MAJOR ACHIEVEMENTS OF RESEARCH

A wholesome technology of "Breeding, Seed production and Farming of high value marine food fishes" was developed and successfully transferred the technology to the end user. The details of major technologies involved in this endeavor are given below:

1. ***Broodstock development***

   It comprises of collection from wild, conditioning under captive environment and development into brood fishes by feeding with specialized feeds to cater to their physiological requirements.

2. ***Captive breeding and spawning***

   It involves tagging, sexing, assessment of reproductive stages, selection of parents and induction of spawning.

3. ***Mass culture of live feed, larviculture protocols and fingerling production***

   This include green water technique, mass production of appropriate live feed, nutritional enrichment protocols of live feed, weaning, grading, fingerling production and transportation of seed.

4. ***Farming or culturing***

   It involves the nursery rearing, development of suitable feed formulations, grow-out farming (pond culture or sea cage farming) and health management.

5. ***Transfer of technology***

   It comprises of field demonstrations of sustainable pond and sea cage farming, capacity building through hands-on training in hatchery management, nursery and farming techniques

Selection of species for seed production

The factors considered for selection of the species of food fishes were as follows:

- Availability of the species in Indian waters
- Demand in both national and international trade
- Adaptability to environmental variations
- Feasibility of breeding under captive conditions
- Feasibility of completion of larviculture within a reasonable time frame
- Suitability to farming (pond or sea cages)
- Growth rate and disease resistance
- High market value

Based on the above criteria, the species of food fishes identified and selected were:

1. Cobia (*Rachycentron canadum*)
2. Silver Pompano (*Trachinotus blochii*)

The Cobia possesses the special characteristics namely fast growth rate, adaptability to captive conditions, lower cost of production, good meat quality and high market demand, while the pompano is highly preferred delicacy in the domestic market. In addition, the pompano can easily adapt to low saline conditions and also has ornamental value during its juvenile stages for its bright, glossy and silvery appearance.

Wild-caught cobia does not support a major commercial fishery and generally considered as incidental catch. Hence, the seed production and farming of cobia is rapidly gaining momentum in many Asian countries. Under culture conditions, cobia can reach 4-8 kg body weight in one year and 8-16 kg in two years. The fecundity of the species is very high and it has protracted spawning season so that seed production throughout the year would be possible. The Silver Pompano is amenable to various methods of culture namely sea cage farming, pen culture, pond culture, etc. The vast low saline waters of our country could be effectively used for farming of pompano due to its adaptability to low saline waters, besides its potential for sea cage farming. It is also one of the highly priced fin fishes, mainly due to its good meat quality.

Initially, available information on captive breeding of cobia and pompano was collected and then the biology of the species in our waters was studied. Then, trials were made to develop broodstock in captivity and to standardize the hormonal protocols under our conditions. Once, the captive broodstock development was successfully completed, focus was given on evolving larviculture protocols. The major bottleneck of mass production of live feed was addressed to increase the larval survival and quality. Thereafter, the protocols for nursery rearing and long distance transportation of seeds followed by farming methodologies were developed and standardized.

A brief narration of the technology developed is given below.

Broodstock Development of Cobia and Pompano

Envisaging the prospects of Cobia and Pompano farming in India, broodstock development was initiated at the Mandapam Regional Centre of Central Marine Fisheries Research Institute during the year 2007 and 2008, respectively. Initially, the sea cages were designed and fabricated by the team of scientists. The wild caught brood fishes of cobia (2 to 10 kg) and pompano (0.25 to 0.75 kg) were collected. Immediately after collection, the fishes were treated with 100 ppm formalin for 2 to 5 minutes and then conditioned for 2-3 weeks in 100 ton FRP tanks. After the quarantining, the fishes were released into the broodstock cages. Eventually, they were reared in cages of 6 meter diameter and 3.5 meter depth. The fishes were sexed by cannulation techniques and tagged with PIT tags.

As a refinement of the technology, to develop bio-secure broodstock on-shore, Recirculating Aquaculture System (RAS) was also adopted. The RAS incorporates systems for treatment and reuse of water with less than 10% of water volume replaced per day. Of late, the brood fishes were developed both from the wild collection and hatchery produced stock with the help of pedigree information. A high plane of nutrition was followed based on their physiological need in order to become good quality brood fishes. These fishes were fed with high plane of nutrition twice daily with sardines (*Sardinella* species), squids, portunid crabs and other species like *Pellona* and *Ilisha* @ 5 % of their body weight. They were supplemented with vitamins and minerals in addition to essential nutrients like rich protein and HUFA/PUFA. Subsequently a more cost effective indigenous RAS was designed and installed in the Centre. Broodstock development of *Lutjanus argentimaculatus* was initiated in the indigenous RAS system.

