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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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Dr. A. Gopalakrishnan
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Fishers returning with catch of large carangids
Photo credit: Joe K Kizhakudan

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.

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Marine Fisheries Information Service
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From the Editorial Board

Warm greetings to all our esteemed readers

With a coastline exceeding 8000 km and spanning an Exclusive Economic Zone of 2.02 million sq. km, India has a rich and thriving marine biodiversity spanning across several groups from plankton, sponges, corals, seaweeds, crustaceans, fishes and the marine mammals. Several fishing craft-gear combinations operate in the different unique ecosystems within the Indian EEZ providing livelihoods and nutritional security to over 28 million stakeholders. A recent analysis of 135 fish stocks (Marine Fish Stock Status of India 2022) in the Indian EEZ concluded that 91.1% were in "healthy" condition with none in "collapsed" category. However, 8.2% were in overfished category highlighting the need for vigil and importance of appropriate science based fisheries management interventions. The lead article in this issue of MFIS highlights new approaches such as passive geo referencing while other communications capture the diversity of the marine fisheries sector in India.

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Lead Article

Passive georeferencing: A promising approach for finding probable fishing grounds

Eldho Varghese, J. Jayasankar*, Pratibha Rohit, Somy Kuriakose, K. G. Mini, Grinson George, Vinay Kumar Vase, Reshma Gills, Shelton Padua and A. Gopalakrishnan

ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala

*E-mail: jj.sankar@icar.gov.in

Abstract

Fishery management can benefit greatly from the use of geographic information system tools for habitat mapping, georeferencing fish catch and fishing effort data, and linking catch to oceanographic and biochemical parameters. As exploratory fishery resource surveys are time-consuming and expensive, landing centre-based surveys are frequently used in India to estimate the marine fishery resources. But it is challenging to map the habitat of the resources in such surveys as the resources seen at the landing centre are not geo-tagged. Passive georeferencing refers to the process of determining the geographical location of an object or entity using external information without actively transmitting any signals and is useful in situations where active transmission may not be desirable or feasible, and it allows for effective tracking and positioning without relying on active participation from the object being located. In this paper, the application of passive georeferencing approach for finding probable fishing grounds has been discussed along with its pros and cons and concluded with the way forward.

Keywords: *Marine fishery, resource assessment, fishing grounds, passive georeferencing*

Introduction

India has a rich and diverse marine fisheries sector due to its extensive coastline of about 8118 kilometres and a vast Exclusive Economic Zone (EEZ) of approximately 2 million square kilometres (https://dof.gov.in/marine-fisheries). The marine fisheries sector in India plays a crucial role in providing livelihoods, food security, and economic growth for millions of people. The Indian marine waters are home to a wide variety of fish species, including both pelagic and demersal species. The Arabian Sea on the west coast and the Bay of Bengal on the east coast are the major fishing grounds. India is one of the world's largest producers of fish, both marine and inland. The marine fish production in India is substantial, contributing to both domestic consumption and export markets.

Marine fishery management is of paramount importance for various ecological, economic, social, and sustainable reasons. Proper management ensures the responsible use and conservation of marine resources, enabling long-term benefits for both current and future generations. Effective fishery management helps maintain the health and integrity of marine ecosystems. By preventing overfishing and destructive fishing practices, ecosystems can maintain their ecological balance, support biodiversity, and provide essential services like nutrient cycling and habitat provision. Proper management ensures that fish stocks are harvested at levels that allow them to reproduce and replenish, thereby supporting food security and livelihoods.

Effective management relies on accurate and up-to-date data about fish stocks, ecosystem dynamics, and fishing practices.

Fishery management encourages scientific research and data collection, leading to better-informed decisions. Sustainable fishery management contributes to the conservation of marine biodiversity by protecting habitats and reducing the impact of fishing on non-target species. To this end, an assessment of the availability of marine resources will be helpful in deriving management plans by ensuring the sustainable harvest of the resources. Geographic Information System (GIS) tools are very useful in fishery management for mapping of habitats, georeferencing information on catch and effort and linking catch with the oceanographic and biochemical factors. GIS is a powerful technology used to capture, store, manipulate, analyse, and present geographic or spatial data. It combines various types of data, such as maps, satellite imagery, aerial photography, and attribute data (information about specific locations or features) to create interactive maps and visualisations. GIS allows users to present their findings and analyses in various formats, from printed maps to interactive web applications. This makes it easier to communicate information and insights to a wider audience. It allows users to understand and make informed decisions about spatial relationships and patterns, by providing tools for analysing and manipulating data to uncover spatial designs, associations, and trends. GIS applications are diverse and span various fields, including environmental management, natural resource exploration, disaster management, agriculture, and more. It aids in monitoring and managing natural resources, tracking changes in ecosystems, assessing environmental impacts, and planning conservation efforts. GIS has transformed the field of environmental management by providing insights into complex ecosystems. Researchers can make informed decisions about biodiversity preservation, ecosystem restoration, and sustainable resource management by visualising data on species distribution, land cover, and pollution levels.

Application of GIS in Fisheries

While terrestrial applications of GIS began in the late 1960s, its use in the marine environment didn't expand until the 1980s. The importance of computer-based mapping and spatial analysis in fisheries was stressed by Caddy and Garcia in 1986. During 2000, Meaden proposed a conceptual model for GIS in fisheries, explaining why its adoption in the sector was initially complex. Although mapping proved successful in capture fisheries, it has also gained importance in aquaculture (Mooneyhan, 1985). Initially, GIS for location analysis relied on remote sensing imagery. Subsequently, aquaculture locations, characterised by relatively stable nearshore environments, facilitated the development of GIS-based methods through simple survey mechanisms. Simpson (1992) recognised the potential of remote sensing to provide marine data relevant to GIS applications, including monitoring fishing effort, tracking pollutants, mapping bathymetry and seabed habitats, and measurements of water column properties, in the early stages of GIS adoption in fisheries. Early improvements witnessed in this using coastal GIS datasets included creating models of fish-habitat suitability, especially in inshore zones with features like mangroves, estuaries, seagrass beds, and littoral environments that could be easily mapped. GIS tools have found extensive applications in marine fisheries management and research, enabling scientists, policymakers, and stakeholders to make informed decisions for sustainable and efficient fisheries practices. The integration of spatial data and advanced analytical tools in GIS has revolutionised how marine resources are monitored, managed, and conserved. Despite advancements throughout the latter part of the last century, GIS applications in fishery-related work remained fragmented, incomplete, and predominantly small-scale (Jayasankar *et. al*., 2013). Owing to the potential it offers to the fisheries sector here we discuss a few thematic areas where GIS tools can be effectively utilised:

Fisheries Resource Mapping: GIS can be used to create detailed maps of marine habitats, including seafloor topography, coral reefs and other critical habitats. These maps provide a spatial context for understanding fish distribution, migration routes, and spawning areas, helping fisheries managers identify regions where conservation efforts should be concentrated.

Fisheries Management Zones: It aids in defining and demarcating different fisheries management zones based on factors such as species distribution, depth, and fishing regulations. By dividing fishing areas into zones with specific regulations and restrictions, authorities can enforce sustainable practices and prevent overfishing.

Vessel Monitoring Systems (VMS): Many fishing vessels are equipped with GPS devices that track their movements in real time. GIS helps integrate VMS data with other spatial datasets, enabling authorities to monitor vessel activities, track fishing patterns, and enforce fishing quotas and restricted areas.

Bycatch Reduction: GIS helps in identifying areas with high bycatch rates, where non-target species are accidentally caught. By analysing spatial data, fisheries managers can devise strategies to reduce bycatch, such as adjusting fishing gear, modifying fishing techniques, or designating bycatch mitigation areas.

Marine Protected Areas (MPAs): GIS tools help in managing marine protected areas, which serve as sanctuaries for fish and other marine organisms. By overlaying habitat maps, migration routes, and fishing zones, authorities can strategically locate and size MPAs to ensure effective conservation and sustainable fisheries.

Ecosystem-Based Management: GIS facilitates a holistic approach to fisheries management by incorporating environmental data like ocean temperature, currents, and nutrient levels. This helps in understanding the interconnections between species, habitats, and environmental factors, leading to more informed and integrated management strategies.

Illegal, Unreported, and Unregulated (IUU) Fishing Detection: GIS plays a role in combating IUU fishing by analysing vessel movement patterns, identifying unusual behaviours, and detecting potential IUU fishing activities. This enhances surveillance and enforcement efforts to curb illegal fishing practices.

Impact Assessment: Before initiating new development projects in marine areas, such as offshore wind farms or oil rigs, GIS can be used to assess their potential impact on fisheries. By overlaying project plans with fishery habitat and migration data, planners can mitigate negative effects on fish populations and habitats.

Data Visualisation and Communication: GIS provides a platform for presenting complex fisheries data in visually intuitive formats, such as interactive maps and dashboards. This aids in effective communication among stakeholders, policymakers, and the public, fostering collaboration and understanding.

In this paper, the application of passive georeferencing approach for finding probable fishing grounds has been discussed along with its pros and cons.

Passive Georeferencing: A GIS Tool for Finding Probable Fishing Grounds

Passive georeferencing in marine fisheries refers to the practice of inferring the geographic coordinates of fishing grounds, fishing activities, or other marine phenomena using existing data sources and environmental indicators. This approach is particularly valuable when direct data collection methods like active georeferencing (e.g., GPS) are not feasible or when researchers aim to make informed predictions about potential fishing locations. Identifying potential fishing grounds using passive georeferencing involves using existing data sources and environmental indicators to infer areas where fish are likely to be abundant. Given the substantial diversity of marine fishery resources in tropical countries, adopting a scientific sampling scheme for data collection is the most pragmatic approach. As exploratory fishery resource surveys are time-consuming and expensive, landing centre-based surveys are commonly practised to make an assessment of resources. In such surveys, the lack of geo-tagging of the resources observed at the landing centre makes it difficult for the mapping of the habitat (Jayasankar *et. al*., 2020). India stands out among a handful of nations for utilising a sampling theory-based approach to gather data on marine fish catches and fishing efforts. To facilitate this, data on marine fishing villages, landing centres, fishing vessels, and equipment were compiled to construct a sampling framework. This framework is routinely updated to accommodate sector changes through comprehensive surveys conducted across India.

To obtain species-specific catch details, fishing efforts, particulars about fishing vessels and gears, and other relevant information, a systematic scientific sampling scheme named stratified multistage random sampling design (SMRSD) being employed (Sukhatme *et al*., 1958). This methodology is leveraged to calculate monthly landings and fishing efforts within distinct, non-overlapping fishing zones that span the entire coastline of India, encompassing 1269 landing centres distributed across 65 coastal districts in 9 coastal states and 2 Union Territories (CMFRI-FSI-DoF, 2020). The SMRSD approach ensures comprehensive data collection from all these landing centres. Under the current data collection system, proficient technicians (harbor-based observers) equipped with species identification expertise adhere to schedules devised through SMRSD.

In the past, due to the limitations in the level of mechanisation of fishing vessels, Indian fishermen had a restricted range, and the reported catch at a designated landing centre was typically linked to the nearby coastal area. However, the scenario changed significantly as powerful engines became prevalent, transforming fishing into a more professional pursuit, with mechanised boats embarking on extended journeys lasting for weeks. This extensive fishing activity had an immediate consequence: there was a lack of accurate information about the specific locations where the catches were obtained. This spatially specific data is crucial for comprehending and simulating the dynamics of fish resources.

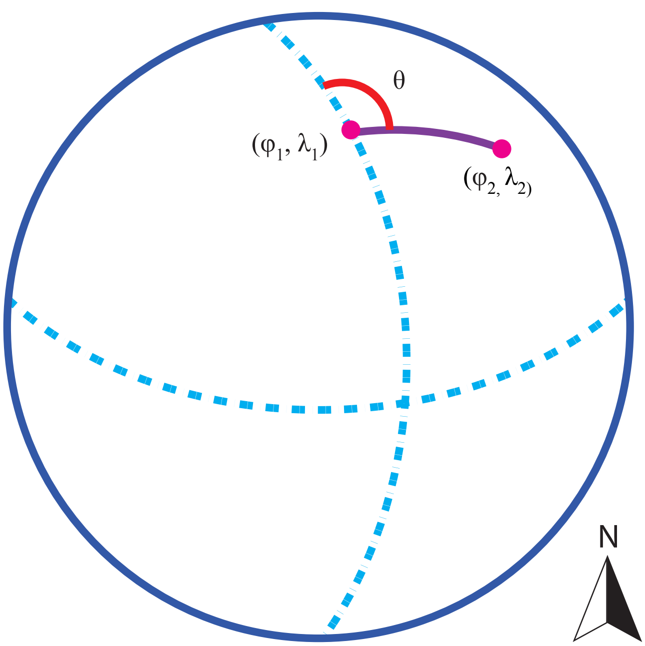
While the GPS devices could aid in precisely pinpointing fishing grounds, the challenge lies in retroactively assigning geographical coordinates to historical data that lacked latitude and longitude details.

Usually, the landings records have information about bearing and the distance covered by the craft surveyed and using the following Haversine formula for finding the destination coordinates given distance and bearing from start point coordinates, probable latitude and longitude of the fishing grounds can be obtained:

$$\varphi_2 = \text{asin}(\sin \varphi_1 \cdot \cos \delta + \cos \varphi_1 \cdot \sin \delta \cdot \cos \theta)$$

$$\lambda_2 = \lambda_1 + \text{atan2}(\sin \theta \cdot \sin \delta \cdot \cos \varphi_1, \cos \delta - \sin \varphi_1 \cdot \sin \varphi_2)$$

where φ is latitude, λ is longitude, θ is the bearing (clockwise



from north), δ is the angular distance d/R; d being the distance to destination, R the earth's radius (mean radius = 6,371km), 'asin' is arcsine (i.e. the inverse sine) of a given number and 'atan2' is the arctangent (or inverse tangent) of the specified x- and y-coordinates.

Algorithm for finding the probable fishing ground

Steps in implementing the passive georeferencing for finding the probable fishing ground are as follows:

Step1: Obtain the Coordinates (latitude and longitude in degrees decimals) of the fish landing centre (φ_1, λ_1)

Step 2: Extract the distance travelled (in kilometres) and direction (in degrees from North) in which the distance covered from the landing centre-based surveys

(mostly, the bearing is recorded in the form of eight directions: viz., north, northeast, east, southeast, south, southwest, west and northwest in the landing centre-based surveys)

Step 3: Choose a random number from (337.5–360 & 0–22.5), 22.5–67.5, 67.5–112.5, 112.5 -157.5, 157.5–202.5, 202.5–247.7, 247.5–292.5 and 292.5–337.5 according as the direction travelled are north (0°), northeast (45°), east (90°), southeast (135°), south (180°), southwest (225°), west (270°) and northwest (315°), respectively as the new bearing.

(The range of deviation for a given direction is set at ±22.5 degrees to account for any variations in the actual bearing. The goal is to choose a random bearing that is still relatively close to the given direction without straying too far off track. Deviating beyond 22.5 degrees would make the chosen direction closer to a different nearby direction. By adding and subtracting this range from the given direction, a random bearing within reasonable proximity is determined.)

