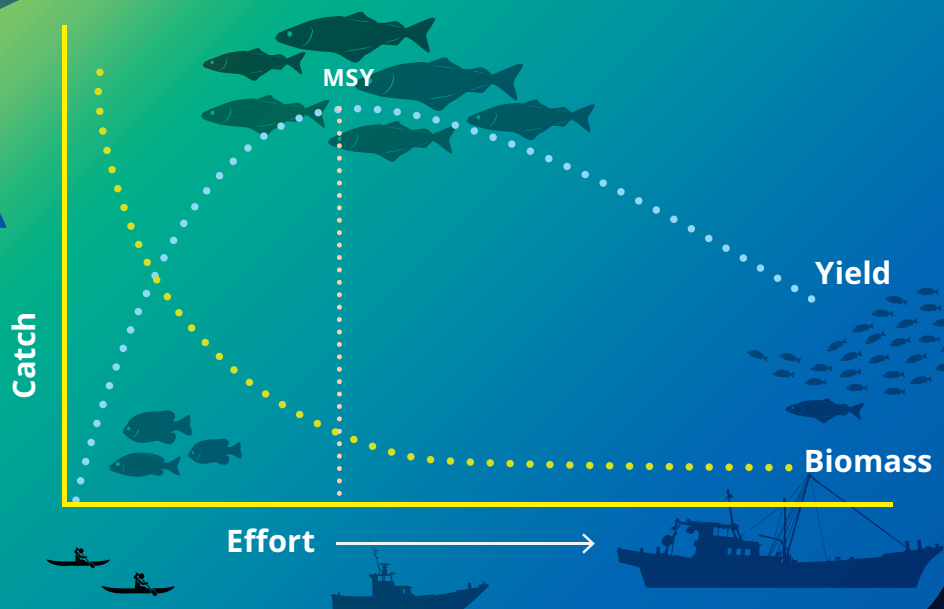


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The Marine Fisheries Information Service, Technical & Extension Series (MFIS) is a quarterly publication of ICAR-Central Marine Fisheries Research Institute disseminating latest research information on marine fisheries and mariculture in India. Research 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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Director
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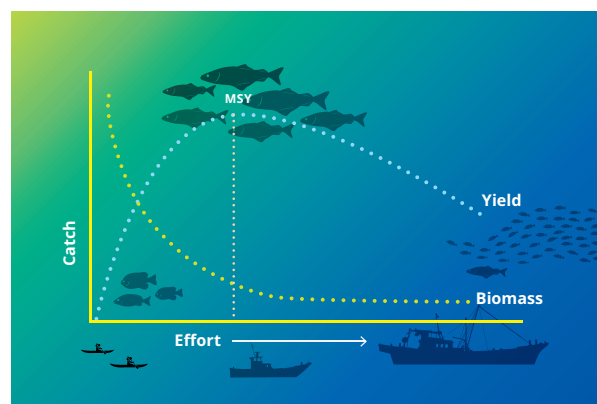
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A pictorial depiction of marine fish stocks dynamics over time and fisheries management goals (See page 9)

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
Technical & Extension Series

From the Editorial Board

Warm greetings to all our esteemed readers

With a coastline of 8000+ kilometre that provides 2 million square kilometre Exclusive Economic Zone and an estimated marine fishery potential of around 5 million tonnes, India was ranked 6th among the top 10 countries in global marine capture fisheries production (2020). Aided by good science, transparent fisheries assessments, appropriate regulations and well enforced harvest rules the marine fishery resources can be tapped on a sustainable basis to support livelihoods and nutritional security needs of the country. ICAR-CMFRI with a legacy of over 75 years in marine fisheries research since its inception in 1947, has collected vast information on the biology and fishery characteristics of various marine fish stocks in the Indian EEZ. Moving from single species stock assessments to multi-species and ecosystem approaches, fish stock assessment routines are constantly evolving and its nuances as deliberated during two recent workshops are presented along with other articles of contemporary interest.



Marine Fisheries Information Service
Technical & Extension Series

Contents

Lead Article

1. Marine Capture Fisheries sustainability in India– the challenges and way forward 7
2. Proceedings and Recommendations of the Training on Tropical Finfish and Shellfish Stock Assessment cum Brainstorming Session on Indian Marine Capture Fisheries Research and the Way Forward..... 11

Brief Communications

3. Seafood Watch Assessment of Indian Squid-A Clarification by ICAR-CMFRI 28
4. Protocol developed for the hatchery production of marine model fish *Oryzias dancena* (Hamilton, 1822) 32
5. Intense spawning aggregation of ragged sea hare, *Bursatella leachii* Blainville, 1817 in Netravathi estuary 36
6. Some observations on the biology of Blubberlip snapper *Lutjanus rivulatus*..... 37

Kaleidoscope

7. Ascidians from the gut of crimson jobfish 40
8. Indian Ocean humpback dolphin stranded at Arthunkal landing centre, Kerala. 40
9. Rare occurrence of Yellowmargin trigger fish from Kerala coast..... 41
10. Unusual heavy landing of cephalopods from Vizhinjam coast 41
11. Rabbit fish grazes on scyphozoan cnidarians. 42
12. Deep-sea squat lobster *Eumunida multispina* recorded at Sakthikulangara Fisheries Harbour 42

Marine Capture Fisheries sustainability in India—the challenges and way forward

A. Gopalakrishnan, J. Jayasankar and U. Ganga
ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala

Wild marine capture fisheries provide nutritional security and livelihoods to millions of people globally. The global marine capture fisheries harvest was an estimated 78.8 million t in 2019 (State of World Fisheries and Aquaculture, SOFIA, 2022) and sustainably fished stocks contributed 82.5% of this, which was up by 4% as compared to year 2017. The right to fish and manage the fisheries in the Exclusive Economic Zone comprising a 200 nautical miles boundary (declared in the mid 70s and incorporated in UNCLOS by the 90s) is the prerogative and responsibility of each coastal nation. The fisheries resources within the EEZ, however, are public resources which means that individuals will seek to

maximize their own benefits, giving rise to sustainability issues and social discontent, unless there are regulatory mechanisms and collective stakeholders' action based on social values and responsibilities within any management unit or state. Healthy levels of fish stocks, positive social impacts (sustaining and enhancing livelihoods, ensuring nutritional security) and profits (for fishers, seafood based industries) thus become the cornerstone of any successful Fisheries Management Plan, that should ideally be based on best available science. The High Seas or Areas Beyond National Jurisdiction (ABNJ) fall within the purview of Regional Fisheries Management Organizations (RFMOs) for managing fishing activities in such areas.



A picture depicting a typical fish landing centre for small scale fishers. An estimated 10 million people are actively involved in the Indian marine fisheries sector (Marine Fisheries Census 2015). Source: Jayaprakash, 2016, *Glimpses of Indian Fisheries- A caricature*

Compared to land-based food production systems, seafood can be considered as a relatively benign and less environment impacting method. In India, the marine fisheries production has increased from around 0.5 million tonnes in the 1950s to around 4 million tonnes during the last decade. A multi-species, multi-gear tropical fishery that it is, it is powered by a marine fisher population of 3.8 million, of which around 25% are active fishers. In 2021-22 the Indian seafood exports of 1.3 million t was worth US\$ 7.76 billion, in which the contribution of the wild capture fisheries was 51% and 30% in terms of volumes and value, respectively. This underlines the importance of sustainable fisheries backed by science from national fisheries research institutions and active collaboration of the primary stakeholders, the fishers.

ICAR-CMFRI as a pioneer marine fisheries research institute established in 1947, has contributed significantly to the development of a knowledge base on the taxonomy and biology of several important marine organisms. This facilitated several policy outcomes (eg, seasonal fishing ban through Marine Fishing Regulation Acts of the various maritime states, Minimum Legal Sizes, species wise advisories such as for sharks, endangered species such as dugongs and marine mammals) aimed at conserving fish stocks and other valuable marine biological resources in the Indian EEZ. Rapid developments in craft and gear technologies post 80s could tap the largely underutilized marine fishery resources. Simultaneously, there was a proactive approach to fisheries management, with the enactment of Marine Fisheries Regulation Acts in the various maritime states of India. These acts were concerned with fisheries conservation by advocating regulations on fishing methods and gears

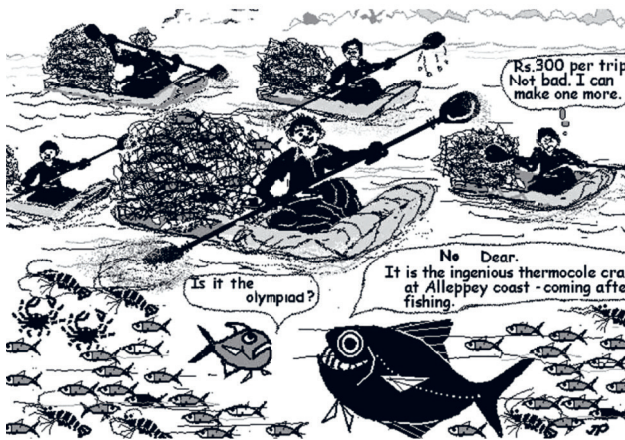


Cartoon depicting the potential in producing value added products from tunas. Viewed from an angle of economic value and value-addition possibilities, oceanic species such as yellowfin tuna are a largely under-utilised marine fishery resource in India. Post-harvest processing methods and value addition are crucial to ensure good returns to producers as market prices for traditional fresh, frozen or highly- fresh quality (Sashimi) products differ on huge scales. Better harvest techniques, fish handling and processing techniques, proper storage infrastructure and market linkages are crucial to ensure sustainability of the tuna value chain in India.

used, effort restrictions by seasonal fishing bans, gear regulations through mesh sizes and engine hp etc. At a later stage, certain regulations in output such as Minimum Legal Size of fish landed have also been added.

Maximum Sustainable Yield- the balancing act

The concept of Maximum Sustainable Yield (MSY) is that it is theoretically the largest yield (or catch) of a species that can be taken on a sustainable basis, for an indefinite period. The concept was laid down in the 1930s and gained acceptance globally. Yet, it also had among others, its share of strong criticism (Larkin, 1977; Sissenwine, 1978) which were classified into 3 categories by Mace (2001). The concepts of F_{MSY} (the fishing mortality that produces MSY of a stock) and B_{MSY} (long-term average biomass that can be achieved when fishing mortality rates equal to F_{MSY}) followed. In any case, the fishing effort is considered a critical factor, which has to be regulated effectively but considering the socio-economics aspects (livelihoods, nutritional security) this is often given less priority by management and enforcement agencies. As indicated in a typical single-species stock model, in the initial phase



This picture depicts a popular and innovative gear developed by fishermen in Alleppey (Kerala) on subsistence basis. Here, thermocole crafts powered only by sails for short fishing trips in inshore waters for shrimps and other coastal fishes.

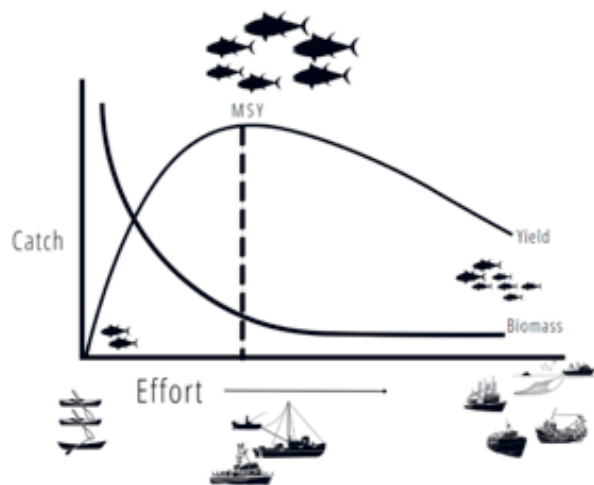
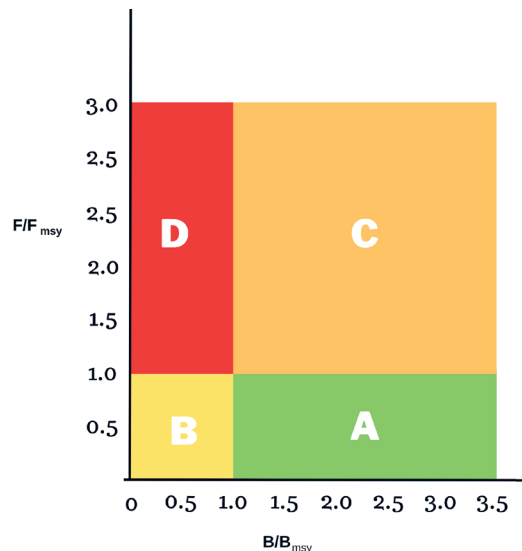


Fig. 1. Timeline of a marine fisheries stock

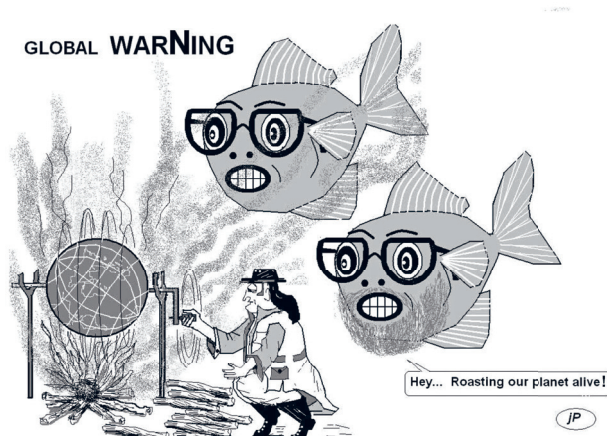
The picture denotes a single species fisheries development time line. Initially the fishing effort inputs are small (number of boats, gear technology level) but develops with time (technology creep). Fisheries management strategies to maximize yield (MSY) use fishing effort controls via their effects on fishing mortality. This requires knowledge of the biology of the species whose yield is to be maximized and the resulting response to effort controls. The multispecies, multi-gear tropical fisheries in India are subject to environmental factors affecting the fishery resources through the biological loop of ocean productivity, predator-prey dynamics, spawning and recruitment pulses etc., and adds to the complexity of assessing the fisheries.

of fisheries development, there are fewer boats, perhaps with most of them being artisanal and the resource is not tapped to optimum, with few fishes landed. As technology uptake improves and often more boats enter the fray, the yields increase and optimize (Maximum Sustainable Yield or MSY). Technology Creep (bigger and more efficient crafts and gears) is inherent to any developing fishery and fishing pressure on the resources increase over time (Fig. 1). If this fishing is managed efficiently through appropriate regulations to keep biomass levels high ($B/B_{msy} > 1$), the resources can withstand the scaled up fishing pressure ($F/F_{msy} > 1$) and the fishery will be sustainable, as the Kobe Plot indicates.

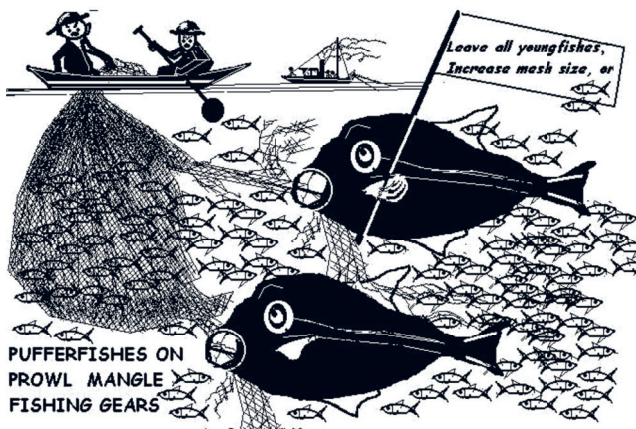
Today, another set of challenges, through the climate change phenomenon is manifesting globally causing disruptions in the lives of fishers and the industry. In the form of extreme weather events, global sea level rise, changes in species distribution and abundance patterns or regime shifts, the fishing activities and livelihoods are being impacted in complex and inter-related manner. Not subject to geopolitical boundaries, favorable environmental windows of temperature, preferred food availability and spawning/



Kobe plot is often used to depict the fisheries management needs following a traffic light signals method. Here, depending on the parameters and limits for F/F_{MSY} and B/B_{MSY} , the Green (A) depicts a perfectly sustainable fishery; Yellow (B)- Rebuilding- Fishery may have been depleted due to fishing and non-fishing related causes, but is rebuilding with fishing curbs in place; Orange (C) indicates a fishery with relatively high fishing pressure, but since it is also having a relatively good biomass it is sustainable but proper monitoring of resource to be intensified; Red (D) unsustainable with biomass levels low as well as very high fishing pressure, which warrants urgent and drastic fishery management measures to prevent a fishery collapse.