Broodstock Development under captivity

Fabrication of sea cage

Fabricated sea cage ready for launching

Sea cages at Mandapam

Sea cages for brood stock development

Broodstock of cobia in sea cage

Broodstock of pompano in sea cage

Catching of brood fishes from cage

PIT Tagging equipment

PIT Tagging of cobia brood fish

Reading the tag in a brood fish

Reading the PIT tag for identification

Transferring of tagging information to computers

Marine fish brood bank at Mandapam

Marine fish brood bank facility

Indigenously designed biofilter system for broodstock tank

Marine fish spawning tank

Broodstock of cobia in spawning tank

Brood fishes of cobia at RAS tank

Imported RAS facility

Imported RAS components (Sump, Drum filter & Protein skimmer)

Indigenously designed RAS Unit (Tank)

Indigenous RAS components (UV filter, Bead filter, Protein skimmer & Reactors)

Captive breeding and Induced Spawning

The brood fishes were sexed and tagged with Passive Integrated Transponder (PIT) tags in order to maintain the breeding history. The PIT tag is a device to permanently mark fishes internally with radio frequency tags. The assessment of their stage of reproduction from gonadal biopsies was carried out through direct cannulation technique. The females were cannulated every fortnightly interval to assess the stage of development in reproduction through the diameter of the intra-ovarian eggs. Females of cobia with intra-ovarian eggs of minimum 700 µ size were selected for breeding. The males were selected based on the pedigree information. The selected parents were brought from the sea cages to the breeding cum spawning tanks or tanks with RAS facility. The sex ratio was standardized as two males for one female in order to have maximum fertilization. The induction of spawning was carried out with exogenous hormones. The dosage for induction was standardized for both sexes in cobia and pompano.

Successful induction could be achieved with human chorionic gonadotropin at a dosage of 500 IU and 250 IU per kg body weight for females and males of cobia, respectively, whereas 350 IU per kg body weight for both the sexes of pompano. The spawning was obtained usually 36 to 48 hours after the hormone injection. Various experiments were conducted to ascertain the optimum temperature for spawning and it has been found that a temperature range of 28 to 30.5°C is ideal. The fertilized eggs would be floating and unfertilized eggs would sink to the bottom of the tank. The total number of eggs spawned was estimated and the fertilized eggs were stocked in separate incubation tanks. Usually the fertilization rate would be 80 to 90 per cent. The first successful breeding and spawning of cobia and pompano were achieved in India at Mandapam Regional Centre of CMFRI during the year 2010 and 2011, respectively. After the first success, successive breeding and seed production are regularly being achieved.

Volitional spawning of cobia in RCC tanks was achieved at the brood bank facilities of Mandapam Regional Centre of CMFRI -Two sets of cobia broodstock, each with one female and two males, which were maintained at the National Marine Fish Brood Bank facility at the Mandapam Regional Centre, spawned volitionally without any hormonal induction during the month of May 2013. The water quality parameters were maintained at highest standards with indigenously designed filtration systems. The broodstock were fed with good quality squid and crabs. A total of 2.5 million fertilized eggs were obtained and 85 % hatching was achieved in the volitional spawning.

First Successful spawning of cobia in RAS was achieved at Mandapam on 20th September 2013. The RAS facility inaugurated by the Director General, ICAR during May 2013 was effectively utilized for the maintenance of cobia brooders. In this system, the brooders could be conditioned and maintained in healthy condition. One female and two male brooders were kept in the system. The ova size was assessed by cannulation biopsies based on which, the brooders were induced with HCG. The total number of eggs spawned was 2.40 million and the fertilization percentage was 86.1. The temperature range was 27.5 – 29°C. The hatching started by late evening of 20th September 2013 and completed by early morning of 21st September 2013. A total of 1.80 million larvae hatched out with a

hatching percentage of 86.7%. The larvae were stocked at different densities in the larviculture tanks.

Volitional spawning of cobia in RAS – The same brooders of cobia were maintained in healthy condition in the RAS by maintaining optimal water quality parameters. The first volitional spawning in the RAS was recorded on 29th October 2013. The total number of eggs spawned was 1.3 million and the fertilization percentage was 0.27 and total number of fertilized eggs was 3,600. Since the spawning happened unexpectedly, arrangements for facilitating maximum fertilization rate could not be made in the system which might be the reason for the low fertilization rate. The temperature maintained was 30.5°C, pH 8.2, DO 4.98 ml/litre and salinity at 36 ppt. The fertilized eggs were collected and stocked in the incubation tank for hatching.

The first successful off-season spawning of cobia through thermal regulation has been achieved in the RAS on 02nd December 2013. Breeding experiment was conducted in the RAS through thermal regulation by installing titanium water heaters. During this season the temperature in source seawater was 25.1 to 26.0°C and it was raised in the RAS to 29.7 to 30.3 °C, by titanium heaters. The cobia brooders were healthy and broodstock development was continued in the RAS by regulating the temperature. Intra-ovarian cannulation biopsy revealed the maturation of ova in the altered temperature. The female cobia was weighing 9.29 kg and males were 9.89 kg & 10.34 kg. Successful hormonal induction with hCG was carried out on 30th November 2013 and spawning was achieved on 2nd December 2013. The fertilized eggs were collected and stocked in the incubation tanks for hatching. It is felt that the present success is a major breakthrough which can pave way for the successful spawning and seed production of cobia all through the year.