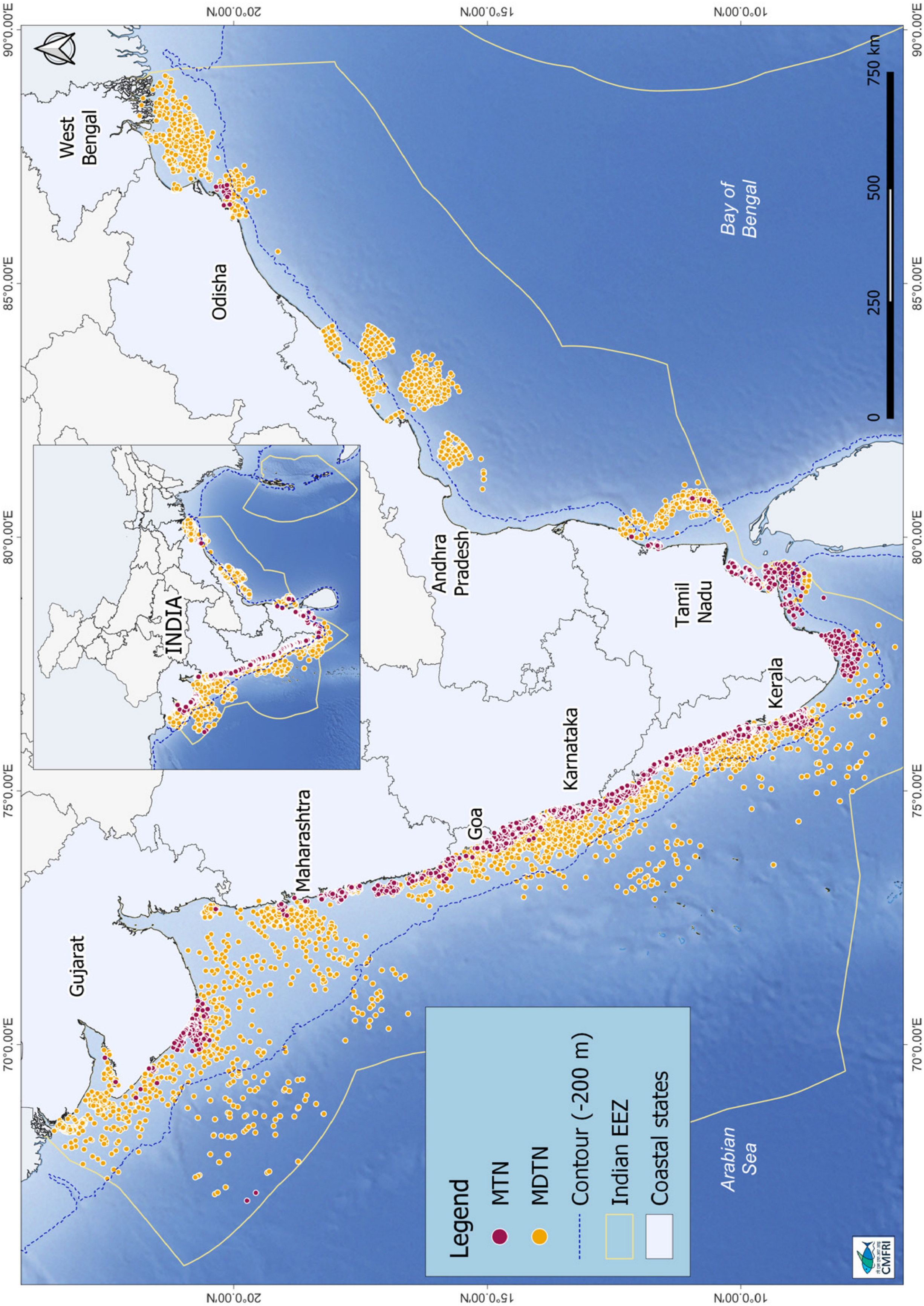
Step 4: Use the Haversine formula discussed earlier to work out the destination coordinates (φ_2, λ_2) using the start point coordinates, distance and the new bearing.

(The degree decimal values are converted in radians by multiplying by $\pi/180$ whereas radians are converted back to degree decimals by multiplying the values by the $180/\pi$)

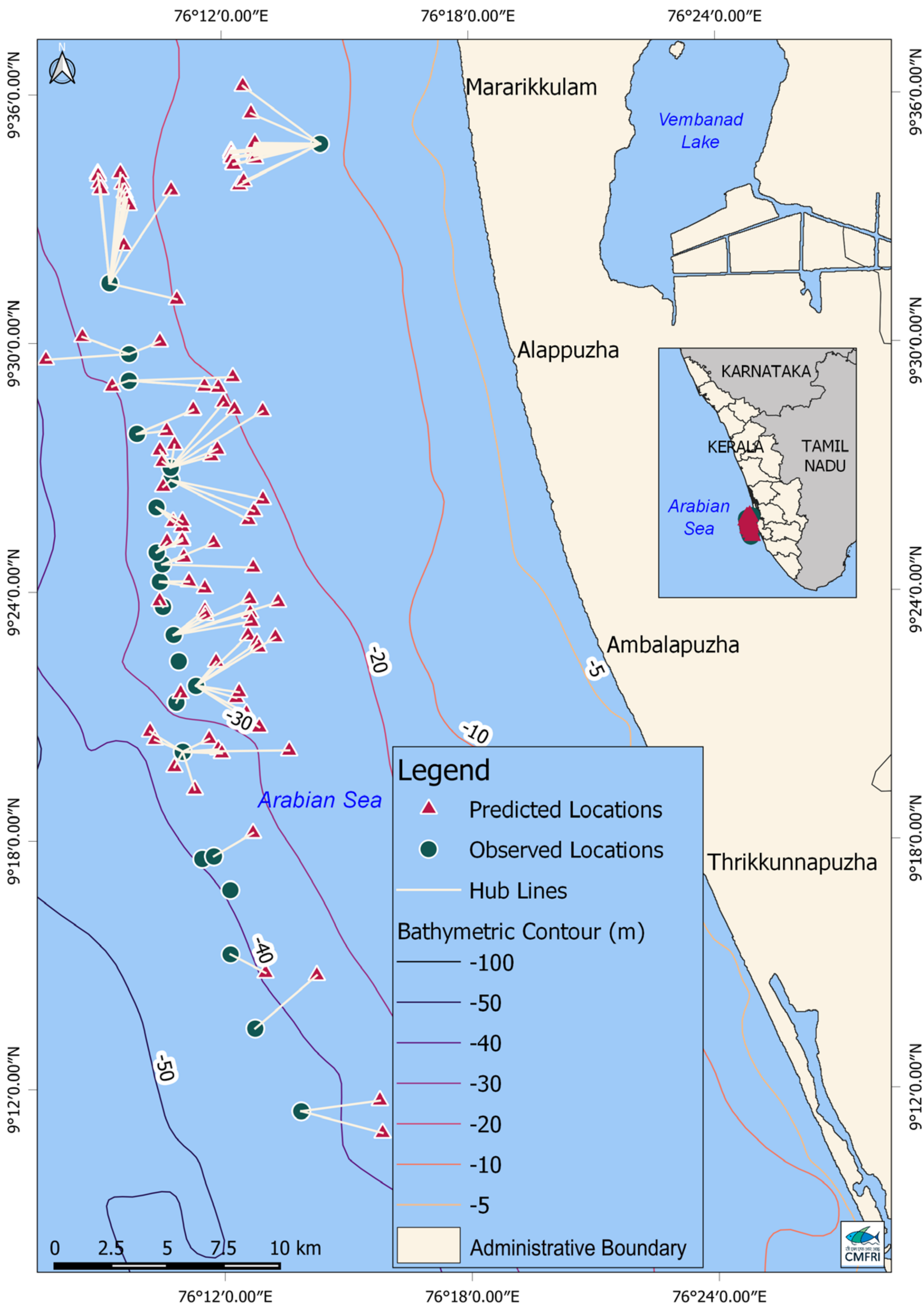
Finding Probable Fishing Grounds: An Illustration

Trawlnet fishing is a major contributor to India's seafood production and exports. It plays a crucial role in providing livelihoods for coastal communities and meeting the protein needs of the population. Trawlnet fishing in India targets a wide range of species, including shrimps, cephalopods and other various demersal fish species. Shrimp trawling, in particular, is a significant sub-sector of trawlnet fishing due to the high demand for shrimp in international markets.

Like in many parts of the world, trawlnet fishing in India faces challenges related to bycatch—unintended species caught



Probable trawl fishing grounds in Indian EEZ during the year 2018



Observed grounds of Indian oil sardine and passive georeferenced points off Kerala coast along with the target species. This can include juvenile fish, non-target fish species, and even endangered species. The landing centre-based survey data collected using SMRSD on bearing and distance from landing centre of trawlers operated in the Indian Exclusive Economic Zone (EEZ) during the year 2018 has been taken as a case study to depict the probable trawl fishing grounds (spatial coordinates). This has been done separately for single-day trawl net (MTN) and multi-day trawl net (MDTN).

It is very evident from the above figure that the predicted coordinates of the MTN operations are mostly near shore. Besides, the predicted coordinates indicated significantly lesser MTN operations on the east coast compared to MDTN, with very meagre in the northeast region. It can also be noted here that few predicted coordinates on MTN operations are much farther from the coast and nearing the boundary of EEZ, which probably requires more analysis. It also pointed the need of a thorough sea truthing either by VMS or by GPS records of some randomly selected boats to validate the algorithm and to ensure the accuracy of the predicted points. A validation for all the projected points would be time consuming and very expensive and hence, a study on the accuracy of projection can be made based on few randomly selected points.

In this line, an attempt was made by Varghese *et al.* (2022) using a few data points on the actual fishing grounds of Indian oil sardines on the southwest coast collected under the ICSSR-IMPRESS Project (Gills *et al.*, 2022) during 2020. The projected coordinates were found out using the algorithm explained in previous section. The observed and projected coordinates in the region were plotted and it is very evident that there are discripancies between the observed and projected coordinates and found that the difference was nearly 5 Km on an average. The difference between the observed and projected coordinates could be because of the inaccuracies associated with the information pertaining to the distance travelled and the bearing or with regard to the limited number of points used for the validation. Relying solely on the Haversine function, it is possible to calculate the bearing and distance to reach a specific target point. However, when it comes to fishing, this task becomes considerably more complex. It is also to be mentioned here that while projecting the probabale fishing gounds, consideration of the species available depth could be a candidate to improve the prediction accuracy. Another attempt in this direction was done by Vase *et al.* (2022) to account for the probable error in the information provided by the crew on the distance travelled by conducting a survey in the northeastern Arabian Sea and found an error limit of ±20% from the actual distance and hence, another random number chosen from distance travelled ±20% could be taken as the new direction to work out the destination coordinates. The above discussions lead to the scope for the improvement of the existing algorithm so that such kind of inaccuracies can be corrected and prediction can be done with reasonable reliability.

Conclusion

The Indian marine fisheries sector plays a vital role in providing nutritional security, livelihoods, and economic growth to millions of people. As the sector navigates challenges related to sustainability and environmental concerns, there is an increasing emphasis on adopting responsible and science-based approaches to ensure the long-term viability of India's marine fisheries resources. Marine fishery management is crucial for maintaining the health of marine ecosystems, supporting livelihoods, ensuring food security, and promoting economic stability. It involves a combination of science-based approaches, regulations, and stakeholder cooperation to strike a balance between resource utilisation and conservation for the benefit of present and future generations. GIS has revolutionised the way we make decisions by providing a spatial perspective on data, allowing us to see patterns, trends, and relationships that were previously hidden. As technology continues to advance, the potential for GIS to address complex challenges and drive innovation across various sectors remains boundless. The integration of spatial data and advanced analytical tools enhances our ability to understand and address the complex dynamics of marine ecosystems and their interactions with human activities.

Passive georeferencing can be a cost-effective alternative to active methods like vessel-based GPS tracking or underwater mapping. It relies on existing data sources and can make use of remote sensing technologies. By integrating various environmental data, such as sea surface temperature, chlorophyll concentration, and ocean currents, researchers can create a holistic picture of potential fishing grounds. This multidimensional approach enhances the accuracy of predictions. Passive georeferencing allows for relatively quick analysis and decision-making, especially when time-sensitive factors like seasonal fish migrations are involved. Passive georeferencing has its limitations, as the accuracy of the inferred location depends on the quality of available reference data, the precision of the methods used, and potential errors in the data sources. However, it can be a useful approach when active data collection methods like GPS are unavailable or impractical.

The Way Forward

Whenever a task of this nature and magnitude is taken up, the pitfalls are just part of the discourse. When an attempt is made to backcast information, unlike forecasting, the level of accuracy must be a tad higher. Though spatial backcasting is not new, a necessity of this kind is really a big challenge.

Going strictly by the Haversine function, the bearing and distance can always lead to the point of the target. However, in the case of fishing, this is much more complicated. With mathematical functions yielding consistent and constant results, there is always the possibility of the fishing ground being pinned down to a small point. Towards this, as part of the Evolutionary Algorithm (EA), randomisation of the presumed grounds was the next logical stop. However, how much random and whether they need to be fuzzy, whereby radial randomness is induced, or vectorised randomness is to be targeted etc. were in the realms of further focus and thus, the second-level tools and techniques of passive georeferencing evolved. But outside the purview of the methodological arena, there were challenges lurking in the form of inadmissible projections of landing centres. In specific instances, randomising the bearing may result in a direction that would lead towards the coastline. To address this, some correction factor needs to be made to limit the randomisation range on one side to enhance the realism of the randomisation process. This correction factor could range from a small parameter governing the proportion of randomness to a full-fledged factor that apportions the uncertainty dynamically. Studies in this direction too have been pursued.

At this juncture, it would be worthwhile to revisit the whole need and utility value of this method and, thus, the tool. It's important to note that while passive georeferencing can provide valuable information about potential fishing grounds, it's just one tool among many that fishers and fisheries managers use. With fisheries being locality/ground specific alongside being gear and resource-specific, the grounds targeted, although there could be many, may not be infinite and certainly not perfectly random. There is a component of repeatability in the behaviour of fishermen targeting a specific set of resources as much as the habitat similarity of the fishes in that region. Thus, any refinement in the attempt of passive georeferencing must be biologically vibrant too while being stochastically alert. It is here the indigenous wisdom of fishermen and their involuntary switch to better "neighbourhood" options come into play. Combining passive georeferencing with active methods and local knowledge can result in more accurate and comprehensive predictions of potential fishing grounds.

Passive georeferencing predictions might lack direct confirmation of fish presence, potentially leading to false positives or overlooking important fishing areas. This is the hallmark of this tool, as it is perceived as a seemingly independent assessment of fishing grounds, thus indirectly an indicator of pockets of fish presence. Different fish species have varying habitat preferences and respond differently to environmental cues. The knowledge on the availability depth of marine species, referring to the specific range of depths at which a particular species is found in the ocean, holds crucial significance and this can be integrated through machine learning algorithms to improve the prediction accuracy in passive georeferencing. For example, when one can be sure of the depth of straddling of a set of resources, especially epipelagic and mesopelagic ones, the algorithm to trace back their pocket boroughs could always have an element of multivariate discrimination. Tools that help estimate the probability of classification and grouping through misclassification error minimisation can very well be a candidate for being considered. Support Vector Machines, roughly put, a non-linear all pervasive discrimination tool, can come in handy here. Such discriminatory power propped up by computational power can really make wonders in unravelling patterns of fish aggregation hitherto playing coy to traditional modelling wisdom. Thus, tools of data science can always hone up the effort to improve the accuracy and reduce the prediction variability of passive georeferencing.