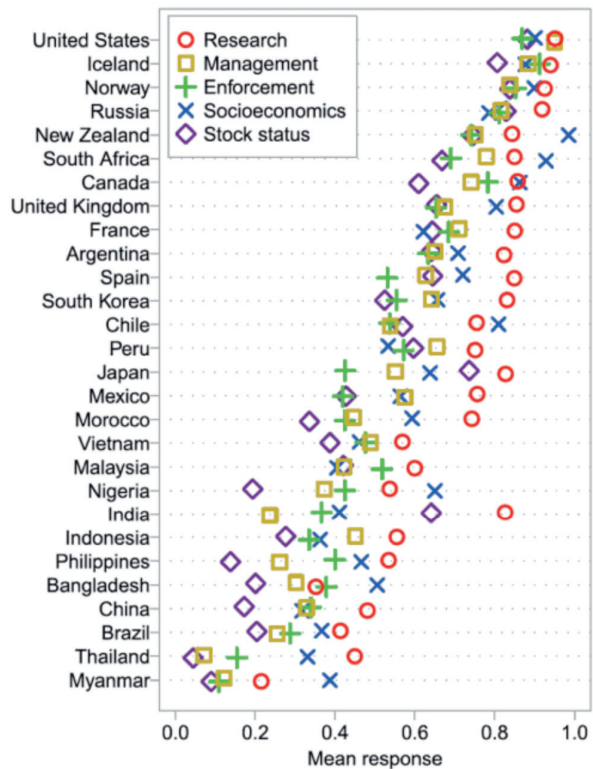
The picture depicts the global warming phenomenon and its repercussions for marine fisheries sustainability have been flagged in numerous studies globally. In a recent study on impact of climate change on marine fisheries sector by ICAR-CMFRI, the carbon footprint in India's marine fisheries has been estimated at 1.32 t of CO_2 to produce one tonne of fish which is much lower than the global average of around 2 t CO_2 . Yet, it is imperative that all actions to minimize the carbon footprint and work for sustainable production systems are taken up.



There are occasional huge population explosion of certain marine species such as that of puffer fishes in 2005-06 and the Red toothed Triggerfish *Odonus niger* in 2019 that is perhaps best explained with an ecosystem approach. Climate and environmental perturbations, changes in fishing pressure on apex predators in marine realm have been attributed to such phenomenon, but evidence provided largely remains coincidental. The cartoon humorously portrays the pufferfishes who were found to be destroying fishing nets and feeding on the fish catch as natural avengers for fishermen ignoring mesh size regulations.

larval survival dynamics are changing fish distribution and availability. With Climate Change impacting distribution and abundance of fish in the sea, availability of locally preferred species, fish catch volumes in the usual fishing grounds and possible new species interactions at the ecosystem level are being created and the patterns of fisheries are showing changes. Ocean-acidification and coral bleaching that affect marine biodiversity is another concern. Hence, focus on ecosystem approaches in fisheries research and management is being mooted but has its own shortcomings. Needless to say, capture fisheries research should look at all these challenges while assessing the marine fish stocks and bring forth innovative solutions so that it ensures sustainability.

Marine fish stocks can be assessed using different assessment models as biomass dynamic (only catch-effort data) or Analytical models with biology and fishery data (length frequency, gear selectivities, growth, maturity, fecundity, stock-recruitment relation etc.) used as inputs directly or indirectly. Both data availability and the goal for the management of the stocks concerned is to be considered. A study that surveyed 28 countries for a Fishery Management Index (based on metrics like research support, Management, Enforcement, Socio-economics and Stock status which in turn were assessed on various parameters) reported positive correlation between a well functioning fisheries management program



The five dimensional FMI was assessed from feedback of various stakeholders and used as an indirect indicator of the likely success of local fish stocks to be sustainable in the future also.

Source : Ray Hilborn @ <https://sustainablefisheries-uw.org/>

and the fish stocks status of the particular country. Needless to say, good funding support, skilled human resources and a receptive audience of fishery stakeholders are a pre-requisite for ideal outcomes.

Fish stock assessments require knowledge on the population biology as well as the fishing activity they are subject to and the institute has collected a vast knowledge base on the various marine fishery resources (eprints@cmfri.org.in). Scientific data collection including and analysis over past several decades on several species and groups has put India in a pole position, over several developing nations as the above figure on the 5-dimension FMI indicates. The lacunae as reported in this study mainly appears to be in aspects of “enforcement” and “management” which falls under the purview of fishery managers who make suitable policies and legally enforceable regulations which are to be implemented with the support of the stakeholders. It is in this context, ICAR-CMFRI recently organized a brainstorming workshop on marine capture fisheries research to pave the way forward for meaningful research outcomes for the marine fisheries sector in India.

Proceedings and Recommendations of the Training on Tropical Finfish and Shellfish Stock Assessment cum Brainstorming Session on Indian Marine Capture Fisheries Research and the Way Forward

A training on Tropical Finfish Stock Assessment was conducted by the Finfish Fisheries Division (FFD), ICAR-CMFRI, for Fisheries Resource Management scientists at ICAR-CMFRI Headquarters, Kochi during 16-27 August 2022, in hybrid mode. The program was inaugurated by Dr. A. Gopalakrishnan, Director, ICAR-CMFRI on 16th August 2022, and was attended by Dr. Sanjay Pandey, Asst. Commissioner (Fisheries), Govt. of India, Heads of Divisions at ICAR-CMFRI Headquarters and scientists of Finfish and Shellfish Fisheries Divisions of ICAR-CMFRI. In the second phase, a training - workshop on 'Stock assessment of shellfish species' was organised from 9 -17 November 2022 by the Shellfish Fisheries Division

(SFD), with focus on specific methods for shellfish species. Scientists from the Fishery Resources Assessment, Economics and Extension Division (FRAEED), FFD and SFD were participants and resource persons in the respective programmes (Table 1).

The FFD training program commenced with an address by Dr. Gopalakrishnan who welcomed Dr. Sanjay Pandey, Dept. of Fisheries, Govt. of India to the program and gave an overview of the various Divisions functioning in ICAR-CMFRI. He highlighted the technical strength of ICAR-CMFRI in tropical marine fish stock assessment in terms of the Institutes' extensive data collection system

Table 1. List of Participants in the training program on Tropical Finfish / Shellfish Stock Assessment

Sl. no	Name	Designation	Sl. no	Name	Designation
1	Dr. A. Gopalakrishnan	Director, ICAR-CMFRI	10	Dr. Rajan Kumar**	Scientist
2	Dr. Sanjay Pandey	Asst. commissioner (Fisheries) Dept. of Fisheries, Govt. of India	11	Dr. A. P. Dineshababu +	Principal Scientist
3	Dr. E. M. Abdussamad (Overall co-ordinator)	Principal Scientist and Head(I/C), FFD	12	Dr. Somy Kuriakose +	Principal Scientist
4	Dr. P. Laxmilatha (Overall co-ordinator)	Principal Scientist and Head(I/C), SFD	13	Dr. K. G. Mini+	Principal Scientist
5	Dr. J. Jayasankar+	Principal Scientist and Head(I/C), FRAEED	14	Dr. Geetha Sasikumar+	Principal Scientist
6	Dr. Josileen Jose *	Principal Scientist	15	Dr. Dr. R. Narayana Kumar+	Principal Scientist
7	Dr. Shoba J Kizhakudan*	Principal Scientist	16	Dr. Eldho Varghese+	Senior Scientist
8	Dr. M. Muktha*	Senior Scientist	17	Dr. Vinaya Kumar Vase+	Scientist
9	Dr. Gyanaranjan Dash**	Senior Scientist	18	Dr. Sujitha Thomas	Principal Scientist
			29	Dr. U. Ganga	Principal Scientist
			20	Dr. Rekha J. Nair	Principal Scientist

Sl. no	Name	Designation
21	Dr. Shubhadeep Ghosh	Principal Scientist
22	Dr. T. M. Najmudeen	Principal Scientist
23	Dr. K. M. Rajesh	Principal Scientist
24	Dr. Margaret A. Muthu Rathinam	Principal Scientist
25	Dr. S. Lakshmi Pillai	Principal Scientist
26	Dr. Rekha Devi Chakraborty	Principal Scientist
27	Dr. V. Venkatesan	Principal Scientist
28	Dr. G. B. Purushottama	Senior Scientist
29	Dr. Anulekshmi Chellapan	Senior Scientist
30	Dr. Swatipriyanka Sen Dash	Scientist
31	Dr. Mohamed Koya	Scientist
32	Dr. K. V. Akhilesh	Scientist
33	Dr. L. Remya	Scientist
34	Dr. Subal Kumar Roul	Scientist
35	Dr. Livi Wilson	Scientist
36	Dr. V. Mahesh	Scientist
37	Dr. Shikha Rahangdale	Scientist
38	Dr. P. Abdul Azeez	Scientist
49	Dr. S. Surya	Scientist
40	Dr. H. M. Manas	Scientist
41	Shri. Nakhawa Ajay Dayaram	Scientist
42	Shri R. Vinothkumar	Scientist
43	Dr. Indira Divipala	Scientist
44	Dr. R. Vidya	Scientist
45	Dr. F. Jasmine	Scientist
46	Smt. M. Kavitha	Scientist
47	Dr. Bhendekar Santhosh Nagnath	Scientist
48	Dr. Rajesh Kumar Pradhan	Scientist
49	Shri M. Rajkumar	Scientist
50	Smt. P. Gomathi	Scientist
51	Shri Sunil Kumar S. Ail	Scientist
52	Smt. P. M. Nimija	Research Scholar
53	Smt. A. V. Rosmy	Research Scholar

+ Resource Person *Course Co-ordinator **Co-ordinator

and fish stock assessment expertise exemplified in the marine fish stock assessment literature published by the Institute, both historical as well as more recent ones in *PLoS ONE* (Mohamed *et al.*, 2021) and *ICES Journal of Marine Science* (Sathianandan *et al.*, 2021) based on catch-based methods which had been the topic of intense discussions. He mentioned the recent stock assessment exercise of FAO, ICAR-CMFRI and Bay of Bengal Programme BoBP for the marine resources from FAO Area 57 in which Dr. J. Jayasankar, Principal Scientist and Head, FRAEED, ICAR-CMFRI had participated. The Director stressed on the need to adopt biology-based stock assessment and highlighted that the stock assessment training program should focus on the necessary standard methodologies to be followed. Director also stressed on the need for hard parts (otoliths, vertebrae, gastric mill, statoliths, beak, gladius etc.) based ageing for the selected species of finfishes and shellfishes, to be included in stock assessment protocols. The points flagged by the Director to be addressed by the participants of the training program included,

- Frequency of stock assessments for different marine resources depending on their longevity and associated life history traits
- Prioritization of species for regular stock assessments
- Standard data processing protocols and methodologies for stock assessment of different groups/resources, such as teleost fishes, elasmobranchs, crustaceans, and molluscs
- Determine the Scale (national or region-wise) of biology-based stock assessments for different species, based on their distribution and genetic stock information available
- Approaches to be adopted if results of surplus production (catch based) and micro analytical (biology based) stock assessment models give divergent results. Also if the ageing based on hard parts and length frequency sampling from wild caught fish indicated divergent results, the standard procedures to be followed.
- Categories to define stock status - over-fished, optimal, under-fished and rebuilding to be defined
- Assessing sustainability of stocks through Maximum

Sustainable Yield (MSY) and/or Maximum Economic Yield (MEY) and any other indicators

- Hard-parts ageing studies (otoliths in finfishes; vertebrae in elasmobranchs; statoliths, beaks, gladius in cephalopods; gastric mill in crustaceans) and the possible validation with captive rearing experiments in select species
- Experimental fishing / exploratory surveys to obtain fish biomass estimates in fishing grounds that can be used to supplement findings from commercial fish landings based stock assessment
- Explore options for incorporating citizens in marine science research by involving selected group(s) of fishermen/skippers to provide data for selected species to get better spatial information of species distribution.
- Genetic stock identification, especially for straddling or highly migratory fishes that come under purview of Regional Fisheries Management Organisations (RFMOs)
- Strategies for applying Ecosystem Based Fisheries Management methods

Highlighting the need for a centralized database for marine fishery resources at ICAR-CMFRI which will help in prompt

replies to queries from ministries, Parliament, and other agencies, the Director indicated the formation of resource-based Working Groups (Tables 2 & 3) as a welcome beginning. This will be followed by a comprehensive data-sharing policy which will be prepared by a Committee comprising Heads of Divisions, PME and HRD for the Institute and will be implemented after appropriate discussions. Following this, the data collected under various research programs of the Institute will have to be mandatorily deposited in the centralized database within a specified time frame which will ensure credible data from ICAR-CMFRI for wider use at the national level. Concluding his remarks, the Director expressed the need for a brainstorming session on the last day of the training program, to prepare a road map for re-vitalising capture fisheries research and marine fish stock assessment programs in the country and wished all success for conduct of the training program. Dr. E. Abdussamad, HoD i/c FFD, thanked Director for his whole-hearted support in organizing the training program and the HRD Cell, ICAR-CMFRI for facilitating the same.

The program organised by the SFD was inaugurated by Dr A. Gopalakrishnan, Director, ICAR-CMFRI, on 09 November 2022. In his address, Director emphasized the need for prioritising species for fish biology-based stock assessments and stressed all to follow internationally recognised standards while bringing out stock assessment

Table 2. Working Groups constituted for finfish stock assessments

Marine Fish Stock Assessment Working Groups

I. Finfish fishery resources

Resource / Thematic Area	National Working Group (NWG)	NWG Leader	Groups/Genus/ Species prioritized
Sardines	Dr. K. M. Rajesh, Dr. U. Ganga, Ms. S. Surya, Dr. H. M. Manas, Dr. C. Anulekshmi, Shri. R. Vinothkumar	Dr. Prathibha Rohit	<i>Sardinella longiceps</i> , <i>S. fimbriata</i> , <i>S. gibbosa</i> , <i>Sardinella albella</i>
Indian Mackerel	Dr. Prathibha Rohit, Dr. A. Margaret Muthu Rathinam, Dr. C. Anulekshmi, Dr. H. M. Manas, Shri. Ajay D. Nakhawa	Dr. U. Ganga	<i>Rastrelliger kanagurta</i> ; <i>Rastrelliger</i> spp.

