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Marine Fisheries Information Service

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Front Cover : Seeds of orange spotted grouper

Back Cover : Harvested Indian pompano from sea cage farm

The 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 field.

Marine Fisheries Information Service

From the Editorial Board.......

Warm greetings to all

The National Policy on Marine Fisheries (NPMF) 2017 notified by the Ministry of Agriculture and Farmers' Welfare was a major step towards a framework for a sustainable marine fisheries development model in the country. It involved wide stakeholder consultations process in which ICAR-CMFRI played a key role. The lead article of this issue of MFIS summarises the various facets of this exercise that ultimately led to the NPMF. Mariculture is the key to increasing marine fish production in the country and several potential species of fishes for mariculture have been identified by the institute. The recent breakthrough in the seed production and hatchery rearing of two economically important marine finfishes, the Indian pompano and orange spotted grouper is a major achievement for the mariculture programmes planned in the country. The seed production technology which has been developed and standardized is presented. Also, various recent trends and developments in the marine capture fisheries and mariculture sectors have been compiled.

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Abbreviation - *Mar. Fish. Infor. Serv., T & E Ser.*

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Brief results of the national stakeholder survey leading to National Policy on Marine Fisheries - 2017

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Introduction

India's marine fisheries development has been guided in the past by the five-year plans and by the policy documents of 1994 and 2004 brought out by the Department of Animal Husbandry, Dairying and Fisheries (DADF), Ministry of Agriculture and Farmers' Welfare, Government of India. As a renewable natural resource, fish harvests need to be ecologically and economically sustainable to ensure equity and livelihood security to fishers. Numbering nearly 40 lakhs, fishers and allied workers are one of the economically weaker sections of the society and their well-being and economic development is of paramount importance to the country. In order to uplift this section of the society, meet the food security and also to ensure sustainable harvests of fishery resources, comprehensive policies are necessary. It is in this context that the DADF, embarked on the exercise to develop a new National Policy on Marine Fisheries (NPMF) to act as a guidance for future development and sustenance of marine fisheries in the country. The DADF formed a seven member committee in July 2015 to draft the policy as per a broad Terms of Reference (TOR). The Committee submitted its report in July 2016 after a series of multi-locational stakeholder consultations, and the Government of India (GOI) published this as a gazette notification in May 2017.

The approach that the committee took to develop the draft policy was remarkably different from that of the earlier one. The Committee in its first sitting emphasized the need for wide stakeholder consultations before drafting of the policy. Considering the more than 40 lakh strong diverse stakeholders in all maritime states of the country, the committee took a pragmatic approach of getting all opinions of stakeholders before drafting the national policy. The committee tasked the scientists of ICAR-CMFRI to conduct a national survey. The detailed results of the survey are not available in the published NPMF-2017, and therefore, a summary of the results of the survey are presented in this article.

Approach to the National Survey

A set of 84 questions with 51 sub-questions were drafted by scientists of ICAR-CMFRI. The questionnaire addressed issues under 9 broad categories including fishermen welfare, management and regulations, decline in catch, deterioration of marine environment, deep sea fishing, harvest and post-harvest and mariculture. The questionnaire was wide ranging, but because of the complex issues involved, was not expected to be all-inclusive. Furthermore, a Yes/No format was preferred for answers because of the practical difficulty in consolidating large number of discursive textual answers that could be expected. However, respondents who felt strongly on certain issues had the opportunity to respond with written representations. These national survey answers and the representations ultimately led to policy directions contained in NPMF-2017.

The national survey questions were made available to stakeholders in print (offline) and online (websites of DADF and ICAR-CMFRI). The printed questionnaire forms were posted to over 1000 fisheries organizations in the country. Adequate publicity to the exercise was given in regional and national print media as news and advertisement.

Initially 45 days time (October 26 to December 10, 2015) was given for submission of forms, and based on popular demand from some quarters, the last date was extended by another 6 days. However postal submissions continued even after this date, and all forms received until December 31st were used in the analysis. Responses numbering 401 received after December 31st 2015 were not used in the analysis. The online form had adequate cyber security (one time password received on mobile phone or email) to ensure protection against spam generation and hackers.

The responses were made into a database in MS-ACCESS and was used to make query based outputs. Category-wise outputs were taken and then pooled to generate question-based outputs. These outputs were used to draw up the NPMF-2017.

Brief Results of the National Survey

A total of 3895 responses were received before December 31, 2015 of which 402 (10.3%) were online responses. Among the 11 categories of respondents, maximum response was from fishers and fish workers (86.6%, see Table 1). More than 65% of the response was from Maharashtra, followed by Tamil Nadu, Kerala and Karnataka (Fig. 1). Responses from other states were meagre.

Table 1. List of category-wise responses.

Respondent Category	Number of Responses
Fishers/ fish workers	3374
Fish auctioneers/ transporters	26
Fishermen Association/ leaders/ unions	39
Fishing boat owners	65
NGOs/ Civil Society groups	21
Seafood processor/ exporters	14
Academicians/ Researchers	167
General public	47
Government officials	89
Fisheries Cooperatives	36
Others	17
Total	**3895**

Results of the survey are presented as a stacked bar (% Yes/No) in Table 2. The results are self-explanatory. Some of the highlights of the survey are:

Stakeholders have strongly (>95%) opined that the marine fisheries policy of India needs periodic revisions to give direction to the developments in the sector, and the GOI should evolve a permanent mechanism for periodic (decennial) revision of the NPMF. An overwhelming majority (92.6%) of stakeholders agree that marine fish resources are not inexhaustible, and uncontrolled harvests will lead to depletion of resources which they are already experiencing for a number of marine fish resources. More than 98% of stakeholders call for more regulations to manage the marine fishery resources in a sustainable manner. Close to cent percent (98.7%) of the respondents agree that there is overcapacity (too many boats) across the sector affecting the livelihood security of existing stakeholders. Respondents strongly (>95%) feel that the decline in catches that they are experiencing are due to pollution harming fish breeding grounds, over exploitation of juveniles and spawners and impacts of climate change affecting fish stocks.

Very strong (97.5%) concern has also been raised about the lack of income to stakeholders during the fishing ban period. It is well established that the ban has a general salutary effect on fish stocks and fishing grounds. However, the cost of this conservation of national fish stocks is borne by the stakeholders, and it is only fair to expect that they are adequately compensated for this effort. The increasing amount of low-value by-catch was flagged by a majority (84-93%) of stakeholders. Use of implements and modifications to gears to reduce by-catch was favoured by 89% of stakeholders. More than 95% of stakeholders were also in favour of declaring as closed, fishing areas of the sea where more juveniles are occurring. Majority (>95%) stakeholders agree that inter-sectorial conflicts are rampant in the fisheries sector. Again a conspicuous majority (93.3%) of stakeholders agree that all fishing gears must follow specifications in Marine Fisheries Regulation Act (MFRAs) and should be individually licensed.

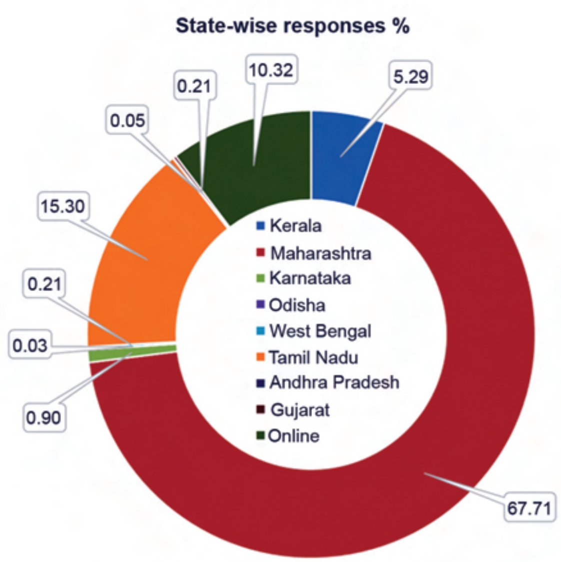

Fig. 1. Maritime state-wise responses. (Online responses not allocated to different states)

More than 85% of stakeholders have held that a separate Fishing Vessel Act by the GOI is necessary for ensuring sea safety and to ensure best labour mandated basic amenities to fishing crews. A majority (69%) of the stakeholders were not aware of the advantages of having Vessel Monitoring System (VMS) on board fishing vessels. Consequently, an equal percentage of stakeholders were not agreeable to fitting VMS transponders on board vessels with government subsidy. The stakeholders seem fairly (61.7%) satisfied with the welfare measures provided by the governments in general, and with compensation provided during the fishing ban, although there appears to be room for improvements. The insurance coverage in vogue for loss of life and property of fishers is assessed as strongly (90.8%) inadequate. Forming cooperatives for marketing, storage, processing and value addition of fish and investments in vessel and gear got a resounding Yes (>98%).

The existing rules and regulations for governing fisheries in the MFRAs have been considered as altogether inadequate to ensure sustainability by a majority (88.4%) of stakeholders. Also more number of stakeholders (94.3%) felt that there is need to amend the existing MFRAs to cover all aspects of fisheries management. Scientific management and control of harvests at Maximum Sustainable Yield (MSY) level for all fish stocks is agreeable to 98% of stakeholders. They are also agreeable (>95%) to all conventional input control methods (control on fleet size, number of fishing days, area of operation, season, engine horsepower, gear size and destructive gears) excepting limiting duration of fishing per day, mesh size and limiting number of gears per boat. In the matter of deep sea fishing and the developmental schemes to promote it, the majority (>85%) stakeholder opinion is for revoking the current Letter of Permit (LOP) scheme being practiced by the DADF. As an alternate to the LOP scheme, maximum (>97%) stakeholder agreement was for providing skill enhancement support, and then for providing state-owned mother vessels and modernization of existing indigenous deep sea going vessels and fleets.

There is more than 90% agreement among stakeholders that the fishing ban being put in practice in the country has helped in sustaining the marine fish wealth of the country. They also agree (>80%) that periodic revisions of the fishing ban period and season be done based on new and emerging scientific information. More than 90% of the stakeholders have opined that India also move toward this mode of management in marine fisheries. More than 95% of the stakeholders want Ecosystem Approach to Fisheries Management (EAFM) to be implemented with due consideration to the well-being of all living and non-living components in the marine ecosystem and the social status of stakeholders. More than 85% of the stakeholders feel that ecolabelling of key Indian fisheries would benefit the fish stocks, seafood industry and fishers.