Many neural network algorithms, especially those that have classification, grouping and finalisation of causal factors, could prove to be quite useful in these challenging scenarios. Presence-absence or even ordinally trained models with suitable activation functions like those used in recurrent neural networks (RNN) like Long Short Term Memory (LSTM) machines can be quite useful. The recurrence of factors and derived factors would reinforce the tree of decision-making more placidly with sufficient robustness. Hence such machines are always a vista to explore when it comes to reverse estimating the fishing grounds.

Environmental indicators are integral to passive georeferencing of marine fish species as they provide the environmental context that influences species distribution, movement, and behaviour. Incorporating these indicators enhances the reliability and applicability of passive georeferencing methods in understanding and predicting the spatial dynamics of marine species. As in the case of any spatio-temporal series analysis, extraneous variables certainly add rigour to the efforts of maximising the model entropy. Despite being a tradeoff between precision and parsimony, more informed models are always robust in facing unprecedented scenarios. Thus, a branch of derived information on the environment that usually is supportive of detrimental to the growth and reproduction of targeted resources can always be a game changer in such modelling exercises. With deep-niched resources, these factors get more complex as their direct influence gets less pronounced, and thus it makes all the more imperative to treat any information pertaining to environments as a three-dimensional one, the third tag of depth joining the latitude-longitude markings.

Sea truthing holds significant importance in the context of passive georeferencing. Sea truthing involves collecting ground-truth data from actual observations at sea, and it plays a critical role in validating and improving the accuracy of passive georeferencing techniques. It enhances the accuracy, reliability, and applicability of georeferenced data by validating methods, refining algorithms, and accounting for real-world variability. As it is said in survey literature, for a local level sampling 20% would be ideal so that in a period of five years or so a cumulative sampling of size matching the population could be achieved, the sea truthing mechanism if put in place in a structured manner would always be a boon to improving such prediction paradigms. Though 20% is quite expensive going by the sheer volume of boat trips, having a sample of at least 2- 5% will augur well in tuning the model machines well. As is in vogue, with 75% plus of the surveyed information needs to be put for training the models, the higher their number, the better would be their performance. Sea truthing has another dimension, too. If done on a voluntary basis, the fishermen would find the same as an extension of their traditional wisdom and thereby, such exercised would be chronicling that part of their profession, too. Any tool to passively locate the fishing grounds must be constantly focussing on improving itself on the basis of such real-time information. A participatory approach, too, is worthy of mooting between the modelers and the fishermen, which will end up mutually beneficial. In a way, these may reinforce other methods of resource density tracking and prediction like Potential Fishing Zone (PFZ) advisories too.

Advances in remote sensing technology and data availability will enhance the accuracy and timeliness of passive georeferencing predictions. Utilising machine learning algorithms can help analyse complex environmental datasets and identify patterns that are not readily apparent to human analysts. Such deployment of multi-sensor data coupled with fine-tuned machine algorithms can give wings to efficient conversion of computer intelligence and, thereby bringing unexpected yet crucial patterns of factorial interplay to the fore. This can prove to be worthy of its salt as it mixes traditional modes of modelling concepts with evolutionary as well as expectation maximisation algorithms. The result of such an amalgamation of the algorithmic renaissance with faster to obtain information could always be an optimistic proposition in these kinds of challenging assignments. Continued efforts to validate passive georeferencing predictions through ground-truthing and collaboration with fishers will enhance the reliability of results. Even the reliability metrics can be professionally attuned to the fisheries. Rather than just being dependent of root mean squared error (RMSE) or certain information criteria, the model selection based on a more studied prediction involving the fishery dynamics, even the economics of it would make the reliability more organic and comprehensive.

Once the predicted coordinates are validated at species level on a spatially gridded scale, the potential distribution of fish species in marine environments based on the analysis of environmental variables and species occurrence records can be studied through species distribution models (SDMs). It would further help in estimating marine resource biomass on a gridded scale and thereby enable more informed and sustainable management of marine fisheries resources. Modeling fish biomass is a uniquely challenging proposition due to its myriad dissimilarities and equally numbered associations. Starting from trophic level-based modelling to individual-based models, these kinds of models always lacked proper anchoring on the niche under study. Though primary production coupled models have always been there, their success rate had been diminishing with the increase in diversity of the ecosystem. Thus, if through independent or nearly independent means, the niches could be arrived at, modelling gets all the more simpler, be it on a mass scale or individual level.

With climate change scenarios under CMIP6, which are based on a totally different basis of shared socioeconomic pathways (SSPs) available, the incorporation of niche locating algorithms can propel the possibility of studying their dynamics in the longer run. With a sufficiently longer set of seasoned niche predictions coupled with biomass dynamics available, the coming decade may see the possibility of strong projections of shift of resource pockets founded on a very strong spatio-biological platform. This would be a springboard for a plethora of predictions and policy precursors. The envelopes rooted in bio-climate blocks are a strong step forward in this pursuit. Even though bioclimatic envelope models provide valuable insights into potential species distributions, they are strongly based on correlations between species occurrence and environmental variables. Therefore, needless to add, the model accuracy depends on the quality and quantity of input data, as well as the complexity of the species' interactions with its environment. These aspects, when properly addressed, would always fit into the larger scheme of things, which may see a humble beginning with exercises like passive georeferencing.

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Successful cage rearing of snubnose pompano *Trachinotus blochii* in coastal waters of Karnataka

A. P. Dineshbabu[1], Sujitha Thomas[2], K. M. Rajesh[3], G. B. Purushottama[4], Divya Viswambharan[2], G. D. Nataraja[2] and Prathibha Rohit[4]
[1]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala
[2]Mangalore Regional Centre of ICAR-Central Marine Fisheries Research Institute, Mangaluru – 575 001, Karnataka
[3]Field Centre of ICAR-Central Marine Fisheries Research Institute, Puri–752 002, Odisha
[4]Karwar Regional Station of ICAR-Central Marine Fisheries Research Institute, Karwar, Uttara Kannada-581 301, Karnataka

*E-mail: dineshbabuap@yahoo.co.in

Abstract

Cage rearing of pompano in coastal waters for the first time in Pavanje Estuary, Koluvailu Village, Haleyangady Panchayat, Dakshina Kannada, Karnataka under the Scheduled Caste Sub Plan program (SCSP). Hands-on training on various aspects of the cage culture was imparted to the beneficiaries through participatory mode. The average growth observed during the five months grow out period was 300 g with a FCR of 1.5. The results of this cage rearing programme of the snubnose pompano has proved the rapid growth rate of the species attaining table size in a short span of 5-6 months. Further, after witnessing the success of the farming demonstration and the good market price (₹400/kg) for the cultured snubnose pompano, several aquafarmers have become interested in taking up its farming.

Keywords: *Dakshina Kannada, cage culture, grow out, pompano, SCSP program*

Introduction

The snubnose pompano, *Trachinotus blochii*, wits its rapid growth potential, good meat texture and high market demand, is a preferred farmed fish species among the high-value marine tropical finfishes. Many Asia-Pacific countries, such as Taiwan and Indonesia, have successfully established pompano aquaculture. It is rarely observed in the commercial fishery in India and therefore its supply in the market is also limited. Successful induced breeding and larval rearing of this candidate species was achieved by ICAR-CMFRI in 2011 (Gopakumar *et.al.,* 2012) and thereafter, the rearing of this species in ponds and cages was demonstrated by ICAR-CMFRI in different parts of the country. In Karnataka, the farming of pompano in cages installed in open waters were done for the first time in Pavanje Estuary, Koluvailu Village, Haleyangady, Dakshina Kannada District under the Scheduled Caste Sub Plan (SCSP) program.

Selection of prospective farmers

The selection of farmers belonging to the Scheduled Caste was done in consultation with Panchayat Development Officer (PDO), President and members of Haleyangady Panchayat. Accordingly, 12 members from four families of the Mundala Community residing close to the Pavanje Estuary were selected as beneficiaries of the SCSP programme implemented by the Mangalore Regional Centre of ICAR-CMFRI. They were provided hands-on training on several aspects including selection of suitable sites for farming, cage fabrication, maintenance of the cages, candidate species that could be considered for culture, feeding protocols, etc. through a participatory mode.

Site selection

A preliminary survey was conducted before installation of the cages and important water quality and other parameters

Demonstration of cage fabrication

such as requirement of a minimum water depth of 2.5 m at lowest low tide, tidal flux, distance from navigational channel, closeness to beneficiaries' residence, ease of accessibility, etc. were taken into account. Pompanos are sensitive to changes in water quality especially to turbidity and salinity changes (Gopakumar *et al.,* 2012; Kalidas *et al.,* 2012) therefore, need for maintaining good water quality conditions throughout the culture duration was important.

Cage fabrication

Customised cage (6m x 2m x 2m, with water holding capacity of approximately 24 tonnes) was fabricated (Dineshbabu *et al.,* 2019). The bi-layered cage had an outer layer of netlon material and inner layer of nylon. The netlon structure protected the inner net from predators and other materials drifting in the water that could possibly cause damage to the net structure. In addition, it aided in holding the shape of the cage even during strong water currents without compromising on the water holding capacity.

Seed procurement and stocking density

The snubnose pompano seeds (1-2 cm) produced at the marine finfish hatchery of the Vizhinjam Regional Centre of ICAR-CMFRI was procured and reared to stockable size (~15 g) in the rearing facility at the Karwar Regional Station of ICAR-CMFRI. The reared seeds (900 numbers) weighing on an average of 14 g per seed was transported from Karwar to Haleyangadi and stocked in the fabricated cage on 17th December 2021. The seeds were acclimatised to the local condition before they were released into the cage. As the farming of the snubnose pompano was being done for the first time a lower stocking density than normal (40-50 fishes /m^3) was followed for this programme.

Rearing, feeding protocols and cage maintenance

The stocked fingerlings of the snubnose pompano were reared in the cage for a period of five months and fed twice a day with pelleted floating feed (Nutrilla Growell feed). The feeding ratio was calculated based on the total biomass (Table 1). Cage cleaning was done routinely to remove debris and fouling organisms attached to the outer surface of the cage.

Table 1. Feeding schedule of the cage reared fish stock

Weight of fish	Feed size	Pellet feed provided per day (%)
15-100 g	1.8 mm	5
100-250 g	3.0 mm	4
>250 g	3.0 mm	3

Growth of pompano in cages

Growth of the stocked snubnose pompano was monitored regularly. Fingerlings stocked with an average weight of 14 g attained an average weight of 320 g in a period of 5 months. The growth as well as the specific growth rate of the snubnose pompano stocked in the cage at Haleyangadi is given in Table 2.

Harvest of the fish

The reared snubnose pompano was harvested in May 2022 after a period of 5 months. It was timed before the onset of the southwest monsoon as the rains would result in a sudden decline in salinity and increase in water turbidity, both factors not conducive for growth of the stocked pompano. The average weight of the individual fish was ~300g and a total of 265 kg of pompano was harvested. A high survival of 96 percent was recorded. The FCR was 1.51. Generally, the FCR for fish production is between 1.2 to 2.2 and the FCR of 1.51 during the present culture programme showed an efficient conversion of feed to biomass (Jayakumar *et al.*, 2014). The major portion of the harvest (250 kg) was taken by the Karnataka Fisheries Development Corporation (KFDC), Mangaluru at a farm gate price of ₹400 per kg. The rest of the harvest was sold by the beneficiaries locally at a similar rate. The total of amount ₹1,06000/-was realized by the beneficiaries from the harvest of cultured snubnose pompano.

The successful rearing of the pompano in cages for the benefit of SC families along the coastal area has opened an avenue for a profitable alternate livelihood option. The active participations and collective effort of the local Panchayat members, the beneficiaries of the SCSP programme along with the dedicated team of personnel from Mangalore Regional Centre ensured this success. It has created interest among

Table 2. Monthly growth increment in length (cm), weight (g) and Specific growth rate (%).

Growth parameters	Stocking size Dec. 21	Jan 22	Feb 22	Mar 22	Apr 22	May 22 Final	Survival rate (%)
Length (cm)	9.7 ± 0.3	13.5 ± 0.32	19.1 ± 0.3	21.5 ± 0.3	24.6 ± 0.6	27.54 ± 0.2	96.2
Weight (g)	14.1 ± 1.5	45.4 ± 3.2	87.9 ± 3.2	151.9 ± 6.7	258 ± 2.9	319.9 ± 4.8	-
Specific Growth Rate (SGR %)	-	222.0	523.4	977.3	1729.8	2168.8	-

Harvested pompano after 5 months of rearing locals, including members of the SC and ST communities to initiate fish farming and local Panchayat and State Fisheries Department officials too have agreed to further the interest of the weaker sections with the proven cage farming technology of ICAR-CMFRI.

The availability of seeds especially good quality seeds of cultivable marine finfish species has always remained a challenge for aquafarmers. Presently, because all the marine finfish hatcheries are located along the east coast, transportation and timely procurement of sufficient number of seeds has deterred the large-scale adoption of finfish farming along Karnataka coast. The successful breeding and the seed production of snubnose pompano at the Vizhinjam Regional Centre, Kerala has to a large extent solved the availability of fin fish farmers along the Karnataka and Kerala coasts. Finfish farming in coastal Karnataka was mainly focussed in Udupi and Uttara Kannada districts and the present programme done in Dakshina Kannada has ensured the horizontal expansion of the cage farming to the third coastal district. This is also the first-time pompano seeds have been stocked and reared to marketable size in cages for Karnataka which has confirmed the suitability of the species for profitable farming.

Reference

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Brief Communication

Noctiluca scintillans bloom and measures to protect marine hatcheries

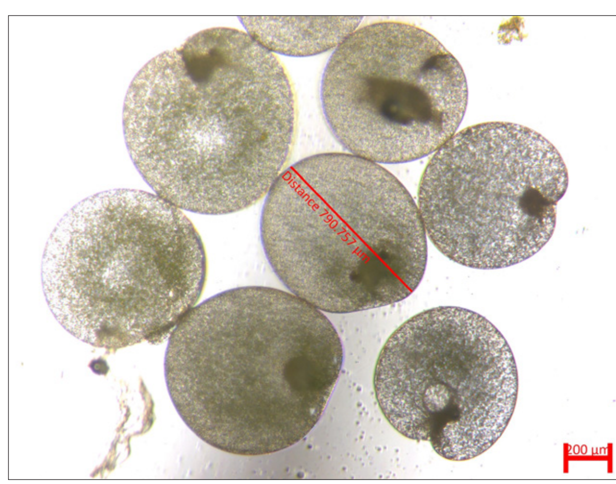
Ambarish P. Gop[1], M. K. Anil[1], N. Nandini Menon[2], H. Tanveer[1], S. Surya[1], K. S. Sudarshan[1] and O. Shalini[1]

[1]Vizhinjam Regional Centre of ICAR-Central Marine Fisheries Research Institute, Vizhinjam P. O., Thiruvananthapuram – 695 521, Kerala

[2]Nansen Environmental Research Centre India, KUFOS Amenity Centre, Madavana Junction, Kochi-–682 506.