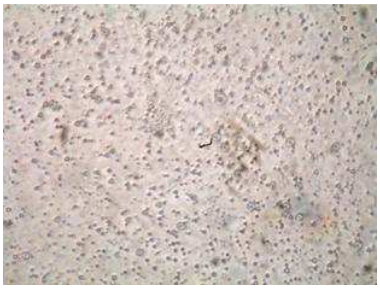
Captive Breeding and Spawning

Catching of brooders from sea cage

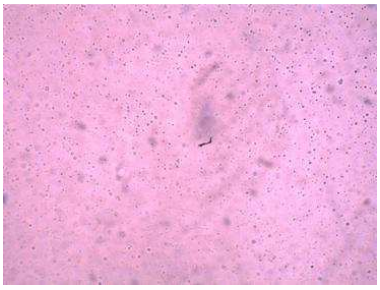
Cannulation of cobia at sea cage for gonadal biopsy

Cannulation of cobia at brood bank for biopsy

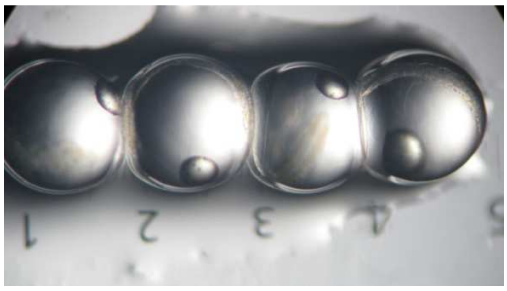
Cannulation of pompano for gonadal biopsy



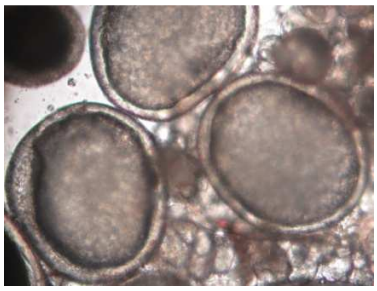
Matured spermatozoa of Cobia



Matured spermatozoa of Pompano

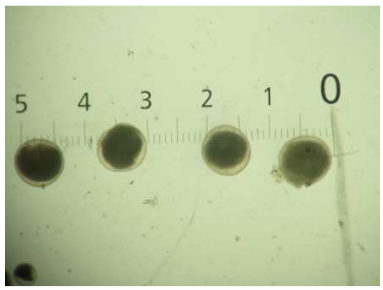


Cannulated eggs from Cobia



Cannulated eggs from Pompano

Assessment of Egg maturation in Cobia



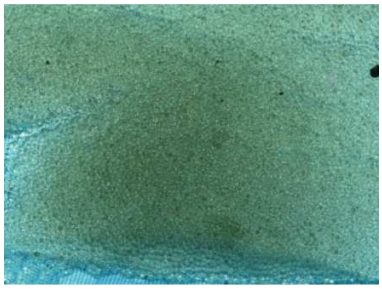
Assessment of Egg maturation in Pompano

Administration of hormones for Final oocyte maturation and spawning in Cobia

Administration of hormones for Final oocyte maturation and spawning in Pompano

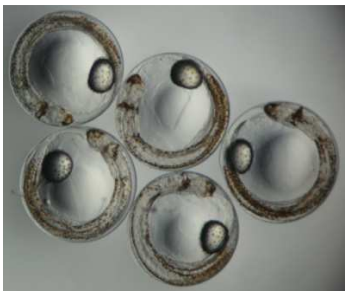
Cobia spawners

Pompano spawner



Fertilized eggs of cobia collected from spawning tank

Zygotes of cobia under microscope

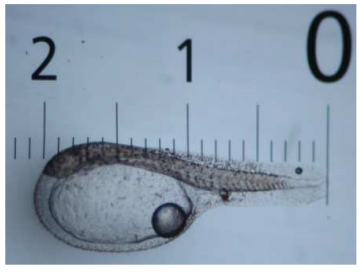


Embryonic development in Cobia

Embryonic development in Pompano

Hatching of cobia larva in progress

Newly hathced larvae of cobia



Newly hatched larva of pompano

Larviculture and fingerling production

The fertilization rate was determined by counting the floating as well as sunken eggs using sampling techniques. The fertilized eggs (zygotes) were transferred from spawning tanks to the hatching tanks. The developmental stages were observed and studied periodically for ascertaining the embryonic development. Various experiments were conducted to ascertain the optimum temperature for hatching and it has been found that a temperature range of 29°C to 30.5°C is ideal. The hatching would take place within 18 to 22 hours of fertilization. The newly hatched larvae were transferred to larviculture tanks for further rearing. The stocking density was standardized as five larvae per liter for better survival during the larviculture period. The protocols were developed and standardized for larviculture by appropriate management of live feeds in suitable quantities and also taking into consideration the nutritional requirements of the larvae.

The mouth opening was observed on third day post hatch (dph) and was measuring around 200 µ in size. The larvae were stocked in FRP tanks of 5 ton capacity for larviculture. The intensive larviculture tanks were provided with green water at a density of about $1x10^5$ cells per ml and rotifers enriched with DHA SELCO/Sparkle at a density of 8 to 10 nos. per ml from 3 to 9 dph. The critical stage for the larvae was 5 to 7 dph when they entirely resorted to exogenous feeding from yolk sac feeding. From 9 to 21 dph, the larvae were fed four times daily with enriched *Artemia* nauplii by maintaining a nauplii concentration of 3-5 nos. per ml. During this period, co-feeding with rotifers was also continued due to the presence of different size groups of larvae.