Resource / Thematic Area	National Working Group (NWG)	NWG Leader	Groups/Genus/ Species prioritized
Tunas	Dr. Prathibha Rohit, Dr. Shubhadeep Ghosh, Dr. K. M. Rajesh, Dr. K. Mohammed Koya, Dr. C. Anulekshmi, Dr. P. Abdul Azeez	Dr. E. M. Abdussamad	<i>Euthynnus affinis</i> <i>Auxis thazard</i> <i>Auxis rochei</i> <i>Thunnus albacares</i> <i>Thunnus tonggol</i> <i>Katsuwonus pelamis</i>
Live Baits	Dr. P. Abdul Azeez	Dr. K. Mohammed Koya	
Billfishes	Dr. Prathibha Rohit, Dr. E. M. Abdussamad, Dr. U. Ganga, Dr. Shubhadeep Ghosh	Dr. S. Surya	<i>Istiophorus platypterus</i> <i>Istiompax indica</i> <i>Makaira nigricans</i> <i>Xiphias gladius</i> <i>Kajikia audax</i>
Seerfishes	Dr. A. Margaret Muthu Rathinam, Dr. H. M. Manas, Shri. R. Vinothkumar, Dr. P. Abdul Azeez	Dr. Shubhadeep Ghosh / Dr. E. M. Abdussamad	<i>Scomberomorus commerson,</i> <i>S.guttatus</i>
Cobia	Dr. Prathibha Rohit, Dr. A. Margaret Muthu Rathinam, Dr. K. Mohammed Koya, Shri. R. Vinothkumar	Dr. U. Ganga	<i>Rachycentron canadum</i>
Carangids	Dr. Prathibha Rohit, Dr. E. M. Abdussamad, Dr. C. Anulekshmi, Dr. Subalkumar Roul, Shri. Ajay D. Nakhawa	Dr. H. M. Manas	<i>Decapterus russelli</i> <i>Megalaspis cordyla</i>
Ribbonfishes	Shri. K. Mohammed Koya, Dr. Prathibha Rohit, Dr. Shubhadeep Ghosh, Ms. S. Surya, Shri. Ajay D. Nakhawa	Dr. K. M. Rajesh	<i>Trichiurus lepturus</i>
Anchovies	Dr. S. Surya, Dr. C. Anulekshmi, Dr. H. M. Manas, Shri. Ajay D. Nakhawa, Shri. R. Vinothkumar	Dr. P. Abdul Azeez	<i>Coilia dussumieri</i> <i>Encrasicholina devisi</i> <i>E.punctifer</i> <i>Stolephorus waitei</i> <i>S. macrops</i> <i>S.indicus</i> <i>S.commersonii</i>
Bombay duck	Dr. P. Abdul Azeez, Dr. Subalkumar Roul, Dr. Shubhadeep Ghosh, Shri. Ajay D. Nakhawa	Dr. C. Anulekshmi	<i>Harpadon nehereus</i>
Mahi-mahi	Dr. E. M. Abdussamad, Dr. A. Margaret Muthu Rathinam, Dr. K. M. Rajesh,	Dr. K. Mohammed Koya	<i>Coryphaena hippurus</i>
Barracuda	Dr. A. Margaret Muthu Rathinam, Dr. K. M. Rajesh, Dr. Shubhadeep Ghosh, Dr. K. Mohammed Koya, Dr. Subal Kumar Roul,	Shri. R. Vinothkumar	<i>Sphyraena putnamae</i> <i>S.obtusata</i>

Resource / Thematic Area	National Working Group (NWG)	NWG Leader	Groups/Genus/ Species prioritized
Belonids	Dr. K. Mohammed Koya, Dr. S. Surya	Dr. Subalkumar Roul	<i>Ablennes hians</i> <i>Tylosurus crocodilus</i>
Shads	Dr. P. Abdul Azeez, Dr. Subalkumar Roul, Shri. R Vinothkumar	Shri. Ajay D. Nakhawa	<i>Tenualosa ilisha</i> <i>Tenualosa toli</i> <i>Chirocentrus nudus</i>
Elasmobranchs	Dr. Shoba Joe Kizhakudan, Dr. Rekha J. Nair, Dr. T. M. Najmudeen, Dr. G. B. Purushottama, Dr. Muktha Menon, Dr. Swatipriyanka Sen, Dr. K. V. Akhilesh, Dr. L. Remya, Dr. Livi Wilson, Dr. V. Mahesh, Dr. Subal Kumar Roul, Dr. Shikha Rahangdale	Dr. Sujitha Thomas	<i>Scoliodon laticaudus</i> <i>Rhizoprionodon oligolinx</i> <i>R. acutus</i> <i>Brevitrygon imbricata</i> <i>Gymnura poecilura</i>
Groupers	Dr. G. B. Purushottama, Dr. Muktha Menon, Dr. V. Mahesh, Dr. Shikha Rahangdale	Dr. Rekha J. Nair	<i>Epinephelus diacanthus</i>
Snappers	Dr. Rekha J. Nair, Dr. L. Remya, Dr. Livi Wilson, Dr. S. Surya	Dr. Muktha Menon	<i>Lutjanus johnii</i> <i>Lutjanus fulvus</i> <i>Lutjanus quinquilineatus</i> (All assessed for the south-east coast of India)
Pigface breems	Dr. L. Remya, Dr. S. Surya	Dr. T. M. Najmudeen	<i>Lethrinus lentjan</i> (SW & SE coast) <i>Lethrinus mahsena</i> (SW coast) <i>Lethrinus nebulosus</i> (SE coast)
Threadfin breems	Dr. Sujitha Thomas, Dr. V. Mahesh, Dr. Livi Wilson, Dr. Shikha Rahangdale	Dr. Shoba Joe Kizhakudan	<i>Nemipterus</i> spp. <i>Parascolopsis</i> spp. <i>Scolopsis</i> spp.
Sciaenids	Dr. Shoba J Kizhakudan, Dr. Rekha J. Nair, Dr. Swatipriyanka Sen, Dr. K. V. Akhilesh	Dr. Shikha Rahangdale	<i>Otolithes ruber</i> <i>Otolithes cuvieri</i> <i>Nibea maculata</i> <i>Otolithoides biauritus</i> <i>Protonibea diacanthus</i>
Silverbellies	Dr. Shoba J Kizhakudan, Dr. V. Mahesh, Dr. H. M. Manas	Dr. L. Remya	<i>Karalla dussumieri</i> <i>Gazza minuta</i>
Lizardfish	Dr. Shoba J Kizhakudan, Dr. G. B. Purushottama, Dr. K. V. Akhilesh Dr. Shikha Rahangdale	Dr. T. M. Najmudeen	<i>Saurida tumbil</i> <i>Saurida undosquomis</i>
Goatfish	Dr. Shoba J Kizhakudan, Dr. Rekha J. Nair, Dr. G. B. Purushottama	Dr. L. Remya	<i>Upeneus moluccensis</i> <i>U. supravittatus</i> <i>U. sulphureus</i>

Resource / Thematic Area	National Working Group (NWG)	NWG Leader	Groups/Genus/ Species prioritized
Flatfish	Dr Sujitha Thomas, Dr. Shoba J Kizhakudan, Dr. Swatipriyanka Sen	Dr. Rekha J. Nair	<i>C. macrostomus</i>
Catfish	Dr. Swatipriyanka Sen, Dr. Shikha Rahangdale	Dr. G. B. Purushottama	<i>Plicofollis layardi</i> <i>Arius maculatus</i> <i>Osteogeneiosus militaris</i>
Pomfrets	Dr. T. M. Najmudeen, Dr. Muktha Menon, Dr. Swatipriyanka Sen, Dr. K. V. Akhilesh	Dr. Sujitha Thomas	<i>Pampus candidus</i> <i>Pampus griseus</i> <i>Parastromateus niger</i>
Whitefish	Dr T. M. Najmudeen, Dr. K. V. Akhilesh, Dr. V. Mahesh	Dr. Sujitha Thomas	<i>Lactarius lactarius</i>
Threadfins	Dr. G. B. Purushottama, Dr. Swatipriyanka Sen	Dr. K. V. Akhilesh	<i>L. indicum</i> <i>E. tetradactylum</i>
Priacanthids	Dr G. B. Purushottama, Dr. Livi Wilson	Dr. V. Mahesh	<i>Priacanthus hamrur</i>
Eels	Dr. T. M. Najmudeen, Dr. Muktha Menon	Dr. Swatipriyanka Sen	<i>Muraenesox</i> <i>bagio</i>
Flatheads	Dr. Sujitha Thomas, Dr Muktha Menon	Dr. Livi Wilson	<i>Platycephalus indicus</i> <i>Grammoplites suppositus</i>
Puffer & trigger fishes	Dr. Sujitha Thomas, Dr. K. M. Rajesh, Dr. T. M. Najmudeen	Dr. K. V. Akhilesh	<i>Lagocephalus</i> spp. <i>Aluterus monoceros</i>
Sillago	Dr. L. Remya, Dr. Subal Kumar Roul	Dr. Shoba Joe Kizhakudan	<i>Sillago</i> spp. <i>Sillaginopsis</i> spp.
Grunters, sweetlips & sea breams	Dr. Livi Wilson, Dr. Shikha Rahangdale	Dr. Muktha Menon	<i>Pomadasy kaakan</i> (assessed for the south-east coast of India)

Table 3. Working Groups constituted for shellfish stock assessments

Shellfish fishery resources	National Working Group (NWG)	NWG Leader
Kiddi Shrimp (<i>Parapenaeopsis stylifera</i>)	Dr. A. P. Dineshbabu, Dr. S. Lakshmi Pillai, Dr. Gyanaranjan Dash, Dr. Indira Divipala	Dr. P. T. Sarada/ Dr. S. Lakshmi Pillai
Speckled Shrimp (<i>Metapenaeus monoceros</i>)	Dr. P. T. Sarada, Dr. S. Lakshmi Pillai, Dr. Indira Divipala, Dr. Gyanaranjan Dash , Dr. Rajan Kumar, Ms. M. Kavitha	Dr. A. P. Dineshbabu
Flower Tail Prawn / Thelly Shrimp / Kadal Shrimp (<i>Metapenaeus dobsoni</i>)	Dr. A. P. Dineshbabu, Dr. Gyanaranjan Dash, Dr. Indira Divipala	Dr. S. Lakshmi Pillai

Shellfish fishery resources	National Working Group (NWG)	NWG Leader
Indian White Prawn (<i>Penaeus indicus</i>)	Dr. A. P. Dineshbabu, Dr. P. T. Sarada, Dr. Indira Divipala	Dr. S. Lakshmi Pillai
Coastal mud shrimp (<i>Solenocera crassicornis</i> , <i>Solenocera</i> spp.)	Dr. A. P. Dineshbabu, Dr. Rajan Kumar, Dr. Indira Divipala	Dr. Gyanaranjan Dash
Green Tiger Prawn (<i>Penaeus semisulcatus</i>)	Dr. P. T. Sarada, Dr. Gyanaranjan Dash Ms.M. Kavitha	Mr. M. Rajkumar
Deep-sea Shrimps <i>Plesionika quasigrandis</i> <i>Heterocarpus chani</i> <i>Aristeus alcocki</i>	Dr. P. T. Sarada, Dr. Indira Divipala, Dr. F. Jasmine	Dr. Rekha Devi Chakraborty
Flower crab/ Blue Swimmer crab (<i>Portunus pelagicus</i>)	Dr. A. P. Dineshbabu, Dr. P. T. Sarada, Dr. Gyanaranjan Dash, Dr. Indira Divipala, Dr. Rajan Kumar Mr. M. Rajkumar	Dr. Josileen Jose
Blood Spotted Crab (<i>Portunus sanguinolentus</i>)	Dr. Josileen Jose, Dr. Gyanaranjan Dash, Dr. P. T. Sarada, Dr. Indira Divipala Dr. Rajesh Pradhan	Dr. A. P. Dineshbabu
Crucifix Crab (<i>Charybdis feriata</i>)	Dr. A. P. Dineshbabu, Dr. Gyanaranjan Dash Dr. Rajan kumar Dr. Rajesh Pradhan	Dr. Josileen Jose
Sand Lobster (<i>Thenus unimaculatus</i>)	Dr. P. T. Sarada, Dr. Indira Divipala, Dr. Rajan Kumar	Dr. Rekha Devi Chakraborty
Spiny Lobster <i>Panulirus polyphagus</i> , <i>Phomarus</i> , <i>Pornatus</i>	Dr. Gyanaranjan Dash, Mr. M. Rajkumar Dr. Santosh Bhendekar Dr. Sunil kumar Ail	Dr. Rajan Kumar / Dr. Rekha Devi Chakraborty
Cephalopods <i>Sepia pharaonis</i> <i>S. aculeata</i> <i>S. elliptica</i> <i>S. prashadi</i> <i>Sepiella inermis</i> <i>Sepioteuthis lessoniana</i> <i>Uroteuthis duvaucelii</i> <i>U. edulis</i> <i>Amphioctopus neglectus</i> <i>Sthenoteuthis oualaniensis</i>	Dr. Geetha Sasikumar, Dr. V. Venkatesan, Ms. M. Kavitha, Dr. F. Jasmine, Dr. R. Vidya Dr. Santosh Bhendekar, Dr. Rajesh Pradhan Mr. Sunil Kumar Ail Dr. Gyanaranjan Dash Dr. Rajan Kumar Mr. M. Rajkumar	Dr. P. Laxmilatha

Shellfish fishery resources

Bivalves (Clams, Mussels, oysters)

Paphia malabarica

Villorita cyprinoides

Meretrix casta

Perna viridis

Perna indica

Crassostrea madrasensis

Saccostrea cucullata

Pinctada fucata

Gastropods

Babylonia spirata

Chicoreus ramosus

Turbinella pyrum

National Working Group (NWG)

Dr. M. K. Anil,

Dr. R. Vidya,

Dr. V. Venkatesan

Dr. Gyanranjan Dash

Dr. F. Jasmine

Ms. P. Gomathi,

Dr. Santosh Bhendekar,

Dr. Rajesh Pradhan

Ms. M. Kavitha

NWG Leader

Dr. Geetha Sasikumar

Dr. V. Venkatesan

Ms. M. Kavitha

Dr. R. Vidya

Dr. F. Jasmine

Mr. M. Rajkumar

reports. He suggested conducting comparative ageing studies using hard parts and the length based ageing to decide their selection as inputs for further stock assessment steps. He advised the participants to attempt modelling and scenario setting for stock assessment of shellfishes, in collaboration with FRAEED, that will enable effective fisheries management. If necessary, experimental fishing with standard gears to gather information on population parameters and selectivity of concerned species must be attempted. He also mentioned that genetic stock identification for select commercially important species and principles of Ecosystem Approach to Fisheries Management (EAFM) must also be accorded due attention.

Topics covered under the Training

Hands on training was undertaken with each participant working on common data analysis procedures and protocols (for learning) and applying it to individual species-specific data that they had collected at their respective locations. Major topics covered under the training in the first phase under the FFD included –

- Overview of Finfish Stock Assessment (FSA)
- Basic Biostatistics using Microsoft Excel (*Measures of central tendency, Measures of dispersion, Applications of descriptive statistics, Regression, Correlation – Length-weight relationship, Analysis of covariance*)
- Growth estimation using Microsoft Excel & FiSAT (*Understanding VBGF Data collection – length frequency, Modal progression, Bhattacharya analysis,*

Gulland-Holt Plot, Ford-Walford Plot, ELEFAN)

- Mortality & Exploitation using Microsoft Excel & FiSAT (*Z (Length-converted catch curve), M (Pauly's empirical equation), F, E, U, Probability of capture*)
- Virtual Population Analysis using Microsoft Excel & FiSAT
- Prediction models using Microsoft Excel & FiSAT (*Thompson & Bell analysis, Beverton & Holt analysis*)
- Macro-analytical models (*Schaefer & Fox*)
- Working with R (*Introduction to R-studio – basic operations, TropFish R package*)
- Catch MSY (CMSY) and Bayesian State Space implementation of the Schaefer Production Model (BSM)

The topics covered in the second phase which was organised by the SFD, included,

- FAO fishery statistical tool FiSAT II – ELEFAN (K scan, response surface, automatic search), mortality estimation etc.
- TropFishR package in R for fisheries assessment using length-frequency data
- Length-based Bayesian Biomass estimation (LBB) using Bayesian Monte Carlo Markov Chain approach.
- Length-based Spawning Potential Ratio (LBSPR), to

assess stock status by the spawning potential ratio of a fish stock

- CMSY++, an advanced state-space stock assessment method that includes CMSY which requires only catch data, and BSM which requires additional abundance data.
- CatDyn – stock assessment based on fishery catch dynamics, using high or medium frequency catch in biomass or numbers, nominal fishing effort, and mean fish body weight by time step, from one or two fishing fleets, estimate stock abundance, natural mortality rate and fishing operational parameters.
- GMACS - General Model for Assessing Crustacean Stocks
- JABBA - Just Another Bayesian Biomass Assessment, which can rapidly generate reproducible stock status estimates for fisheries management
- SizeMat for size at maturity estimation
- Growth models using the Bayes Growth package
- FESTA package in R for standardising fishing efforts in a multi-gear, multi-species fishery
- Three Stock-Recruitment models including the Beverton & Holt, Ricker, and Cushing Models using the R program.