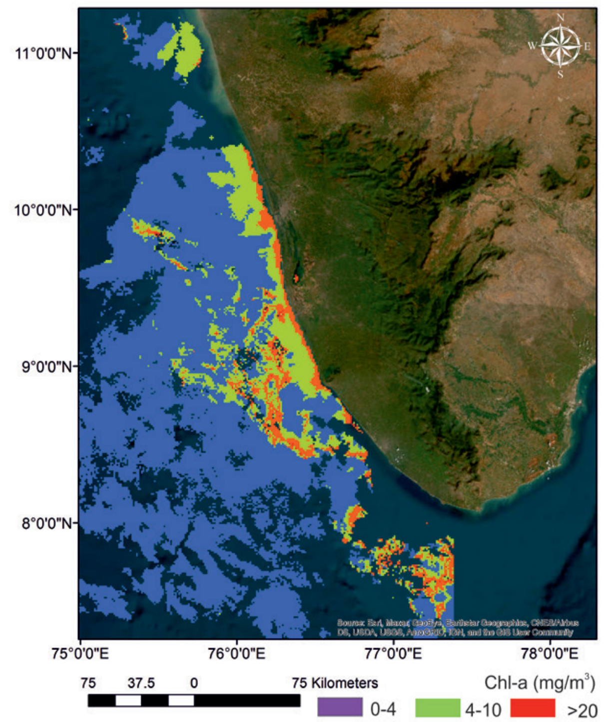
*E-mail: gopidas.ambarish@gmail.com

During the third week of November 2022, bloom of *Noctiluca scintillans* (Macartney, 1810) was observed in multiple locations along the coastal waters off Thiruvananthapuram. *Noctiluca* bloom is commonly called as 'sea sparkles', as it produces blue bioluminescence at night. In the present bloom in Vettucaud, Shanghumukham, Valiyathura, Vizhinjam, Azhimala and Pullivila areas along the Thiruvananthapuram coast, *N. scintillans* was identified as the causative organism. This bloom was also observed at the seawater intake point of the Vizhinjam Hatchery complex which put the staff on alert. Even though the dinoflagellate is considered non-toxic, it has been reported to cause 'fish kill', associated with anoxia during the crashing phase of the bloom. Hence, to protect the fish larvae and broodstock in the rearing systems, precautions were taken to ensure the quality of seawater taken for the



Noctiluca scintillans–microscopic view hatchery. A new offshore intake well was constructed, and the 6-inch PVC pipe with 22 mm-sized holes which is primarily used for the seawater input system was covered with two layers of foot valve protecting boring mesh (200 microns mesh size) for effective filtration of the pumped seawater. The stored seawater was aerated to ensure oxygenation of the water. Water quality parameters such as Dissolved oxygen (DO) and ammonia were monitored daily since the detection of the bloom so as to confirm that the levels are normal (DO between 4.04 to 5.1 ppm; total ammonia nitrogen less than 0.001). The precautionary measures were continued for a week after the bloom started crashing which happened three days after the detection of the peak bloom on 16 November 2022.

N. scintillans blooms have reportedly become a regular feature in the coastal waters of the Arabian Sea and Bay of Bengal during the winter monsoon period of October – February. Fish kills associated with these blooms are also increasing. Mixotrophic behaviour of the dinoflagellate helps in the sustenance of the bloom in low-nutrient waters as well as in low prey-dense waters. Therefore, with a view to closely monitor the sustenance and spread of the bloom, Sentinel 2 level 1 image were obtained from Copernicus open access HUB and processed using Case-2 regional coast colour processor to derive chl-a concentration for the coastal waters of Thiruvananthapuram. Due to cloud cover, clear chlorophyll images were not available across the region. Hence a mosaic of three S2-A scenes during the first week of November 2022 (1-7) was used for Chl-a extraction, wherein the chl-a concentrations were greater than 4 mg C m^{-2},



Sentinel 2 image of 7 November 2022 showing high chlorophyll in the coastal waters off Thiruvananthapuram

indicating bloom condition. This points to the fact that the bloom was initiated much earlier than it was visible in the form of green discolouration and bioluminescence on 16th November 2022. Timely identification of the bloom and the interventions taken to prevent the intake of contaminated water into the hatchery served to protect the broodstock and fish larvae, and in turn, avoid economic loss.

Brief Communication

Algal bloom of *Diatoma vulgaris* in coastal waters of Dakshina Kannada

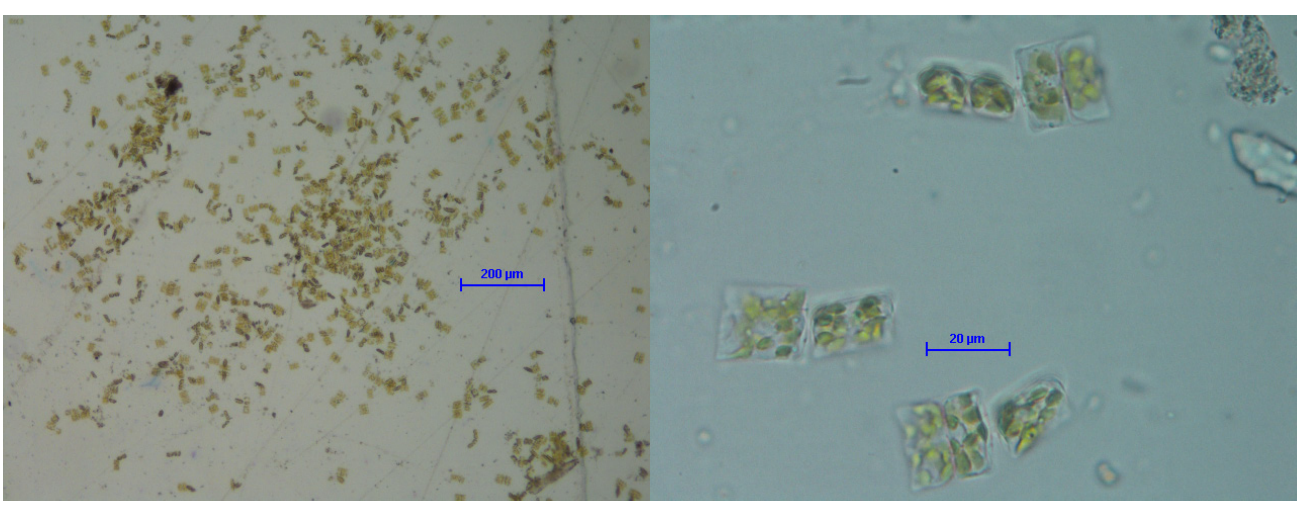
Bindu Sulochanan[1], Veena Shettigar[1], Prathibha Rohit[2] and K. S. Sobhana[3]
[1]Mangalore Regional Centre of ICAR-Central Marine Fisheries Research Institute, Mangaluru–575 001, Karnataka
[2]Karwar Regional Station of ICAR-Central Marine Fisheries Research Institute, Karwar, Uttara Kannada-581 301, Karnataka
[3]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala

*E-mail: binduchaithanya@yahoo.co.in

A bloom of *Diatoma vulgaris* (1.20 x 10^5 cells ml^{-1}) was found in the coastal waters off Iddya (12°59'28.5"N 74°47'28.3"E) near Surathkal in Mangaluru city on 14th May 2022, and the changes in nutrient status dissipated the bloom within a week. *D. vulgaris* cells form zig-zag chains and are found attached to submerged rocks, concrete, pipes and other structures as they are benthic diatoms. Diatoms prefer distinct ranges of pH, salinity, nutrient concentration, suspended sediment, flow regime, elevation and are influenced by anthropogenic disturbances. Climate affects diatoms in complex ways and frequency, severity of droughts, floods etc. impacts the occurrence of diatom species and their distribution. Hence, monitoring the occurrence and distribution of diatoms gives an idea about the impact of the changes in the water quality. Diatoms are divided into two major groups based on the structure and shape of the valves, the Centrics (Order: Biddulphiales) and the Pennates (Order: Bacillariales). Diatoms which reproduce efficiently are adapted to changing conditions by forming resting spores which remain on the bottom in shallow coastal waters until conditions favor their germination. Nitrogen, phosphorus, potassium, magnesium, oxygen, hydrogen, carbon, sulfur and iron are essential for the normal development of diatoms as to that of higher plants.

The water quality parameters recorded on 14th May 2022 were compared with those recorded from nearby sampling stations during the subsequent days of the bloom to assess the extent of the bloom (Table 1). The ammonium nitrogen in near-shore waters ranged from below detection level (BDL) to 0.002 mg l^{-1} while in the estuarine stations it ranged from 0.065 to 0.105 mg l^{-1} indicating utilization of ammonia nitrogen by the diatoms. The highest level of chlorophyll a 717 mg m^{-3} was observed on 14th May 2022 with value higher than 25 mg m^{-3} considered as eutrophic condition. The Kuloor station in the river side too had a high Chl a of 40.99 mg m^{-3}. A high DIP/DIN ratio of 54.57 was observed in Idyaa sample. The dissolved oxygen ranged from 2.54-5.83 mg l^{-1} in the Sea and the lowest was observed in the area of the bloom on 17th May 2022. In the river stations during the succeeding days, the dissolved oxygen ranged from 2.82-3.43 mg l^{-1}. The highest TDS of seawater of 30.2 g l^{-1} and density 20.8 ρt was observed off Panambur. Presence of the diatom was observed in the other stations also but the diversity of other plankton is evident from the lower DIP/DIN ratio recorded during the subsequent days. A higher value of Chl c is an indicator of presence of diatoms. The diversity of plankton in other areas is also indicated by the variability in Chl a, b and c (Table 2).

During extreme events of rainfall, the combined volume of non-point sources of pollution into the ocean system will be greater than the point sources of pollution. During summer season, the beaches will have enough width and volume of sand for filtering the eutrophic water from the land based channels before reaching the sea. The characteristic of the water flow into the ocean is based on the catchment area of the non-point sources of pollution. The non-point sources of pollution outlets and natural channels from the city during extreme events and during monsoon season drain directly into the sea. The variability of the inflow along the coast varies along the shoreline due to the variability in land slope and soil conditions and anthropogenic activities. The rainfall during the first week of May carried water hyacinth, an invasive floating plant found in eutrophic inland water bodies into the sea and on to the beaches along the coast. As the nutrient condition continued to be favorable, the diatoms bloomed with the result that no other algae were observed in the



Photomicrograph of *Diatoma vulgaris,* normal (200 µm-left) and magnified (20 µm-right)

Table 1. Water quality parameters recorded at Near-shore coastal stations (s) and River stations

Date	Station	AT (°C)	WT (°C)	pH	DO (mg l^{-1})	TDS (g l^{-1})	TSS (mg l^{-1})	Salinity (ppt)	Density (ρt)
14.05.2022	Iddya (S) 12°59'28.5"N 74°47'28.3"E	28.9	30.13	8.07	2.54	30.1	576.0	32.83	20.2
18.05.2022	KFDC 12°50'51.2"N 74°50'12.4"E	30.5	30.14	8.15	2.92	29.7	72.0	31.8	19.4
19.05.2022	Bengre (S) 12°51'09.2"N 74°49'14.8"E	25.1	27.03	8.21	5.57	29.7	92.0	31.8	20.4
19.05.2022	Thannerbhavi (S) 12°54'02.4"N 74°48'40.6"E	26.5	27.4	8.24	4.17	28.7	104.0	30.59	19.4
19.05.2022	Panambur (S) 12°56'40.3"N 74°48'02.3"E	26.5	27.54	8.22	5.48	30.2	60.0	32.39	20.8
19.05.2022	Chitrapur (S) 12°57'35.9"N 74°47'54.9"E	25.1	27.27	8.24	5.83	28.3	76.0	30.11	19.1
19.05.2022	Surathkal (S) 13°00'57.6"N 74°47'12.3"E	24.9	27.6	8.24	4.88	29.3	104.0	31.29	19.9
19.05.2022	Coast Guard (GR) 12°52'06.8"N 74°49'22.0"E	25.1	27.68	8.07	3.43	26.5	112.0	27.97	17.4
19.05.2022	Bhokapattana Bengre (GR) 12°53'28.4"N 74°48'58.9"E	26.5	26.2	7.81	3.07	15.9	112.0	15.59	8.6
19.05.2022	TB (GR) 12°53'33.6"N 74°49'13.3"E	26.5	27.72	7.72	2.82	14.8	52.0	14.38	7.3
19.05.2022	Kuloor (GR) 12°55'33.3"N 74°49'34.8"E	28	27.84	7.67	3.04	8.82	140.0	8.2	2.8
25.05.2022	Netravathi River 12°50'31.3"N 74°51'10.1"E	30.1	29.25	7.55	2.83	4.070	20.0	3.47	0
25.05.2022	Someshwar (S) 12°47'50.4"N 74°50'43.8"E	30.0	28.97	8.06	3.43	29.70	128.0	32.1	19.8
25.05.2022	Ullal (S) 12°50'19.7"N 74°49'51.5"E	29.0	28.85	8.28	3.94	29.60	92.0	32.53	20.4

AT: Air Temperature; WT: Water Temperature; DO: Dissolved oxygen; S: coastal station; GR: Gurupura River

Table 2. Nutrients and biological parameters recorded at Near-shore coastal stations (s) and River stations

Date	Station	Nitrate (mg l^{-1})	Nitrite (mg l^{-1})	Silicate (mg l^{-1})	Phosphate (mg l^{-1})	Ammonia (mg l^{-1})	DIP/DIN	Chl a (mgm^{-3})	Chl b (mgm^{-3})	Chl c (mgm^{-3})
14.05.2022	Idyaa (S)	0.006	0.002	0.472	0.434	BDL	54.57	717.38	-17.56	381.1
17.05.2022	KFDC	0.008	0.003	0.047	0.044	0.008	2.34	28.99	26.74	82.08
19.05.2022	Bengre (S)	0.008	0.003	0.046	0.030	BDL	2.62	9.34	6.12	16.93
19.05.2022	Thannerbhavi (S)	0.011	0.002	0.043	0.048	BDL	3.67	11.14	5.90	19.94
19.05.2022	Panambur (S)	0.011	0.004	0.047	0.032	BDL	2.12	24.64	25.05	78.40
19.05.2022	Chitrapur (S)	0.005	0.004	0.049	0.047	0.002	4.35	18.32	5.55	25.36
19.05.2022	Surathkal (S)	0.007	0.004	0.048	0.040	BDL	3.54	12.36	2.47	9.63
19.05.2022	Coast Guard (GR)	0.007	0.003	0.061	0.155	0.065	2.06	6.79	4.56	11.85
19.05.2022	Bhokapattana Bengre (GR)	0.010	0.004	0.114	0.206	0.107	1.70	8.00	0.78	5.94
19.05.2022	TB (GR)	0.009	0.003	0.088	0.113	0.079	1.24	9.28	1.56	8.48
19.05.2022	Kuloor (GR)	0.009	0.003	0.106	0.093	0.057	1.34	40.99	32.77	105.4
25.05.2022	Someshwar(S)	0.003	0.003	0.032	0.116	0.015	5.47	13.11	4.08	13.90
25.05.2022	Ullal (S)	0.004	0.003	0.026	0.064	0.012	3.27	3.938	0.86	6.72
25.05.2022	Netravathi River	0.020	0.003	0.399	0.054	0.047	0.76	4.449	4.72	21.58

collected sample on 14th May 2022. This was evident from the high DIP/DIN ratio as well as the high Chlorophyll a and c value obtained in the sample compared to the other days (18th to 24th May 2022) when samples were collected along the shore. Though the salinity observed on the consequent days in the sea ranged between 30.59-32.53 ppt, the presence of other plankton was also noticed in the other locations along with *D. vulgaris*, indicating that the eutrophic conditions at the location triggered the bloom. It has been reported that *D. vulgaris* survives both in fresh and marine conditions (World Register of Marine Species Id 149347).