Larviculture and High density mass scale Live feed culture

The Marine Hatchery Complex developed at Mandapam

Fin fish hatchery at Mandapam

Phytoplankton stock culture

Phytoplankton stock culture

Intensive culture of live feed (Rotifers)

Intensive culture of live feed (Rotifers)

Extensive mass culture of live feed (Micro-algae)

Green water culture

Inter-mediary culture of micro-algae

Intensive culture of Rotifers

Green water addition to larviculture

Enriched *Artemia* nauplii for larviculture

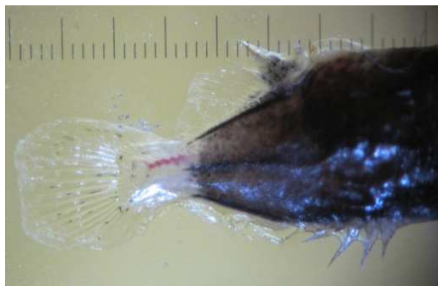
Larvae of cobia

Cobia larva (3 DPH)

Larvae of Cobia

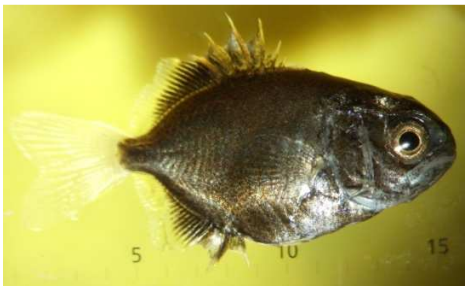
Pompano larva (5 DPH)

Larvae of Cobia (15 DPH)



Larva of Pompano (20 DPH)

Cobia Fingerling (30 DPH)



Pompano fingerling (30 DPH)

A simple skimming device employed in the larviculture tank

Larval inert feed

Feeding of larvae with inert feed

Feeding larvae with artificial feed

Extensive larviculture facility

Pompano larviculture in progress

Fingerlings of cobia (35 DPH)

Pompano fingerlings (35 DPH)

Fingerlings of cobia (40 DPH)

Pompano fingerlings (40 DPH)

Juveniles of Cobia (45 DPH)

Juveniles of Pompano (45 DPH)

Cobia fingerlings for stocking

Pompano fingerlings (45 DPH)

Nursery cage for fingerlings

Measurement of Pompano from grow-outs cage (4 months old)

Cobia seed for transportation

Pompano seed transportation

Pompano seed distribution

Pompano seed releasing into hapa by the team leader at Andhra Pradesh

Green water was also maintained in appropriate densities in the larval tanks. From 7 and 12 dph onwards, the larvae of cobia and pompano, respectively, were fed with *Artemia* nauplii. The larvae were weaned to larval inert feeds from 18 dph onwards. From 25 dph, grading of larvae was started. The shooters were fed exclusively with the artificial feed of the size 500-800 µ and 800-1200 µ. On 30 dph, three size groups of juveniles were

noted in cobia with mean sizes of 10 cm (10%), 6 cm (25%) and 4 cm (65%). The juveniles measuring 10 cm length were ready for stocking in nursery tanks or ponds. In pompano, size variation is minimal and hence, grading is not mandatory.

The period of larviculture was 30 to 35 DPH depending on the growth of larvae. Then, the nursery rearing was carried out up to 55 to 60 DPH. At this stage they can be called as fingerlings/seed ready for stocking in cages or ponds. Several batches of seeds were produced for farming by aqua farmers. The packing and transportation protocols for cobia and pompano for long distance transport were developed and seeds were distributed to aqua farmers in majority of maritime States of India.

Larviculture experiments revealed that maintaining a larval density of 5 numbers/litre and live feed (rotifer) at a density of 35- 40 numbers/ml up to 18 days post hatch (dph), early grading starting from 10 dph onwards and continuing on a daily basis yielded better survival for cobia. Maximum survival rate obtained was 8.4%. A few tanks with better light intensity and extended duration of higher temperature yielded up to 10% survival in cobia. Larviculture experiments on silver pompano revealed that a larval density of 10 numbers/litre and live feed (rotifer) at a density of 35- 40 numbers/ml yielded better survival in pompano larviculture. Maximum survival rate obtained was 31 per cent.

Farming/ Culturing

The seed transported from the hatchery were first acclimatized to the local water conditions of the ponds or sea cages. Then they were stocked in ponds or sea cages after ensuring their successful adaptability to the local environment. Cage farming of cobia was experimented for the first time in India at Mandapam Regional Centre of CMFRI from the hatchery produced fingerlings. The fingerlings were stocked in grow-out cages after nursery rearing. The fish were fed with trash fish *ad libitum* twice a day initially and later once a day. The grow-out fishes of cobia could reach an average weight of 2 to 3 kg in 6 months and 4 to 8 kg in one year of culture period. The results show that cobia is a lucrative species for sea cage farming in India.

Pond farming of pompano was experimented for the first time India at Andhra Pradesh from the hatchery produced fingerlings. Pompano fingerlings were transported to

low saline ponds at Anthervedi, East Godavari District, Andhra Pradesh to conduct demonstration of farming in earthen ponds. After proper acclimatization to the local environment, the fingerlings were released into ponds for grow-out culture. They were fed with floating pellet feed formulated specially by the Mandapam Centre of CMFRI and manufactured by a private feed mill operator in Andhra Pradesh. The feeding, farm and health management procedures were also developed and standardized according to the availability of resources in the farming area. The common diseases of cobia and pompano recorded were Vibriosis and Gill parasitism, respectively. They were addressed with suitable preventive and control measures to have successful farming.