Brainstorming Session on Indian Marine Capture Fisheries Research

The brainstorming session was held on 27 August, 2022 with active participation of scientists from FFD and SFD. Detailed discussions were held on the need for biology based stock assessment (BSA), scale of assessment, methods used by the Institute, data requirements, data collection, issues faced and strategies to be adopted etc. Data Requirements for Biological Stock Assessment (BSA) which include time series of length frequency (LF) and other biological information (growth and mortality rates, length-weight relationship, fecundity, recruitment etc) of the species to be assessed along with gear-wise spatio-temporal landings data was discussed. It was decided

to use the term “landing” and instead of “catch” in all reports/documents. Individual measurement of length and weight of respective species, proportionally covering all size groups in the landing (gear-wise) and day’s landing to the extent possible uniformly cover entire area along the fishing range, collection of biological information-maturity and spawning seasonality, length-weight relationship, food and feeding etc especially of less studied but emerging fishery resources and monthly gear-wise landing details of the prioritised species were emphasised. The data collection, recording and documentation procedures were discussed and finalised to ensure uniform standard reporting and analysis formats for prioritised species for stock assessment by the various Working Groups. The need for innovative advanced stock assessment tools to fit the requirements of assessing typical tropical marine fisheries, regional considerations for fish stocks assessments and application of concepts of genetic stocks in fisheries management were also to be addressed by Working Groups (Tables 4,5,6,7&8).

Concerning data collection, for length measurements continuing the regimen of collecting unsorted samples giving proper representation to all major gears targeting the species, with sampling preferably on the same days selected by FRAEED under the Stratified Multi-Stage Random Sampling (SMRS) programme covering the landing centres, and the adoption of standardised fishing effort (Varghese *et al.*, 2020) for stock assessment process, were reiterated. Considering the multi-gear, multi-species fisheries with strong regional characteristics in species landed, gears employed etc, it was suggested to have a state/ region wise analysis for determining target species and gears for modelling stock biomass, following the methodology of Varghese *et al.* (2021) which can be published in the *Marine Fisheries Information Service, Technical and Extension Series* of the institute as guidelines for the biological stock assessment exercises that would henceforth be conducted regularly.

The criteria for defining unit of stock assessment and/or management can be either, “geographical scale” using life history traits or genetic “stock structure information” depending on the clarity in the spatio-temporal distribution of stock. In cases where results from these two methods differ, priority would be given to life history traits to define geographical scale. The appropriate geographical scale for marine fish stock assessment would be either on a regional (NW, SW, SE and NE) or coastwise (East and West) or national level based on expert view within Working

Table 4. List of Finfish species prioritised for stock assessment

Sl. No.	Family	Species	Stocks /Regions	Full Stock Assessment frequency	LF as TL/FL/SL/ Others	LF measurement (mm,cm)	Length Frequency interval	Hard parts age data available (Y/N)	Stock assessment method Biology based (BSA)/Catch based (CMSY/others)
1	Clupeidae	<i>Sardinella longiceps</i>	1	Annual	TL	mm	0.5 cm	Y	BSA + CMSY
2	Clupeidae	<i>Sardinella fimbriata</i>	1	Annual	TL	mm	0.5 cm	Y	BSA + CMSY
3	Clupeidae	<i>Sardinella gibbosa</i>	1	Annual	TL	mm	0.5 cm	Y	BSA + CMSY
4	Clupeidae	<i>Sardinella albella</i>	1	Annual	TL	mm	0.5 cm	Y	BSA + CMSY
5	Scombridae	<i>Rastrelliger kanagurta</i>	2 (Mainland, Andaman & Nicobar)	Biennial	TL	mm	1 cm	N	BSA + CMSY
6	Synodontidae	<i>Harpodon nehereus</i>	2 Arabian sea Bay of Bengal	Annual	TL	mm	10mm	N	BSA(West coast) +CMSY (east coast)
7	Trichiuridae	<i>Trichiurus lepturus</i>	2 East and West Coast	Triennial	TL	cm	2 cm	N	BSA + CMSY
8	Nemipteridae	<i>Nemipterus japonicus</i>	Mainland	Annual	TL	mm	10 mm	N	BSA + CMSY
9	Nemipteridae	<i>N. randalli</i>	Mainland	Annual	TL	mm	10 mm	N	BSA + CMSY
10	Stromateidae	<i>Pampus candidus</i>	Mainland	Triennial	TL	cm	1 cm	N	BSA+CMSY
11	Stromateidae	<i>P. griseus</i>	Mainland	Triennial	TL	cm	1 cm	N	BSA+CMSY
12	Carangidae	<i>Parastromateus niger</i>	Mainland	Triennial	TL	cm	1 cm	N	BSA+CMSY
13	Engraulidae	<i>Coilia dussumieri</i>	2 (NW &NE)	Annual	TL	cm	0.5 cm	N	BSA+CMSY
14	Synodontidae	<i>Saurida tumbil</i>	Mainland	Triennial	TL	mm	10 mm	N	BSA+CMSY
15	Synodontidae	<i>S. undosquamis</i>	Mainland	Triennial	TL	mm	10 mm	N	BSA+CMSY
16	Ariidae	<i>Plicofollis layardi</i>	Mainland	Triennial	TL	cm	1cm	N	BSA
17	Carangidae	<i>Decapterus russelli</i>	1, East & West coasts	Annual	TL	cm	1.5 cm	N	BSA+CMSY
18	Carangidae	<i>Megalaspis cordyla</i>	East & West coasts	Annual	TL	cm	1.5 cm	N	BSA+CMSY
19	Lactariidae	<i>Lactarius lactarius</i>	Indian coast	Triennial	TL	cm	1 cm	N	BSA+CMSY
20	Sciaenidae	<i>Otolithes ruber</i>	EC & WC	Annual	TL	cm	2 cm	N	BSA
21	Sciaenidae	<i>O. cuvieri</i>	WC	Annual	TL	cm	2 cm	N	BSA
22	Sciaenidae	<i>Otolithoides biauritus</i>	Indian coast	Triennial	TL	cm	3 cm	N	BSA+CMSY
23	Sciaenidae	<i>Protonibea diacanthus</i>	Indian coast	Triennial	TL	cm	3 cm	N	BSA+CMSY

Sl. No.	Family	Species	Stocks /Regions	Full Stock Assessment frequency	LF as TL/ FL/SL/ Others	LF measurement (mm,cm)	Length Frequency interval	Hard parts age data available (Y/N)	Stock assessment method Biology based (BSA)/Catch based (CMSY/others)
24	Sciaenidae	<i>Nibea maculata</i>	SE coast	Annual	TL	cm	1 cm	N	BSA
25	Leiognathidae	<i>Karalla dussumieri</i>	SE coast	Triennial	TL	mm	0.5cm	N	BSA
26	Leiognathidae	<i>Gazza minuta</i>	SE coast	Triennial	TL	mm	0.5cm	N	BSA
27	Mullidae	<i>Upeneus supravittatus</i>	SE coast	Triennial	TL	mm	0.5 cm	N	BSA
28	Mullidae	<i>Upeneus sulphureus</i>	SE coast	Triennial	TL	mm	1 cm	N	BSA
29	Mullidae	<i>Upeneus moluccensis</i>	NW coast	Triennial	TL	mm	1 cm	N	BSA
30	Cynoglossidae	<i>Cynoglossus macrostomus</i>	SW coast	Triennial	TL	mm	1 cm	N	BSA
31	Serranidae	<i>Epinephelus diacanthus</i>	SW/NW	Triennial	TL	mm	5 cm	N	BSA
32	Coryphaenidae	<i>Coryphaena hippurus</i>	All India	Triennial	TL	mm	2 cm	Y	BSA
33	Rachycentridae	<i>Rachycentron canadum</i>	3 stocks NW, SW, East coast	Triennial	FL	cm	5 cm	N	CMSY
34	Scombridae	<i>Scomberomorus guttatus</i>	Mainland	Annual	TL	mm	1 cm	N	BSA + CMSY
35	Scombridae	<i>S. commerson</i>	Mainland	Annual	TL	mm	1 cm	N	BSA + CMSY
36	Priacanthidae	<i>Priacanthus hamrur</i>	North west and South west	Triennial	TL	mm	1 cm	N	BSA+CMSY
37	Sphyraenidae	<i>Sphyraena putnamae</i>	South west and South east coast (Main land)	Annual	FL	mm	5 cm	N	BSA
38	Chirocentridae	<i>Chirocentrus nudus</i>	mainland	Triennial	TL	mm	20 mm	N	BSA+CMSY
39	Chirocentridae	<i>C. dorab</i>	mainland	Triennial	TL	mm	20 mm	N	BSA+CMSY
40	Haemulidae	<i>Pomadourys kaakan</i>	East coast	Triennial	TL	mm	50 mm	N	BSA
41	Muraenesocidae	<i>Muraenesox bagio</i>	Mainland	once in five years	TL	cm	5 cm	N	CMSY
42	Carcharhinidae	<i>Scoliodon laticaudus</i>	Mainland	Triennial	TL	cm	3 cm	N	BSA
43	Carcharhinidae	<i>Rhizoprionodon acutus</i>	Mainland	Triennial	TL	cm	3 cm	N	BSA
44	Carcharhinidae	<i>R. oligolinx</i>	Mainland	Triennial	TL	cm	3cm	N	BSA
45	Sphyridae	<i>Sphyrna lewini</i>	Mainland	Once in five years	TL	cm	5 cm	N	CMSY
46	Triakidae	<i>Iago sp</i>	Mainland	Triennial	TL	cm	1 cm	N	BSA
47	Dasyatidae	<i>Brevitrygon imbricata</i>	Mainland	Triennial	DW - disc width	cm	1 cm	N	BSA

Sl. No.	Family	Species	Stocks /Regions	Full Stock Assessment frequency	LF as TL/ FL/SL/ Others	LF measurement (mm,cm)	Length Frequency interval	Hard parts age data available (Y/N)	Stock assessment method based (BSA)/Catch based (CMSY/others)
48	Gymniridae	<i>Gymnura poecilura</i>	Mainland (South east)	Triennial	DW	cm	5 cm	N	BSA
49	Rhinobatidae	<i>Rhinobatos lionotus</i>	Mainland (East coast)	Triennial	TL	cm	5 cm	N	BSA
50	Istiophoridae	<i>Istiophorus platypterus</i>	National	Triennial					BSA
51	Clupeidae	<i>Tenualosa ilisha</i>	NW and NE	Triennial	FL	mm	10 mm	N	BSA+ CMSY
52	Xiphiidae	<i>Xiphias gladius</i>	All India	Triennial	FL	cm	2 cm	N	BSA
53	Scombridae	<i>Thunnus tonggol</i>	All India	Triennial	FL	cm	2 cm	N	BSA
54	Scombridae	<i>Euthynnus affinis</i>	All India	Biennial	FL	cm	2 cm	N	BSA
55	Scombridae	<i>Thunnus albacares</i>	All India	Triennial	FL	cm	2 cm	Y	BSA
56	Scombridae	<i>Katsuwonus pelamis</i>	All India	Biennial	FL	cm	2 cm	N	BSA
57	Scombridae	<i>Auxis rochei</i>	Mainland (southwest coast)	Annual	FL	cm	2 cm	N	BSA
58	Platycephalidae	<i>Platycephalus indicus</i>	South west	Five years	TL	mm	10 mm	N	BSA
59	Platycephalidae	<i>Grammolites suppositus</i>	south east coast	Five years	TL	mm	10 mm	N	BSA
60	Sillaginidae	<i>Sillago indica</i>	Mainland	Biennial	TL	mm	10 mm	N	BSA
61	Sillaginidae	<i>Sillago sihama</i>	Mainland	Biennial	TL	mm	10 mm	N	BSA
62	Sillaginidae	<i>Sillago vincenti</i>	Mainland	Biennial	TL	mm	10 mm	N	BSA
63	Lethrinidae	<i>Lethrinus nebulosus</i>	SE coast	Triennial	TL	cm	1 cm	N	BSA+CMSY
64	Lethrinidae	<i>Lethrinus lentjan</i>	SW & SE coasts	Triennial	TL	cm	1 cm	N	BSA+CMSY
65	Lethrinidae	<i>Lethrinus mahsena</i>	SW coast	Triennial	TL	cm	1 cm	N	BSA+CMSY

*Additionally, annual stock status reports for all species will be prepared

BSA- Biological Stock Assessment Methodologies used will be based on exploitation characteristics, life history traits and other relevant parameters derived from the age/length data of the species sampled from various fleets

CB- Catch Based methods which use Catch and Abundance (optional) data with informed priors

CMSY-Catch MSY

LF- Length Frequency, TL- Total Length, FL -Fork Length, SL – Standard Length

Table 5. List of Shellfish species prioritised for stock assessment

Family	Species	Stocks/Regions	*Full Assessment frequency	LF measurement		Length Frequency interval	Hard parts age data available (Y/N)	Stock assessment method Biology based (BSA)/Catch based (CMSY/others)	
				TL/ CL/DML/ Others	LF measurement (mm,cm)				
1	Sepiidae	<i>Sepia pharaonis</i>	NW, SW, NE	Triennial	DML	mm	10	No (in process)	BSA
2	Sepiidae	<i>S. aculeata</i>	Odisha (NE)	Triennial	DML	mm	5	No	BSA
3	Sepiidae	<i>Sepiella inermis</i>	East and West coast	Triennial	DML	mm	5	No (in process)	BSA
4	Sepiidae	<i>Sepia elliptica</i>	Kerala	Triennial	DML	mm	5	No	BSA / LBB
5	Sepiidae	<i>Sepia brevimana</i>	SE	Triennial	DML	mm	10	No	BSA/LBB
6	Loliginidae	<i>Uroteuthis (Photololigo) duvaucelli</i>	NW, SW, NE	Triennial	DML	mm	10	Yes	BSA
7	Loliginidae	<i>Uroteuthis edulis</i>	East and West coast	Triennial	DML	mm	10	No	BSA / LBB
8	Loliginidae	<i>Sepioteuthis lessoniana</i>	East coast	Triennial	DML	mm	10	Yes	BSA
9	Octopodidae	<i>Amphioctopus neglectus</i>	SW	Triennial	DML	mm	5	No	BSA
10	Octopodidae	<i>Amphioctopus aegina</i>	SE	Triennial	DML	mm	5	No	BSA
11	Octopodidae	<i>Cistopus indicus</i>	SW, SE	Triennial	DML	mm	5	No	BSA
12	Penaeidae	<i>Metapenaeus dobsoni</i>	SW & SE	Triennial	TU/CL	mm	5	No	BSA/CB
13	Penaeidae	<i>M. monoceros</i>	East & West coasts	Triennial	TU/CL	mm	5	No	BSA/CB
14	Penaeidae	<i>M. affinis</i>	NW	Triennial	TU/CL	mm	5	No	BSA/CB
15	Solenoceridae	<i>Solenocera crassicornis</i>	NE	Triennial	TU/CL	mm	5	No	BSA/CB
16	Penaeidae	<i>Parapenaeopsis stylifera</i>	West and East coast	Triennial	TU/CL	mm	5	No	BSA/CB
17	Penaeidae	<i>Penaeus semisulcatus</i>	SE	Triennial	TU/CL	mm	5	No	BSA/CB
18	Penaeidae	<i>Penaeus merguensis</i>	SE	Triennial	TU/CL	mm	5	No	BSA/CB
19	Penaeidae	<i>Metapenaeus brevicornis</i>		Triennial	TU/CL	mm	5	No	BSA/CB
20	Pandalidae	<i>Heterocarpus woodmasoni</i>		every 5 years	TU/CL	mm	5	No	BSA/CB
21	Pandalidae	<i>Heterocarpus chani</i>		every 5 years	TU/CL	mm	5	No	BSA
22	Aristeidae	<i>Aristeus alcocki</i>	SW & SE	every 5 years	TU/CL	mm	5	No	BSA
23	Portunidae	<i>Portunus sanguinolentus</i>	West and East coast	Triennial	CL/CW	mm	5/10	No	BSA
24	Portunidae	<i>P. pelagicus</i>	SW, NE, SE	Triennial	CL/CW	mm	5/10	No	BSA
25	Portunidae	<i>Charybdis feriata</i>	West and East coast	Triennial	CL/CW	mm	5/10	No	BSA
26	Scyllaridae	<i>Thenus unimaculatus</i>	SW, NW, SE	every 5 years	TU/CL/CW	mm	5	No	BSA