Brief Communication

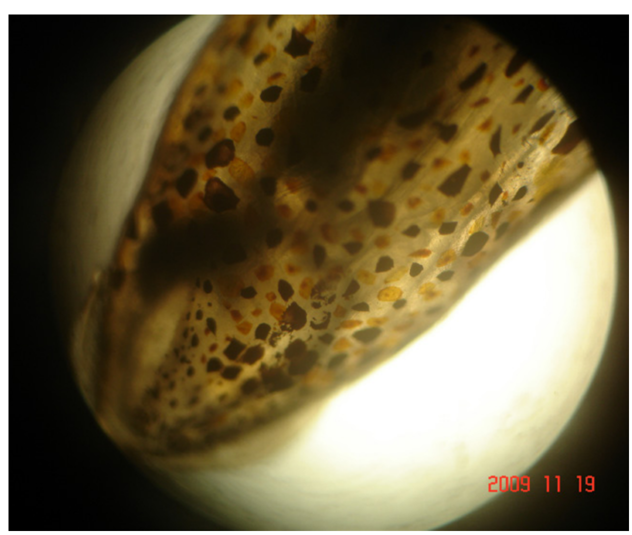
Rearing of hatchlings of *Uroteuthis* sp. and *Sepia* sp.

P. Laxmilatha[1]*, Phalguni Pattnaik[2], S. Chandrasekhar[2], S. Balu[3], S. Padmaja Rani[2]
[1]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala
[2]Visakhapatnam Regional Centre of ICAR-Central Marine Fisheries Research Institute, Visakhapatnam -530 003, Andhra Pradesh
[3]Central Institute of Fisheries Nautical Engineering, Visakhapatnam, Andhra Pradesh

*E-mail: laxmil@yahoo.com

Egg capsules of *Uroteuthis* sp. obtained from sea off Visakhapatnam were maintained in 1 t black FRP tank in 35 psu provided with gentle aeration. The egg mass consisted of two strings of viable egg capsules. The total number of capsules in the strings was 1288. Strings were suspended in the tank to be submerged in the water. The string might be of different batches of egg laying or laid by different females. The capsules were observed to be viable with embryos moving inside the capsules. Water level was maintained at 70 percent of the tank providing a gap from above. They were maintained in black tanks with mild light regime covering half portion of the tank with black cloth. Water quality parameters were maintained. About 20-30 percent water was exchanged daily after siphoning off any debris at the bottom of the tank. Para larvae hatched out continuously for 6 days starting from 11th day of collection of egg. The hatchlings ranged from 4.6 to 6.2 mm in length with a weight range of 11.6 to 14.8 mg. After hatchlings were released, they are initially sluggish and mainly pelagic mostly moving in straight lines seldom zigzag. Green water phenomena was maintained with *Isochrysis galbana* and *Chaetoceros calcitrans* throughout the culture period. From 2nd day onwards, they were fed with live *Artemia* naupli. It was found that they do not capture the prey at first attempt but capture the live food once or twice and they feed. From 9th day onwards they were fed with larger live *Artemia* and small *Acetes*, but they did not prefer *Acetes*. They were sensitive to both bright light and vibrational disturbances. This was manifested with sudden release of ink and became dormant for hours. In many cases there was mortality with release of ink. The paralarvae survived for 22 days. The growth after 22 days was 17.8 to 19.7 mm length range and weight ranged from 675 to 842 mg.

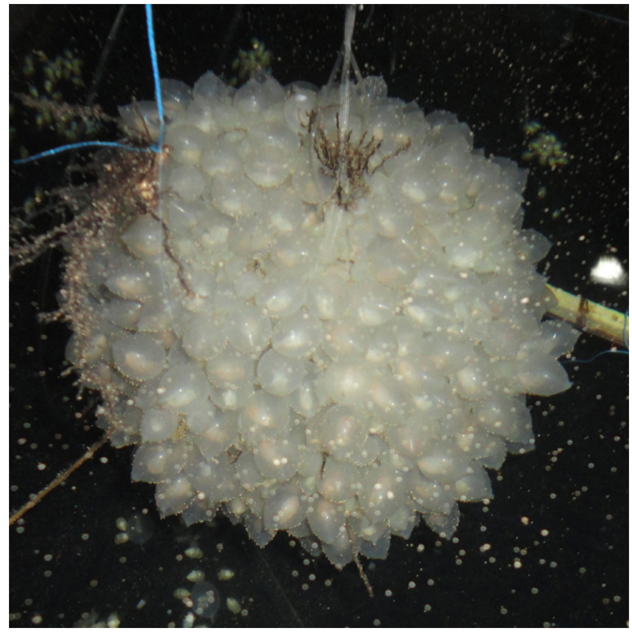
The paralarvae were observed under binocular microscope (Lawrence & Mayo model XSZ). In the live paralarvae, light and dark coloured chromatophores could be observed. The patterns were distinct and also changed as per their movement. The paralarvae had all the typical characters



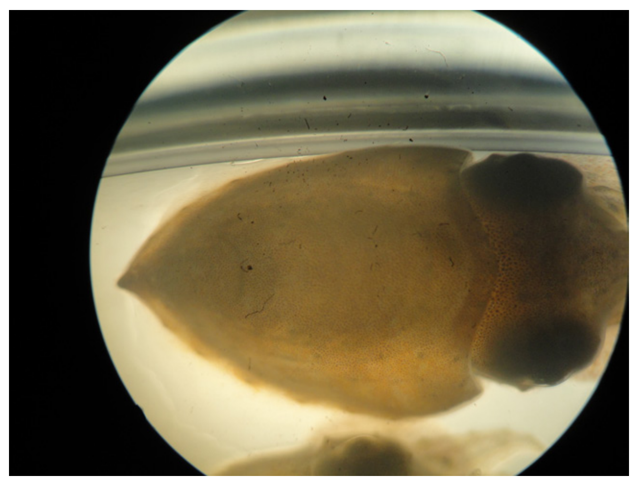
Paralarva of *Uroteuthis* sp., anterior portion (left) and posterior portion (right) of the squid paralarvae such as the presence of corneal membranes, fins, well developed arms and tentacles with distinct suckers, chromatophores more numerous on ventral than dorsal side.

Egg capsules (50 numbers) of *Sepia* sp. collected off Visakhapatnam Fisheries harbour were maintained in small plastic troughs in 35 ppt salinity, provided with gentle aeration and 30 percent hatching occurred releasing 47 paralarvae. Again, another batch of 200 egg capsules were obtained and maintained in the hatchery from which 51 paralarvae were released (27 percent hatching). The paralarvae were fed live *Artemia* naupli., however, they did not survive beyond six days. Another batch of egg capsules of *Sepia* sp. obtained from sea off Visakhapatnam were maintained in 1 t black FRP tank in 35 ppt provided with gentle aeration. The egg mass was a big bunch of nearly 1000 eggs and looked like a bunch of grapes. The capsules, white and transparent, were observed to be viable with embryos moving inside the capsule. Water level was maintained at 70 percent of the tank capacity. They were maintained in black tanks with mild light regime covering half portion of the tank in black cloth. Water quality parameters were maintained. Para larvae hatched out continuously for 6 days starting from 11th day of collection of egg. In total, 776 para larvae hatched out from the bunch. The hatchlings released were initially sluggish.

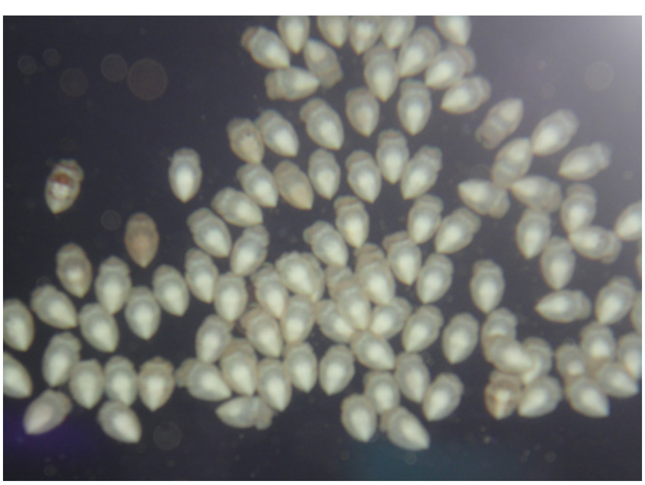
From 2nd day onwards, they were fed with live *Artemia* naupli. From 9th day onwards they were fed with larger live Artemia and small *Acetes*, which was slowly being accepted by the paralarvae. Since live feed could not be provided continuously and mortality started occurring, the hatchlings were ranched into the sea off Visakhapatnam coast.

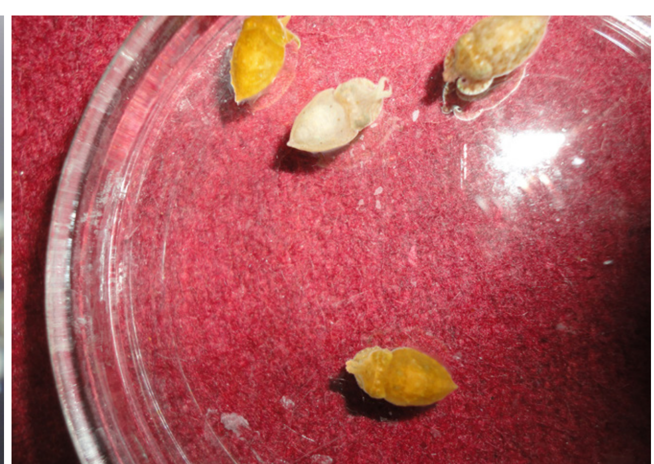


Egg capsules of *Sepia* sp. obtained from sea off Visakhapatnam



Hatchling of *Sepia* sp., posterior view under microscope





Hatchlings of *Sepia* sp.

Brief Communication

Self-regulatory quota system in the brown mussel fishery at Vizhinjam

P. Gomathi[1]*, M. K. Anil[1], P. Laxmilatha[2] and Geetha Sasikumar[3]

[1]Vizhinjam Regional Centre of ICAR-Central Marine Fisheries Research Institute, Vizhinjam P. O., Thiruvananthapuram – 695 521, Kerala

[2]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala

[3]Mangalore Regional Centre of ICAR-Central Marine Fisheries Research Institute, Mangaluru–575 001, Karnataka

*E-mail: gomathimfsc@gmail.com

Managing fisheries of bivalve mussels is challenging because these are highly variable resources due to their strong dependence on annual recruitments. As a result of environmental and oceanic conditions, their abundance may also exhibit cyclical tendencies. The sedentary nature, combined with the coastal nature of the fishery, makes them highly vulnerable, particularly at low stock sizes, increasing the risk of overfishing and depletion. Therefore, the management of sedentary bivalves needs to adapt to the fluctuations in productivity and abundance of these resources to minimize the chances of collapses. The Vizhinjam-Kovalam region of Kerala is one of India's important brown mussel (*Perna indica)* fishing areas. The mussel fishery supports the livelihood of nearly 300 fishermen in the area. This communication is a detailed description of the self-regulatory quota system in continuation of the earlier initiatives instituted in 2019 by fisherfolk to protect juvenile brown mussels (Gomathi *et al.,* 2019). The "*Diving Workers Welfare Society*" of the Vizhinjam-Kovalam Coast has established a new fishing quota system for brown mussels and set 23rd October as the start date for the 2022 mussel fishery season. This policy change is being implemented to lengthen the fishing season. This system is also known as Individual transferrable quota (ITQ). The daily limit for a single mussel fisherman under this system is 40 kg or two baskets ('Kutta'). An individual who catches more than his quota must transfer the excess catch to a fisherman who catches less.

Besides the quota system, the committee has also fixed a minimum Landing Centre Price (LCP) for mussels, where one '*Kutta*' of about 20 kg will realize an LCP of ₹800. This guaranteed minimum LCP provides a stable income for the fishermen throughout the year, regardless of when they land their daily catch, besides a minimal value guarantee. In the past, when outside auctioneers set the price, it dropped from ₹1000 to ₹200 per basket during the glut and there was no guaranteed minimum price; in addition, the day's landing time affected the mussels' prices, with early landings fetching higher prices. These mussel pickers formed the 'Mungal Thozhilali Kshema Sangom' (Diving workers' welfare society) (Reg.No.TVM/TC/1514/2014) to uplift the diving community, which has 252 fishermen as registered mussel fishers who elect office bearers of the society which includes a President, Vice President, Secretary, Joint Secretary, Treasurer and Executive members. The Society decides the commencement of mussel fishing season, timing of fishing activities, and quantity of mussels allowed per diver. The welfare society has a bank account and collects ₹50 from each diver every week which will be used for the fishermen in case of medical emergencies or fishing accidents. Money is collected at the landing centre every Thursday, and the person in charge of this activity hands it over to the President of the welfare society who deposits it in a bank. The Society also determines the optimal time to go mussel harvesting based on the engine power of the vessel. Mussel fishing begins at 6.30 am and ends at 10.00 am. Fishermen who use non-motorized catamarans, which require more time to reach the fishing spot, are granted special consideration and permitted to leave for fishing earlier (6.10 am). The next category consists of fishermen who use catamarans or boats powered by motors of two hp capacity. The earliest time a fishermen using nine hp motors are permitted to go out is 6.30 am.

For the timely management of the mussel fishery, committee members meet every Thursday to take crucial decisions affecting mussel fishing regulations and financial aspects. Since 2019, the committee has formulated and efficiently implemented new rules and regulations. Decision/ information is communicated to the fishermen verbally and by posting

Brown mussel in 'Kutta/basket' harvested from the Vizhinjam-Kovalam Coast.

notices at the mussel landing centre. The fishery's voluntary management is followed without enforcement by the government or other institutions. Further, different rules and regulations implemented are limiting the collection of juvenile mussels and there is a closed holiday for fishing on Fridays. There is also a restriction on fishing by outsiders, and the fishermen are not allowed to collect both lobster and mussels on the same day. Mussel collectors and traders are subject to penalties for ordering or purchasing juvenile mussels. Since it is self-regulated and voluntary, there have been no known violations, though the committee has decided on a fine of ₹2000–₹10,000 for anyone breaking the rules.

Brief Communication

Jellyfish menace in shoreseines operated off Visakhapatnam, Andhra Pradesh

Pralaya Ranjan Behera[1]*, Visal Yadav[1], P. Bhaskar Rao[1], V. Ravikant[1] and Raju Saravanan[2]
[1]Visakhapatnam Regional Centre of ICAR-Central Marine Fisheries Research Institute, Visakhapatnam -530 003, Andhra Pradesh
[2]Mandapam Regional Centre of ICAR-Central Marine Fisheries Research Institute, Mandapam Camp- 623 520, Tamil Nadu

*E-mail: beherapralaya213@gmail.com

Jellyfish form seasonal swarms that mainly negatively impact fisheries, aquaculture and tourism sectors. In recent years, mass swarming of jellyfish has increased in world oceans and has become a topic of current scientific interest and research. Recent studies link their blooms to a combination of global climate events and several local anthropogenic stressors like overexploitation of finfish, eutrophication, and an increase in marine artificial structures which provide substrate for jellyfish attachment. Menace of jellyfish often seen in coastal areas of India and impact of jellyfish swarms on coastal artisanal shore seine fisheries along the coast of Andhra Pradesh is reported. Two types of seines are operated in the coastal water one without cod end and other with cod end which are locally called 'Alivi vala' and 'Pedda vala' respectively, in calm weather conditions from October to April. During the post-monsoon season, inshore coastal waters serve as a nursery ground for shoaling fishes such as sciaenids, clupeids, anchovies, and mullets and traditional fishermen operate shore seines to catch these.