Grow-out Farming/ Culture

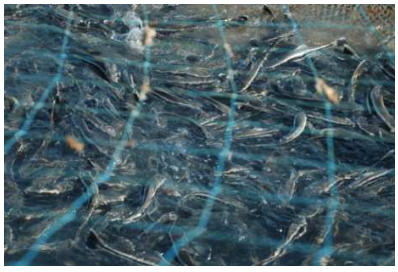
Sea cage farm at Mandapam

Sea cages with security cabin

Cobia fingerlings for stocking

Cage stocked cobia

Cobia sampling in demonstration



Cobia fingerlings in demonstration

Cobia fingerlings in demonstration cage

Cobia seed distribution for demonstration

Artificial feed for cobia and pompano

Low value fishes as feed for sea cage farming

Preparation of low value fishes for feeding

Feeding at sea cages with low value fishes

Cobia grow-out sampling

Cobia grow-out

Cobia grow-out sampling

Participatory demonstration of cobia farming in Tamil Nadu

Harvested cobia being weighed

Measuring the harvested cobia

Fish farmer with harvested cobia

Harvested cobia from sea cage farming

Harvested cobia from sea cage farming

Transportation of harvested cobia

Disease monitoring of pompano farming

Disease monitoring of pompano farming

Participatory farming of pompano in Tamil Nadu

Participatory farming of cobia in Tamil Nadu

Feed manufacturing by collaboration with a private feed mill in Andhra Pradesh

Pompano farming in Andhra Pradesh

Pompano nursery in Kerala

Pompano nursery at Andhra Pradesh

Pompano nursery at Andhra Pradesh

Pompano seed release at Andhra Pradesh

Pompano nursery and grow-out in Andhra Pradesh

Pompano nursery pond at Andhra Pradesh

Pompano harvest function at Andhra Pradesh

Harvested Pompano from pond culture

Harvest of pompano in a participatory demonstration farm in Andhra Pradesh

Pond cultured pompano from Andhra Pradesh

Creating awareness on cage farming

Cage farmed pompano in Tamil Nadu

Cage farmed pompano

Harvested Pompano from sea cages

Pond harvested Pompano ready for marketing

Cage harvested pompano in Tamil Nadu

Transfer of Technology

CMFRI has developed the technology for breeding, seed production and farming in cages and ponds for selected marine fin fishes to meet the need of fisher-folk for carrying out small scale mariculture. This is a better alternate livelihood option to sustain the marine capture fisheries. Initially on farm trials were carried out for both cobia and pompano in

cages and ponds. Based on the trials, it was concluded that the cobia was more successful in sea cages and the pompano was successful in ponds with low saline waters although both the species can be reared in either conditions.

The information about the technology has spread to different parts of the country. The awareness about the technology was created among the aqua farmers/entrepreneurs and the officials of Central and State Government through mass media (TV, videos, magazines, Journals, news stories, newspaper, internet *etc*.), group contacts (meetings, lectures, demonstrations, workshop, seminar and trainings) and individual contacts (farmer to farmer approach). Several hands-on training programmes were also conducted on hatchery and farming techniques (Annexure 5) in order to develop technical man power and to disseminate the technology.

The field demonstrations conducted at different places of the maritime States have aroused interest amidst the aqua farmers/entrepreneurs. Further, the participatory demonstrations conducted at different locations with aqua farmers created confidence among the farmers on the performance of the technology. Farmers' feedback and perception about the technology were also collected and evaluated. Field day and harvest programmes were organized periodically to project the technology among the group of interested aqua farmers/entrepreneurs.

''Seeing is believing'', by seeing the performance of cobia and pompano farming, the attitude has completely changed and many are now venturing into cobia and pompano farming in different coastal states of our country. At present the awareness and knowledge about the farming of cobia and pompano is very high. Hence, the demand for cobia and pompano seeds is very high from the maritime States of the country. In order to meet the demand of seeds, participatory demonstrations of the hatchery technology are also being initiated at Tuticorin in Tamil Nadu, Bhimavaram, Palakol and Visakhapattinam in Andhra Pradesh and Karwar in Karnataka.

Experiments on Technology Demonstration of farming of cobia and silver pompano

(i) Sea cage farming demonstration of cobia through participatory mode with Cobia Aquaculture Fishermen Welfare Society, Rameshwaram, Tamil Nadu

Nine sea cages made up of GI pipes were fabricated by the private fishermen society, the Cobia Aquaculture Fishermen Welfare Society and installed in Gulf of Mannar with the technical guidance from CMFRI. The circular cages of 6 m diameter and 3 m depth were fabricated and installed. About 6000 nos. of cobia fingerlings of 12 cm length and an average weight of 20 grams were stocked. The fishes were fed *ad libitum* twice daily with low value fish. The water temperature in the cage sites are being recorded at regular intervals. The cost of cages, feed and labour are fully borne by the society. The hatchery produced seeds and technical inputs were provided by the institute.

(ii) Demonstration of cage farming of cobia through participatory mode with M/s. Vitality Aquaculture Pvt. Ltd., Thoothukudi, Tamil Nadu

A total of four numbers of sea cages made up of GI pipes were fabricated by the private entrepreneur and installed in Gulf of Mannar with the technical guidance from CMFRI. The circular cages of 6 m diameter and 3 m depth were fabricated and installed. About 2000 nos. of cobia fingerlings of 12 cm length and an average weight of 20 grams were stocked. The fishes were fed *ad libitum* once in a day with low value fish. The water temperature in the cage sites are being recorded at regular intervals. The cost of cages, feed and labour are fully borne by the entrepreneur. The hatchery produced seeds and technical inputs were provided by the institute.