The general condition and hygiene of fishing harbours and fish markets in the country is a cause for worry among a majority (>96%) of stakeholders. Paradoxically nearly 80% of the stakeholders believe

Table 2 - National Survey Questionnaire Outputs

QID	Question	Count	Yes (Green)/No (Red)
Q1	Do you think that the 2004 marine fisheries policy (MFP) to guide and control fisheries and allied activities needs revision	1465	96%
Q2	If yes do you think that there should be a permanent mechanism for periodic review of MFP	3744	99%
Q3	Do you think that marine fisheries resources are inexhaustible?	3764	93%
Q4	Do you feel that uncontrolled harvest will result in depletion of resources	3842	99%
Q5	Do you agree that regulations and management are necessary for sustainable harvests	3844	100%
Q6	Do you agree that additional regulations to the existing are required to manage and conserve fishery resources	3844	99%
Q7	Are you experiencing reduction in catches of major resources over the year	3751	98%
Q8	What in your opinion are the reasons for decline in catches (multiple choices are possible)		
Q8a	There are too many number of boats targeting same resources	3209	99%
Q8b	There is marine pollution harming the resources and their breeding grounds	3181	99%
Q8c	There is too much exploitation of young ones of fishes	3188	99%
Q8d	There is too much exploitation of spawners during spawning season	3092	99%
Q8e	Climate change is affecting the abundance of fish stocks in the sea	3034	98%
Q8f	All of the above	1226	96%
Q8g	None of the above	290	72%
Q9	What in your opinion are the risks associated with marine fishing		
Q9a	Uncertainty about catch	3048	96%
Q9b	No knowledge of where abundant resources are available	3042	79%
Q9c	Rough seas and associated loss in catch property and life	3042	97%
Q9d	Lack of insurance compensation	717	75%
Q9e	No income during off season and fishing ban period	3064	98%
Q9f	All of the above	3411	96%
Q9g	None of the above	297	72%
Q10	Are you getting sufficient catch of high value fish such as:		
Q10a	Shrimps	3577	89%
Q10b	Hilsa	3477	90%
Q10c	Seerfishes	3497	89%
Q10d	Pomfrets	3480	90%
Q10e	Cephalopods	3597	85%

QID	Question	Count	Yes (Green)/No (Red)
Q10f	Perches	3441	91%
Q10g	Others	3289	90%
Q11	Is the proportion of low value bycatch increasing over time	3799	85%
Q12	Are you agreeable for implementing devices which can reduce low value bycatch	1504	89%
Q13	Do you agree that discarding low value bycatch in the sea is detrimental to sustenance of the fisheries	3818	93%
Q14	Do you agree to closing of fishing in areas where more juveniles are occurring	3819	96%
Q15	Are you experiencing reduction in catch of some resources over the years	3810	98%
Q16	Are you experiencing reduction in catch of all resources over the years	3803	93%
Q17	Do you think that fish breeding grounds are deleteriously affected by fishing/ pollution	3806	98%
Q18	Do you agree to protecting known fish breeding grounds by declaring them as no-fishing zones permanently	3818	92%
Q19	Do you agree that there are conflicts between groups practicing different fishing methods	3811	96%
Q20	Do you think that conflicts are due to differing economic returns	3775	67%
Q21	Do you think that conflicts are due to competition for same resources	3764	70%
Q22	Do you think that forming local and regional fisheries councils is an effective way for resolving conflicts	3785	96%
Q23	Do you think that Government of India should take a proactive stance in curbing fishing in other countries waters?	3779	96%
Q24	Do you consider it necessary to have RFMOs for the Arabian Sea and Bay of Bengal to address shared stocks and manage conflicts?	3711	98%
Q25	Do you agree to registration of all fishing crafts (traditional motorized mechanized) irrespective of size and sector	3789	98%
Q26	Do you agree to inspection of registration by enforcement agencies at sea and at port	3766	98%
Q27	Do you think that all gears used must follow MFRA and should be licensed individually	3776	93%
Q28	Do you agree to prescribing vessel size limits for each type of fishing method	3763	64%
Q29	Do you agree to restricting vessel engine capacity for each type of fishing method	3800	64%
Q30	Do you think that a separate fishing vessel act should be made to address the above and also to address sea safety	1445	86%
Q31	Do you think that multiday vessels in the fleet should have basic human living amenities on board	3761	99%
Q32	Are you aware of the advantages of having vessel monitoring system (VMS) on board fishing vessels	3763	69%
Q33	Do you agree to fitting of VMS transponders on board fishing vessels with government subsidy	3772	63%
Q34	Are you satisfied with the existing welfare measures provided by the government to fishers	3772	62%
Q35	Do you think that the present government scheme to monetarily compensate fishers during the fishing ban period is adequate?	3804	61%
Q36	Do you think that the insurance coverage provided by the government for life/property of fishers is sufficient	1491	91%
Q37	Do you think that there is need for development of cooperatives for marketing/ storage facilities		
Q37a	Marketing	3428	99%
Q37b	Preservation/ Storage of fish	3445	99%

QID	Question	Count	Yes (Green)/No (Red)
Q37c	Processing and value addition	3488	99%
Q37d	Investments in vessel and gear	3504	98%
Q38	Do you agree to a minimum cess on fish catch to support welfare/research activities in the sector	1402	72%
Q39	Do you agree to link monetary support as above with compliance to fishing laws and good fishing practices	3633	93%
Q40	Do you think that existing rules and regulations governing fisheries are adequate to ensure sustainability	3789	88%
Q41	Is there need to amend the existing MFRAs in order to cover all aspects of fish and fisheries management	3737	94%
Q42	Do you think that there should be separate rules and regulations for 12 to 200 nmi fishing area	3620	96%
Q43	In your opinion who should enforce regulations in 12 to 200 nmi		
Q43a	State government marine enforcement/ police	3296	94%
Q43b	Central government/ coast guard	3226	73%
Q44	Do you agree that coastal security related issues are to be dealt by central government and fishing issues by state	3606	96%
Q45	Are you satisfied with the LOP scheme of the central government	1229	86%
Q46	Do you consider the following as an alternate option for LOP		
Q46a	Modernization of existing indigenous deep-sea going vessels and fleets	3459	68%
Q46b	Introducing state owned processing mother vessels	3403	73%
Q46c	Introducing financial schemes to support modernization	3474	67%
Q46d	Providing skill enhancement support	3470	98%
Q47	Has the fishing ban helped in sustaining the fish wealth of the country	3662	91%
Q48	Do you agree to periodic revisions of the fishing ban period and season based on new scientific information	1462	82%
Q49	Do you think that FAOs CCRF should be implemented fully in the country to sustain fish production	1441	92%
Q50	Do you feel that a participatory or co-management system would be helpful to manage and sustain the fisheries	1391	93%
Q51	Should India implement the ecosystem approach to fisheries management (EAFM)	1350	95%
Q52	Do you agree that the following components of EAFM should be addressed		
Q52a	Consider all the living and non-living components in the ecosystem	3476	99%
Q52b	Consider the well-being of fishers	3579	100%
Q52c	Consider the wellbeing of the environment	3573	100%
Q52d	Consider the social setup	3511	99%
Q52e	Consider co-management in governance	3528	99%
Q53	Do you think that ecolabelling of fisheries in India would benefit fish stocks, fishing industry and fishers	1318	88%
Q54	Do you consider the territorial user rights to traditional fishers are		
Q54a	Sufficient in its present form	1005	68%
Q54b	Not enforced properly	3403	98%

QID	Question	Count	Yes (Green)/No (Red)
Q54c	Should be greatly improved	1328	97%
Q55	Do you feel it is necessary to collect detailed information on fish catch and effort	3727	100%
Q56	Do you agree that there should only be a single national agency to collect and publish fish catch and effort data	3776	70%
Q57	Do you agree that harvest control of all fish stocks at MSY level is necessary for sustainable fisheries management	3605	98%
Q58	Which among the following input control measures are necessary for sustainable exploitation		
Q58a	Fleet size regulation	3532	98%
Q58b	Control on number of fishing days	3537	97%
Q58c	Control on area of operation	3559	97%
Q58d	Control on season	3573	98%
Q58e	Limiting engine horse power	3670	97%
Q58f	Limiting duration of fishing per day	3568	68%
Q58g	Limiting number of gears per boat	3532	68%
Q58h	Restriction on gear size	3557	98%
Q58i	Restriction on mesh size and number of hooks	3540	66%
Q58j	Ban on fishing practices declared as destructive in MFRA	1238	96%
Q59	Which among the following output control measures are necessary for sustainable exploitation		
Q59a	Harvest at MSY level	3442	95%
Q59b	Enforcement of minimum legal size (MLS) for major stocks	3504	93%
Q59c	Introduction of fleet quota system on selected resources	3315	94%
Q60	Are you satisfied with the present hygienic condition of fishing harbours	3757	96%
Q61	Are you satisfied with the present hygienic condition of fish markets	3790	96%
Q62	Do you consider the infrastructure for fish processing and marketing as sufficient	3758	96%
Q63	Do you consider that there is excess capacity in the seafood processing industry	3690	80%
Q64	Is the seafood processing industry getting sufficient raw material throughout the year	3658	94%
Q65	Do the exported Indian fishery products get maximum value abroad	3640	76%
Q66	Is there scope to diversify fishery products on par with international standards	3648	95%
Q67	Should the Indian fish and fish products be integrated with FSSAI benchmarks	1330	84%
Q68	Is there a need to improve the fish marketing value chain	1357	97%
Q69	Will it be beneficial to develop traceability and chain of custody standards for Indian marine fish and fish products	3651	95%
Q70	Do you think that adequate care is taken to reduce post-harvest losses	3702	74%
Q71	Are the wastes generated from fish processing properly utilized	3681	91%

QID	Question	Count	Yes (Green)/No (Red)
Q72	Do you think that there is excessive use of low value fish such as sardine in fish feed/ poultry feed/ manure industry	3710	71%
Q73	If so do you think that this should be regulated	3607	91%
Q74	Is the state of the marine environment in India healthy	3674	91%
Q75	Do you consider pollution as a reason for depletion of certain marine fish stocks	3733	95%
Q76	Do you think that there is no adequate waste processing on land leading waste dumping in the estuaries and seas	3766	72%
Q77	Is the level of plastics in the sea at a very high level	3720	66%
Q78	Do you think that discarding old nets in the sea will harm marine life	3773	66%
Q79	Do you consider climate change impacts as a reason for change in fish stock abundance	3729	95%
Q80	Is the unscientific port development along the coast of India a cause for erosion and accretion along the beaches	3727	98%
Q81	Do you consider mariculture as a method by which fish production in the country can be increased	3747	90%
Q82	Should the government formulate policies to help setting up of mariculture farms in the country	3777	98%
Q83	Is there sufficient seed production centers to cater to the mariculture activity	3776	69%
Q84	Should the government consider setting up hatcheries and mariculture parks for development of the sector	3752	99%

that there is excess capacity in the seafood processing sector and they are unable get sufficient raw materials for processing. Nearly 75% of stakeholders believe that post-harvest losses are adequately addressed, although a significant 25% do not think so.

According to stakeholders (>90%) the state of the marine environment in India is unhealthy and they perceive pollution as major reason for decline in fish stocks. Nearly 95% of stakeholders believe climate change is a reason for change in fish stock abundance. About 90% of stakeholders agree that mariculture is a method by which marine fish production in the country can be increased. They also overwhelmingly (>98%) support formulation of policies to set up mariculture farms/ parks and setting up government run hatcheries for seed supply for development of the sector.

In conculsion, this first of the kind national stakeholder survey paved the way for a wide-ranging and inclusive national policy on marine fisheries. Earlier, most stakeholders were unhappy with their non-inclusion in the expert committee and the lack of consultative process in the policy making process. Most of the comments made by stakeholders were incorporated in the final policy. It is hoped that this method will be adopted more often in future. A bottom-up rather than a top-down approach in fisheries policy making will ensure more compliance.

Acknowledgements

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Technology on seed production and culture of Indian pompano - A new potential candidate fish for coastal aquaculture and mariculture

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Species diversification is considered as an important means to enhance the aquaculture production. Pompanos *(Trachinotus carolinus* and *T. blochii*) are globally recognized as promising candidate species for mariculture because of their attractive appearance, fast and uniform growth rate, adaptability to culture environment, acceptability to formulated feed, firm white and tasty meat with high market demand. The broodstock development and seed production techniques for both florida pompano (*Trachinotus carolinus*) and silver pompano (*Trachinotus blochii*) was well established globally by the 1980s. Subsequently, farming technology for both was standardized and perfected. Presently, the aquaculture of pompano is being successfully practised in many Asia – Pacific countries like Taiwan and Indonesia.

Indian pompano (*Trachinotus mookalee*) belonging to the family Carangidae (jacks and pompanos) is a potential candidate species for marine and brackishwater aquaculture in India. It is reported to grow to a size of 90 cm in total length and upto 8.1 kg body weight. In offshore cages, when cultured for 9 months under captivity, the fish grew from 42.8 g to 969.90 g (Ranjan *et al.*, 2017, *Prioritized species for mariculture in India*, ICAR-CMFRI, Kochi, 450 p.). As the wild catch of Indian pompano is very low, the existing high demand for this fish among consumers can only be met through aquaculture. Realizing this the Visakhapatnam Regional Centre of ICAR-Central Marine Fisheries Research Institute has now developed broodstock, induced bred and produced larvae of the Indian pompano, for the first time in the world.