A survey was conducted at Ramakrishna Beach, Visakhapatnam during the months of October to April

Box jellyfish, *Chiropsoides buitendijki*

Jellyfish *Cyanea nozakii*

2021 from 140 units of shore seine. Altogether, 20-26 fishermen operated each shore seine without cod end by country craft at water depth 5-10 m during the day time in coastal water. The net is made of 210/2/3 nylon and the main central piece is fabricated with 10 mm mesh having 18 m length and 20 m width. Usually, a 20 mm mesh size of 175 m length and 20 m width is attached on either side of the middle piece. A total of 16 units of netting with a mesh size of 30 mm and a length of 20 m are attached. The operation of the seine net lasted between 4-5 hours per haul. Based on the survey, it was found that the shore seine net was choked with enormous quantities of jellyfish. Although several varieties of jellyfish species were caught in shore seine nets (*Carybdea* sp., *Aequorea* sp., *Lychnorhiza malayensis, Rhopilema hispidum, Lobonemoides robustus*), catches were dominated by several species of *Chrysaora* (*Chrysaora chinensis* and *Chrysaora* sp.), box jellyfish (*Chiropsoides buitendijki*) and *Cyanea nozakii*. The weight of the total catch varied from 5 kg to 801 kg per haul with a mean catch of 126.38 ± 13.11 kg. The weight of the commercially important varieties in the total catch ranged from 3 kg to 710 kg per haul with a mean catch of 69.24 ± 8.87 kg. The wet weight of jellyfish catch varied from 0.25 kg to 850 kg per haul with a mean catch of 34.35 ± 9.75 kg. The estimated biomass of total catch per haul was recorded from 33.80 kg/km^2 to 5415 kg/km^2 with a mean biomass of 854.44 ± 88.64 kg/ km^2. The biomass of commercial catch per haul varied from 20.88 kg/km^2 to 4799 kg/ km^2 with a mean biomass of 468.54 ± 60.02 kg/km^2. The biomass of jellyfish per haul ranged from 1.35 kg/km^2 to 5408 kg/ km^2 with a mean biomass of 224.89 ± 65.91 kg/km^2. Month-wise variation of mean catch rate (mean catch per haul) showed that the highest total catch was in January (142.8 ± 26.99 kg) whereas the lowest was in February (90.95 ± 26.44). The highest commercial catch was in January (100.6 ± 23.87 kg) reduced to 34.89 ± 10.43 kg in March due to jellyfish menace. The mean wet weight of the jellyfish catch was lowest in November (6.33 ± 4.60 kg) and increased to highest in March (83.57 ± 38.23 kg). This indicates the intensity of swarms in coastal water.

These jellyfish are also a great menace to artisanal fishers as their nets get clogged, reducing their filtering capacity. In addition, more efforts are required to sort the catch, which consumes much time and labour for fishermen. Some of these jellyfish, mostly box jellyfish and *Chrysaora* spp., cause skin irritation. Fishers sometimes have to discard whole catches due to difficulty sorting them from jellyfish and skin irritation. Nets get damaged due to jellyfish's weight, which comes along with water flow, necessitating repairing the nets and also losing fishing days for fishers.

Brief Communication

Wild black-lip pearl oyster, *Pinctada margaritifera* spat: growth and broodstock development

P. Laxmilatha[1]*, P. Pattnaik[2] and Padmaja Rani[2]
[1]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala
[2] Visakhapatnam Regional Centre of ICAR-Central Marine Fisheries Research Institute, Visakhapatnam -530 003, Andhra Pradesh
*E-mail: laxmil@yahoo.com

The black lip pearl oyster, *Pinctada margaritifera* (Linnaeus, 1758) is a marine oyster distributed in the South Pacific, Indo-Pacific regions and the Red Sea. Globally, it is one of the three valuable pearl producing oysters in the pearl culture industry, apart from *Pinctada fucata* and *Pinctada maxima.* However, in India, the distribution of *P. margaritifera* is limited to Andamans and Nicobar Islands and occurring very rarely in Gulf of Mannar. (Alagarswami, 1983). Spat of *Pinctada margaritifera* was collected from the intertidal rocks off the coast of Visakhapatnam 17.7° N–83.3° E, Andhra Pradesh (Bay of Bengal) during low tides. The spat was light green in colour with alternate white and green radial pattern with distinct growth processes. They were acclimatized and reared in 1 t fiberglass tanks in the marine hatchery.

The fouling on the oysters were carefully scraped of taking care not to damage the growth processes and gently washed to remove the silt. The chrysophycean yellow-brown flagellate *Isochrysis galbana* was used as a standard feed for the spat. Filtered (1 µm) and UV treated seawater was enriched with Walne's medium and inoculated with *I. galbana* and *Chaetoceros calcitrans.* The pH of the cultures was

Pinctada margaritifera spat collected from intertidal rocks off Visakhapatnam coast maintained between 7 and 8. The microalgae were grown under 24 hours light conditions at a temperature of 21 ± 1°C and harvested daily in the exponential growth phase. Algal concentrations were counted daily using a Sedgwick counting cell. Shell dimensions of the oysters, excluding the growth processes were measured using a digital Vernier calipers (0.01 mm precision) and the total weight by a portable electronic balance (0.01 g precision).

The spat of *P. margaritifera* collected from along intertidal rocks off the coast of Visakhapatnam 17.7° N–83.3° E in Andhra Pradesh (Bay of Bengal) ranged from 4 mm to 15 mm (DVM) in size. The spat reared in controlled conditions

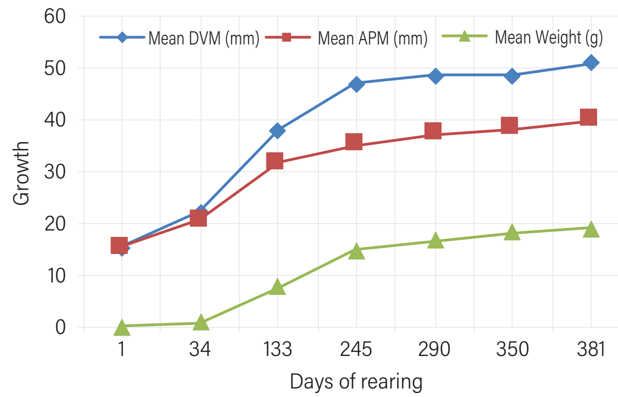
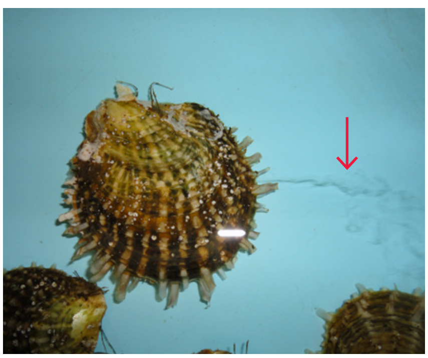
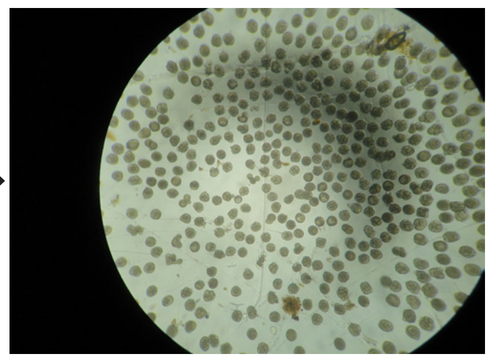


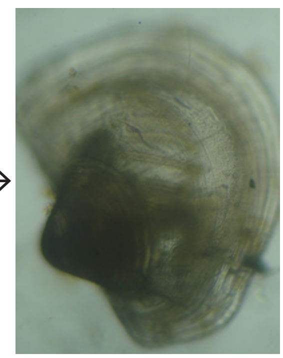
Fig. 1. Growth of *Pinctada margaritifera* spat



P. margaritifera Broodstock developed in the hatchery



Fertilised eggs of *P. margaritifera*

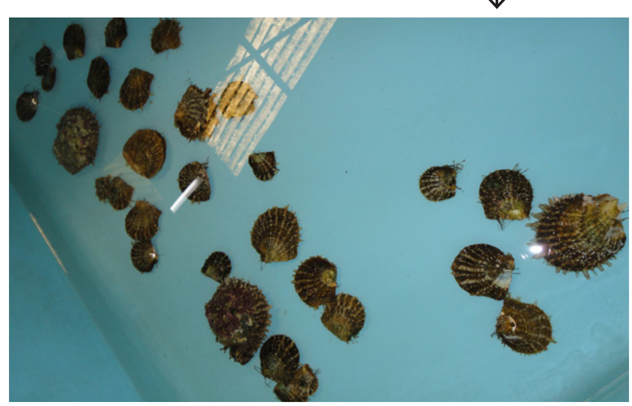


P. margaritifera spat ready to settle

in the hatchery attained an average of 51.01 mm (DVM), 39.94 mm (APM), 11.92 mm (Thickness) and 19.30 g Total weight) in 381 days from an initial average of 15.63 mm (DVM), 15.62 mm (APM) and 0.40 g. The gonadal development was observed at 45 mm DVM.

The Specific growth rate (SGR) per day was monitored and the mean SGR was 33.09 during 350 days of rearing and 35.37 at the end of 381 days of rearing. The SGR per day was 0.114 mm /day. The spat of *P. margaritifera* was reared for 381 days and isometric growth was observed throughout the rearing period. The relationship between the shell height (DVM) and shell length (APM) of the *P. margaritifera* spat was also linear.

Pinctada margaritifera has been reported from the Andamans and Nicobar Islands and stray numbers from the Gulf of Mannar (Alagarswami *et al.*, 1989). Spat of *P. margaritifera* collected from the Visakhapatnam coast, was successfully reared in the hatchery to adult size and brood stock was developed. Several spawnings occurred in the hatchery thereafter and larvae could be reared to spat settlement stage

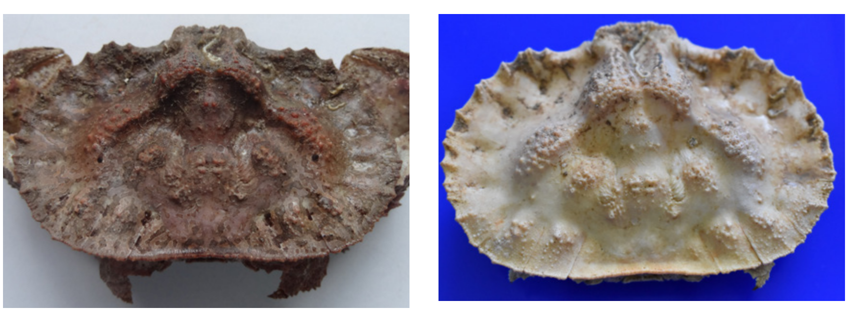


P. margaritifera spat grown in the hatchery

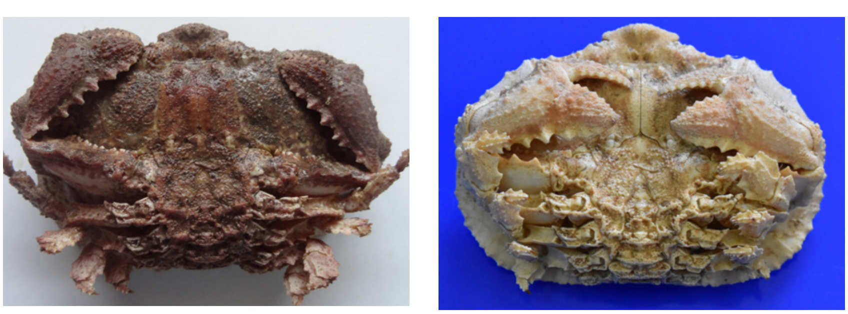
in the hatchery. Standard technology for seed production of *P. margaritifera* in hatchery is already available (Alagarswami *et al.* ,1989). This research indicates the scope for developing the *P. margaritifera* stock under controlled hatchery conditions which can be utilized for pearl culture in the open waters on the north east coast of India.

Flat elbow crab spotted

During a routine field survey, two specimens were collected from the landing of the bottom set gillnet operated at a water depth of 6-7 m on a rocky substratum at Chepala Kancheru, Visakhapatnam on 15th November 2018. The specimen was identified as Flat Elbow Crab, *Aethra edentata* Edmondson, 1951. The length and width of the carapace varied from 52 mm to 54 mm and 62 mm to 65 mm respectively. The length of the abdomen ranged from 22 mm to 25 mm. The species is characterized by transversely oval-shaped carapace. The margin of the carapace is thin and slightly turned up, with seven lateral lobes, the closed suture lines being distinct. Minute punctae and granules roughen the intervening margin of the lobe. Presence of a few dispersed warts on the upper surface of the carapace. Hepatic and lateral parts of the carapace are lowered, the gastric area raised, and distinct on either side of the midline, topped by a transverse row of warts. The cardiac region is elevated by a curved ridge, indistinguishably broken into five portions, the middle one the largest. The rostrum appears much flatter as the longitudinal median groove is shallower. The carapace is brownish with a violet tinge in fresh whereas whitish in preserved condition. The ventral side of the body and appendages are pale brown with a violet tint. Chelipeds equal, upper and lower borders carinate; merus smooth, lower border bicarinate. Carpus, superseding proximal end of propodus toothed on upper and outer borders. The inner surface of the palm and fingers is smooth and concave to conform to the surface of the carapace with which they are in contact when at rest. The posterior margins of the chela are finely serrated, and quite uneven, but never with well-defined teeth. Oval spots of violet colour mark the outer surface of the palm and fingers. Walking legs are short and decrease in length from first to fourth. Abdomen with nearly parallel sides; segments, except terminal one, pitted and eroded, crossed transversely by ridges; terminal segment flat, surface marked by minute punctae.



Dorsal view *of Aethra edentate* a) fresh sample b) preserved sample



Ventral view *of Aethra edentate* a) fresh sample b) preserved sample

The genus *Aethra* Latreille, 1816 is an Indo-Pacific parthenopid and currently consists of four valid extant species (A. *scruposa* (Linnaeus, 1764); *A. scutata* Smith, 1869; *A. edentata* Edmondson, 1951 and *A. seychellensis* Takeda, 1975) and one extinct species, *Aethra stalennyii* (Collins, 2023; Alex, 2018). The species *A. edentata,* commonly known as Flat elbow crab, belongs to the family Aethridae. Geographically, it is distributed in Indo-Pacific Oceans on sandy bottoms at depths between 1 and 30 m. Only species *A. scruposa* (Linnaeus, 1764) has been reported in India's Gulf of Mannar, the East coast of India, and Andaman waters. There is no report on the occurrence of *A. edentata* in Indian waters. This is the first record of the species from India's coastal and marine waters.