(iii) Demonstration of cobia farming in sea cages through participatory mode with a fishermen group of the adjoining village (Maraikayarpatinam) of CMFRI

Two numbers of sea cages made up of GI pipes were fabricated by the private entrepreneur and installed in Gulf of Mannar with the technical guidance from CMFRI. The circular cages of 6 m diameter and 3 m depth were fabricated and installed. About 400 nos. of cobia fingerlings of 15 cm length and an average weight

of 25 grams and 2000 nos. of cobia fingerlings of 10 cm length with an average weight of 18 grams were stocked. The fishes were fed *ad libitum* once in a day with low value fish. The water temperature, salinity and pH in the cage sites are being recorded at regular intervals. The cost of cages, feed and labour are fully borne by the fishermen themselves. The hatchery produced seeds and technical inputs are provided by the institute.

(iv) Demonstration of pond farming of silver pompano through participatory mode with private entrepreneurs in Chidambaram, Tamil Nadu

About 1000 nos. of pompano fingerlings of 6.5 cm length and an average weight of 8.7 g were stocked in a one acre pond. The growth of pompano in six months culture period was observed to be an average length of 20.5 cm and a weight of 135.0 g. Another batch of about 1400 nos. of pompano fingerlings of 5.0 cm length and an average weight of 7.2 g were stocked. The growth of pompano in three months period of culture was observed to be an average length of 14.2 cm and a weight of 50.3 g.

(v) Demonstration of silver pompano farming at Pedda Kammavaripalem, Nagayalanka , Krishna District, Andhra Pradesh

About 3,500 nos. of pompano fingerlings of 6.5 cm length and an average weight of 8.7 g were stocked in a one acre pond. In the same pond *Litopenaeus vannamei* seeds were stocked to study the co existence of silver pompano and *L. vannamei*. The growth of pompano in eight months culture period was observed to be an average length of 21.8 cm and a weight of 150.0 g. This slow growth was due to zero salinity prevailed for a period of 3 months in the water source and pond. Whereas *L. vannamei* reached an average size of 120 grams and were harvested. Another batch of about 3,500 nos. of pompano fingerlings of 5.0 cm length and an average weight of 7.2g were stocked in the HDPE cages by the farmer in the Krishna river.

Transfer of Technology

Initial happa rearing of pompano fingerlings

Pond farming of pompano at Pedda Kammavaripalem, A.P.

Feeding zones created for dispensing the floating pellet feed to pompano

Cage farming of pompano in Nagayalanka, Krishna District, Andhra Pradesh

Paddle wheel aerators installed in the pond at Pedda Kammavaripalem, A.P.

Sampling of pompano in the pond located at Pedda kammavaripalem, Nagayalaka, Krishna District, Andhra Pradesh

Co - culture of pompano and *L. vannamei*

Harvested *L. vannamei* from the pompano pond

Pompano farming demonstration at Elanthirimedu Village, South Pichavaram, Chidambaram, Tamil Nadu

Sampling of pompano in cultured at South Pichavaram, Chidambaram, Tamil Nadu

Disease Management Studies as a part of innovations in cage farming revealed that the dinoflagellate *Amyloodinium ocellatum* is one of the most important pathogenic ecto-parasite affecting the cultured marine and brackish water fish, causing *Amyloodiniosis*. A total of thirty silver pompano, *Trachinotus blochii* with an average length and weight of 20 cm and 900 g respectively, were maintained for broodstock development and breeding purpose at Mandapam Regional centre of CMFRI. Suddenly all the animals showed difficulties in breathing, loss of appetite, rubbing its body on the sides of the tank/ objects in the tank and also an erratic swimming behavior and finally caused acute mortality. Grossly the operculum showed focal area of erosion. Gill showed excessive mucus secretion and pale discolouration. Microscopic examination of the fresh gill filaments showed the presence of the adult parasite feeding stage (Trophont). Histopathologically, the gill showed erosion and necrosis of primary and secondary lamellar filament. The causative organism A. *ocellatum* was identified based on the clinical signs, gross and microscopic lesions. Fresh water dip and 5 per cent Povidone Iodine dip treatment was effective to control the condition in affected fish.

***A. ocellatum* infestation in ompano broodstock gill lamellae**

Histological sections showing the damege caused to gill lamellae and presence of trophonts

Trial on Integrated Multi Trophic Aquaculture (IMTA) in a participatory mode

One trial on Integrated Multi Trophic Aquaculture (IMTA) by integrating the seaweed *Kappaphycus alvarezii* with cobia is being initiated at Munaikadu (Palk bay) in a participatory mode with fishermen group. Three GI square cages of 4.5×4.5 m outer dimension and 3.5×3.5 m inner dimension were launched on 31st March 2014. Hatchery produced 400 cobia fingerlings (133 nos. in each cage) of average length and weight of 20.3 cm and 49.2 grams respectively were stocked in three cages on 1st April 2014. The stocking density was between 5-6 numbers per cubic meter. The fishes are being fed with trash fish twice a day.