Family	Species	Stocks/Regions	*Full Assessment frequency	LF measurement TL/ CL/DML/ Others	LF measurement (mm,cm)	Length Frequency interval	Hard parts age data available (Y/N)	Stock assessment method Biology based (BSA)/Catch based (CMSY/others)
27	Palinuridae	<i>Panulirus homarus</i>	SE	every 5 years	TL/CL/CW	5	No	BSA/CB
28	Veneridae	<i>Paphia malabarica</i>	Ashtamudi Lake, Kerala	Annual	APW/ DVM/TH	2	No	Survey based /SPM
29	Veneridae	<i>Villorita cyprinoides</i>	Vembanad lake, Kerala	Annual	APW/ DVM/TH	2	No	Survey based /SPM
30	Veneridae	<i>Meretrix casta</i>	SW, SE	Annual	APW/ DVM/TH	2	No	Survey based stock status / SPM
31	Turbinellidae	<i>Turbinella pyrum</i>	SE	Triennial	APW/ DVM/TH	2	No	Survey based /SPM
32	Muricidae	<i>Chicoreus ramosus</i>	SE	Triennial	APW/ DVM/TH	2	No	Survey based /SPM
33	Babyloniidae	<i>Babylonia spirata</i>	SW	Triennial	APW/ DVM/TH	2	No	BSA/SPM

*Additionally, Annual Stock Status reports for all species SPM Surplus Production Model

TL-Total Length; CL-Carapace Length; CW-Carapace Width; DML-Dorsal Mantle Length; APM- Antterio-Posterior Margin; DVM- Dorsal ventral margin; TH-Total Height

BSA- Biological Stock Assessment Methodologies used will be based on exploitation characteristics, life history traits and other relevant parameters derived from the age/length data of the species ; CB- Catch Based methods which use Catch and Abundance (optional) data with informed priors

Table 6. Working group on new approaches to tropical marine fish stock assessment

Theme	National Working Group (NWG)	NWG Leader
Stock Assessment Techniques/Tools/ Software for an evolutionary approach to marine fish stock assessment	Dr. Shubhadeep Ghosh Dr. Muktha, M. Dr. Rajan Kumar Dr. Gyanranjan Dash Dr. Abdul Azeez Dr. Santosh Bhendekar Dr. Eldho Varghese Dr. Somy Kuriakose Dr. Mini, K. G. Dr. Ganga.U	Dr. Jayasankar J

Table 7. Working group on Genetic Stock Identification of marine fishery resources

Theme	National Working Group (NWG)	NWG Leader
Advanced molecular markers in Genetic Stocks identification	Dr. A. Gopalakrishnan Dr. M. Sakthivel Dr. N. S. Jeena Dr. Sekar Megarajan Dr. Sajeela, K. A.	Dr. Sandhya Sukumaran

Table 8. Working Group for Zone wise Regional Marine Fish Stocks Assessment

Theme	National Working Group (NWG)
Northwest coast	Dr. Rajan Kumar and Dr. Santosh Bhendekar
Southwest coast	Dr. Dineshbabu, A. P., Dr. U. Ganga and Dr. Eldho Varghese
Southeast coast	Dr. Shoba J Kizhakudan
Northeast coast	Dr. Muktha, M. and Dr. Gyanaranjan Dash

Groups. Information is available on the occurrence of two or more distinct genetic stocks in certain resources/species but the spatio-temporal extent or stock boundaries is yet to be demarcated, for which detailed analysis covering entire distributional range of the species and all seasons needs to be undertaken (Table 9). Genetic stock studies were proposed for a few among the prioritized species, which would enable assessments at genetic stock level in the future.

Growth parameters like L_{∞} , K , t_0 , LWR, etc. are species/stock specific and population parameters with appropriate confidence limits may be estimated for each species or for all spatially segregated discrete stocks, based on available best information. A re-estimation maybe warranted only if substantial change in the fishery or ecosystem over a minimum gap of 10 years as reflected in changing size structure in the landing /samples is evident. Moreover, development of growth models (K) with independent

Table 9. Finfish and Shellfish species assessed for genetic stocks

Species	Number of Stocks identified using genetic markers / life history parameters/other parameters	Reference
<i>Sardinella longiceps</i>	2 (NW & rest of India)	Sebastian <i>et al.</i> , 2017. <i>Conservation Genetics</i> , 18, p. 951-964. Sebastian <i>et al.</i> , 2021. <i>Nature Scientific Reports</i> , p. 1-16
<i>Rastrelliger kanagartha</i>	2 (mainland & A&N)	Sukumaran <i>et al.</i> , 2017. <i>Fisheries Research</i> , 191 (2017): 1–9.
<i>Harpadon nehereus</i>	2 (West coast & East coast)	Pazhayamadom <i>et al.</i> , 2014. <i>Journal of Applied Ichthyology</i> , 31, p. 37–44.
<i>Trichiurus lepturus</i>	2 (East and West coasts)	Mukundan <i>et al.</i> , 2022; under review in <i>Marine Biodiversity</i>
<i>Nemipterus randalli</i>	2 (East and West coasts)	Raj <i>et al.</i> , Unpublished; work completed
<i>Pampus griseus</i>	1 (Bay of Bengal)	Roul <i>et al.</i> , 2021. <i>Frontiers in Marine Science</i> , 8.
<i>Coilia dussumieri</i>	2 (Northeast and Northwest)	Kathirvelpandian <i>et al.</i> , 2014. <i>Mol. Biol. Rep.</i> , 41(6):3723-31
<i>Decapterus russelli</i>	1 (all over the Indian coast)	Jose <i>et al.</i> , (Work completed, not yet published.)
<i>Lactarius lactarius</i>	2 (East and West coast)	Gopalakrishnan <i>et al.</i> , (Work completed, not yet published)
<i>Rachycentron canadum</i>	3 (Two in the Arabian sea and one along the Bay of Bengal)	Divya <i>et al.</i> , 2019. <i>Mar. Biodiv.</i> , 49, p. 381–393
<i>Scomberomorus guttatus</i>	2 major stocks (east and west coasts)	Jeena <i>et al.</i> , 2022. <i>Frontiers in Marine Science</i> , 9.
<i>Scomberomorus commerson</i>	1 (all over the Indian coast)	Jeena <i>et al.</i> , 2022. <i>Frontiers in Marine Science</i> , 9.
<i>Auxis thazard</i>	3 lineages with overlapping geography. Cannot be geographically differentiated	Kumar <i>et al.</i> , 2012. <i>Marine Biology Research</i> , 8(10): 992-1002,
<i>Scoliodon laticaudus</i>	2 stocks (East and west coasts) to the level of species (<i>S. laticaudus</i> along west coast and <i>S. cf. laticaudus</i> along east coast)	Sukumaran <i>et al.</i> , 2022. <i>Marine Biodiversity</i> . Accepted
<i>Sphyrna lewini</i>	1 stock (all along the Indian coast)	Sukumaran <i>et al.</i> , 2020. <i>Marine Biodiversity</i> , 50 (18): 1-6
<i>Carcharhinus longimanus</i>	1 stock (all along the Indian coast)	Sreelekshmi <i>et al.</i> , 2020. <i>Marine Biodiversity</i> , 50(5): 78pp
<i>Tenualosa ilisha</i>	2 found based on freshwater systems to which they migrate	Mohindra <i>et al.</i> , 2021. <i>Environ. Biol. Fish.</i> , 102, p. 939-954
<i>Thunnus tonggol</i>	1 (all along the Indian coast)	Koya <i>et al.</i> , 2021, Ph.D Thesis
<i>Euthynnus affinis</i>	1 (all along the Indian coast)	Kumar <i>et al.</i> , 2012. <i>Turkish Journal of Fisheries and Aquatic Sciences</i> , 12, p. 555-564
<i>Thunnus albacares</i>	3 (Northwest, LD & rest of India)	Kunal <i>et al.</i> , 2013 <i>Conservation Genetics</i> , 14, p. 205–213
<i>Uroteuthis (Photololigo) duvaucelii</i>	3 clades (one along west coast and 2 along the east coast)	Nisha <i>et al.</i> , Unpublished. Work completed
<i>Panulirus polyphagus</i>	2 major stocks (east and west coasts)	Jeena <i>et al.</i> , Unpublished. Work completed
<i>Perna viridis</i>	2 stocks (east and west coasts)	Divya <i>et al.</i> , 2022. <i>Mol. Biol. Rep.</i> , 49(4):3357-3363
<i>Paphia malabarica</i>	1 major stock along the Indian coast	Sukumaran <i>et al.</i> , 2020. <i>Regional Studies in Marine Science</i> , 27, p. 1-6

A&N- Andaman & Nicobar ; LD – Lakshadweep

estimates from hard part-based ageing techniques may be suitably incorporated in the stock assessment procedures. Species were prioritized for hard part ageing and training programs in hard parts based fish ageing were recommended for the young scientists to take up the work in future. Preparation of age-length keys for select species following standard methodologies and best practices (Morison *et al.*, 1998) was suggested.

In most of the well-managed fisheries across the world, assessments are done annually to have timely fisheries management interventions. As a mandatory output from the Institute, a brief stock status and possible fishery indicators for the major marine fishery resources, along with advisories for fishery managers and concerned stakeholders for facilitating timely fishery management interventions, to be released annually, preferably following the annual Institute Research Council meetings. The full stock assessment is to

be done each year (Annual) for fishes with short life span (<2 years); once in two years (Biennial) for resources of medium life span (>2 and <4 years) and every three years (Triennial) for species with longer life span (> 4 years). The BSA procedures would be followed for the data-rich (length/age based growth and mortality parameters, selectivity, recruitment rates etc.) species. For those data-limited species having only catch and/or limited length frequency data, suitable catch-based surplus production models and methods like CMSY (or as decided by the concerned working group) would be followed. The concerned Principal Investigators of the various capture fisheries monitoring projects operating in all maritime states and Working Groups constituted for various marine fishery resources will thus be able to address the needs of stakeholders for species/gear specific advisories. Also, a dynamic "Interactive web-based Atlas" for various marine fishery resources monitored to provide easily accessible information on the fish stocks for the stakeholders, will be developed by the institute and will be updated annually.

For improving data collection, adequate budgetary provision was highlighted and separate allocation for resource monitoring works at Centres also, as followed at Headquarters was promised. Small grants for case-specific research programmes, strengthening of infrastructure facilities for capture fisheries research at Centres and support for field sampling and fish biology works were requested. It was also suggested that externally funded projects may be explored to overcome the fund and manpower shortages, if any. Possibilities of inviting international experts in marine fish stock assessment to train the young scientists either with the institute's HRD funds or through similar funding programmes of the Department of Science and Technology were mooted.

Publication policy was discussed in detail. After completing full stock assessment of the resource(s), following publication protocols of the Institute, authors must ensure quality of data and results presented, preferably in a peer-reviewed science journal with NAAS rating. As part of the Publications Policy, a data disclaimer statement 'The marine fish landings data used in this study/publication are research data of ICAR-CMFRI collected through diachronic primary surveys following a stratified multi-stage random sampling design across the coastline of mainland India' to be mandatorily included in all publications made by the staff was recommended. The State Policy Briefs based on data collected under the in-house capture fisheries projects and conduct of the

stakeholders' workshops prior to the annual Institute Research Council meeting, which are prepared for the benefit of fishery managers and policy makers of each maritime state, must be updated periodically (every 5 or 10 years). The need for critical assessment and check of data quality in various reports pertaining to fish stocks in Indian EEZ should be addressed proactively by the concerned Working Groups. It was also decided to bring out special publications on the following unique marine fisheries resources of regional importance at the earliest. These included, Unicorn cod (*Bregmaceros mclellandi*) to be led by Dr. Sikha R., non-penaeid shrimp *Acetes* spp. (to be led by Dr. Rajan Kumar); Golden anchovy (to be led by Dr. Abdul Azeez; Sprats (by Drs. Mohammed Koya and Abdul Azeez); Indian mackerel (to be led by Dr. U. Ganga); Bombay duck (to be led by Dr. C. Anulekshmi) and ribbonfishes (to be led by Dr. K. M. Rajesh).

The workshop ended with vote of thanks and distribution of certificates to all participants

References for Standard methods and Good Practices

- CMFRI, 1995. A Manual for standardised linear measurements of exploited finfish and shellfish
- Mohamed, K. S., Sathianandan, T. V., Vivekanandan, E., Kuriakose, Somy, Ganga, U., Pillai, S., Lakshmi and Nair, Rekha, J. 2021. Application of biological and fisheries attributes to assess the vulnerability and resilience of tropical marine fish species. *PLoS ONE*. p. 1-31.
- Morison, A. K., S. G. Robertson and D. C. Smith. 1998. An integrated system for production fish ageing: Image analysis and quality assurance. *North American Journal of Fisheries Management*, 18:587 - 598
- Sathianandan, T. V., Mohamed, K. S., Jayasankar, J., Kuriakose, Somy, Mini, K. G., Varghese, Eldho, Zacharia, P. U., Kaladharan, P., Najmudeen, T. M., Mohammed, Koya, K., Sasikumar, Geetha, Bharti, Vivekanand, Prathibha, Rohit, Maheswarudu, G., Augustine, Sindhu K., Sreepriya, V., Joseph, Alphonsa and Deepthi, A. 2021. Status of Indian marine fish stocks: modelling stock biomass dynamics in multigear fisheries. *ICES Journal of Marine Science*, 78 (5): 1744-1757
- Varghese, Eldho, Sathianandan, T. V., Jayasankar, J., Kuriakose, Somy, Mini, K. G. and Muktha, M. 2021. Bayesian State-space Implementation of Schaefer Production Model for assessment of stock status for multi-gear fishery. *Journal of the Indian Society of Agricultural Statistics*, 74(1): 33-40
- Varghese, Eldho, Kuriakose, Somy, Mohamed, K. S., Sathianandan, T. V., Mini, K. G., Augustine, Sindhu. K., Sreepriya, V., Reshma, A. R., Athulya, C. K. and Joseph, Alphonsa. 2021. Determining target species for assessment in multispecies and multigear fisheries: insights from an expanded CMFRI-NMFDC database. *Marine Fisheries Information Service, Technical and Extension Series*, 250. p. 7-17. ISSN 0254-380X
- Wang, K., Zhang, C., Xu, B., Ying, X. and Yipping, R. 2020. Selecting optimal bin size to account for growth variability in Electronic Length Frequency Analysis (ELEFAN), *Fisheries Research*, 225.