Pralaya Ranjan Behera*, Subhadeep Ghosh, Vishal Yadav, and Safet Padhan | Visakhapatnam Regional Centre of ICAR-Central Marine Fisheries Research Institute

Observations on the incidental landings of bowmouth guitarfish along north Andhra Pradesh coast

Rhina anclystomus landed by hook and line gear at Bandaruvanipeta on 26th December 2021

The bowmouth guitarfish *Rhina anclystomus* has been assessed as Critically Endangered by the IUCN (Kyne *et al*., 2019). Though not targeted in fisheries along the coast of Andhra Pradesh, the species is landed as incidental bycatch. Here we present details of the species landed along north Andhra Pradesh coast during 2017-2021. Incidental landings of *R. anclystomus* at Visakhapatnam Fishing Harbour have been observed mainly from mechanized trawlers and gillnetters. The average size of *R. anclystomus* landed at Visakhapatnam Fishing Harbour was 133.8 cm during 2010-2021 which was lower than the estimated size at maturity for both females (180 cm TL) and males (150-175 cm TL) (Last and Stevens, 2009, Last *et al*., 2016). Of the 9 specimens measured over the years,

Table 1. Details of *R. anclystomus* incidental landings along the coast of north Andhra during 2010-2021

Day	Month	Year	Total Length (cm)	Total Weight (kg)	Sex	Gear	Location of catch
26	11	2010	94	-	-	-	-
9	8	2011	169	-	-	Trawl	-
13	9	2013	137	20	F	Trawl	-
10	6	2014	135	-	-	-	-
5	1	2016	175	-	F	Trawl	-
4	2	2017	146	-	F	Trawl	-
5	1	2019	67	-	F	Gillnet	Uppada
6	7	2021	147.5	-	F	Trawl	-
26	12	2021	168	50	-	Hook and line	Bandaruvanipeta

5 were females; the others could not be noted for sex. Though there was no clear seasonal indication, most of the incidental landings brought to Visakhapatnam Fisheries Harbour were during the post-trawl ban months, from June onwards. The most recent observation of incidental landings of *R. anclystomus* was at Bandaruvanipeta, Srikakulam district on 26th December 2021. A 50 kg sized bowmouth guitarfish measuring 5.5 feet (approximately 168 cm) in total length was landed by hook and line fishers. The species was caught as bycatch from approximately 60 m depth. Local fishermen indicated that this was the first time it was caught by hook and line gear, usually the species is caught as bycatch in trawls or bottom set gillnets once every 3 to 5 years. The species is landed mostly as a single animal, indicating its possible solitary lifestyle. The low numbers seen in the incidental landings along north Andhra Pradesh coast also indicates its low occurrence in the region. The flesh of the animal is utilized fresh and dried, and is mostly sent to markets situated outside Andhra Pradesh. The species has now been included in Schedule I by The Wildlife (Protection) Amendment Act, 2022.

Ashok Maharshi and M. Muktha | Visakhapatnam Regional Centre of ICAR-Central Marine Fisheries Research Institute

Report on spider crab *Paramaja* sp. from Southwest coast of India

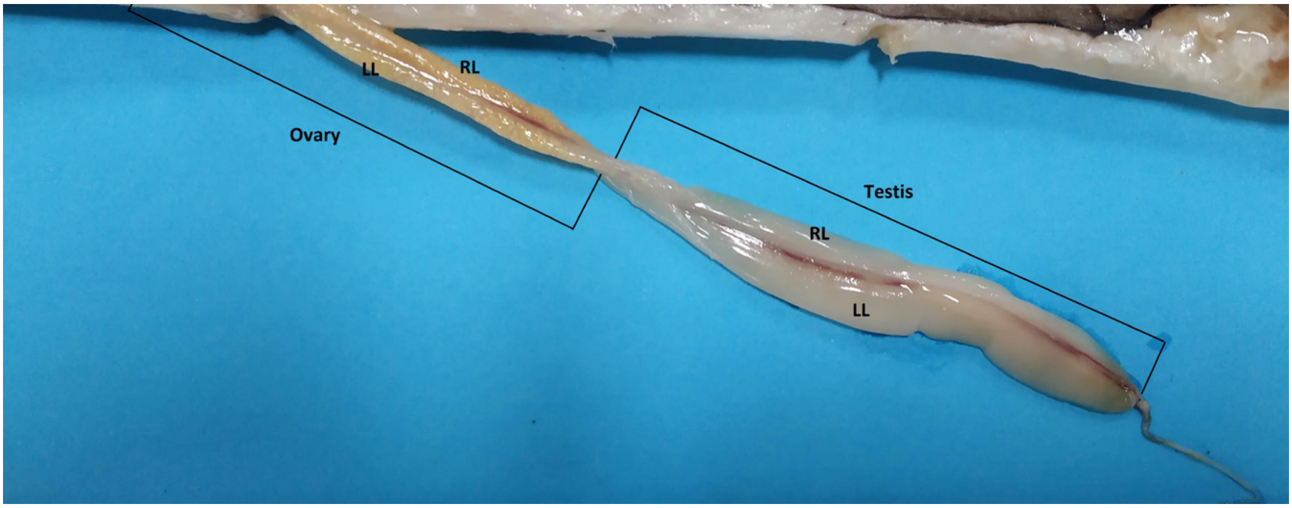
Paramaja sp. adult female crab

Recently, a female specimen of the spider crab, *Paramaja* sp., belonging to the Majidae family was collected from Sakthikulangara Fisheries Harbour. *P. gibba* is reported from Andaman Sea, off Kollam and Gulf of Mannar. Earlier reports about this species mentions only male specimens recorded from Indian seas. Carapace pear-shaped, narrow anteriorly, posterior wider and convex. Dorsal surface of the carapace densely covered with pointed small to rounded medium sized tubercles. The regions are well defined, branchial and cardiac regions are inflated and separated from the gastric region by prominent deep grooves. The basic colour of the dorsal carapace, chelate and ambulatory legs are creamish white; tubercles and their bases in the orbital, gastric, cardiac regions and distal part of merii of the ambulatory legs are bright orange. Rostrum bifurcated, prominent and 'V' shaped, orbital area surrounded by spines; lateral spines small and only few moderately bigger/ longer. Chelates are slender, shorter and devoid of hairs; ambulatory legs relatively longer and hairy, reducing in length from first to fourth. Abdomen broad with six somites and a telson. Lateral and medial edges of the ambulatory legs, surface of the abdominal segments and base of the rostral spines are fringed with long and short hairs, visible clearly in the ventral view.

The collected female crab was in berried condition with a carapace length (CL) of 82 mm and total weight (TW) of 49.2 g. The presently procured specimen may belong to *P. gibba*, as various diagnostic characters observed were in agreement. However, to identify the species from its closely related species, *P. turgida* and *P. kominatoensis* and final species confirmation, the structure of the adult male pleopods must also be examined. The few male specimens collected along with the female crab, were in highly spoiled condition with only exoskeleton remaining. Hence, more numbers of male and female crabs are required to complete the species identification process.

Jose Josileen*, Paulose Jacob Peter , T. Retheesh, M. T. Vijayan, K. T. S. Sunil and P. Laxmilatha | ICAR-Central Marine Fisheries Research Institute, Kochi

Note on hermaphroditism in largehead hairtail *Trichiurus lepturus*



Gonad of *T. lepturus* showing testicular and ovarian lobes

The ribbonfishes earlier formed low-value bycatch, mainly used as dry fish and for local consumption. An increase in export demand in the international market, mainly from China, Japan, and Southeast Asia has led to its targeted fishing along the Indian coast and the resource is regularly monitored for assessing its stock status. Hermaphroditism in ribbonfish *Trichiurus lepturus* was reported from the southwest coast of India but further reports are scanty. During a routine fish biology investigation in *T. lepturus* (35 numbers; length: 690.42 ± 48.01 mm; weight: 206.57 ± 49.45 g) samples collected from the multi-day trawl landing at the New Ferry Wharf landing centre of the Mumbai coast, three hermaphrodite fishes were observed. The details of the hermaphrodite and normal specimens are given in Table 1.

The total length and post-anal length of three hermaphrodite specimens ranged between 681.33 ± 56.22 mm and 252.67 ± 17 mm respectively. Hermaphroditic gonads of all three specimens were testicular at the anterior side and ovarian at the posterior side with clear distinction between the two. The testicular portion was creamy white, while the ovarian was orange to yellowish in color. The testicular portion occupied 59.32% ± 10.8% of the total gonad and the rest was formed by the ovarian portion at 40.68% ± 10.8%. Ovarian tissues in the hermaphrodite gonads were maturing (III and IV stages in 2 specimens) and mature stage (V stage in one specimen). The gonads of the hermaphrodite specimens were elongated, and the length and width of both lobes of the testis and ovary were identical. Hermaphrodite specimens of ribbon fish exhibited a normal appearance like other specimens.

Ajay D. Nakhawa*, Punam Khandagale, Anuleskhmi Chellappan, K. V. Akhilesh, Santosh Bhendekar, Sunil Ail, Thakurdas and V. Venkatesan| Mumbai Regional Station of ICAR-Central Marine Fisheries Research Institute

Table 1. Gonadal measurements of normal and hermaphrodite *T. lepturus*

	Testis						Ovary					
		Length (mm)		Width (mm)				Length (mm)		Width (mm)		
Specimens	Stage	RL	LL	RL	LL	Weight (gm)	Stage	RL	LL	RL	LL	Weight (gm)
Hermaphrodite I	Gravid	69.94	71.39	2.81	3.4	0.276	IV	45.11	44.45	2.41	1.92	0.138
Hermaphrodite II	Gravid	56.51	85.7	1.34	1.42	0.075	III	31.06	30.78	2.55	2.2	0.106
Hermaphrodite III	Gravid	56.57	55.96	2.98	2.58	0.628	V	61.99	61.43	1.97	1.83	0.278
Male/Female	Developing, Gravid	72.68	70.88	1.87	1.77	0.265	III-VI	76.47	74.55	5.24	4.04	2.8

Recent landings of portunid crab *Monomia gladiator* at Cochin Fisheries Harbour

Adult male crab of *Monomia gladiator*

A good landing of *Monomia gladiator* (Fabricius, 1798) was recorded at Cochin Fisheries Harbour on 5th April 2023. Approximately 30 kg of the species was landed along with *Charybdis natator*. In the regular field visits to different landing centres in Kerala, *M. gladiator* generally observed only in very few numbers or in stray catches. This marine crab has good landings along the east coast; major contribution is from Tamil Nadu, where, good seasonal fishery exists in different coastal areas.

M. gladiator (original name- *Portunus gladiator*) belongs to the family Portunidae. The carapace is light brown in colour; different regions with distinct patches of reddish brown granules and markings in specific pattern. Carapace is broader than longer, transversly hexagonal with 9 anterolateral teeth and their margings are beset with thick smooth setae; last one is long and stout bearing setae. Frontal margin with four teeth, lateral ones distinctly bigger than the middle two. Chelipeds are stout and robust moderately lined with setae. Second to fourth ambulatory legs are long and gradually decreasing in size from 2nd to 4th and the margins are with tuft of brownish black setae. Fifth one is natatory, posterior border of the propodus is with a clear white band, which is very clear in all the specimens and middle of the dacylus beset with a small white dot. All the ambulatory legs including the natatory are with prominent glabrous longitudnal bands. In males the anterior sternal plates (1-4) are bright orange coloured and granulated, which is very distict in larger crabs and 5-8 are tomentose covered with brownish black soft setae. Whereas female sternites are white, smooth and granulated; 5-8 sternal paltes are non-tomentose.

Monomia gladiator landings (along with *Charybdis natator*) at Cochin Fisheries Harbour

About 15 kg of sample procured for the sample analysis. The size of the male crabs varied between 51–101 mm (average 80.0 mm) carapace width (CW) and total weight between (TW) 13–101 g (average 53.34 g). In females CW ranged between 49–84 mm (average 68.33 mm) and TW between 14–68 g (average 33.42 g). One male and one female specimens were deposited in the Designated National Repository (DNR) of ICAR-CMFRI with the accession number ED.5.5.4.2.1. The crab is edible, however, in Kerala consumers do not prefer this species unlike other edible portunids.

Jose Josileen*, T. Retheesh, M. T. Vijayan, K. T. S. Sunil, T. M. Najmudeen and P. Laxmilatha | ICAR-Central Marine Fisheries Research Institute, Kochi

Occurrence of Japanese sponge crab *Lauridromia dehaani*

Adult *Lauridromia dehaani* collected from Sakthikulangara Fisheries Harbour

In recent times, good numbers of Japanese sponge crab *Lauridromia dehaani* were landed at Sakthikulangara Fisheries Harbour, Kollam. Samples were procured from by-catch landings of multiday trawlers which operated at a depth of around 40 m, off the southwest coast of Kerala. This sponge crab is usually found in the landings along with puffer fish, *Lagocephalus inermis*. The estimated landings of the crab in multiday trawls operated from Sakthikulangara Fisheries Harbour during September 2022, was 20 kg. One female specimen was deposited in the Designated National Repository (DNR) of ICAR-CMFRI with accession number ED.5.1.2.1.1. The species was studied in detail with samples collected during January–March 2023 period which is reported below.

L. dehaani belongs to the suborder Pleocyemata and the family Dromiidae. The species is distributed in the Indo-west Pacific region and in India distribution is along both east and west coasts. Crab is known to camouflage itself by carrying something above it such as a piece of sponge, a shell of similar dimensions or leaves with a clear preference for sponges (Morton, 1989) and hence are commonly known as sponge crabs.

The carapace of the crab is broader than wide and blackish brown in colour. The dorsal, ventral surfaces of the carapace in both male and female crabs, chelate and ambulatory legs as well as the margins of the pleon are covered with tufts of soft silky setae. The tips of the chelate legs are very noticeable as they are in brilliant pink colour. The last two pairs of ambulatory legs are comparatively smaller and placed one above the other. Carapace bears four antero-lateral teeth; the first three are placed at equidistance, whereas the last one is more prominent and widely separated. The male crabs were in a size range of 70-79 mm carapace width (CW), 59-69 mm carapace length (CL) and total weight (TW) between 72-98 g each. Female crab sizes varied between 59-78 mm CW, 50-68 mm CL with TW between 30-99 g each. All the crabs were matured and among the females, two were in berried condition. The eggs are bright orangish-yellow in colour with an average size of 576 ± 0.05µ. To confirm its genetic identity gene sequences captured from the mitochondrial COI gene were used. Possibility of antimicrobial peptides from the crab's haemolymph, which is functionally important against pathogens has been reported (Anbuchezian *et al.*, 2018). Presently the species has no consumer preference and belongs to the non-edible category. However due to its reported content of valuable bio-compounds, it may become a targeted fishery resource in the future.