Broodstock Development

Juveniles of Indian pompano weighing on an average 45.1 g were collected using cast nets from the coast off Visakhapatnam and raised in RCC tanks fitted with Recirculatory Aquaculture System (RAS) for grow-out to adults. After 21 months of rearing, they reached an average weight of 2.84 kg and length of 47.6 cm and were then used as broodstock. During the grow-out phase, there were initially fed on artificial pelleted feed, after which they were fed progressively on low value fishes, squid meat and clam and oyster meat, respectively at 6 – 10% of biomass, twice a day.

For broodstock development, 18 fish in sex ratio (female: male) of 1:2 were selected and stocked in 125 t capacity circular RCC tank fitted with RAS for broodstock development. The fishes were individually tagged with a tag transponder (PIT TAG FS 2001) for identification and for maintaining a record of their gonadal development. The fishes were continually fed on fresh squid and clam meat twice (0900 and 1530 hours) in a day till satiation. Additionally, various vitamins namely, vitamin A (25,000 IU), vitamin B-complex, vitamin C (500 mg), vitamin E (400 mg) and vitamin-mineral mix were supplemented twice a week along with the feed to avoid any possible nutritional deficiencies in their diet. Excess feed was removed from the bottom of the tank after 30 minutes. Gonadal maturity was assessed fortnightly by live gonadal biopsy using a flexible catheter of 1 mm inner and 2 mm outer diameter. Biopsy was performed by anaesthetizing the fish using 200 ppm of 2-phenoxyethanol for 2 minutes or until the opercular movement was significantly reduced and then the fishes were cannulated to collect the gonadal tissue. The collected gonadal tissues were examined under a trinocular microscope with in-built photo-imaging system for morphometric analysis. Female oocyte development in Indian pompano is synchronous batch-type. One set of eggs of similar size was seen to develop synchronously, ready to spawn. Even before this set was spawned, immature oocytes were visible in the ovary samples. The numbers of immature oocytes was much higher than that of mature oocytes. Some medium-sized maturing oocytes were also visible; however, their numbers were very few. Final stage of vitellogenesis was observed in oocytes larger than 350 μm, which is marked by large opaque mass in the oocytes. The maximal vitellogenic oocyte diameter was 570 μm. Fish in the final stages of vitellogenesis with more than 500 μm were considered as mature The male became ripe after attaining 3.0 kg and were found to ooze milt on applying slight pressure to the abdomen.

The physiochemical parameters such as salinity (31.35 ppt), temperature (29.33 °C), dissolved oxygen (4.64 ppm), free carbon dioxide (0.18 ppm), total ammonia nitrogen (TAN) (0.037 ppm), nitrite (0.003 ppm), alkalinity (102.40 ppm) and pH (7.98) of the tank water were analyzed weekly and were found to be optimal for gonadal development, maturation and spawning.

Spawning induction and egg collection

Three induction trials with the same sex ratio were attempted for induced breeding of Indian pompano. Mature females containing vitellogenic oocytes with mean diameter larger than 500 μm and oozing males were selected for induction. Sex ratio (female to male) for induced spawning trial was 1:2. Females and males were injected with a single dose of human chorionic gonadotropin (hCG) at the rate of 350 IU kg^{-1} body weight and were stocked in the same tank for spawning. Spawning occurred within 36-38 hours (h) of induction at an average temperature of 29 °C. The spawned eggs from the broodstock tank were collected by passing the surface water through an egg-collecting chamber fitted with a hapa of 500 μm. While collection, eggs get sieved in the hapa, and then, the accumulated eggs were collected through a scoop net and treated with 20 ppm iodophore for 10 minutes and were finally stocked in 1 t FRP tank for hatching. Fertilization and hatching rate of the three spawning trials were estimated and were used as indicators for egg quality. Average fertilization rate was 69%. Fertilized eggs were differentiated from unfertilized eggs based on the colour. The embryonic development in fertilized eggs makes them transparent, whereas unfertilized eggs are opaque in colour. The size of the fertilized eggs of Indian pompano was 950-1000 μm which hatched after 18-20 h of incubation at temperature of 29 °C (Fig. 1). Average hatching rate was 87.67%.

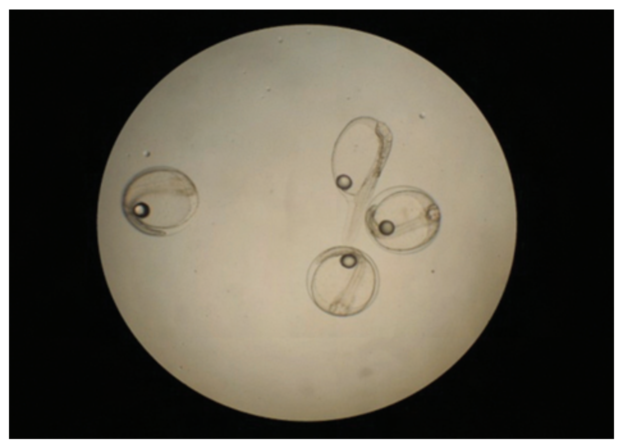

Fig. 1. Hatching of fertilized egg of Indian pompano in progress

Larval rearing

The hatched out larvae were stocked in 2 t circular FRP tank with 1 t sea water at the rate of 10 numbers per liter. The tank was provided with one central air stone with mild aeration. Larviculture was carried out using green water technique by employing different microalgae viz., *Nannochloropsis oculata* and *Isochrysis galbana* in 3:1 ratio @ 1 x 10^5 cells /ml. The morphological development of *T. mookalee* prior to metamorphosis was similar to that of other pompano species such as *T. blochii* (Abdul Nazar *et al.*, 2012, *Ind. J. Fish.*, 59(3): 83 -87). The newly hatched larvae were 2.12 ± 0.02 mm in total length with an oval shaped yolk sac of 0.55 mm^2 and an oil droplet of 0.06 mm in area. The body length increased to 2.58 mm on 1^{st} DPH while the yolk sac decreased to 0.06 mm^2. By 46 h post hatch, the yolk sac was almost absorbed, the eyes started to show visible pigmentation and mouth opened with a mouth gape of around 228.10 ± 1.31 μm. Enriched rotifers screened with 100 μm net and copepod nauplii were utilized as the initial feed during this stage. The yolk sac was completely absorbed by 3^{rd} DPH, when the larval body length was about 2.66 ± 0.03 mm. Larval body length reached about 4.64 ± 0.3 mm by 6^{th} DPH. By this time, the amount as well as size of rotifers given was increased to satisfy the feed demand. Larval body length reached about 6.35 ± 0.02 mm by 8^{th} DPH, with the appearance of the dorsal, caudal and pelvic fins. At this stage, enriched *Artemia* nauplii were fed to the larvae to grow faster. The larvae reached about 9.04 ± 0.06 mm by 10^{th} DPH, by this time, all fin types were well demarcated. Melanin pigmentation started from embryo development onwards which became intense as the larvae grew. Therefore, larvae body colour was dark till this stage. Artificial formulated feed was fed to the larvae from 12^{th} DPH, when larval body length reached about 11.91 ± 0.07 mm. Larvae started metamorphosis by 17^{th} DPH onwards, when larval body length reached 20.55 ± 0.08 mm and metamorphosis was completed by 21^{st} DPH, when larvae reached 27.33 ± 0.10 mm. The larval body colour changed from dark to silvery on completion of metamorphosis. The juveniles developed the entire components of all fins and fed on artificial pellets of 0.8 mm (Fig. 2). After 24 days of culture, length of the larvae increased to 32.8 mm. Specific growth rate per day estimated for Indian pompano during larval rearing was 11.4% which was found to be higher than that reported (8%) for *T. blochii* (Abdul Nazar *et al.*, 2012 *Indian J. Fish.*, 59(3):83-87).

Fig. 2. Metamorphosed larvae of Indian pompano

Larval rearing protocol developed for successful seed production is depicted in Fig. 3. The physiochemical parameters such as salinity, temperature, dissolved oxygen, total ammonia nitrogen (TAN) and nitrite of the tank water were estimated daily and maintained at the optimum level required for the larval rearing of marine finfish. Artificial lighting of 700-800 lux was provided to the tank by fixing fluorescent tube over the tank for duration of 14-16 h. During the larval rearing, an average survival rate of 21.53% was achieved till complete metamorphosis, which is a first record globally for *T. mookalee*. Critical period for larval survival in Indian pompano was between 5^{th} and 6^{th} DPH, when the larval mortality was observed in rotifer fed larvae. However, this has reduced significantly after feeding the larvae with copepod nauplii. In these rearing experiments, a systemic and overlapping regime of live feeds beginning from copepod nauplii and rotifer to *Artemia* and artificial pellets were utilized. The adequate supply of live feeds meeting nutritional requirements, as has been developed, holds the key for improving survival rates of *T. mookalee* larvae in future.

Nursery rearing and grow-out

Nursery rearing of Indian pompano was standardized with different feed and culture conditions. In rearing tanks, when nursed for a period of two months at a density of 150 numbers/m^3, fry weighing on an average 3.95 g reached 28.08 g with a weight gain percentage of 610. Fry were fed artificial pelleted feed containing 45 % protein and 10% fat during this period @ 10% of biomass four times a day. In ponds, Indian pompano fry weighing on an average 2 g were nursed in hapas at a density of 150 numbers/m^3 and the fry attained a weight of 20 g after 60 days of rearing. The feeding regime followed was similar. The produced fingerlings were either used for grow-out in ponds or were distributed to private entrepreneurs in

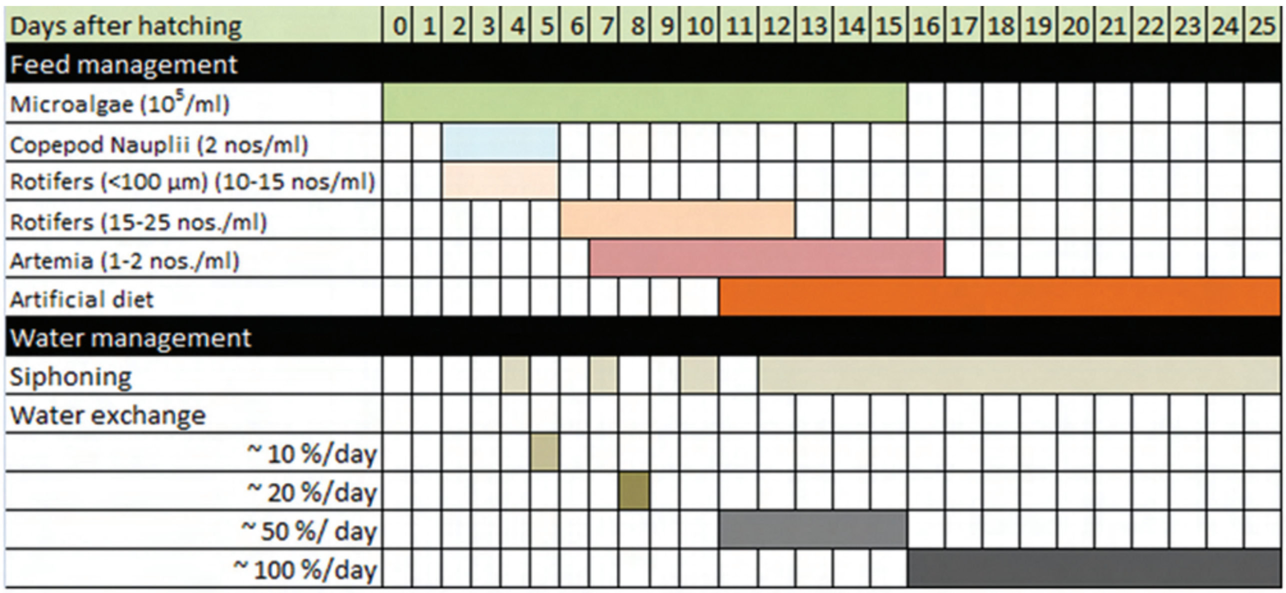

Fig. 3. Standardized feeding and water management protocol developed for larval rearing of Indian pompano

Andhra Pradesh. For stocking in ponds, advanced fingerlings of approximately 20 g size is ideal. Optimum stocking density for pond grow-out culture is 1 number/m^3. The fishes were fed with artificial pelleted feed having 40 % protein and 10 % fat @ 5-8% of biomass thrice a day. Aeration in the pond was an absolute necessity. Indian pompano reached 27.8 cm and 335 g after nine months of grow-out.