Launching of cages for IMTA trial

Launching of cages near the seaweed farm

Dr.G.Gopakumar & scientists handing over cobia seed to fishermen group at Munaikadu, Tamil Nadu

Stocking of Cobia seed inside the cages for IMTA

Table 1: Components of Transfer of Technology - Cobia

S.No	Details	Period	Outcome
1	**Trial**		
	a. Mandapam, Tamil Nadu	2010	• Farming methods were tested and evolved
	b. Karwar, Karnataka	2010	

2	**Field demonstration**		
	a. Mandapam, Tamil Nadu	2011	• Technology was demonstrated and validated. • Farmers feedback and perception about the technology was collected and evaluated
	b. Karwar, Karnataka	2011	
	c. Veraval, Gujarat	2011-12	
3	**Participatory demonstration**		
	a. Mandapam, Tamil Nadu	2012	• Successful harvest was conducted. • Field day and Harvest programme was organized • Created confidence amidst of aqua farmers
	b. Marakayarpattinam, Tamil Nadu	2012	
	c. M/s Vitality Aquaculture, Tuticorin	2012	
4	**Adoption of the technology**		
	a. Marakayarpattinam, Tamil Nadu	2013	• Continuous adoption is in progress
	b. M/s Vitality Aquaculture, Tuticorin	2013	
	c. Cobia Aquaculture Association, Rameswaram, Tamil Nadu	2013	
	d. Thondi, Tamil Nadu	2013	
	e. Olaikuda, Tamil Nadu	2013	
	f. Nagayalanka, Andhra Pradesh	2013	

Table 2: Components of Transfer of Technology - Pompano

S.No	Details	Period	Outcome
1	**Trial**		
	a. Mandapam, Tamil Nadu	2011	• Farming methods were tested and evolved
	b. Karwar, Karnataka	2011	
2	**Field demonstration**		
	a. Mandapam, Tamil Nadu	2011	• Technology was demonstrated and validated. • Farmers feedback and perception about the technology was collected and evaluated
	b. Karwar, Karnataka	2011	
	c. Antervedi, Andhra Pradesh	2011-12	
	d. Akiveedu, Andhra Pradesh	2011-12	
	e. Kochi, Kerala	2011-12	
	f. Narakal, Kerala	2012	

3	**Participatory demonstration**		
	a. Tuticorin, Tamil Nadu	2012	• Successful harvest was conducted. • Field day and Harvest programme was organized • Created confidence amidst of aqua farmers
	b. Vedalai, Tamil Nadu	2012	
	c. Nagayalanka, Andhra Pradesh	2012	
4	**Adoption of the technology**		
	a. Marakayarpattinam, Tamil Nadu	2013	• Continuous adoption is in progress
	b. M/s Vitality Aquaculture, Tuticorin	2013	
	c. Olaikuda, Tamil Nadu	2013	
	d. Thondi, Tamil Nadu	2013	
	e. Dilsumaru, Andhra Pradesh	2013	
	f. Thurpputhadu, Andhra Pradesh	2013	
	g. Perupalam, Andhra Pradesh	2013	
	h. Bhimavaram, Andhra Pradesh	2013	
	i. Pedapattinam, Andhra Pradesh	2013	
	j. Karwar, Karnataka	2013	
	k. Navsari, Gujarat	2013	

Transfer of Technology – Field and Participatory Demonstrations

Seed transportation for field demonstration at Antervedi, Andhra Pradesh

Seed transportation to South Pichavaram, Tamil Nadu

The participatory demonstration hatchery at Konapa Peta, Andhra Pradesh

A view of the participatory hatchery at at Konapa Peta, Andhra Pradesh

The team leader distributing the Pompano seed to a farmer at Vedhalai for participatory demonstration

Dr. M.V. Gupta distributiong the seed to a farmer from Tuticorin

The Press Meet on the prospects of Pompano farming in India

A Press Meet by Dr. S. Ayyappan, Dr. B. Meenakumari and Dr. Madan Mohan on the prospects of Cobia and Pompano farming

The team leader at a function on popularising the Cobia farming at Rajulalanka, A.P.

The team leader along with members distributing the Cobia seed to farmer in Rajulalanka, A.P.

The harvest function of pond-farmed Pompano at Antervedi, Andhra Pradesh

The harvest function of pond-farmed Pompano at Antervedi, Andhra Pradesh

KFDC fish marketing outlet at Bangaluru, Karnataka displaying the Pompano fishes

Distribution of pompano seed to a farmer from Nagaylanka, A.P. by the Director General

The release of of CD on "Pompano Farming" by the Director General and other officials

Felicitation of a successful fish farmer by the Director General

The release of a book "Handbook on Cobia and Pompano Seed Production Technology" by the Hon'ble Minister Mr. Harish Rawat, MoA.

Felicitation of the team leader Dr. G. Gopakumar for the success in cobia and pompano seed production technology by the Director General, ICAR

Training of scientist from fisheries intitutes on finfish seed production technology

Training on Pompano seed production to private hatchery technicians

Hands-on training on live feed culture to hatchery technicians

Training session in progress

Hands-on training on hatchery technology of pompano seed production to govt. officials

Hands-on training on hatchery technology of pompano seed production to hatchery technicians

Hands-on training on cage farming of pompano to govt. officials

Hands-on training on cannulation of cobia to govt. officials

Inauguration of a training programme by the ADG Dr. Madan Mohan

CIFE sholars for training on marine fin fish seed production with the team of scientists

Release of training manual on Seed production technology by the District Collector, Ramanathapuram, Tamil Nadu

Trainees of cobia seed production with the team of scientists

Trainees of cobia seed production course with the team of scientists

Trainees of marine fin fish seed production course with the team

Trainees of pompano seed production with the team

Evaluation of the training programme in progress

Training for hatchery technicians and govt. officials on cobia seed production

Trainees of pompano seed production with the team

Training of Sidhi tribes from Gujarat on cage farming of cobia

Inauguration of a training programme on marine fin fish seed production technology