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Participants from Finfish Fisheries Division with Dr. A. Gopalakrishnan, Director-ICAR-CMFRI



Participants from Shellfish Fisheries Division with Dr. A. Gopalakrishnan, Director-ICAR-CMFRI

Seafood Watch Assessment of Indian Squid-A Clarification by ICAR-CMFRI

Indian marine fisheries have been in a phase of significant expansion over the past decade. As international import standards become increasingly stringent, the transparency and factual accuracy of the state of resources and fisheries in countries such as India, which have a substantial stake and increasing prospects in this sector, are being subjected to the scrutiny by a plethora of agencies. A case in this context is the assessment report of Monterey Bay Aquarium's (MBA) Seafood Watch (www.seafoodwatch.org/recommendation/squid/indian-squid-15605?species=396) which provides recommendations for three major commercially imported squid species to the United States: the Indian squid (*Uroteuthis (Photololigo) duvaucelii*), the Mitre squid (*U. (P) chinensis*) and the Swordtip squid (*U. (P) edulis*). In this backdrop, being a top-notch Research Institute focussing exclusively on marine resource assessment and augmentation, the Indian Council of Agricultural Research-Central Marine Fisheries Research Institute (ICAR-CMFRI) has noted inadequacies and inappropriateness in the evidence furnished as well as in the analysis carried out by the auditors of the MBA's Seafood Watch Report based on the assessment criteria in the Seafood Watch Standard for Fisheries (ver. F3). These three inshore Indo-Pacific species have a wide distribution in three different EEZs extending from west of the Indian Ocean to the western Pacific. According to the Institute's objective evaluation, this report is skewed without taking into cognizance the entire gamut of scientific evidence available and the species has been erroneously branded under the "Avoid" category.

Further, the MBA's report finds the data collection architecture having "shortfalls" despite the fact that marine fish landings in India are incessantly monitored. The estimated production statistics are regularly worked out based on surveys under a multistage stratified random sampling design. These are then populated systematically in the National Marine Fishery Resources Data Centre (NMFDC) of ICAR-CMFRI, along with proper metadata documentation (CMFRI, FRAD, 1969, Varghese *et al.*,

2021). When such a comprehensive mechanism is in place, the assertion made by MBA is unfounded. ICAR-CMFRI team has carried out a detailed scrutiny of the claims which are listed in the MBA report, based on four assessment criteria. Our points of divergence regarding each criterion-based statement are detailed below.

Observations on the Assessment Criteria

Criterion 1: Impacts on the Species under Assessment

Cephalopods including squid, cuttlefish, and octopus are commercially exploited all along the Indian Coast, catering to the export trade since the mid-seventies (Meiyappan and Mohamed, 2000), and the squid fishery which began in 1961 has been systematically monitored and recorded since then. The stock assessment indicates that the yield of *U. (P) duvaucelii* along the eastern Arabian Sea is closer to the estimates of MSY for the squid fishery along the west coast of India (Sasikumar *et al.*, 2017). Further, the smoothed production time series assessment of *U. (P) duvaucelii* off the SW coast of India classifies it under the 'abundant' category (Venkatesan *et al.*, 2017). The recent ageing studies based on hard parts (statoliths) suggest that *U. (P) duvaucelii* has a short lifespan of <1 year, with year-round recruitment, fast growth rates, and rapid population turnover (Sajikumar *et al.*, 2022). Additionally, the occurrence of egg mops in gelatinous finger-like strands attached to the substratum in shallow intertidal areas implies that the spawning of squid happens in coastal benthic habitats (Asokan & Kakati, 1991), which are non-trawlable. In these sheltered areas, the female squids are less susceptible to fishing mortality. This can be corroborated by their skewed sex ratio in trawl catches. Hence, the chances of egg survival and recruitment are also relatively high. Apart from this, the mechanized fishing operation is prohibited in inshore waters by law through various



Uroteuthis duvaucelii

State Marine Fisheries Regulation Act. This minimizes the overlap of the fishing effort (gear interaction) with the inshore distribution of squids, particularly during spawning and egg laying, when they aggregate very close to the shore.

Criterion 2: Impacts on Other Species

To address the impact of bottom trawling, which is widely recognized as having a high impact on benthic invertebrates, it is observed that squids, by virtue of their distribution, are caught by high-opening off-bottom trawl that is operated above the sea bottom.

Bycatch species: In India, specific stock assessment studies have been carried out for many of the dominant bycatch species, including some of the common sharks and rays, and they are not grouped under the common denomination "forage fish". The catch profile for the commercial trawl fisheries in India and detailed reports on bycatch and discards along the Indian Coast are available at <http://eprints.cmfri.org.in/>. The reference, Gibinkumar *et al.*, (2012) used for scoring Criterion 2 is inappropriate since it describes the catch from a shrimp trawl (29m head rope length), which is distinct from the high opening off-bottom trawl employed for squids (99-110m head rope length). The high opening off-bottom trawls used in squid fisheries are therefore less likely to interact with the benthic invertebrates, corals and biogenic habitats of forage fish, finfish, sharks and turtles in the country.

Elasmobranchs: Several measures are currently in place in India to monitor and manage shark fisheries and the adoption of a NPOA-sharks is under consideration. Even though "160 species of sharks" are reported in Indian seas, this number includes many species which either occur occasionally or do not fall in the assorted category so much as to prominently figure in the landings under any category. The dominant species in trawl fisheries are *Rhizoprionodon* spp. and *Scoliodon laticaudus*. Both species are small sharks with faster generation time and hence have the potential for population recovery in the face of overfishing. Other dominant species, including the *Carcharhinus* and *Sphyrna* species are primarily taken with pelagic drift gillnets and longlines, with the exception being smaller individuals of *C. falciformis* in stray numbers and *Sphyrna lewini*, for which management measures have been suggested; Minimum Legal Size has been proposed for *S. lewini* (Thomas *et al.*, 2021). Thresher sharks, Mackerel sharks and Oceanic white tip sharks are also caught in pelagic drift gillnet and longline fisheries.

The high figure of 74,943 MT of elasmobranch landings reported in 1998 was primarily attributable to the rampant whale shark hunting along several parts of the Indian Coast. In 2001, the whale shark was listed under Schedule I of the Indian Wildlife (Protection) Act, 1972 as a "protected species". The subsequent reduction in the proportion of sharks in the total landings may be the result of the diversion of fisheries to other resources or grounds. The complete ban on shark fin trade implemented in India

in 2015 (Govt of India, through Notification No.110/ (RE-2013)/2009-2014) may be a factor for reduced landings of sharks.

The Rapid Stock Assessment (Kizhakudan *et al.*, 2015) which used data on total shark landings, also included landings by gears besides trawls. This is not indicative of landings from trawl fishing alone. Further, being a method that is done exclusively on the smoothed production time series, the results are subject to high levels of sensitivity. The mechanised fishing and deep-water fishing indicated by ICAR-CMFRI (2017) refers to the exploitation of sharks as targeted and/or bycatch resources in gillnets and longlines, especially those directed towards the exploitation of large pelagic resources such as tunas and billfishes. The majority of shark and ray species that are regularly caught as bycatch in trawl fisheries are smaller species with relatively high resilience and therefore with relatively high bounce-back potential.

Turtles: India attaches great importance to the protection of sea turtles. One of the world's largest mass nesting or Arribada "arrival by sea" of the Olive Ridley turtle takes place along the coast of Odisha from December to March, supporting a nesting population of about 0.6 million Olive Ridelys and making this one of the most crucial conservation areas for this species worldwide. The intense turtle nesting beach in Odisha, where 90% of all turtles in India nest, is protected as a wildlife sanctuary and national park. The Empowered Committee of the Supreme Court (2003) recommended banning gillnets within 5 km of the three mass nesting beaches for three months during the breeding season.

In India, the live turtles caught in the nets are released back into the sea.

Turtle Excluder Device (TED) are used in trawls for releasing the turtles and reducing mortality. These measures can potentially reduce the bycatch as well.

Many studies have reported that gear modifications and operational changes are successful in mitigating turtle bycatch.

Religious and cultural values attached to sea turtles in many coastal regions of the country serve as deterrents to targeted hunting.

Almost all coastal states of India have allocated no-trawl fishing zones under the 'Fishing Regulation Act'. Apart from these, coastal states observe a seasonal mechanized fishing closure of 61 days.

The recent study on the turtle-fishing gear interaction conducted concurrently along the whole Indian coastline using a stratified random sample design, has put the mortality figures at a very low level viz., 1025 (Jayasankar *et al.*, 2022). The trawl interactions accounted for the maximum fatality (21%) followed by small gillnets (20%). Despite the uncertainties surrounding the adoption of TED, the overall picture of turtle mortality from fishing elicits the least amount of concern and is within the limits set by NOAA. The Indian fishermen's increased awareness and traditional consciousness toward the ecosystem are mostly responsible for this degree of comfort.

Coral and other biogenic habitats: In scientific research, it is often necessary to rely on information from multiple secondary sources indirectly cited in review papers to evaluate a topic comprehensively. However, to make the best decisions, it is necessary to verify such information before drawing conclusions. This assessment utilizes information from several such indirect sources. For example, Dineshbabu *et al.* (2014) is a review paper that cites Bagirathan *et al.* (2014) to discuss the impact of trawling. However, Bagirathan *et al.* are not describing the impact of high-opening off-bottom trawl or squid fishery on any of the vulnerable coral species. Similarly, Saroj *et al.* (2016) is a review article and doesn't report the results of any pertinent scientific research as cited in the report.

Criterion 3: Management Effectiveness

The effectiveness of Fishery Management is considered "ineffective" in the assessment report, by attributing lack of effective measures to address the overcapacity of the fleets and reducing fishing efforts in India. However, effective input and output controls exist under the Marine Fisheries Regulation Acts in the various maritime states of India. The input controls include cod end mesh size limitations, engine HP capacity, control over destructive fishing practices, seasonal mechanized fishing closures (effort reduction), spatial control limiting the areas fished. The output controls include MLS (8 cm DML for *U. (P.) duvaucelii* Vide GO(P) No:40/15/F &PD dtd. 24.7.2015 & GO(P) No:11/2017/ F &PD dtd.17.5.2017-

Kerala State; GO No. AHF 157 SFS 2018 Bangalore dated 26/6/2019-Karnataka State; GO No. No. DF/ENF/NOTI-IMPL-MLS/2020-21/5042 dated 7/1/2020- Goa, Daman and Diu) to reduce fishing pressure on juveniles and IWPA to protect ETP species. Further, the management effectiveness in the Marine fisheries sector is apparent in the specifics of the fine levied by the respective State Department for the violation of the Marine Fisheries Regulation Act. For instance, the Kerala State, Under the scheme 'Conservation and Management of Fishery resources' details the Monitoring Control and Surveillance measures followed including the fine collected and boats confiscated for violation of MFR Act (Marine Fisheries 2405-00-103-91 <https://fisheries.kerala.gov.in/achievements>).

Criterion 4: Impacts on the Habitat and Ecosystem

The squids are caught in high-opening off-bottom trawl nets operated in the water column. Due to the nature of fishing operations, the squid fishery in the Indian Seas has no impact on the benthic habitat.

Conclusion

In light of these clarifications, the MBA team which has performed this assessment, would be advised to conduct a re-evaluation of the status verdict delivered for the Indian squid, based on scientifically robust data/published information. This would probably lead them to arrive at a "Safe" tag to be issued for the species, which will facilitate the seafood trade by clearing the air in the minds of both consumers and fishers.

References

- Bhagirathan, U. *et al.*, (2014). Impact of bottom trawling on epifauna off Veraval coast of India. *Indian Journal of Geo-Marine Sciences*, 43(2): 294-309
- CMFRI, FRAD (1969) Marine Fish Production in India 1950 – 1968. Technical Report. CMFRI, Kochi. http://eprints.cmfri.org.in/582/1/Bulletin_13.pdf
- Dineshbabu, A P. *et al.*, (2022) Bycatch in Indian trawl fisheries and some suggestions for trawl bycatch mitigation. *Current Science*, 123 (11). pp. 1372-1380. ISSN 0011-3891
- Jayasankar, J. *et al.*, (2022). 'Assessment of Marine Mammals stock and bycatch of Marine Mammals and Sea turtle' Project Report Submitted to Marine Products Export Development Authority, ICAR-Central Marine Fisheries Research Institute, Kochi. 193 p.
- Kizhakudan, S. J. *et al.*, (2015) CMFRI Marine Fisheries Policy Series -2; *Guidance on National Plan of Action for Sharks in India*. Central Marine Fisheries Research Institute, Kochi, pp. 1-102. ISBN ISSN 2394-8019
- Mahesh, V. *et al.*, (2019) Characterization of low-value bycatch in trawl fisheries off Karnataka coast, India and its impact on juveniles of commercially important fish species. *Indian Journal of Geo-Marine Sciences*, 48 (12). pp. 1733-1742.
- Meiyappan, M. M. and Mohamed, K. S. (2003) Cephalopods. In: Status of Exploited Marine Fishery Resources of India. CMFRI, Cochin, pp. 221-227. ISBN 81-901219-3-6 <http://eprints.cmfri.org.in/41/>
- Sasikumar G. *et al.*, (2017). Relating minimum legal size with optimum exploitation pattern in *Uroteuthis (Photololigo) duvaucelii* along eastern Arabian Sea. In: (Thomas, S. N. *et al.*, Eds.) *Fostering Innovations in Fisheries and Aquaculture: Focus on sustainability and Safety-Book of Abstracts*, 11th Indian Fisheries and Aquaculture Forum, ICAR-Central Institute of Fisheries Technology, Kochi and Asian Fisheries Society, Indian Branch, 21-24 November, 2017, Kochi, India, pp. 39-40
- Sathianandan T. V. *et al.*, (2020). Fished taxa species diversity along the Indian Coast and its significance in relation to the harvest of marine fishery resources. In Joshi K. K. *et al.* *Marine Ecosystem Challenges & Opportunities (MECOS 3)*. Book of Abstracts. FES DP-56. p. 119-120.
- Thomas, S. *et al.*, (2021). Status of the hammerhead shark (Carcharhiniformes: Sphyrnidae) fishery in Indian waters with observations on the biology of scalloped hammerhead *Sphyrna lewini* (Griffith & Smith, 1834). *Aquatic Conservation: Marine and Freshwater Ecosystems*. pp. 1-15.
- Varghese E. *et al.*, (2021). Determining target species for assessment in multispecies and multi-gear fisheries: insights from an expanded CMFRI-NMFDC database. *Marine Fisheries Information Service Technical & Extension Series*. 250:7-17.
- Venkatesan, V. *et al.* (2017). Present status of cephalopod fisheries of Kerala with an assessment of the stock status of major resources In: (Thomas, S. N. *et al.*, Eds.) *Fostering Innovations in Fisheries and Aquaculture: Focus on sustainability and Safety-Book of Abstracts*, 11th Indian Fisheries and Aquaculture Forum, ICAR-Central Institute of Fisheries Technology, Kochi and Asian Fisheries Society, Indian Branch, 21-24 November, 2017, Kochi, India, pp. 52

Protocol developed for the hatchery production of marine model fish *Oryzias dancena* (Hamilton, 1822)

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A non-human species that has been widely studied in the laboratory for helping scientists understanding the biological processes is called a 'model organism'. Their inherent characteristics include easy maintenance, anatomical and physiological similarities to humans, high reproductive rate and large offspring number, and a short generation time (the time period from birth to reproduction). Among the fishes, zebra fish (*Danio rerio*) is widely accepted globally as a model organism for research in freshwater providing valuable insights into cell, tissue, organ, and system level. However, for studies involving marine and brackish waters, it is not advisable to superimpose the cues obtained from freshwater model organism, which necessitates the use of a species with marked euryhaline characteristics. *Oryzias dancena* (Hamilton, 1822), with tolerance to varying salinities, are small and easy to bred, and are capable of being maintained in large numbers; therefore offers as an excellent alternate fish model organism for experiments in marine systems.