Nursery rearing and grow-out was carried out in marine cages (HDPE of 6 m in diameter) using hatchery produced seeds. Seeds weighing 2.5 g and measuring 5.25 cm were stocked at 35 nos/m^3 in 6m diameter HDPE cages with 8 mm mesh size inner net. Initially fish fingerlings were fed at 10% of body weight with commercial floating diet containing 45% crude protein and 10% fat twice a day. On attaining an average of 50 g body weight, the fishes were fed with floating pellets having 40% crude protein and 10% fat. The fishes were maintained at the same stocking densities till they reached an average body weight of 280 g after six months of rearing and thereafter, the fishes were stocked into two different stocking densities i.e. 15 and 20/m^3 in two different 6 m HDPE cages with inner net of 2.5 cm mesh size. Henceforth, fishes were fed with low valued finfishes (sardine, scad and tilapia) at 8-10% of body weight twice a day for a culture period of another six months. During the initial six months of rearing, fishes grew from 2.5 g to 280 g with an average FCR of 1.0:1.29 on artificial pelleted feed. In the next six months of culture, fishes stocked at 15/m^3 reached to 769 g with a calculated FCR of 1.0:4.98. The fishes stocked at 20/m^3 reached 478 g with a calculated FCR of 1.0:7.48 (Fig. 5). Specific growth rate for the fishes stocked at 15/m^3 and 20/m^3 were 1.83% and 1.69 % per day, respectively with an average survival of 93.6%. It was observed that feed acceptance of the fish for pelleted feed and low valued fishes were equally good. However, among low valued fishes, acceptance for sardine and Indian scad was comparatively better than tilapia.

Fig. 4. Indian pompano cultured in cage

Technology on seed production and culture of orange spotted grouper - A breakthrough for Indian mariculture

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Mariculture represents an immense opportunity for food production but remains a largely untapped farming activity. At present, the contribution of marine/coastal aquaculture production to the India's production (2014) is around 10% (0.49 million tonnes), in which crustaceans, finfishes and molluscs contributes 0.386 (7.9%), 0.09 (1.84%) and 0.014 (0.29%) million tonnes (t) respectively. The major reason for the low production levels in this sector is that unlike the freshwater sector, the contribution by the finfish is meagre and mainly limited to shellfish such as shrimps and prawns. The contribution of marine finfishes to the world culture fish production is around 8.5% but the revenue generation is more than 25% of the total revenue. While the current marine finfish production trends around the world shows positive trend, in India, significant growth in culture production of the marine finfish has not yet been achieved.

In India, the population growth is projected to be around 1.65 billion by 2050 and hence, nearly 10.5 million t of marine fishes to meet the food requirement is estimated. To achieve the huge fish production, significant contribution through mariculture/coastal aquaculture is essential as wild caught marine fish production of 3.5-4.0 million t reported for the last few years, has stagnated. Achieving the huge production through mariculture would be possible by species diversification using marine finfish species. Therefore, the seed production technology developed for the high value marine finfish, orange spotted grouper would definitely lead to enhancement in the fish production. It would also present enormous scope for foreign exchange earnings and food security of the country in future and also improve the livelihood of the fishermen.

In spite of having huge potential for mariculture India is still at the initial stage in marine finfish production. Unlike shrimps, the marine finfish culture has not been taken up in a big way due to several problems associated with marine finfish culture and mainly due to unavailability of fish seeds. Breeding and seed production of marine finfishes of high value have been expanding in recent years internationally. In India the development of hatchery technology for commercial level seed production of marine finfishes is still in its infancy, except for the Asian seabass (*Lates calcarifer)*, cobia (*Rachycentron canadum*) and snub nose pompano (*Trachinotus blochii*). Hence, research and development needs to be focused in evolving technologies for the seed production and farming of other highly valued marine food fishes.

Orange spotted grouper is highly prized in the world Live Reef Food Fish (LRFF) trade with several traits like fast growth, hardy in nature with tolerance to range of water salinities and high market value. Grouper culture was first introduced in the early 1970s in Singapore, Malaysia, Hong Kong, Thailand and Taiwan and is now practiced throughout south-east Asia with more than 20 species. Grouper culture was initially started using wild caught seeds (fry and fingerlings). Attempts at seed production of grouper started by 1990s and thereafter seed production technology was developed for some of the species. Research on breeding and seed production of orange-spotted grouper (*E. coioides* reported as *E. tauvina* or *E. suillus* in earlier publications) was started during 1970s. Natural and unstimulated spawning of this species in tank using spawners caught from wild was reported (Hussain *et al.*, 1975 Kuwait Institute for Scientific Research, Kuwait, 12 pp.). Successful induced spawning of the species in cage reared broodstock was also reported (Chen *et al.*, 1977 *Singapore J. Pri. Ind*, *5*: 1-21). Research continued and by 1999, groupers were cultured in many south-east Asian countries, including Indonesia, Malaysia, Philippines, Taiwan, Thailand, Hong Kong, south-east China and Vietnam, as well as other parts of the tropics in the south-eastern USA. More recently, other countries such as Sri Lanka, Saudi Arabia, South Korea and Australia have joined them. The establishment of hatchery seed production technology has helped in increasing orange spotted grouper aquaculture and the aquaculture production of the species has enhanced from 75 t in 2004 to 570 t in 2014. This fish fetches an average price of ₹ 1400 to 1500/kg in Live Reef Food Fish (LRFF) trade around the world, especially in Hong Kong. Envisaging the prospects of orange spotted grouper farming in India, broodstock development was initiated at the Visakhapatnam Regional Centre of the ICAR-Central Marine Fisheries Research Institute in 2010 and the first successful induced breeding and seed production was achieved during April 2013. With further efforts, the mass scale seed production with higher survival rates during larval rearing was achieved in October 2016.

Broodstock development and egg production

Dependable quantity of quality seeds of grouper from hatcheries is key to establishing reliable and sustainable grouper culture. The major bottlenecks in the development of commercial aquaculture are the control of reproductive processes of fish in captivity and production of biosecure and quality-certified fry. Broodstock management usually includes collection, selection and domestication of brooders as well as control of maturation, spawning and egg collection.

The broodstock at Visakhapatnam was developed in Re-circulatory Aquaculture System (RAS) of 8 m diameter and 2.5 m depth tank (Ranjan *et al.*, 2017 *Aquaculture Research* 48, 5864-5873). The wild collected adult female fish of 2-2.5 kg weight were stocked in November 2014. These were obtained from the commercial hook and line operations and transported live into 300 l tanks in the mariculture hatchery. After arrival at the hatchery, the fishes were relieved of barotrauma stress through specific procedures and then treated with 200 ppm formalin for 30 minutes followed by a freshwater dip for 5 minutes. After prophylactic treatment, fish with normal body shape, good colouration, devoid of any skeletal abnormalities and injuries were selected and stocked in an RAS tank. The sexes were identified by live ovarian biopsy using flexible catheter of 1 mm inner and 2 mm outer diameter and found that all collected fishes were females. After 15 days of stocking, a total of 15 fish were randomly selected for sex reversal from female to male and were implanted with a combination of 17$\propto$ methyl testosterone (MT) and letrozole at the rate of 5 mg and 0.2 mg per kg body weight respectively (Ranjan *et al.*, 2015 *Aquaculture Research* 46 (9), 2065-2072). The remaining 15 fish were left without any implantation for ovarian development. Thereafter, the females were cannulated every month to assess the diameter of the intra-ovarian eggs.

The fishes were continually fed fresh squid twice (at 0900 and 1530 hours) in a day till satiation. The fresh feed was given piece by piece enabling the fish to feed on the pieces in the water column itself before the feed fell to the bottom of the tank. Moreover, vitamin A (25,000 IU, USV limited, Nani Daman, India), vitamin B-complex (Pfizer, India), vitamin C (500 mg; Abbott Healthcare Pvt. Ltd., Thane, Maharashtra, India), vitamin E (400 mg) (Merck, Goa, India) and vitamin–mineral mix (Agrimin Forte, Virbac Animal Health India Pvt. Ltd., Mumbai, Maharashtra, India) were supplemented twice a week along with the feed to avoid any possible nutritional deficiencies in their diet. The excess feed was removed from the bottom of the tank after 30 minutes. After 3 months of stocking in the tank, females underwent final oocyte maturation with 65.53% of the ova having more than 400 μm size. The hormone implanted female fish got sex reversed to male and were found to be oozing after 2 months of implantation. The natural spawning of orange spotted grouper started from February 2015. The egg collection net of 500 µm was fixed in egg collecting chamber connected to broodstock tank. Early next day eggs were collected by passing the surface water through the egg collection chamber. These eggs were treated in 20 ppm iodine solution for 10 minutes and stocked in aquarium for incubation. The eggs hatched after 18-22 hours (h) of incubation at a temperature range of 28-30 °C (Figs. 1 & 2). A total of 47.23 million of eggs were produced with an overall fertilization and hatching rate of 80.44 ± 0.56% and 85.79 ± 0.50%,

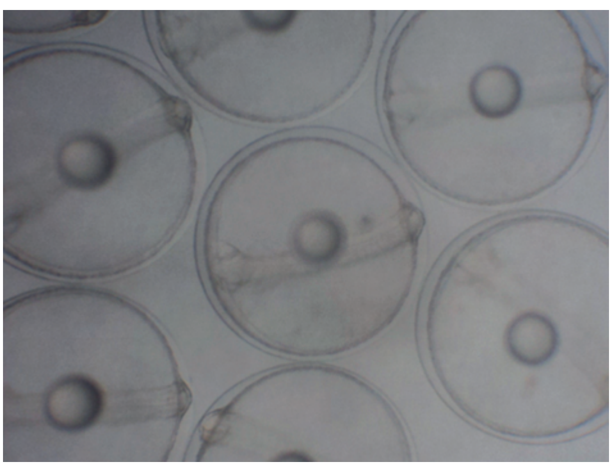

Fig. 1. Initiation of hatching process of fertilized eggs of grouper

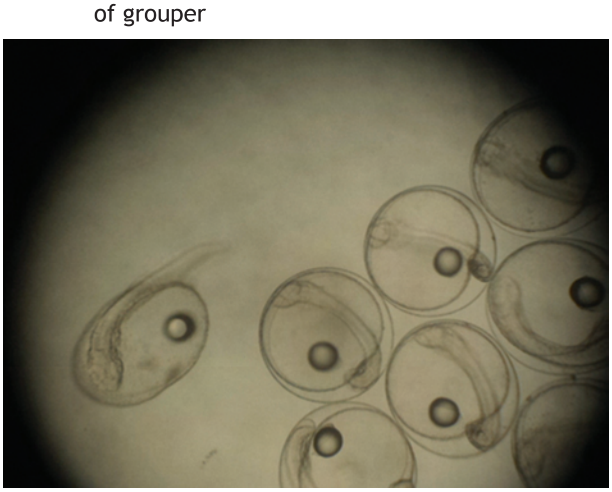

Fig. 2. Hatching process of the fertilized eggs

respectively, without any hormonal intervention during the spawning. The use of an RAS ensured year-round natural spawning of orange-spotted grouper. The newly hatched larvae measured 1.2-1.6 mm in total length. The mouth opening was formed after 52-56 hours at 28-30 °C at a length of around 1.8-2.0 mm.

