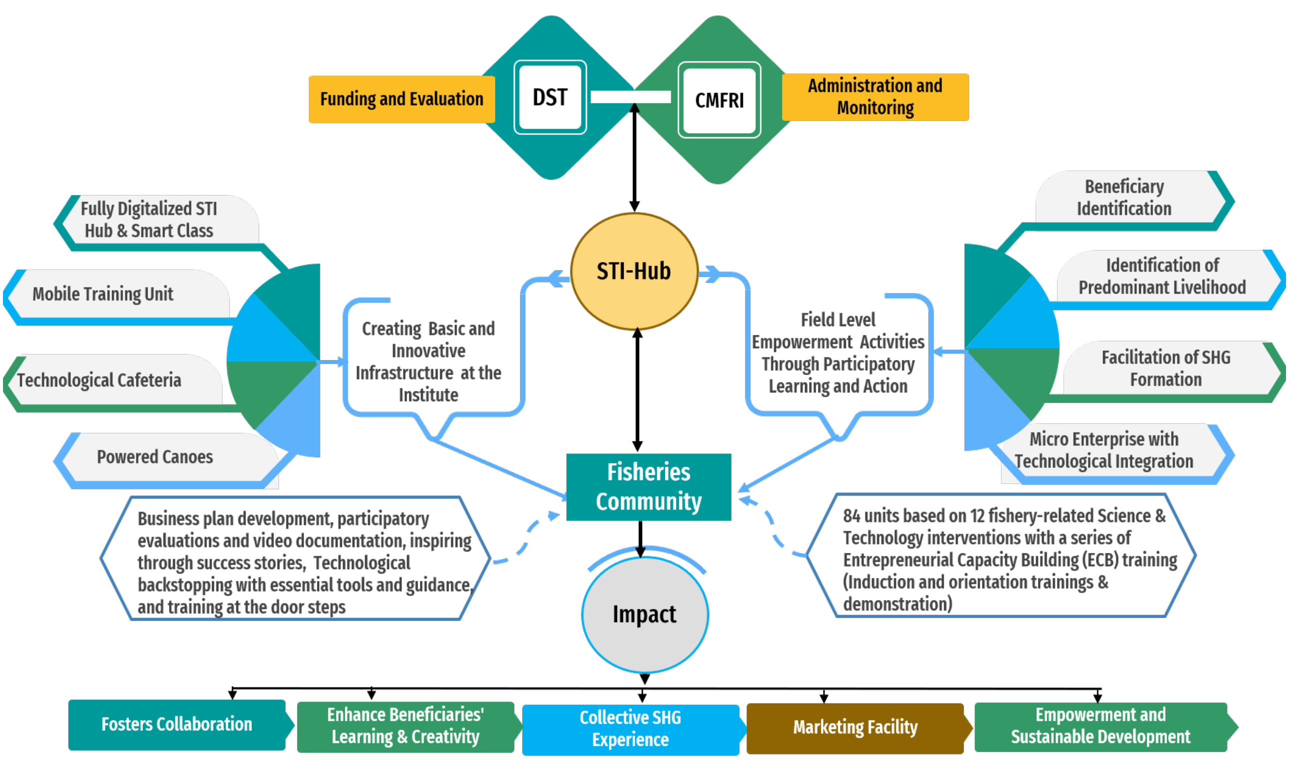
The 'Science Technology and Innovation (STI) Hub in Fisheries Sector' is a visionary project by ICAR-Central Marine Fisheries Research Institute (CMFRI), funded by the Department of Science & Technology (DST), New Delhi, with a budget of 3.18 crores over three years (2022-2025). This transformative initiative aims to revamp infrastructure and implement fishery-based entrepreneurial interventions, particularly benefiting Scheduled Caste (SC) communities. Starting in Ernakulam and expanding across Kerala, it promises to enhance livelihoods and foster sustainable fishing practices. The state-of-the-art STI-Hub at ICAR-CMFRI is being developed as a beacon of scientific collaboration and innovation, propelling entrepreneurial capacity building on fishery-based technologies and unlocking new opportunities for sustainable growth.

The project focuses on identifying fishery-based micro-enterprises based on the predominant livelihood options that meet the needs of SC stakeholders and promotes Entrepreneurial Capacity Building (ECB) through training and sustainable ventures. Successes in ECB are recorded and shared using innovative ICT methods to boost the hub's impact. Additionally, the hub helps SHGs and entrepreneurs connect with institutional, financial, and technical support groups to further their empowerment.