Oryzias dancena (Hamilton, 1822), belonging to the order Beloniformes and family Adrianichthyidae and popularly known as Indian ricefish or Asian medaka, was successfully bred at Visakhapatnam and Vizhinjam Regional Centres of CMFRI, and three generations were produced. A protocol has been developed for continuous hatchery production of this species. *O. dancena* has a short generation time with the individuals becoming sexually mature and spawning just 60–65 days after hatching. This work was carried out based on the suggestion of the Chairperson of the institute's Research Advisory Committee (RAC), Dr B. Meenakumari so as to meet the requirements of CMFRI

for a marine model fish for fish gut microbiome studies. This fish is well studied as a model organism for drug screening, regenerative medicine, genotoxicity studies, pharmacological, genomic and microbiome studies and transgenics in different laboratories across the world and scientists are focussing on developing its breeding technology. In addition to the short generation time, attributes of the medaka that encouraged its laboratory use include small size, external sexual dimorphism, relatively large and clear eggs, longer development time from fertilization till hatching than many other teleosts, ease of maintenance in aquaria, wide availability and reasonable cost (Parenti, 2008). A euryhaline species with strong osmoregulatory capabilities, *O. dancena* is found basically in the coastal and brackishwater areas and is a native of India, Bangladesh, Sri Lanka and Myanmar. With a reported maximum length of only 3.1 centimetres (in the present study, 3.76 cm), this egg-laying teleost is closely related to Japanese killifish or Japanese medaka (*Oryzias latipes*), which is widely used as a model species for biological research. Japanese medaka specimens were sent aboard the US space shuttle 'COLUMBIA' for 15 days and it was the first vertebrate animal species to mate in space in 1994 (Parenti, 2008; In-Seok Park, 2021).

The male individuals of Indian ricefish can be identified easily by the slender body, second dorsal with long filamentous 3rd to 5th rays and the 4th being most extended, some of them tipped with a white marking; and with an elongated and fringed anal fin. In contrast, the female has a broader belly and typical second dorsal and anal fins. They can be easily spotted with recently spawned eggs attached to their bellies when they are



Fig.1. Male and female *Oryzias dancena*

mature (Fig.1). The distal margin of the anal fin is convex in males, straight or slightly concave in females. The genital papilla in males forms a short tube, while in females it is bilobed.

Live specimens of *O. dancena* were collected from West Bengal (total 356 nos) with the help of Mr Rahul G. Kumar, an aquarium hobbyist and were transported to Visakhapatnam and Vizhinjam by air. They were given prophylactic treatment and stocked in 300 l capacity tanks filled with seawater of salinity 30-32 ppt (PSU) with *in-situ* biological filter at Vizhinjam, and in 1 t FRP tanks filled with freshwater and aeration at Visakhapatnam. Taxonomic identity was confirmed based on morpho-meristic characteristics (Parenti, 2008) and partial sequence information (572bp) of the Cytochrome C Oxidase subunit I (COI) gene. Around 120 numbers of sub-adults which survived in both centres together after 5 days of stocking were fed twice daily with pelleted feed of 300 μm particle size or *Artemia* nauplii (2 nos/ml). These specimens matured within a month of arrival without any hormonal treatment and started spawning.

Spawning normally occurs in the early morning hours (~5.00 am), with males darkening in colouration and defending small, temporary territories against one another while attempting to entice females. Egg carrying females are easy to spot with eggs attached to the body. The adhesive eggs are typically expelled as a single mass (28-32 eggs/clutch) and fertilised simultaneously, after which they continue to hang from the genital pore of the female for a period before eventually getting deposited singly or in small clumps among vegetation or other suitable media or they fall off to the bottom in a day or two.

At the Vizhinjam centre, egg collection was done by placing a clean sponge filter at the bottom of the hatchery tank and carefully removing the attached eggs using sterile tweezers and stocking them in aerated beakers or in separate larval rearing containers of 100 l capacity. The eggs from the bottom of the tank were also collected in 1000 μm nylon mesh by siphoning of bottom water.

At Visakhapatnam, an alternative method for egg collection was successfully attempted. The females

carrying fertilized eggs were collected and shifted to different hatchery tubs for shedding of the egg mass. After shifting, the females and egg mass were carefully observed on a daily basis and once the egg mass was released, the fishes were shifted back to the main tank. This method was found to be better, since the adult fish

were cannibalistic and fed on newly hatched larvae. The next batch of egg production was observed in the same females in another 08-10 days.

Fertilised eggs are generally hardy and have hairy outgrowths which help them in getting attached to

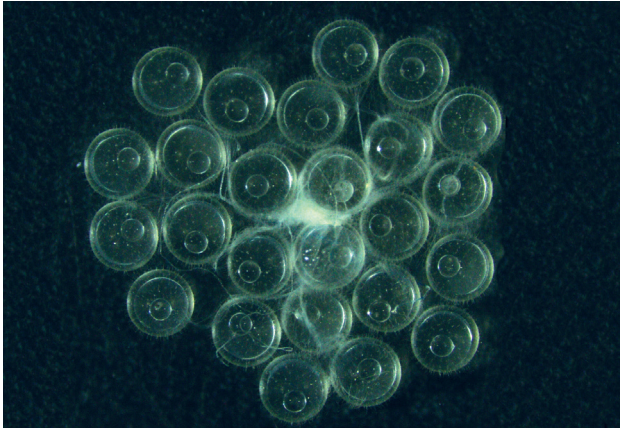


Fig 2. Egg bunch



Fig. 3. Egg 1day after spawning (2 cell stage)

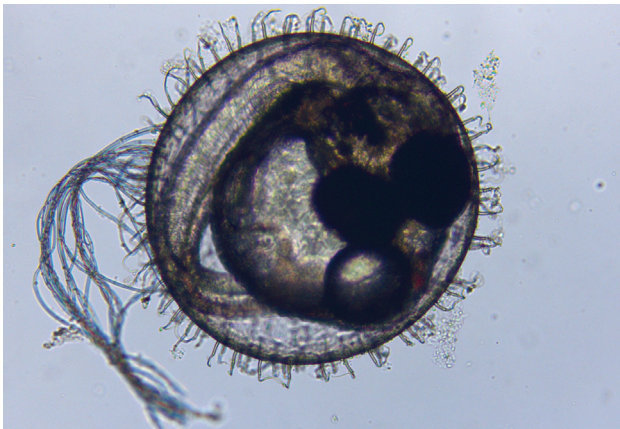


Fig 4. Egg 10 days after spawning

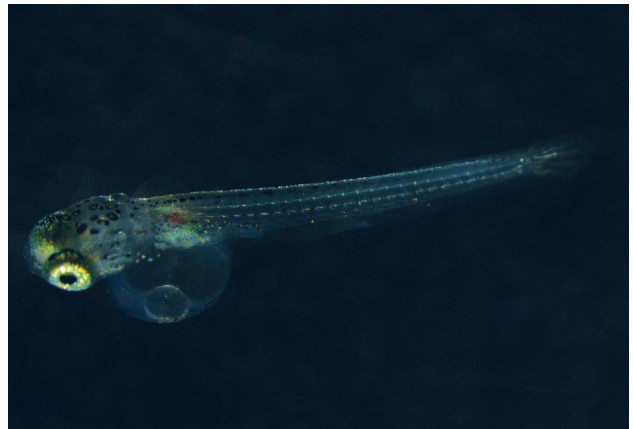


Fig. 5. Hatchling



Fig.6. 20 DPH hatchling



Fig. 7. Hatchery produced *O.dancena* juveniles



Fig. 8 & 9. Hatchery produced F3 generation of *O. dancena*

suitable substrata. Both at Vizhinjam and Visakhapatnam Centres, eggs hatched in 10-11 days (both in salinity 31‰ or in freshwater; water temperature $29 \pm 0.6^\circ\text{C}$) and the hatchlings were fed on *Artemia* nauplii or microencapsulated feed. The hatched larvae averaged 4.50 mm in total length (TL). The yolk sacs of the larvae were almost completely absorbed in 3-4 days after hatching and at 20 days after hatching, the larvae were 7.25 mm TL and had reached the juvenile stage. Mean survival rates of the hatched larvae up to 7 days post-hatching (dph) were >97% in salinity levels ranging from 0 to 31‰. The hatchlings sexually matured and first ovulation occurred in F1 individuals about 9 weeks (57-63 days) after hatching and at 22.6mm TL (mean) in different batches in both the centres. Totally, three generations (F3) of *O. dancena* were produced from different batches to date (Fig. 2-9).

Cho *et al.* (2010) conducted a study on the effects of different salinity conditions on the spawning performance, embryonic development, and early viability of *O. dancena* and observed that the embryonic development and early viability were influenced by higher and lower salinity levels (both in freshwater and > 35‰). Their study concluded that the optimal salinity condition for the normal embryonic and larval development and viability of the species is around 15-27 ppt (PSU). Such information is valuable for the long term maintenance and aquaculture practices involving this species. However, in the present study, no casualties were observed when

the species was reared and bred (up to F3 generation) in two salinities—0 ppt and 31 ppt (PSU).

ICAR-CMFRI is planning to expand the laboratory rearing, mass propagation and maintenance of the living stocks of this valuable marine model fish species with a view to develop as a 'national facility' in its centres (Vizhinjam & Visakhapatnam), by rearing *O. dancena* in saline waters of 25-30ppt (PSU). Embryos, larvae, juveniles and adults at any stage of development could thus be produced year round and can be used for various genetic, genomic and pharmacological studies, not only for our own in-house experiments, but also for supplying to other Indian research and academic institutions. In this regard, efforts have been initiated recently by the institute for the round the year seed production of one more putative marine model species—the miniature Indian ricefish, *Oryzias setnai* (= *Horaichthys setnai* Kulkarni) in addition to *O. dancena*.

References:

- Cho YS, Lee SY, Kim DS, Nam YK. (2010) Spawning performance, embryonic development and early viability under different salinity conditions in a euryhaline medaka species, *Oryzias dancena*. *Korean Journal of Ichthyology*, 22:25–33.
- In-Seok Park (2021) A review of studies on *Oryzias dancena*. *Laboratory Animal Research*, 37(4): 1-12, <https://doi.org/10.1186/s42826-020-00081-x>
- Parenti, L. R. (2008) A phylogenetic analysis and taxonomic revision of ricefishes, *Oryzias* and relatives (Belontiiformes, Adrianichthyidae). *Zoological Journal of the Linnean Society*, 154(3): 494-610.

Intense spawning aggregation of ragged sea hare, *Bursatella leachii* Blainville, 1817 in Netravathi estuary

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Large aggregations of a single species of sea hares were observed during a regular clam survey on 3rd February 2022, in the estuarine stretches of river Netravathi in Mangalore. The 15 x 15 cm quadrants were used to count the egg mass found in the intertidal area of the estuary. Samples of sea hare entangled in gillnets were collected and brought to lab for further analysis with with number of organisms entangled in each panel was documented. Measurements were taken to the nearest 0.1 mm using digital vernier calliper and total body weight was noted to the nearest 0.1 g with an electronic weighing balance. A semi-structured interview was also conducted with the fishers of the region during field visit to record the extend of menace created by the organism.

From a careful examination of 13 collected specimens, the organism was identified as ragged sea hare, *Bursatella leachii* Blainville, 1817 (Fig. 1). The organism was observed to be yellowish tan, with black varied shaped blotches in the body. Blue coloured blotch embedded between black

spot was found scattered randomly throughout the body. The head bears four tentacles: two tentacles originating on the dorsal part of the head called rhinophores and two tentacles, near the mouth. No internal shell was observed in the adult organism, and purple ink was ejected when disturbed. The body was covered with numerous long, branching fleshy papillae (Fig. 1). The size of the organisms ranged from 72-110mm with average size of 86 ± 3.82 mm and weight ranging from 20-54g with an average weight of 30.22 ± 2.75 g. All the individuals collected were mature adults. The egg mass of the organism was observed to be long thin string type with yellow, green or dirty white colour. The average number of egg mass was 9 ± 3 no/sqm in the intertidal zone of the Netravathi Estuary. Careful examination of the egg mass under microscope revealed the presence of live embryos (Fig.2).

Ragged sea hare occurs regularly in the Netravathi and Gurupura estuaries of Dakshina Kannada during post-monsoon phase every year. But this year, the sea hare

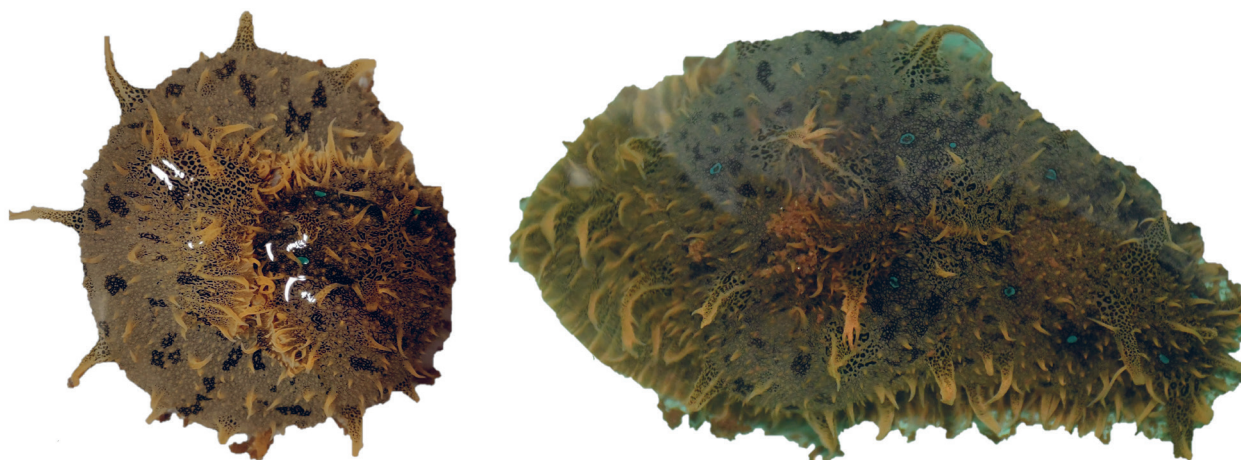


Fig. 1. Ragged sea hare, *Bursatella leachii* Blainville, 1817

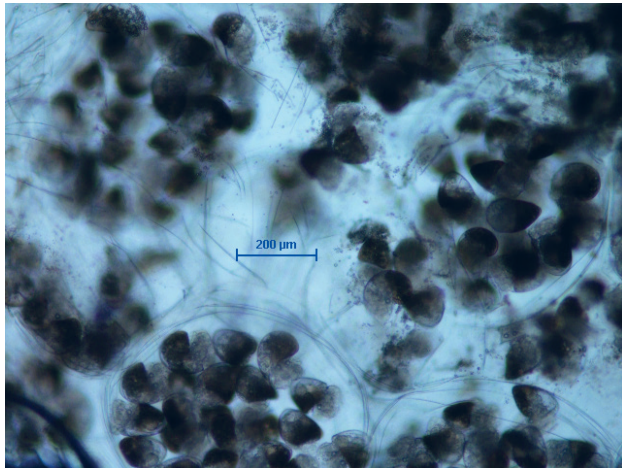


Fig. 2. Microscopic view of live embryos of ragged sea hare

aggregation was very dense in the estuarine sandy and partially muddy bed from December 2021. It was found absent in the rocky regions of the estuary. It was also recorded in Gurupura Estuary but intense aggregations and associated hassles were not as high as in Netravathi. Ragged sea hare is observed to form breeding aggregations after the rainy season. They continue to be in the euryhaline zone of estuary for breeding activities until

the south-west monsoon in June.