Larviculture and seed production

The newly hatched larvae of orange spotted grouper measure 1.2-1.4 mm total length. The mouth opens between 2-3 days after hatching (around 60 hours) and the yolk is completely absorbed by 3rd-4th DPH (Days Post Hatching). At the time of mouth opening, mouth gape was 120 µ which increased to 180 µ after 10-12 hours. The stomach and eyes becomes pigmented on 3rd DPH. From 4th to 6th DPH, there are no major morphological changes, but pigmentation around the stomach increases. At 8th DPH, the buds of the dorsal and pectoral spines appear and by 10th-25th DPH, most of the orange spotted grouper larvae have elongated dorsal and pelvic spines typical of serranids larvae. When the larvae are reared at high densities, they often get entangled because of these spines. This leads to high mortalities between 10th and 25th DPH. After 25th DPH, body pigmentation increases and the larvae appear darker in colour. The dorsal and pectoral spines begin to recede. Orange spotted grouper larvae show drastic changes in their shape as they grow from the newly hatched larva to the juvenile stage, just like in other serranids. The larvae before metamorphosis to the juvenile stage are highly sensitive to environmental conditions and substantial mortality occurs even due to minor stresses. Orange spotted grouper larvae metamorphose to juveniles at about 33rd- 37th DPH, but this can be delayed because of low water temperatures and poor nutrition. After metamorphosis, cannibalism starts with larger larvae attacking the smaller ones. As the orange spotted grouper larvae are highly sensitive, careful management is required throughout the larval-rearing phase. Standard methods for larval rearing are to be applied. Artificial lighting from hatching day (= day 0) was provided as follows: at day 3 when larvae start feeding, from 07:00 to 24:00; at days 4 and 5, continuous; at day 6, from 07:00 to 22:00; at day 7, 07:00 to 20:00. Natural lighting is provided from day 8 onwards. Aeration is to be provided in a 'grid' pattern to ensure even mixing of the water in the tanks and to ensure proper maintenance of dissolved oxygen levels throughout the tank (Sugama *et al.*, 2001 *Manual for the seed production of Humpback grouper*, *Cromileptes altivelis*. Gondol Research Institute for Mariculture and Others. 37 pp.). Airstones are placed in each corner of the tank to prevent stagnation. Aeration is mild during the early stages of larval rearing to avoid physical damage to the larvae. However, it is increased gradually with progression of the larval-rearing cycle when the larvae become more robust. The sea water used in larval-rearing tanks is pre-treated through sand filter to remove particulate matter and is then ozone (0.1 ppm) sterilized to eliminate pathogens. The recommended initial stocking density for orange spotted grouper is 10 larvae/litre (l). Oil is generally added to form a thin film on the water surface (around 0.2 ml/m^2) during 1st-3rd DPH for preventing surface aggregation mortality in early-stage grouper larvae.

Larviculture protocols were developed by appropriate management of live feeds in suitable quantities and also taking into consideration the nutritional requirements of the larvae. The larvae are stocked in FRP tanks of 2 t capacity for larviculture (Fig. 4). The intensive larviculture tanks are provided with green water (*Nannochloropsis* sp. and *Isochrysis* sp. 3:1 ratio) at a density of about 1 x 10^5 cells/ml and screened rotifer with 80 μm enriched with ALGAMAC at a density of 5-10 numbers/ml from 3 to 5 DPH. The copepod nauplii are added @ 2 numbers/ml. The critical stage for the larvae is 3 to 5 DPH when they shift to exogenous feeding from yolk sac feeding. The larvae are fed with rotifer screened with 100 μm from 6th DPH onwards at a density of 10-15 numbers/ml, which is gradually increased to 20 numbers/ml from 11th to 18th DPH. Rotifer density gradually decreases with increase in the rate of rotifer consumption by the larvae and eventually by 30th DPH, the rotifers disappear. Freshly hatched out *Artemia* nauplii are fed at density of 1 individual/ml from 15th DPH and their size increasing with advancing in rearing period. Adult copepods are fed during 16th-20th DPH in larval rearing. Weaning of grouper larvae with artificial diets starts from 15th DPH. Artificial diet with a particle size of 100-150 μm is used initially. The formulated feed is sprinkled onto the surface of the water in small amounts frequently throughout the day. Formulated feed is added in small amounts so that the feed is consumed within 5 or 10 minutes, as excess feed should not be allowed to accumulate on the bottom of the tank where it get decomposed and degrade water quality. The size of particulate feed is increased to 400–800 μm from 30th-45th DPH. In addition, minced fresh fish meat is fed from 30th DPH.

Fig. 3. Larvae of orange spotted grouper reared in green water system

Larval-rearing tanks are maintained statically until 11th DPH, and then from 12th DPH, 5-10% of water exchange per day is required to maintain the rearing water quality. Water exchange is increased to 20% per day, when both rotifers and copepod are being fed together (15th-20th DPH). Water exchange gradually increases to 50% per day from 25th DPH, and is 100% per day from 35th DPH. Bottom siphoning of the tank is started on 8th DPH. From 12th DPH, faeces, dead larvae and uneaten food accumulate on the tank bottom which should be siphoned out at least once daily for maintaining water quality.

A survival of more than 12 % is achieved during the larval rearing. From 35 DPH, grading of larvae is started. The shooters are fed exclusively with the artificial feed of size 500-800 μ. The grading is performed weekly for at least 2-3 weeks to segregate bigger juveniles from smaller to avoid cannibalism. The juveniles measuring 2.5-3.0 cm length (0.4g) (Fig. 4) are ready for stocking in hapas, cement tank or in pond based hapa for nursery rearing for another two to three months.

Fig. 4. Juveniles ready for nursery rearing

Nursery rearing

The nursery rearing of orange spotted grouper is standardized with different feed and culture conditions. Nursery rearing of grouper comprises of two phases. In the first phase, 2.5-3.0 cm (0.4g) fry are cultured in tank for 2 weeks till they accept artificial feeds fully, by which time they reach upto 5-6 cm. The fry during this period is reared in 1 t capacity tank @ 1 number per litre. They are fed on artificial diet and *Artemia* for completely weaning the larvae to artificial feed. Artificial feed containing 45 % protein and 10 % fat is used during this period. Grading is performed every 5 days to grade the larvae according to size. The second phase consists of growing 5-6 cm size to 10-15 cm for stocking in cage as well as in pond. During this period, the fingerlings are reared either in pond based *hapa* (2 mm mesh size), flow through cement tank (Fig. 5) or in re-circulatory system. Pellet feed with different protein levels and minced fish meat are used as feed, among which pellet feed with 45% protein exhibits the highest growth. The rearing system is also found to influence the growth rate, where highest average daily weight gain of 0.59g per day is observed in RAS, followed by 0.4g per day in pond and 0.26g per day in cement tanks. In all the rearing systems, fingerlings of 2-3 g stocked grew to an average size of 15-20 g after a month when fed with pellets containing 45% protein. The fingerlings produced have been distributed to private entrepreneurs in Andhra Pradesh, Tamil Nadu, Kerala and Karnataka.

Fig. 5. Fingerlings reared in *hapa* in cement tank

Grow out culture

Advanced fingerlings are stocked in 6m diameter floating HDPE cage for grow-out. The fishes are maintained here for one year during which different mesh sizes are used at different period of the culture depending on the size of the fish. Advanced fingerlings of approximately 10 cm (15g) are an ideal size for stocking either in cages or ponds for culture. These can reach around 1 kg after 10-11 months of culture in the cages (Fig. 6). Initially the fishes are stocked in cage with 1 cm mesh size net. On reaching 100 g size, fishes are transferred to cages with 2

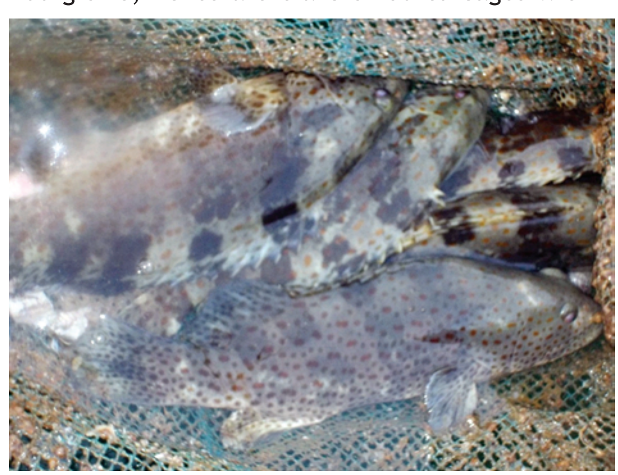

Fig. 6. Grow-out system in cages

cm mesh size nets and finally on reaching 500 g size, they are stocked in 5-6 cm meshed net cages till harvest. During grow-out, low valued fish (sardine, scads, tilapia, etc) is considered as good feed. Additionally, pelleted feed with 40% protein content is also used for grow-out. Net exchange is performed once in 30-45 days for proper management. Based on experience obtained from different trials, fish stocked at 15 g grew to 250g, 500g and 1000g after 6 months, 8 months and 12 months of rearing in cages. The stocking density of 15-20/m^3 is found to be optimum for cage reared grouper.

Indigenous Re-circulatory Aquaculture System (i-RAS) developed for fish nutrition research

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Fish nutrition research is an integral part of aquaculture research. The nutrition research requires a well equipped wet laboratory to conduct research in an effective manner for acceptable research findings. Adequate quantity and quality of water is a prerequisite for research in aquaculture. Also, maintenance of water quality parameters in the optimum range is crucial for the well-being of fish kept in the experimental system. An appropriate filter assembly can maintain the quality of water within the acceptable limits and simultaneously reduce the usage of water. Therefore, an indigenous re-circulatory filtration assembly was set up using 1.25 t capacity rectangular FRP tank (2×1×0.6 m^3) for conducting fish nutrition experiments. The tank was partitioned into five compartments using 10 mm thick glass slabs fixed to the inner walls of FRP tank using silicone gel. The partition may also be done by FRP sheets of 5 mm thickness for better pressure proof during the course of operation. The first compartment was filled with multi layers of bio-sponges in varying pore sizes which helps in the filtration of undissolved and suspended particles from the outlet water. The second partition was filled with bio-balls and ceramic bio-rings which harbors beneficial bacteria for nitrification and de-nitrification process that will reduce the ammonia load in the system. The third compartment was packed with coral sand and oyster shells which complement the role of bio-balls and additionally maintains the pH of the system without much fluctuation. The fourth section was filled with wood charcoal in a net bag for easy handling and cleaning which effectively removes chlorine, volatile organic compounds, odour and improves the clarity of water through adsorption process. The fifth partition was designed for the collection of filtered water at least 500 L capacity. In this compartment, a submersible pump (115W) with an output capacity of 5000L h^{-1} was kept for pumping the filtered clean water to experimental tanks. Further improvement in filtration efficiency is possible by the installation of indigenous type protein skimmer and UV lamps in the filtration chamber which is effective in reducing the organic as well as microbial and parasitic loads in the system.

A battery of 12 numbers of 200 L capacity glass aquarium tanks or FRP tanks can be connected to one indigenous filtration assembly of 500 L filter water capacity for effective operation of re-circulating aquaculture system. Water supply to the experimental tanks was made through nozzles (2 mm) made in PVC pipe (25 mm diameter.) kept on the top of the tank. The inlet water sprinkled on the top of the experimental tanks serve the function of mixing and aeration of water in the tanks.