The project empowers the fisheries community through Participatory Learning and Action (PLA). By analyzing the specific needs of each location, the project forms Self-Help Groups (SHGs) focused on fishery-based micro-enterprises that align with the predominant livelihood of fisherfolk. These groups receive ECB training to engage in sustainable, economically viable activities. The project assesses each phase's technical and financial viability through participatory evaluations and video documentation. Success stories are showcased to inspire collective action. The project addresses the challenges faced by SC fisherfolk by gathering data via structured interviews and ICT-based tools. It connects SHGs and entrepreneurs with technical, institutional, and financial resources, fostering empowerment and sustainable livelihoods. The STI-Hub for the fisheries sector focuses on the Central Zone of Kerala, starting with Ernakulam district's coastal areas, including Vypin, Narakkal, Elamkunnappuzha, and others. The project aims to directly benefit 500 SC



Conceptual Framework of STI-Hub, Ernakulam

fishermen and indirectly support 2,500 others, with plans for future expansion to additional coastal districts.

The project has established innovative infrastructure at the institute, including a fully digitalized STI-Hub, a smart classroom, a mobile training unit, a technological cafeteria, and powered canoes, all designed to enhance beneficiaries' learning, creativity, and empowerment. The STI-Hub provides essential tools and guidance, while the mobile training unit delivers training directly to the beneficiaries. The technology cafeteria fosters collaboration between the fishing community and the research organization. These advancements drive sustainable development, enabling beneficiaries to realize their full potential and make a positive impact on their communities.

The STI-Hub project is focused on practical, location-specific, and environmentally friendly fishery technologies to improve the livelihoods of SC fisherfolk. The ECB training in technologies such as cage culture, pearlspot seed production, fish vending, and more included orientation, awareness programs, and demonstrations. The documented success stories and interventions, practical training using a Mobile Training Unit equipped with ICT facilities, lab equipment, and canoes with safety gadgets and digital recording devices has helped it to address challenges like unemployment, debt, and loss of traditional skills by helping SHGs and individual entrepreneurs connect with government and financial institutions for credit and entitlements through HRD programs. The project leverages collective SHG experience for sustainable business management. Collaborating with ICAR-CMFRI's ATIC and KVK, the Hub has also provided a sales outlet for SHG products, ensuring sustainability. The fully digitalized Hub has worked with NGOs, academic institutions, and SHGs to promote sustainable practices.

A total of 57 microenterprises (23 in 2022-23) and 34 interventions in the second year (2023-24) at Ernakulam, Thrissur, Kottayam, Alappuzha, Kannur, Kozhikkode, Pathanamthitta and Kollam districts of Kerala based on 12 fishery-related Science & Technology interventions, including cage culture, pearlspot seed production, fish vending, fish culture, ornamental fish culture, integrated fish farming, fish fertilizer production, value-added fish products, mussel culture, oyster culture, clam processing units and dry fish units were done. In the current year 200 additional beneficiaries (98 Male, 98 Female and 4 transgender stakeholders) were included into the project. Two women stakeholder beneficiaries of the project, in which, one was a trans-female, engaged in ornamental fish culture and another engaged in fish fertiliser production were honoured respectively during the International Women's Day celebrations of the institute in 2023 and 2024.

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Podophthalmus vigil landings at Kalamukku Harbour

Adult male *Podophthalmus vigil* landed at Kalamukku Harbour

Podophthalmus vigil, a portunid crab less appears in landings of Kerala and does not form a regular fishery in the region. In last two years comparatively good landings were recorded in overall landings of Tamil Nadu and Kerala. In Kerala, the maximum landing was recorded in the year 2014 (205.5 tonnes) followed by 2023 (167.1 t) and 2022 (71.8 t) and in other years no substantial landings were recorded. Recently during April 2024, a good landing was recorded at Kalamukku landing centre, Vypin, Cochin. This species is commonly known as 'sentinel crab' and also long-eyed crab', from its long eye stalks which is an uncommon character in portunid crabs. This species of swimmer crab is found in tropical areas of the Indo-Pacific Ocean, including Hawaii, Japan, South Africa, the Red Sea, and Australia. The carapace is greenish brown, and chelate legs and walking legs are in bright violet in male crabs, whereas the colour is pale violet. The carapace is very distinctly broader than long; the anterior margin is much broader than the posterior border, with a pair of anterolateral spines on either side. The long eyestalks reach or extend beyond the edges of the carapace. Males are larger than females and have more elongated limbs. From the landings, approximately 10 kg of the sample was procured, and brought to the laboratory and sample was segregated sex-wise and details were recorded. Only intact crabs i.e., crabs with all appendages were used for the morphometric studies. Females were dominating, the male: female ratio was 1:1.63. Carapace widths of the crab between the first and second anterolateral teeth were taken and designated as CW-1 and CW-2 respectively.