Nearly 22-35 gillnet fishers target estuarine fishes and crabs in this particular stretch of the Netravathi Estuary who face problems due to population boom of ragged sea hare. All the fishers reported reduction in catch and income earned due to sea hare aggregations. A panel of gillnet of 1.8m X 2.4m dimension was entangling nearly 4-5 sea hares, which hampers the gilling efficiency of the net. About 75% of fishers reported 20-40% loss in income due to the proliferation and aggregation of sea hare in this region while 25% reported income loss up to 20%. All the fishers complained on the additional time spent for removing the sea hare from the nets after fishing, which in turn affects the quality of their catch. In very few cases (6%), damage to the fishing nets were also reported and a few fishers (25%) change their fishing area due to the sea hare aggregation. Ragged sea hare is not commercially exploited in India even though ink gland of the organism reportedly has pharmacological use due to bio-active compounds. Sea hares are effective to check algal growth in reef aquaria and hence utilized in the marine aquarium industry as algae cleaner

Brief Communications

Some observations on the biology of Blubberlip snapper *Lutjanus rivulatus*

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Blubberlip snapper *Lutjanus rivulatus* (Cuvier, 1828) landed in Kasimedu Fisheries Harbour, Chennai in the size range of 16.1 to 69.8 cm weighing from 75 g to 5.91 kg (N= 150) were analysed for biological studies with detailed morphometric analysis for five specimens (Fig. 1, Table 1).

Mouth dimensions indicate the maximum prey size the fish is able to engulf. The mouth gape area was enthralled with the lower and upper jaws of the mouth opened wide and the outline drawn on a graph sheet.



Fig. 1. *Lutjanus rivulatus* landed at Chennai

Table 1. Morphomeristic measurements (cm) of *Lutjanus rivulatus*

Metrics /Specimen	1	2	3	4	5
Total length	65.5	69.8	30.3	27.5	26.8
Fork length	64.0	67.8	27.3	23.3	23.2
Standard length	53.5	61	25.8	21.8	22
Dorsal fin spine + rays	10 + 15	10+15	10+15	10+15	10+15
Anal fin spine + rays	3 + 8	3+8	3+8	3+8	3+8
Pectoral fin rays	17	17	16	16	15
Pelvic fin spine + rays	1 + 5	1+5	1+5	1+5	1+5
Body depth	26.5	30.5	13.1	11	11.1
Eye diameter (inner/outer)	2.1/2.9	2.2/2.95	1.4/1.6	1.1/1.4	1.3/1.6
Head length	22.0	21.4	9.9	8.4	8.3
Snout length (1 st / 2 nd)	3.5/3.8	5.5/5.8	1.6/2.4	1.3/2.1	1.2/1.9
Pectoral fin length	18.5	17.1	8.4	6.8	6.7
Pelvic fin length	10.5	10.9	5.5	4.8	4.2
Anal fin height	15.8	16.1	7.6	6.4	5.8
Caudal fin length	13.4	13.9	5.9	4.8	4.3
Upper jaw length	8.0	8.2	3.2	2.9	2.6
Lower jaw length	5.8	6.6	1.8	1.8	1.9
Fish weight (kg)	5.65	5.91	0.42	0.35	0.30
Liver + spleen weight (g)	71.5	71	5	2	3
Ovary weight (g)/ maturity stage	164.5 (stage6)	5 (stage 7)	Indeterminate	Indeterminate	Indeterminate
Fat weight (g)	20	490.5	2	8	3
Empty Stomach weight (g)	62.5	66	5	4.5	2

The height and width of the full-open mouth were measured (Fig. 2). From these dimensions, which formed an elliptical shape, the mouth gape area was measured as $\pi 0.5A \times 0.5B$, where A is mouth height and B is mouth width (Ward-Campbell *et al.*, 2005).

Compared to the body size of the fish the mouth gape area was found to be very small and the fish capable of consuming only small sized fishes, prawns and crablets. The gut of the *L. rivulatus* comprised of a small, thick and muscular stomach, 5 thick and muscular pyloric caeca and a short intestine which is characteristic of carnivorous fish. The gut content analysis showed that large fishes (<65.5 cm TL) had consumed small cardinal fishes (*Ostorhinchus fleurieu* (90mm/11g) and *Jaydia lineata* (68mm/4.5g)); goatfish (*Upeneus* sp. (78m/5g)) and threadfin breams (*Nemipterus* sp. (80mm/6.5g)), whereas the small

fishes (26cm to 30cm TL) in general consumed prawns (9.4/8g), crablets (4mm/1g and to 12mm/5g) and brittle stars. A large crab leg of 25 mm length and 8 mm width was noticed in a gorged stomach of the fish sized 23 cm. The IRI of each ingested prey was estimated as a linear combination of its frequency of occurrence (FO), abundance (A) and biomass (B). It indicated that the occurrence of crablets was by far the highest (85.5%) followed by fishes (7.6%) and prawns (6.9%). Sex could not be determined by visual examination in fishes below 30 cm length. Fishes in the length range of 26.8 m to 30.3 cm were all indeterminates. It was observed that the gonads were covered by bright orange fatty mass that fills the entire abdominal region in early maturity stages and spent recovery stages. The orange fatty mass reduces to thin red coloured strand on either side of ovary with maturity of ovary (Fig. 3). The female



Fig. 2. Fully open mouth of *Lutjanus rivulatus*



Fig. 3. Gonads of immature (left) and mature female fish

Table 2. Mouth gape area (cm²) of *Lutjanus rivulatus* (n=5) along Chennai coast

Total length of fish (cm)	65.5	69.8	30.3	27.5	26.8
Mouth height	7.9	7.6	3.9	3.1	4.4
Mouth width	7.5	7.4	3.6	2.9	3.8
Mouth gape area (cm ²)	46.5	44.1	11.0	7.1	13.1

fish with 65.5 cm length and 5.65 kg weight had an ovary weight of 164.5 g and fat weight of 20 g in stage 6. Another female fish with 69.8 cm length

and 5.91 kg weight had an ovary weight of 5 g and fat weight of 490.5 g in stage 7 (Table 1).

Big-sized blubberlip snappers (< 4kg) were sold at the rate of ₹220/- to 250/- per kg in the landing centre. FishBase records maximum size of this species as 80.0 cm TL with a weight of 11 kg. *L. rivulatus* is a tasty fish. It is a highly relished food fish in Hong Kong live fish market. Since it is a highly priced commercially important fish in southeastern Asia, more information on the ecology and life cycle of *L. rivulatus* will be useful to assess its potential as a candidate for aquaculture.

Ascidians from the gut of crimson jobfish



Teleost fishes and crustaceans such as shrimp and crabs usually form the major gut content of snappers. In September 2021, two specimens of crimson jobfish (*Pristipomoides filamentosus*) belonging to the family Lutjanidae were observed with entirely ascidians as diet in their fully gorged stomachs. The fish samples were collected from the Kalamukku fish

landing centre in Kochi (09°59'924" N, 76°14'564" E), India and were caught by a hook and line operated at a depth range of 20–40 m off the Kochi coast, Kerala, India. They had a total length of 55.7 and 56 cm, and the weight of the gut content was 44 and 57.2 g, respectively. Ascidians are soft-bodied, marine invertebrate filter feeders inhabiting the coral reef areas.

There are meagre reports of ascidians forming the diets of deep-water snapper species from Indian waters. Besides these two fishes, 21 individuals of *P. filamentosus* were sampled for the feeding biology studies during the month in the size range of 23–38 cm TL and their gut content was dominated by teleost fishes, crabs and shrimp. It is significant to note that the ascidians were observed in the stomachs of fishes belonging to the largest size groups and that both the fishes were adults with mature gonads. Ontogenetic changes in reef fish diet indicate that the strategy will reduce intra-species competition (for food and habitat) between adults and juveniles. Studies on the gut content of a greater number of adult specimens are needed to further evaluate this.

Reported by Livi Wilson*, T. M. Najmudeen, K. T. S. Sunil, S. Pakkri Muthu and M. J. Joseph | ICAR-Central Marine Fisheries Research Institute, Kochi

Indian Ocean humpback dolphin stranded at Arthunkal landing centre, Kerala.



On November 2, 2022, the carcass of a dead dolphin, *Sousa plumbea* (Indian Ocean Humpback Dolphin), was discovered at the Arthunkal landing centre in Alapuzha, Kerala (9°39'42.0"N 76°17'29.5"E). The Dolphin was found to have attained

its average size post maturity. The cause of death seems to be natural since there were no accident marks on the body and the carcass was in a decaying condition. Three days later, the body was buried in the shore of Aareparambu ward 22, with

the presence of ward member of Cherthala South Gram Panchayat.

The morphometric measurements of the body are given below.

Total length of body	: 300 cm
Diameter of the eye	: 3 cm
Tip of Snout to eye	: 49 cm
Tip of Snout to blow hole	: 43.5 cm
Tip of Snout to centre of anus	: 176 cm
Length of jaw	: 41 cm
Weight approximate	: 180 – 200 kg

Reported by P. J. Joby, P. K. Prashanth, Akhil Babu, P. A. Rajesh, Paulose Jacob Peter, Sijo Paul and J. Jayasankar | ICAR-Central Marine Fisheries Research Institute, Kochi

Rare occurrence of Yellowmargin trigger fish from Kerala coast



Fig. 1. *Pseudobalistes flavimarginatus* landed in mechanized gillnetter at Cochin fisheries harbour.

The fishes of the family Balistidae are popularly known as trigger fishes and distributed along the Indian and the Pacific Oceans, though certain species are restricted to particular regions. In India, these fishes are abundant in the Gulf of Mannar, Palk

Bay, off Maharashtra and Gujarat coast, off Kerala, Andaman and Lakshadweep Islands. Three specimens of *Pseudobalistes flavimarginatus* (Ruppel, 1829) commonly known as yellow margin trigger fish, were observed in a mechanized gillnetter

which operated hook and line, measuring 14, 24, and 34 cm in total length and weighing 1.7, 2.1 and 2.5 kg at Cochin Fisheries Harbour on 7th June, 2022 (Fig. 1). The operational depth of hook and line was at 50 m off North West Coast of Kerala. The species was identified by its blotchy pinkish to greyish body colour and a yellowish-pink snout, darkish stripes behind the eye, and yellow fin margins. The local populations consume fresh and dried *Pseudobalistes flavimarginatus*, but there are reports of cases of ciguatera, a serious intoxication caused mainly by its herbivorous alimentation, which may include poisonous sea weeds.

Reported by M. A. Jishnudev*, T. G. Kishor, Sijo Paul and Paulose Jacob Peter | ICAR-Central Marine Fisheries Research Institute, Kochi

Unusual heavy landing of cephalopods from Vizhinjam coast

Unusual landing of cephalopods was observed along the Vizhinjam coast during the period between 25.7.2022 to 28.7.2022. On 25.7.2022, about 170-180 boats operated along the Vizhinjam coast 25-35 km from the shore at a depth range of 30- 40 fathoms, landed an estimated 15 tonnes of cephalopods. The catch was composed mainly of cuttlefish *Sepia pharaonis* locally known as thondikanava (Kallan kanava) and the octopus *Amphioctopus marginatus* locally known as peikanava (Neerali). Cuttlefish and octopus landing at Vizhinjam are of high quality as they are caught using either hook and line or jigs and hence command good market prices. An average catch of 30-280 kg/unit was recorded from outboard FRP boats (OAL-7.2-9.6 m) fitted with the double engine of

maximum of 25 hp which operated jigs. On 26.7.2022, about 130-140 boats were operated and the estimated landing was about 12 tons. During the month of July in the previous year estimated monthly landing of *S. pharaonis* was only 6.4 tons and cephalopods landings of Vizhinjam harbour was 55.5 tons

The cuttlefish landings comprised adults of sizes 16.5 cm to 27.5 cm Mantle Length (ML) and weighed between 0.350 kg to 1.45 kg each whereas the octopus caught were in the size range of 8-11cm (ML) and weighed between 150 to 300 g. Recommended Minimum Legal Size (MLS) for *S. pharaonis* along the Kerala coast is 11 cm and the catch landed were above MLS. The cuttlefish were sold at the rate of

₹400-450/- per kilogram.

Octopus was earlier brought to the landing centre but in lesser quantity. Since June 2021 octopus is being landed in Vizhinjam harbour in large quantities due to the increased demand for the octopus from seafood companies which offer ₹230-270/- per kg at the landing centre. Earlier with no demand from the seafood companies it had fetched only low price and therefore, fishermen usually discarded the octopus catch at sea. A major portion of the cephalopod catch is being auctioned and sold to seafood companies.

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Rabbit fish grazes on scyphozoan cnidarians

Several marine fishes have short term symbiotic associations with scyphozoan and hydrozoan jellyfishes and few studies suggest that these associations were of ecological significance. Scyphozoan cnidarians are heavy consumers of zooplankton which in turn form the diet of larvae of commercially important finfishes and shellfishes. However, in certain cases, these gelatinous organisms are also part of the diet of some fish and turtles. Information pertaining to such diet contributions are absent in Indian context and Scuba assisted underwater surveys in the coral reefs of Netrani revealed rabbitfish *Siganus cf. fuscescens* (Family:



Fig. 1. Feeding attacks of *Siganus fuscescens* on the *Cephea* sp.

Siganidae), feeding on cepheid jellyfish on the reef at a depth of 8 m. Rabbit fishes are generally considered herbivorous, feeding on turf algae and a major ecological function of siganid fishes in coral reefs ecosystem is to removing algae. A school of 24-28 rabbitfish were found to gaze on *Cephea cf. coerulea*, commonly known as cauliflower jellyfish. Jellyfish blooms were

common during the post-monsoon period and blooms of *Cephea* was observed in the off-shore waters of Karnataka in the month of December. *Siganus rivulatus* has previously been observed feeding on scyphozoan jellyfishes in the Red Sea.

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Deep-sea squat lobster *Eumunida multispina* recorded at Sakthikulangara Fisheries Harbour



Two female specimens and one male specimen of *Eumunida multispina* Komai, Chakraborty, Paramasivam & Gidda, 2019 were recorded from Sakthikulangara Fisheries Harbour, Kollam on 07.10.2022. Total length of the female specimens ranged between 96-115 mm; carapace length (CL): 49-

59 mm; carapace width (CW): 46-54 mm; abdominal length: 47-56 mm; telson: 9-10mm and having 43.8 to 46.5 grams weigh. Male specimen measured total length (TL): 94 mm; carapace length (CL): 50 mm; carapace width (CW): 48 mm; abdominal length: 44; telson: 10 mm and weighed 46.7 g.

The present species which was originally described from India during 2019, is characterized by the presence of two pairs of prominent supraocular spines and transverse ridges on the carapace. Carapace, pleon, telson and pereopods are generally reddish orange; distal parts of mesial supraocular spines, tips of pleural spines of pleomere 2, pleural margins of pleomeres 3-6, tips of several spines on cheliped meri and dorsodistal portions of propodi of ambulatory legs white; carapace with small white spot posterolateral to base of lateral supraocular spine. Generally found in a depth range of 250-400 m.

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