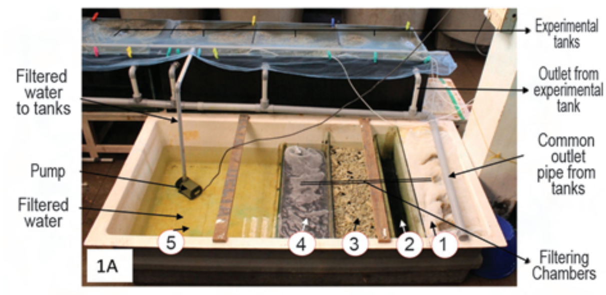

Fig. 1. Filter assembly showing different components (Numbers 1-5 indicates respective compartments) of indigenous Recirculatory Aquaculture System (i-RAS)

Circulated water leave the tanks through outlets fitted on the top corner of the tanks and will be collected in the common outlet pipe which leads to the first compartment of the filter assembly, which gets filtered through different compartments and subsequently gets collected in the fifth compartment (Figs. 1 & 2). Water circulation can be maintained round the clock at a flow-rate of 5 L min^{-1} in each tank. The first compartment of the filter filled with sponge bags and sponge mat were routinely (weekly) taken out, cleaned, dried and replaced with cleaned sponge bags. The components of rest of the compartments were cleaned and replaced on a monthly basis. It is also advisable to siphon the tanks if uneaten feed remains in the tank even after the stipulated time for normal feed consumption, which may reduce the overall load to the filtration assembly. At the time of feeding, water circulation should be stopped for effective feeding, to reduce feed leaching and also for better observation of fishes and feeding activity.

Fig. 2. Indigenous RAS in operation

The experimental tanks should be covered with 20 mm mesh size nylon braided nets to protect the fishes from predatory birds enters inside the laboratory and also to prevent the fishes from leaping out of water. During the initial stages of culture experiment until the fish reaches up to 10 g size, the outlets should be fitted with small sized mesh nets (10 mm) to prevent the escape of fish through the outlet. Under high stocking density, the water circulation should be maintained continuously. Any break in water circulation for more than 3 hours results in severe anoxic conditions in the experimental tanks, which further leads to stress that cause release of copious amount of mucous and sloughing of mucous from the skin. This occurs in most of the marine food fish species which are highly sensitive. Subsequently the fish becomes prone to any opportunistic pathogenic infections. Hence, the type of system mentioned here can be considered ideal for conducting nutrition experiments in marine fish in the weight range of 5 to 250 g.

Occurrence of marine shells and fossilized fish vertebra from two inland sites in Vaikom, Kerala

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Studies conducted by the Geological Survey of India published in the 1980s indicate several transgressions and regressions of sea along the coast of Kerala occurred during the Pleistocene and Holocene era corroborating the mythological concept of Kerala's emergence from the sea.

Reports of unearthing marine molluscan shells, hard corals, parts of sea-going ancient vessels etc from Pattanakad, Thaikkal and Muziris along the Kerala coast are also available. The occurrence of stony corals and marine molluscs observed from a well – cutting at Vazhakala 9 km away from seashore near Kakkanad, Cochin at a depth of 8 m from MSL during February 1995 was reported (Pillai *et al.*, 1999, *Indian J. Mar. Sci., 28:96-98*).

During March 2016 some shells of marine molluscs and woody stem of some plants were found at a depth of 8-10 m in the mud excavated from the piling pit of a house construction site near the famous Vaikom Sree Mahadeva Temple which is one of the oldest Siva temples in Kerala. In the ancient sanskrit text such as *Bhargavapurana* and *Sanalkumar Samhitha* Vaikom is mentioned as Vaiaghragham or Vaiaghrapuram and later under the influence of Tamil the name probably transformed to Vaikom.

Shells were recovered from the clay sediment (9° 45' 066" N ; 76° 23' 620" E) among which, 8 species of mollusc shells were documented (Fig. 1 and Table. 1).

Similar collection of shells and vertebrae of some finfish were recovered from a 3 m deep pond during the pond renovation work near Thirumani Venkitapuram (T.V. Puram), located 6 km south of Vaikom (9° 42' 13" N; 76° 23' 05" E). A total of 17 species consisting of five gastropods and nine bivalves were observed. The shells of *Turbinella* and *Chicoreus* were mineralized and fish vertebra was fossilized. Other shells were intact and fresh when collected. These shells were washed and cleaned

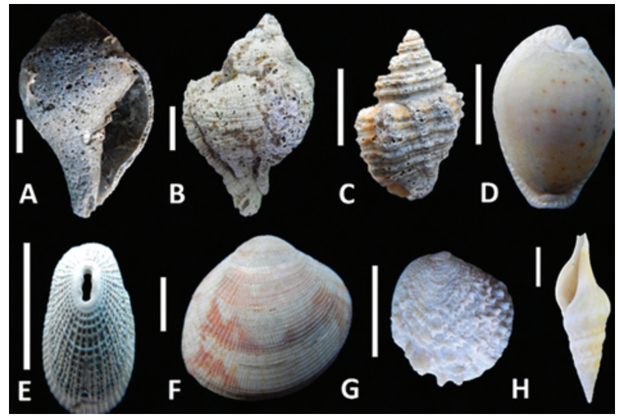

Fig. 1. Shells collected from Vaikom; A: *Turbinella pyrum*, B: *Chicoreus virgineus*, C: *Cantharus tranquebaricus*, D: *Erronea errones*, E: *Diodora ticaonica*, F: *Gafrarium divaricatum*, G: *chama* sp. and H: *Unedogemmula* sp. (Scale bar= 1 cm).

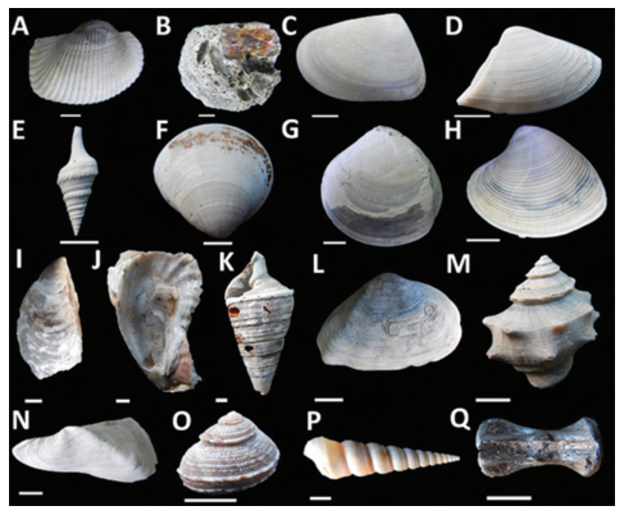

Fig. 2 Samples collected from T.V. Puram; A: *Tegillarca granosa*, *B: Crassostrea* sp., C: *Donax spinosus*, *D: Donax* sp., E: *Unedogemmula indica*., F: *Meretrix casta*, G: *Meretrix meretrix*, H: *Callista* sp., I: *Perna* sp., J: *Saccostrea* sp., K: *Telescopium telescopium*., L: *Tellina* sp., M: *Thais* sp., N: *Trisidos tortuosa*, O: *Turbo* sp., P: *Turritella* sp. and fish vertebrae (Scale bar=1 cm)

Table 1. List of marine molluscan species and their physical dimensions collected from the site near Vaikom

Scientific Name	Number of shells collected	Length range (mm)	Weight range (g)	Accession number
Turbinella pyrum	2	63.9-112	34.1-227	DB.30.2.1.1
Chicoreus virgineus	1	54.2	23	DB.22.7.5.1
Cantharus tranquebaricus	1	35.8	6.9	DB.24.2.1.1
Erronea errones	1	31.7	6	DB.15.5.1.1
Diodora ticaonica	1	16.6	0.25	DB.21.1.5
Gafrarium divaricatum	2	22.3-35.3	1.2-4.8	DC.17.2.9.1
Chama sp.	1	15.4	0.56	DB.9.4.1.1
Unedogemmula sp.	1	51.7	6.2	DB.3.4.3.5

with fresh water and later identified to species level (Fig. 2. and Table 2). These shell samples were deposited in Designated National Repository (DNR) of ICAR CMFRI with accession numbers for future reference.

Both the observation sites are more than 10 km away from seashore and are situated adjoining the Vembanad Lake system. It is well known that the floods in the year 1341 believed to have brought into existence of Vypin Island from the sea. Earlier reports on the existence of marine fossils including reef forming corals at Vazhapalli, Changanacherry (Menon,1967. *A Survey of Kerala History*, N.B.S., Kottayam), Vazhakkala, Ernakulam district (Pillai *et al.*, 1999 *Indian J. Mar. Sci., 28:96-98*) and the present observations appear to indicate that the western part of Kerala did emerge from the sea through regressions.

Table 2. List of shells and fish vertebra collected from T.V. Puram

Scientific Name	**Number of shells collected**	**Length range (mm)**	**Weight range (g)**	**Accession number**
Tegillarca granosa	1	50.6	8.5	DC.1.1.1.1
Crassostrea sp.	2	46.4-50.4	16.3-22.9	DC.3.3.8
Donax spinosus	2	22.8	0.60	DC.18.2.8
Donax sp.	1	30.1	0.93	DC.18.2.7
Unedogemmula indica	2	28.1-30.9	0.63-0.85	DB.3.4.2.5
Meretrix casta	2	33.7	4.3	DC.17.5.10
Meretrix meretrix	1	70.4	21.6	DC.15.4.1.1
Callista sp.	2	39.1-44.4	1.65-4.4	DC.17.2.10
Perna sp.	4	36.5-39.1	1.3-1.8	DC.3.3.7
Saccostrea sp.	3	23.7-74	-	DC.11.4.1
Telescopium telescopium	2	96.9-103	42.9-80	DB.8.1.3.1
Tellina sp.	3	32.9-45	1-6.3	DC.17.3.1
Thais sp.	2	18.1-39.2	0.60-10.6	DB.22.9.2.1
Trisidos tortuosa	2	32.7-58.3	1.3-4.5	DC.3.1.10.1
Turbo sp.	2	13-16.7	0.68-1.3	DB.4.2.8
Turritella sp.	6	31.6-73.7	0.9-23.9	DB.6.1.2
Notocochlis tigrina	1	11.9	0.47	DB.14.1.1
Vertebra of some finfish	1	23.7	4.1	Misc.55

Emergence of night fishing using LED lights for live-baits in Lakshadweep

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The pole and line fishery for skipjack tunas depends totally on consistent supply of live-bait fishes. Small sized fishes belonging to the families clupeidae, apogonidae, pomacentridae, ceasionidae, atherinidae etc constitutes the bait fishes. These are caught from the sandy areas inside the lagoon or coral boulders and reef flats. The pole and line fishing involves release of live-baits in to the sea to attract and retain the tuna shoals near the boat for fishing.

Live bait collection in Lakshadweep has been limited to day time unlike many other nations in the region where the baits and other fishes are attracted and collected during night with the help of lights. During a recent study in January 2018 at Agatti Island, night fishing for live-baits using LED lights was observed. Collection of baits are made late in the night to early next day (12.00 to 05.00 AM).

LED lights (12 V) are fixed to the outer side of the boat with help of 1.5-2 m long poles to attract the fishes (Fig.1). Storage batteries of capacity 12 to 24KW are used for operating the LED lights. On reaching the ground, the fishermen switch on the light and wait for the bait to aggregate under the light in sufficient quantity. Attracted by the light source, the bait fishes gradually gather near the boat. Once sufficient quantity of baits aggregate, the fishermen catch the bait using a lift net. The lift net used for collecting the aggregated baits is made up of 5 mm mesh sized 6 x 4.5 m nylon net tied with coral stone and rope at four corners. At the outset, two fishermen jumps in to the water both carrying end of one rope each while the net is left to sink to bottom by weight of the stone. Other two ends of the rope is retained in the boat. These two fishermen keep the net spread to the bottom and remain away from the boat while observing the bait aggregation. When sufficient bait has aggregated, the net is slowly lifted by pulling the ropes in tandem from all the four corners. As the net surfaces, the end of the net away from the boat is raised slightly faster by the swimming fishermen to prevent movement of the bait out of the net. It is then handed over to the fishermen on the boat who quickly lift the net completely out of water and transfer the bait to the bait tank.