All the crabs were mature and among females, four crabs were in berried stage. In Tamil Nadu, the species forms a minor fishery and local people consume the species. However, presently, the species has no acceptance among the consumers of Kerala.

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Table 1. Details of carapace with/length and total weight of the male and female crabs of *Podophthalmus vigil* from trawl landings Cochin, India.

Sex	CW-1 (mm)	CW-2 (mm)	CL (mm)	TW (g)	Maturity condition
Male	65–115	53–95	28–45	13–111	Mature
Average	88.2 ± 10.9	70.7 ± 8.7	34.5 ± 2.4	45.0 ± 18.0	
Female	64–96	53–75	28–40	13–73	Mature; 4 berried
Average	75.8 ± 6.4	63.1 ± 5.3	32.0 ± 2.4	34.2 ± 8.7	
Pooled	64–115	53–95	28–45	13–111	All mature
Average	80.6 ± 10.3	65.9 ± 8.1	32.9 ± 3.2	38.3 ± 14.1	

CW-1 & CW-2- Carapace width 1 & 2; CL- Carapace length; TW- Total weight

Rare Killer Whale sighting in Lakshadweep

Killer whales (*Orcinus orca*) are the apex marine predators distributed widely in open sea and coastal waters throughout the world's oceans. During our marine mammal survey in Lakshadweep waters on 28th April, 2024, two killer whales were sighted at latitude 11.75361N and longitude 72.7475E (off Chetlat). Of the two orcas, one was larger with a length of about 7 m and the other one was of approximately 5 m. The depth of the sighting area was 1700 m and the closest distance from the shore was 4 nautical miles. The initial cue of sighting was the water spouts and a large dorsal fin observed approximately 300 m away from our research vessel. The height of water spouts from the expiration was nearly 2 m. The observed average blow interval was 44 seconds with a minimum interval of 7 seconds and maximum of 200 seconds. Upon close examination and photographic evidence, their unique body coloration of black and white patterns confirmed the species identification as a killer whale (*Orcinus orca*), from the family Delphinidae. The white underside of killer whales helps them blend in with the lighter water below, while their black back helps them blend in with the darker water above. This camouflage makes it harder for prey to spot them, giving them an advantage in hunting. Initially both of them were observed foraging on fishes and later they started interacting with our research vessel for 20 minutes, blowing, porpoising and observing from the sides, demonstrating their social nature. This rare encounter provides valuable insights into their behaviour and habitat. The surface water temperatures at the sighting locations was recorded as 32°C, with salinity 34.1 ppt, DO 5.6 ppm, pH 7.86, and Chl-a concentration of 0.3 µg/L. The sea state during the sightings varied from moderate to rough, and the weather conditions matched a Beaufort scale reading of four to five. The sighting of a killer whale in Lakshadweep highlights the need for expanded research on cetacean populations in the region. To fully understand killer whale ecology in this region, comprehensive studies on their stock structure, behaviour, feeding habits, and potential threats are essential. Additionally, a broader survey of cetacean diversity is needed to identify other species and assess their ecological roles. This knowledge is crucial for developing effective conservation strategies to protect these magnificent creatures and their fragile marine habitat.

The Killer whales were identified through the morphological features and exhibited various behavioural attributes including blowing (a. & b.), foraging (c. & d.) and porpoising (e. & f.).

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A note on the oceanic Sharp-tail mola landed

On 14th June 2024, an ocean sharp-tail mola (*Masturus lanceolatus*) was landed at Kollam Fisheries Harbour. The fish was entangled in 40 mm gillnet operated from a motorized fibre boat fitted with a 20 hp engine, at a depth of approximately 40 meters. The specimen had an approximate total weight of 40 kg and total length 85 cm. It was grey in colour and similar in appearance to the ocean sunfish (*Mola mola*) but could be differentiated by the projection on its clavus (pseudo-tail). Other common names for this fish include Sharpfin mola fish and Point-tailed mola fish. Rarely encountered, very little is known of the biology or life history of the sharptail mola. This species is the only member of its genus covered with extremely thick, and the extensive fat deposits under the skin observed in the present case is to probably help the fish to resist extreme cold temperature of the deep-sea habitat it occupies. Sharp-tail mola meat is considered a delicacy in Japan, but it's not commonly consumed in India. The preference for other seafood and the rare mola fish landings may be the reason for this limited commercial importance in the region.