Jose Josileen*, M. T. Vijayan, T. Retheesh, K. T. S. Sunil, N. S. Jeena and P. Laxmilatha | ICAR-Central Marine Fisheries Research Institute, Kochi

Unusual landings of Terapons

Terapons belonging to the family Teraponidae, are widely found in the Indo-west Pacific region. They are locally known as "*Karvanda*," "*Naveri*" and "*Hajam*" in Maharashtra. Terapons are usually known to inhabit

inshore marine, brackish waters and some species also enter the freshwater ecosystems. The adults spawn in deeper waters while the juveniles move to the shallow sandy bottom area near the estuarine habitat and inshore areas. Off about 62 species known globally only 5 species such as *Mesopristes elongatus*, *Pelates quadrilineatus*, *Terapon jarbua*, *Terapon puta* and *Terapon theraps* are known from western Indian Ocean. Terapons are mostly caught by artisanal fishers in coastal waters and none of the species form major landings or part of a commercial fishery. On November 24, 2022, an unusual landing of around 8-tonnes of terapons namely *Terapon theraps* (98%), *Terapon puta* (1.2%) and *Terapon jarbua* (0.3%) was observed in the purse seiners catch in the Sassoon Dock landing centre, Mumbai, Maharashtra. Other species such as Indian mackerel (*R. kanagurta*), carangids (*Decapterus russelli*; *Alepes kleinii*) etc. also formed the catch in the purse seines landed. On inquiry from fishers revealed that purse seiners were operated off the Mumbai coast at depths ranging from 30-40 m. Terapons formed around 95-98% of the low-value bycatch (LVB) landing on the particular day; other species contributing to low-value bycatch (LVB) were scads and juveniles of Indian mackerels. *Terapon theraps* constituted mostly adults whose size and weight ranged from 91 to 301 mm and 10 to 378 g respectively, with a dominance of 155-225 mm TL size groups. Terapons catch was sold at ₹16 per kg to the supplier of the fish meal plants located at Taloja, Mumbai.

Ajay D. Nakhawa*, Santosh Bhendekar, Anuleskhmi Chellappan, K. V. Akhilesh, Sunil Ail, Thakurdas , Punam Khandagale and V. Venkatesan | Mumbai Regional Station of ICAR-Central Marine Fisheries Research Institute

Seasonal fishery of blue swimmer crab at Attupuram landing centre

Gill net fishers at Attupuram-Company Kadavu landing centre

Recent visits to the landing centers of Attupuram – Kathiyalam area in Thrissur district of Kerala, it is learnt that a seasonal fishery for Blue swimmer crab – *Portunus pelagicus*- is existing in this area for a few years. Every year during July-August period, gillnet fishing for blue swimmer crab (BSC) is active here. Of the harvested catch 99% is BSC and the rest the Three spotted crab, *P. sanguinolentus*. Crabs are also caught by hand-picking during the season when young boys are engaged in this activity. The BSC caught in the gillnets were bigger in size and males were dominating. Their size range and other details were recorded (Table 1).

For fishing no craft is used and fishermen walk into the sea and spread the gill nets about 100-200 meters from the shore. The width of the one piece of net is 3 meters and the length is 90-100 m, and usually 4 such pieces are joined together. The mesh size of the net is between 160-200 mm.

Every day fishermen keep the nets in the water for about 18-20 hours, between 10 am to 4 am the next day. For collecting the entangled crabs, the nets are brought to the shore and carefully remove the live crabs without damaging the nets. The fishers reported that BSC are found to be calm once it is

Harvested live Blue Swimmer Crabs ready for sale

Table 1. Size range and other details of the crab caught in gill nets

Sex	CW (mm)	CL (mm)	TW (g)	Maturity condition
Male	130-175	58-81	126-346	Mature
Female	142-154	63-74	170-267	Mature not berried

CW- Carapace width; CL- Carapace length; TW- Total weight

entangled and do not cut the nets but Three spot crabs are more aggressive and cause damage to the nets. During the season, approximately 150 kg /day of crabs are harvested from Attupuram-Company Kadavu and 500 kg/day from Kathiyalam (Thattumkadavu), and the wholesale price of crab ranged between ₹ 230 – 250 / kg.

Jose Josileen, K.T. S. Sunil, T. Retheesh, M.T. Vijayan, and A.P. Dineshbabu | ICAR-Central Marine Fisheries Research Institute, Kochi

Sawfishes in Odisha-Fishers' perspective

Sawfishes belong to the family Pristidae among elasmobranchs and are extremely susceptible to fishing gears like trawls and gills because of their saw like toothed rostrum. They easily get entangled in these gears and it is very difficult to remove such fishes. All sawfish species are listed on Appendix I of the Convention on International Trade of Endangered Species (CITES), which bans commercial international trade in sawfishes and their parts and also they are added to Appendix I and II of the Convention on Migratory Species (CMS), for their protection on a regional basis. Sawfishes are also protected under the Indian Wildlife (Protection) Act 1972 which makes its fishing/capture, illegal. With several conservation measures in place such as sawfishes being protected under Schedule 1 of the Wildlife (Protection) Act 1972, use of bycatch reduction devices in Odisha and awareness programs, reports of sawfish landed along the Indian coast were fewer than 10 times in the last decade. On 12th November, 2022 a female sawfish was caught accidentally in a trawler south-east off Paradeep, Odisha. It was 15 feet (>4 m) long in total length (TL) and weighed approximately 150 kg. The species had 17 teeth in each side of the rostrum and was identified as large tooth sawfish (*Pristis microdon*) as the dorsal fin was placed well in forward of pelvic fins and the caudal fin was forked, which are its significant identifying characters. Hence, a survey along the Odisha coast with the local fishermen at the fish landing sites (Balasore, Ganjam, Puri and Paradeep) following a semi-structured questionnaire, including pictures of species was done. Selected, 40 full time fishermen aged between 25-75 years provided the information based on their traditional knowledge (Table 1) which can be considered to execute further scientific investigations.

Sawfishes reportedly grow to massive sizes of upto 7 m in total length (TL) and are mostly found in shallow, warm waters worldwide. They use their rostrum for detecting and catching the prey and removal of the rostrum severely affects its capacity to survive. Usually when the sawfish accidentally get entangled in nets, it causes damage to the net and therefore fishermen in some states of India, consider it as a bad omen. Hence, although rare, efforts are required to create more awareness among the local fishermen to avoid the incidental catch and encourage them not to fish in areas which may be nursery grounds for the juvenile saw fishes. They should be trained to safely release those which get entangled in their nets. Some of the general guidelines developed by US sawfish research and conservation which can be followed are

1. To leave the sawfish in the water without dragging it to the boat or shore
2. Try not to injure the animal or remove the saw
3. Use extreme caution while the sawfish thrash violently from side to side
4. Not to use a rope to secure a sawfish.

During the survey, it was very encouraging to note that all respondents were in favor of conserving the sawfishes on a participatory mode to work with the scientists and to follow the rules which prevents the capture and trade of endangered species under Indian Wildlife (Protection) Act, 1972. Also, they were very positive in sharing information about the sawfishes through catch reporting and releasing the incidental catch. Precautionary approaches are often followed to conserve endangered, threatened and protected (ETP) species. Identifying the important habitats for all life stages of sawfish is a priority for conservation programmes. The sawfishes reportedly rely on freshwater habitats for some period to complete their life cycle and hence conservation

Table 1. Information based on fisher's knowledge of sawfishes along Odisha coast

Species	Local name	Locations of occurrence	Size	Habitat of occurrence	Year of incidences as recounted	Season of occurrence	Depth	Current IUCN Red List status
Pristis microdon	Karatia/Chironi magara/ Khandamagara	Balasore/Kendrapada, Arakhakuda/ Sanopatna	1-5m	Marine, estuarine and fresh water	2-20 years before	June to August and November to December	2-3m	Critically Endangered
Anoxypristis cuspidata	Karatia/Chironi magara/ Khandamagara	Dhamara, Kendrapada, Paradeep	<1-4m	Marine, estuarine and fresh water	7-20 years before	October to December	3m	Endangered
Pristis zijsron	Karatia / Hadicha magara	Puri, Noagaon	1-2m	Marine, estuarine and fresh water	30 years before	November to January	2-5m	Critically Endangered
Pristis clavata	Karatia/Chironi magara/ Khandamagara	Ganjam	1-2m	Marine, estuarine and fresh water	20 years ago	October to December	2-3m	Critically Endangered

of critical habitats in both fresh and marine ecosystems, minimization of bycatch with effective enforcement of species- specific legal protections are measures which will ensure protection to the iconic sawfishes. The mangrove areas Bramhani -Baitarani delta in Kendrapada district of Odisha declared as Bhitarkanika Wildlife Sanctuary in April 1975 and the core area of the sanctuary declared as Bhitarkanika National Park in September, 1998 provides protection to many endangered species such as estuarine crocodile (*Crocodylus porosus*) and Olive ridley turtle (*Lepidochelys olivacea*) which is beneficial for the sawfishes also.

Swatipriyanka Sen*, Sujitha Thomas, Rajesh Kumar Pradhan, Gyanaranjan Dash, Biswajit Dash, Madhumita Das, Prakash Chandra Das, Menaka Das and Shubhadeep Ghosh | Puri Field Centre of ICAR-Central Marine Fisheries Research Institute, Puri, Odisha

Unusual landing of the giant form of Purpleback flying squid

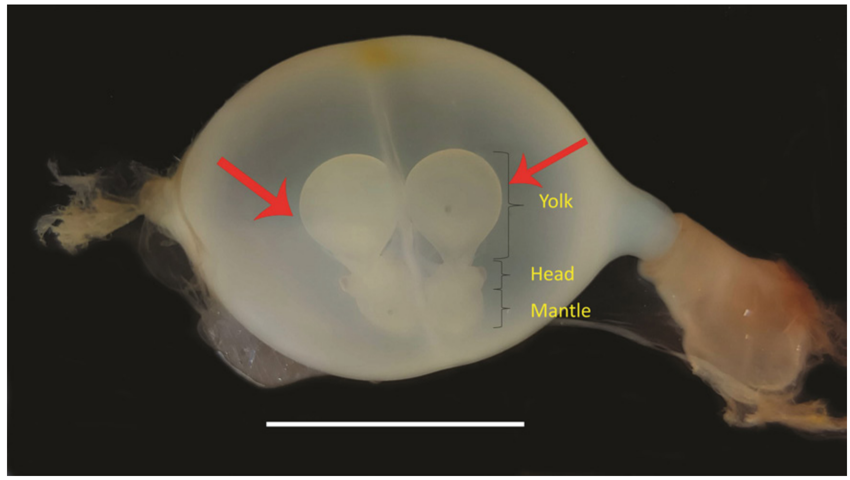
Dorsal view of giant form of *Sthenoteuthis oualaniensis* (scale=20 cm)

The oceanic purpleback flying squid *Sthenoteuthis oualaniensis* (Lesson, 1830) is a promising oceanic fishery resource in the Arabian Sea. Three different morphotypes including a typical medium form with dorsal photophore, dwarf form without dorsal photophore and giant forms occur of which the giant form has been reported only from the Northeastern Arabian Sea. Fifteen specimens of the giant form *S. oualaniensis* was landed in the Cochin Fisheries Harbour on 11 May 2023 by mechanized gill netters targeting large pelagic fishes. Their size measured as dorsal mantle length (DML) ranged from 350 to 462 mm and their weight ranged from 1225 to 3258 g. All these squids were mature females, with 13 squids having attached spermatangia on the buccal membrane indicating that mating has occurred. According to the fishermen, this species is found in the Northeastern Arabian Sea but due to lack of domestic market demand, they are mostly discarded. Further studies on its reproductive biology, age, growth characteristics and identification of internal parasites are being carried out.

R. Vidya*, P. Laxmilatha, K. K. Sajikumar and K. M. Jestin Joy | ICAR-Central Marine Fisheries Research Institute, Kochi

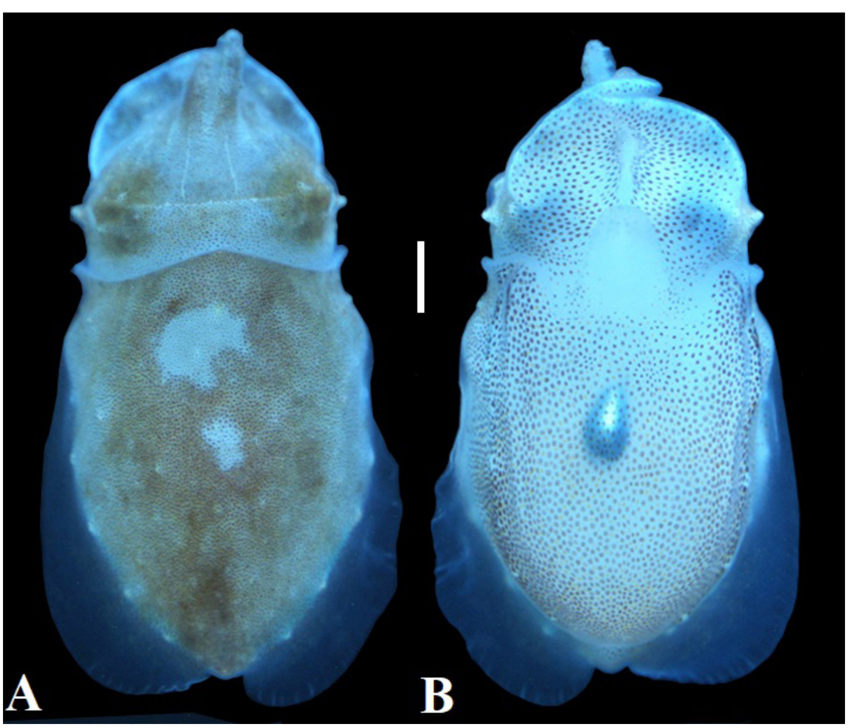
Rare double embryos in the egg capsule of Pharaoh Cuttlefish

The embryonic development of cephalopods is considered unique among molluscs. A recently spawned and deposited egg cluster of Pharaoh Cuttlefish *Sepia pharaonis* (Ehrenberg, 1831) was collected from the Arabian Sea off Kochi (10°01′52″ N; 75°55′09″ E) (40 m depth) on 25th November 2021. The egg stalks were attached to a moored coconut spadix and the colour of the egg cluster was white. Fertilized eggs were brought to the laboratory and allowed to develop in tanks with oxygenated seawater (28°C; pH 8.1-8.3; salinity 34-35 ppt) at the ICAR-Central Marine Fisheries Research Institute, Kochi, India.



Two embryos in a single capsule of *Sepia pharaonis* from the Arabian Sea. Arrow mark indicate the embryos (Scale bar= 10 mm).

Normally cephalopod egg capsules contain a single embryo in a single egg capsule. On the detailed examination of the egg cluster (168 eggs) in the laboratory, a single egg capsule with two embryos was observed. The chorion of each embryo had formed a thin layer inside the egg capsule, transversely dividing the capsule into two chambers. The embryos were observed in the laboratory to determine whether they will grow like normal cuttlefish embryos. The size and shape of the double embryo egg capsule was slightly larger than normal ones and the embryo size is not different than normal ones. Two embryos developed independently and hatched on the same day (8th December 2021). The hatchlings were benthic. The hatchling size (dorsal mantle length) and weight of the individuals were 6.1 and 6.4 mm and 0.12 and 0.14 g wet weight. The mantle width of the hatchlings were 5.2 and 5.0 mm respectively. The incubation period of the eggs and the size of the hatchlings were like the normal ones. Previously, 26 double embryos capsule observed in several egg clusters of *S. pharaonis* collected from the Thailand water (Nabhitabhata, 2003) indicating it does happen occasionally.



Dorsal (A) and ventral (B) view of the rare hatchling of *Sepia pharaonis* from the southwest coast of India (Scale bar=1 mm)

P. Laxmilatha and K. K. Sajikumar | ICAR-Central Marine Fisheries Research Institute, Kochi

भाकृअनुप
ICAR
सी एम एफ आर आइ
CMFRI
Indian Council of Agricultural Research
Central Marine Fisheries Research Institute

Post Box No.1603, Ernakulam North P.O., Kochi-682 018, Kerala, India.
Phone: +91 484 2394357, 2394867 Fax: +91 484 2394909
E-mail: director.cmfri@icar.gov.in **www.cmfri.org.in**