The night fishing at present targets only the *Spratelloides delicatulus* (Fig. 2) though a closely related species *S gracilis* is also caught occasionally especially in the deeper part of the lagoon. Though many species of fishes including wrasses, half beaks, full beaks etc also get attracted to light, they mostly escape from the net during the lifting process as they don't aggregate in shoals. The bait collection is best done during dark nights *i.e* first and last quarter of the moon's phase. The fishermen carry out night collection of baits only when they are set to target tuna shoals near anchored fish aggregation devices (aFAD) or when the shoals are expected in the vicinity of the islands. Fishermen report that night collected bait has shorter survival period (4 to 5 hours) than daytime collected bait (9 to 12 hours). Hence the same cannot be used for fishing from free shoals where the shoal scouting time is normaly very long. Also, the fishermen may have to fish from multiple shoals appearing at different time of the day keeping the fishing time very long. Though the FADs are often set away from the island, the fishermen complete their fishing faster as the catch

Fig. 1. Lights set at the outer side of the boat

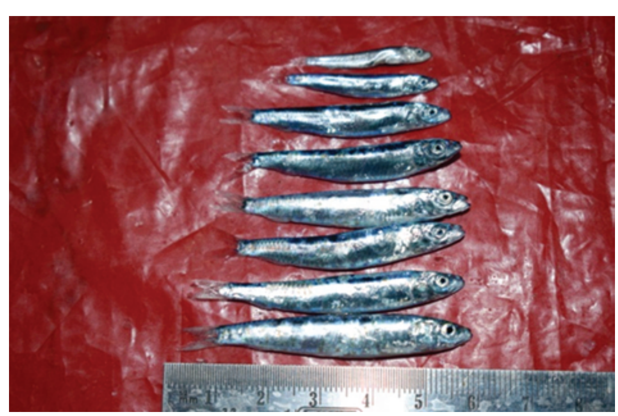

Fig. 2. Size range of *Spratelloides delicatulus* from the fishery

is almost assured near the FADs, especially when there is good aggregation and the boats are able to return of base before noon. As such, night collection of the tuna live-baits in Lakshadweep is limited to only a few days during the fishing season at present.

The by-catch is low at present mainly because the fishing is done inside the lagoon and in sandy areas only as the target species are sprats. The catch composition may be different if the target species is any other groups such as fusiliers, cardinal fishes or damsels, that mainly inhabit the outer reef areas and live close to corals. The fishery therefore needs to be monitored further for impacts on the ecosystems.

Report on *Amyloodinium* spp. cysts infection in clownfish

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A study was undertaken to record the occurrence of parasitic infections in ocellaris clownfish, *Amphiprion ocellaris* (Fig. 1). Of a total eight *A. ocellaris* maintained in hatchery, three were found infected with different developmental stages of *Amyloodinium* spp. and were kept under observation.

Fig. 1. *Amphiprion ocellaris*

Clinical signs and symptoms observed were that the infected fishes became lethargic and came to the surface water of the tank which could be due to respiratory problems developed by the invasion of the parasites. External examination revealed slight dorsal and pectoral fin erosion. Gills were pale in colour with high mucus secretion. Liver and other internal organs did not show any clinical signs of infection. Loss of appetite and irregular swimming behaviour was observed in the infected fishes. The infected fishes were brought to the laboratory in axenic condition. These fishes were processed for standard necropsy study and vital organs like gills, skin, fins, intestine and kidney were examined under microscope for the presence of parasites.

Results indicated that *A. ocellaris* maintained in the hatchery were infected with *Amyloodinium* spp. and prevalence of infestation was 37.5%. The presence of ovoid cysts in the vascular tissue of the gill lamellae were identified as developmental stages of *Amyloodinium* spp. Wet mount of gill revealed numerous groups of brownish round to ovoid structures, each group contains four spherical

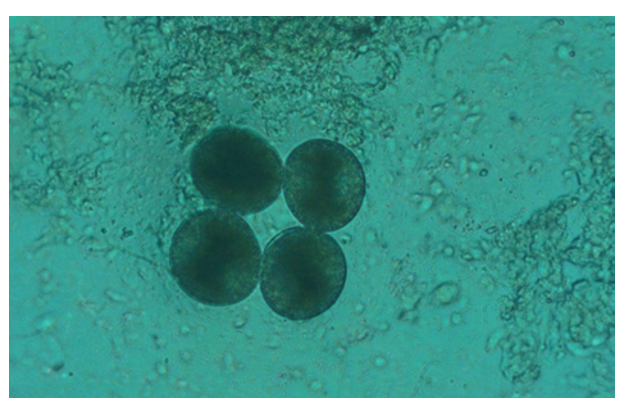

Fig. 2. Wet mount of gill of *A.ocellaris* showing tomonts of *Amyloodinium* spp. (400x)

structures in clusters (Fig. 2), which are presumptive tomonts of *Amyloodinium* spp. In addition, clusters consisting of 2-16 spherical forms were also observed (Fig. 3). Similar structures were reported in silver pompano, *Trachinotus blochii* (Kumar *et al.*, 2015 *Indian J. Fish.*, 62 (1): 131-134).

The infected fishes were shifted to quarantine facility and treated with formalin dip (10 ppm) followed by freshwater bath treatment for ten minutes with vigorous aeration. All fishes recovered from the infection after the treatment. However, avoiding potential source of infection is recommended for successful maintenance of healthy ornamental fishes in marine aquariums.

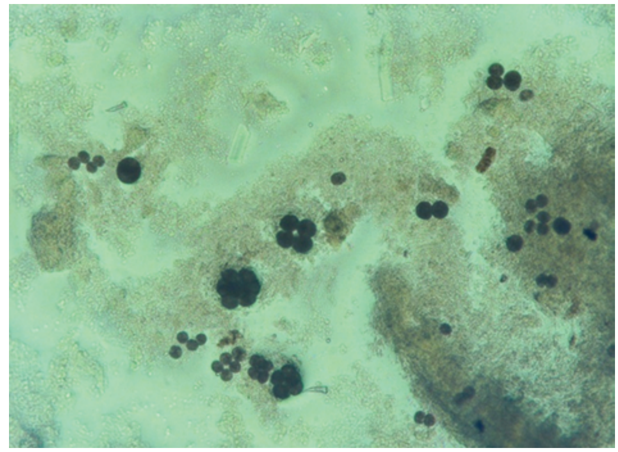

Fig. 3. Clusters of *Amyloodinium* spp. cysts with 2-16 spherical forms in gill tissue of *A. ocellaris* (100x)

Record of double operculum in silver conch

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Lentigo lentiginosus Linnaeus, 1758 is a caenogastropod belonging to the family Strombidae. The species is found in coral reefs and shallow parts of lagoon and widely distributed across Indo-Pacific region. The shells are moderately large, solid with a characteristic deep stromboid notch, and a flared, very thick and posteriorly expanded outer lip with a pinkish cream aperture and glossy parietal wall. Size of the shell varies from 55 to 104 mm in length and used in shell crafts industry. A medium sized silver conch, *L. lentiginosus* with an anomaly (double operculum) was observed during sampling at Kavaratti Island, Lakshadweep in January 2018. The silver conch had two operculums attached to the muscular foot. It and collected at a depth of 1.5 meter by skin diving. Morphometric

Silver conch (Shell on)

Silver conch showing two operculums attached to the foot measurements were recorded. The total length (TL) of the specimen was 72.21 mm with width of 44.66 mm and length of the aperture canal was recorded as 49.03 mm. The natural operculum was 18.57mm in total length with width of 5.10 mm and the additional operculum was 10.94 mm in total length with the width of 3.75 mm. The probable explanations for the anomaly could be genetic, pollution or repair due to injury. Reports of such anomaly in strombs is very rare.

A brief note on the ribbonfish *Tentoriceps cristatus* from the southwest coast of India

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Tentoriceps cristatus (Klunzinger, 1884) commonly called as crested hair tail is a monotypic genus of cutlassfish family Trichiuridae. During the experimental fishery survey conducted by *FV Silver pompano* on 28 September 2016, specimens were obtained in the trawl net operated off Alappuzha (09º 21'N, 75º 56'E and 09º 21'N, 76º 18' E) at a depth of 50- 60m along with other fishes and crustaceans. Length and weight of the specimens ranged between 57.1 - 73.1 cm and 84.4 - 142 g respectively. The distinguishing morphological characteristics included an elongate body silvery in colour, profile of head convex, front teeth without barbs, pectoral fins short, not reaching the lateral line and pelvic fin represented by a pair of scalelike structures inserted below 9-12th dorsal fin ray. Biological analysis revealed 87% were male. 13% were female with mature (Stage V) gonads. The egg diameter ranged from 0.3 - 0.9 mm. Most of the fishes had empty stomachs (97%) or half full stomach with semi digested fish. Voucher specimen (GB 31.153.9.5) was deposited in the National Designated Repository (NDR) of ICAR- CMFRI, Kochi. This is the first report of the species from the south-west coast of India.

Fig. 1. *Tentoriceps cristatus*

Red-toothed triggerfish emerges as the popular live bait for handline based yellowfin tuna fishery in Lakshadweep

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Live-bait is an integral part of pole and line tuna fisheries of Lakshadweep waters. Nearly 14 species belonging to families Dussumieriidae, Apogonidae, Caesiodidae, Pomacentridae, Emmelichthyidae and Atherinidae are collection island to island and seasonal variations in species dominance. *Spratelloides* spp., *Apogon* spp., *Archamia* spp, *Ceasio* spp., *Pteroceasio* spp., *C caeruleus, L. tapainosoma* and *Spratelloides delicatulus* are the most dominant live-bait species across atolls.

Fig. 1. Red toothed triggerfish

However, species and size of bait for pole and hand-line fisheries of yellowfin tunas differ from those for skipjack tuna. Relatively larger fishes belonging to the family of damsels and fusiliers are the common baits for the yellowfin tunas.

In recent years, red-toothed triggerfish, *Odonus niger* (Fig. 1) has been observed to be gaining popularity as live bait in hand-line fishing for larger yellowfin tuna in most of the islands of Lakshadweep. It is found in the lagoons and shelves. The *Ceasio* spp. and *Pteroceasio* spp. (fusiliers) which were commonly used as live baits for the yellowfin tuna are presently scarce. Though the preferred bait is still fusiliers, *O. niger* which is easy to catch and hardy for handling has a comparatively higher survivability in both live-bait tank onboard and live bait storage cages used for storing excess bait in the lagoon.

Presently, *O. niger* is abundantly available throughout the outer reef of the Islands and at times inside the lagoons at depths ranging from 5 and 30m. The fish is caught by specialized live bait lift net having mesh size of 8 mm. Two sizes of nets 12 x 12 m and 15 x 15 m are commonly used depending on the size of the boat. The fishers spread the live bait net in the water column with the help of four fishermen swimming with the bridles. One of the fishermen carry *chum* (fish paste ball made up of chopped fish waste covered in a piece of mosquito net) tied on a rope and drop it into the sea slightly away from the net. The juvenile *O. niger* gets attracted to the fish chum and congregate in large numbers. Then, the fishermen slowly bring the chum along with the aggregated trigger fishes into the centre of the live bait net spread. The fishermen then hand over the bridles of the net to the boat for lifting the same gradually and put the bait-fishes caught into the bait tank onboard. The fishermen at present are able to catch sufficient bait in one or two operations of one to one and a half hours duration.

Size of *O. niger* used as live-bait for yellowfin tuna vary from 5 to 10 cm. On reaching the yellowfin tuna ground, the fishermen release the *O. niger* into the sea for attracting the yellowfin tunas from depths. Meanwhile, they release hand lines baited with relative larger sized baits and wait for the tunas to get hooked. Due to the convenience of catching and handling the *O. niger*, even the smaller canoes, fitted with outboard motors are carrying out fishing for yellowfin tuna using live baits. They carry smaller fibre reinforced plastic (FRP) tanks as live bait tanks. In general, the fishers release the remaining live bait into water or to live bait cages kept afloat inside the lagoons for next days use. Chopped fish or fish waste is given as feed for the live baits held in such cages if they are to be maintained longer.