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Carcass of Indian Ocean humpback dolphin recorded

Carcass of Dolphin '*Sousa plumbea*' (Indian Ocean humpback dolphin) was beached at Cherai landing centre, Ernakulam (10.1274909, 76.1825399), Kerala on 8th March 2024 afternoon. Ghost net (Gill net) was found entangled to the tail part of the dolphin and carcass was in a highly decomposed condition. The carcass had a total length of 163 cm, with measurements from the tip of the snout to the eye being 27 cm, from the tip of the snout to the blowhole being 33 cm, and from the tip of the snout to the centre of the anus being 108 cm, with a fin height of 13 cm and an approximate weight of 60 kg.

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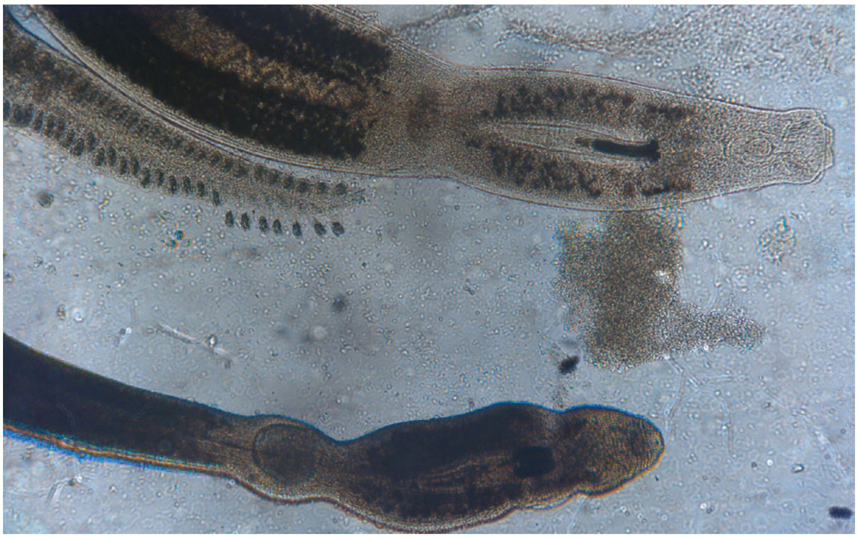
Microcotyle spp. infestation in the juveniles of wild Narrow-barred Spanish mackerel



Wet mount of gill showed the presence of *Microcotyle* spp. (50x) with attachment clamps

A study was undertaken to record the occurrence of parasitic infestations in the juveniles of the Narrow-barred Spanish mackerel, *Scomberomorus commerson* landed in Karwar, Karnataka. Twenty-three fishes (300 ± 30g and 30 ± 5cm) collected from Karwar fish landing centre in January 2023 were analysed using standard necropsy procedures. Gills, skin, fins, intestine, spleen, liver and kidney were examined under the microscope for the presence of parasites. Of the 23 fish examined, five were infected with *Microcotyle* spp. on their gills (PFI: 21.74%). The infested gills were pale in colour and covered with a thick coat of mucus. Wet mount of the gill showed the presence of *Microcotyle* spp. Parasites of the genus *Microcotyle* mainly infect the gills of marine fishes and generally feed on blood of the host. Mild infestations may not show any clinical symptoms but severe infestations may damage the gill filaments leading to anaemia, respiratory and osmo-regulatory dysfunctions and mortalities. *Microcotyle* spp. infestations have been reported in the gills of many fishes from various countries and considered a serious threat to cultured marine finfish.

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Unusual landings of *Satyrichthys laticeps*

An unusual landing of *Satyrichthys laticeps* was observed at Munambam Fisheries Harbour, Ernakulam on 9th April 2024. About 600 kg (20 boxes of 30 kg each) of *Satyrichthys laticeps* was landed by a multiday (6 days fishing trip) trawler operated at 120-150 m depth off Cochin, Arabian Sea. Other commercially important fish caught by the same trawler were *Synagrops* spp. (1200 kg) and *Plesionika quasigrandis* (660 kg). The sizes of the fishes ranged between 200-500 mm in total length and between 200-1500 g in weight. These fishes are locally called "*Helicopter meen*" as they resemble helicopters according to local fishermen. They were sold at the landing center at ₹10-15/kg to fish meal units. The *Satyrichthys laticeps*, distributed from Ratnagiri to Vizhinjam on the southwest coast of India, is rarely observed in commercial fishery landings and occurs in few, stray numbers only. Belonging to the family Peristediidae they are commonly known as 'Armoured gurnards' or 'Armored Sea robins'.

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