Though the bait fishery is targeted and free from by-catches, dependence on juveniles makes it susceptible for growth overfishing. Hence, the bait fisheries need to be monitored closely. Ensuring sufficient number of spawning population of *O. niger,* identifying alternative bait species and hatchery production of *O. niger* are some of the options for ensuring sustainability of the resource in Lakshadweep Seas.

Environmental DNA (eDNA) metabarcoding approach in fisheries research in India

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Environmental DNA (eDNA) is defined as the genetic material obtained from a water sample containing no distinguishing signs of source macro-organisms. The method utilizes DNA which is continuously excreted by organisms into the surrounding environment through mucus, gamates, faeces, blood and other cells, and captures, analyses and obtains the nucleotide sequence of this DNA based on an environmental sample. eDNA analysis has emerged as a potentially powerful tool to access aquatic community structures. Analysis of eDNA can give us information on the organisms, their abundance and biomass through two approaches – eDNA barcoding and eDNA metabarcoding. In the former, specific species are targeted in samples using standard or quantitative PCR, and using traditional Sanger sequencing method. In the latter, the whole community is screened using multiple conserved primers and Next Gen Sequencing (NGS) is done. Studies suggest that eDNA metabarcoding outperforms traditional survey methods in terms of non-invasive sampling, sensitivity and cost incurred. There is now increased interest in using eDNA to supplement existing survey methods.

Since 2012 there has been a plethora of studies on eDNA metabarcoding as applied in biodiversity conservation, fish community identification, fisheries management, invasive species, as well as in fish biomass/abundance estimations (Hansen *et al*., 2018 *Fish and Fisheries*, 1-18). A total 25 research papers related to eDNA metabarcoding/ metagenomics by Indian authors are predominantly pertaining to the study of microbial biodiversity from food, soil and deep sea sediments (Jiang and Yang, 2017 *Current Science* 112(8): 1659-1664). Not a single publication related to such study in fish has been cited from India.

Metabarcoding is constrained by factors like PCR efficiency, primer tags and sequencing efficacy. Another limitation is lack of comprehensively cured reference databases for certain metazoans for assigning taxon to the Operational Taxonomic Units (OTUS). Further studies are needed to improve sampling strategies (selection of season, sampling location within habitat, etc.) and to understand the relationship between sequence reads and species density. Gaps in knowledge about the dynamic mechanisms relating to shedding of tissue into the environment and metabolism related processes which could also affect quantity of DNA released by an organism into the water have to be filled. Dynamics of eDNA under field conditions, such as patterns of release, degradation, and diffusion will have to be taken into consideration to get estimates of fish distribution and biomass/abundance based on eDNA.

Methodology includes seawater filtration, quantitative real-time PCR, library preparation, Next Gen Sequencing (NGS) and statistical analysis. Copy number of DNA could be quantitatively interpreted in terms of fish abundance and biomass. High throughput sequencing data analysis using the state-of-the art tools could throw light on family level abundance in general and species level abundance of fish in particular. However, the strength of the relationship depends on environmental parameters, such as water temperature, and technical parameters, such as the filter being used for capturing eDNA. Species biology, environment and filtration methods and other factors (e.g. extraction and fish ecology and spatial distribution) are likely to interact and significantly influence eDNA concentration variation. Caution is needed when interpreting the patterns of eDNA concentration in practical contexts. Parameters such as detection limits in water samples, influence of microbial activities on eDNA degradation, sampling design, seasonal conditions, nature of eDNA and fish ecology should be considered in future studies before predicting fish abundance from eDNA in natural conditions.

A basic study design and sampling strategies are essential for estimation of biomass using eDNA surveys. The decision on sample number and density within various habitats is an important aspect whiling developing a statistical sampling strategy. Further, the relationship between fish density and eDNA abundance depends on factors such as taxon- and age-specific shedding rates, specific eDNA degradation rates in the given environment and non-local eDNA transported with sea currents. The effect of these factors has to be measured and taken into account while analyzing the data.

A preliminary study was initiated on eDNA barcoding from known fish samples in marine aquarium tanks in the institute. Five hundred milliliters (ml) of water (salinity 35 ppt; water temperature 26.2^{o}C) were collected from each of 4 different tanks (Table 1). The pooled water sample was filtered through 0.45µ filter (Millipore), DNA extracted and PCR-amplified. DNA was purified and cloned, and initially 5 positive clones were sequenced.

Of the five clones sequenced, as per BLAST (NCBI) search, four of them belonged to silver moony (*Monodactylus argenteus*) and one to skunk clown fish (*Amphiprion akallopisos*). The results were in agreement with the dominance of species in the samples as given in Table 1, thereby confirming efficacy of the present methodology used. Although the scale of the aquarium experiment was much smaller than that of a natural population, the results provide basic information on the relationship between eDNA concentration and biomass. In addition, biotic and abiotic factors such as microbial activity, temperature, salinity and pH can influence eDNA survival and availability. Statistically, the effect of these factors on eDNA concentrations can be evaluated by using a general linear model. In general, type II regression model which can treat two variables with equal magnitude of random variation is be used to study the relationship between eDNA concentration and biomass of each species per milliliter water sample. After optimizing the methods to evaluate the concentration in a controlled aquarium, they can be tested in a natural environment. Research in this novel area can generate eDNA signatures of exploited fish species, which would facilitate for accurate estimation of biomass/abundance of fish in Indian seas. Further, India-specific eDNA-linked database on exploited marine species can also be developed.

There has been amazing advancement in technology from quantitative real time PCR to smart phone-powered sequencer, which would minimize many of the classical logistical and practical challenges of handling, storing and transport of

Table 1. Particulars of fish species sampled in the preliminary study

Tank #	Fish species	Number	Total length (mm)
1	Blackbar Triggerfish (*Rhinecanthus aculeatus*),	1	70
	Threespot Dascyllus (*Dascyllus trimaculatus*)	1	90
2	Yellow tail Angelfish (*Apolemicthys xanthurus*)	1	120
	Blue streak cleaner wrasse (*Labroides dimidiatus*)	1	80
	Canarytop wrasse *(Halichoeres leucoxanthus)*	1	90
3	Skunk Clown fish (*Amphiprion akallopisos*)	10	70-80
	Cerulean damsel (*Pomacentrus caeruleus*)	1	70
	Threespot Dascyllus (*Dascyllus trimaculatus*)	1	90
4	Silver moony (*Monodactylus argenteus*)	20	90-100

environmental samples. Finally technological advancement has reached in automated real time DNA measurements as in Environmental Sample Processor (ESP), which is set to monitor a specific geographic location ranging from coastal to deep sea, and does everything right from regular water sampling and storing to real-time molecular analysis. ESP may be costly, but cost-competitive compared to extensive ship time for visual monitoring or to continuous collection of water samples. eDNA is under the influence of many physical, chemical and biological parameters, which need to be analysed. Its role in direct quantitative assessment is still challenging. Current focus of research in this field should be around relative strengths on detection of presence/absence, migration patterns and life history events, broad ecological understanding, taxonomic coverage and providing basis for ecosystem-based management. Despite the caveats, eDNA-based monitoring will continue to develop to have profound impact on futuristic fisheries research and management.

Boat building - A livelihood focused intervention for fisherfolk

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Fisher folk's dependence on depleting fishery resources and open access nature of fisheries reflecting the tragedy of the commons, has resulted in a core of adaptation measures which has led them to seek livelihood diversification. Fishermen families within themselves are seen to engage in multiple income generating activities or observed to move away to fishery/non fishery related livelihoods. This study documents the case of boat building as a livelihood occupation among fisher folk of Chinnamuttom fishing village, Kanyakumari district.

There are 47 coastal villages in Kanyakumari district with total 1,43,388 fisher folk population. As per the Marine fisheries Census 2010, 96.96 % of the fisherfolk are actively involved in fishing. Among fishery related activities, 48.51 % of fisherfolk are involved in fish marketing, followed by 17.92 % in net making/repairing, 12.99% in fish curing,12.72% in shrimp peeling sheds, 10.84 % as labourers and 12.90 % in other miscellaneous works. Boat building is an additional source of income for these fishermen. Though the *Kattumaram* and the canoe are the two main types of crafts operated by the traditional sector, the number of motorised and mechanised crafts in the fishery have increased significantly over the years. There are two mechanised boat building yards in Agatheeswaram taluk of Chinnamuttom village in Kanyakumari and one mechanised boat building yard in Kanyakumari. These yards specialize in the making of single day trawlers or multiday (70 feet length and 18 feet breadth) trawlers. The boats are made of wood plus fibre coating. *Vagai* (*Albizia lebbeck*) is used for building the base of the boat and *Aini* (*Artocarpus hirsuta*) is used for the sides of the boat. It takes 4 months to build a mechanized boat and normally 2 boats are built in a year. There are nine carpenters and one supervisor involved in this endeavor.

Table 1. The economics of boat building (for 1 mechanised boat)

Components	Cost (₹)
Wood (*Vagai and Aini)*	8,16,250
Cost of engine (540 HP)	18,50,000
Cost of fibre coating	2,75,000
Cost of insulated cold storage holder	16,50000
Cost of dinghy boat	2,50,000
Cost of otterboards (2 numbers)	30,000

Cost of 1600 m rope with fibre coating @ ₹ 90/metre of rope	1,44,000
Cost of equipments and electronic gadgets on board	
Wireless set	39,000
Echosounder	96,000
GPS	24,000
Batteries (2 numbers)	19,000
Wire ropes = 190 m @ ₹ 78/meter	14,820
Steel propeller	1,37,500
Nets (8-12 types)	7,00,000
Syntex tank (1000 litre capacity)	14,000
Gas cylinders (2 numbers)	9,500
Boat trial run	45,000
Labour charges (for 9 carpenters @ ₹ 750/day x 25 days/month x 4 months) + ₹ 1,20,000 for 1 supervisor (@ ₹ 1,200/day x 25 days x 4 months)	7,95,000
Interest paid by owner for a loan of ₹ 70 lakhs/boat building = (@ ₹ 1.75 lakh/month x 4 months)	7,00,000
Total cost incurred for one boat	7609070
Selling price/boat	85,60,000
Net profit/boat builder	**9,50,930**
Income earned per labourer (@ ₹ 750/day x 25 days/month x 4 months)	75,000

Thus the net profit earned per boat builder accrues to ₹ 9,50,930 and the income earned per labourer for a period of four months (duration of boat building) is ₹ 75,000. Fisher folk who work as labourers in boat building yards are from nearby places such as Pinnakayal,Chettikulam,neighbouring district of Tuticorin as well as migrants from other states such as Andhra Pradesh.

Wetland floral diversity of Devagad Island

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There are eight islands around Karwar in the Uttara Kannada District of Karnataka which are located between 14^0 45’ N to 14^0 55’ N and 74^0 00’ to 74^0 07’ 30" E. The Devagad Island, regionally known as Devagadagudda Island, is one such island with a reserve forest that covers 2.5 sq. km. with 41m elevation above Mean Sea Level (MSL). The climate is wet monsoon type, with average total rain fall of around 3000 mm/year and temperature range between 20 ^{0}C to 38 ^{0}C. Post-monsoon survey was conducted in the island for 5 months during September 2015 to January 2016 and a monsoon survey during August 2016 to assess the diversity of wetland flora associated with the island. The vegetation in the island is similar to that found in the Western Ghats. A small rock pool near the north western side of the island harbours the single mangrove species *Avicennia officinalis* (Family Avicenniaceae) present in the Island. Along with this mangrove, seven mangrove associates were present (Table 1).

Table 1. Mangrove associates in Devagad Island

Common name	Scientific Name	Family
Rattle Pod	*Crotalaria sagittalis*	Fabaceae
Poison Wine	*Derris trifoliata*	Fabaceae
Portia Plant	*Thespesia populnea*	Malvaceae
Crown Flower	*Calotropis gigantea*	Apocynaceae
Flat Edges	*Cyperus malaccensis*	Cyperaceae
Bush-Grapes	*Cayratia trifolia*	Vitaceae
Glory-Bower	*Volkameria inermis*	Lamiaceae

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