Inauguration of national workshop on cobia seed prouction technology

National workshop on marine fin fish seed production technology

National Agricultural Innovation Project (Component-2)

Brief description about the innovations/technologies developed under the project Export Oriented Marine Value Chain for Farmed-Seafood Production using Cobia (*Rachycentron canadum*) through Rural Entrepreneurship

- Development of broodstock of cobia (wild-collected) was done in sea cages with special broodstock feed supplemented with vitamins, mineral mixture, cod liver oil, krill oil, etc.
- Tagging of individual brooders was carried out with Passive Integrated Transponder (PIT) tags, a kind of electronic tag with radio-frequency identification.
- The reproductive history was maintained and monitored regularly for induction of spawning
- Gonadal biopsies were performed at periodic intervals for assessing the sexual maturity of the brood fishes
- For the first time in India, the induced breeding of cobia was achieved in Mandapam Regional Centre of CMFRI

- The techniques of larviculture, nursery rearing and grow-out culture of cobia were developed
- Standardization of the techniques of induced spawning, larviculture, nursery and grow-out culture of cobia were done.
- Successfully bred cobia in the Recirculation Aquaculture System (RAS) for the first time in the country
- Successful volitional spawning of cobia in the Recirculation Aquaculture System and also broodstock holding cement tanks for the first time in the country
- Successful off seasonal spawning of cobia achieved through thermal regulation in the RAS for the first time in the country.
- The seed of cobia was supplied to Karwar Centre of CMFRI and private fish farmers in Andhra Pradesh for field trials
- The F_1 generation cobia was developed into broodstock at Mandapam Regional Centre of CMFRI and are being successfully used for breeding and seed production
- The demonstration of cobia grow-out culture was carried out in sea cages as well as in ponds
- Motivated fishermen self help groups to start sea cage farming of cobia in Tamil Nadu

Process/ Product/Technology developed

S.No	Technology Developed	Adoption/ Validation/ Commercialization, etc.
1.	Methodology of broodstock development under captivity in open sea floating cages	Adoption and validation completed
2.	Methodology of controlled breeding and induced spawning for the first time in India	Adoption and validation completed
3.	Methodology of larviculture and seed production	Adoption and validation completed
4.	Methodology of nursery rearing	Adoption and validation completed
5.	Methodology of open sea cage grow-out farming	Adoption and validation completed

National Initiative on Climate Resilient Agriculture (NICRA) Project

Results from the mariculture component of NICRA

A) Experimental studies on the impact of temperature on the embryonic development and larval growth of cobia and silver pompano

Cobia (*Rachycentron canadum*)

Effect of temperature on incubation, hatching, development and growth of larvae

The minimum incubation period (18:04±0:12 h) was at 34°C and the same increased as the temperature decreased (Table 1). The hatching rate was significantly reduced ($P<0.01$) at 33 and 34°C. The highest hatching rate (89.06±1.48 %) was at 31°C. The time taken for the opening of mouth and complete formation of alimentary tract was significantly reduced ($P<0.01$) with increase in temperature. The minimum time taken for formation of mouth opening (36:53±1:39 h) and for complete development of alimentary canal (43:06±0:01 h) was at 34°C. The metamorphosis period significantly reduced ($P<0.01$) with increase in temperature. The minimum duration was 17.84±0.01 days at 34°C. The maximum length of larvae on D28PH (53.41±1.54 mm) was at 33°C (Fig. 1). As the temperature increased the survival rate reduced. The maximum survival rate was at ambient temperature (8.65±0.82 %) and the minimum at 34°C. The overall specific growth rate (SGR) calculated for the entire period of the experiment was not significantly different between the temperatures.

Table 1: Influence of temperature on the embryonic and larval parameters of R. canadum. Means in the same row followed by the same superscript letter are not significantly different (Duncan's, P-value)

Parameters	Control (27.5-29.5)	31°C	32°C	33°C	34°C
Incubation period (h)	21:39±0:36^{a}	20:22±0:10^{b}	19:32±0:07^{b}	18:38±0:07^{c}	18:04±0:12^{c}
Hatching rate (%)	88.31±1.60^{a}	89.06±1.48^{a}	84.67±1.82^{a}	62.96±1.33^{b}	16.50±1.50^{c}
Time taken for mouth opening (h)	53:58±0:47^{a}	49:49±1:05^{b}	43:29±1:07^{c}	38:56±0:34^{d}	36:53±1:39^{d}
Time taken for complete development of alimentary tract (h)	60:29±2:42^{a}	54:56±1:23^{b}	52:04±1:20^{b}	44:12±1:25^{c}	43:06±0:01^{c}
Metamorphosis period (days)	23.28±0.26^{a}	22.58±0.53^{a}	20.65±0.55^{b}	19.11±0.27^{c}	17.84±1.01^{d}

It was noted that many of the advantageous results in the hatchery were at a temperature range of 27.5 to 32°C and hence the same is recommended for better production of cobia seed. It is felt that the range of preferred temperature of eggs and larvae of cobia is comparatively high and hence can contribute substantially to production through aquaculture in future years, even when the anticipated rise in sea water temperature is becoming a reality due to climate change.

Fig 1: Growth in terms of total length of R. canadum larvae from 1 to 28 dph at different temperatures

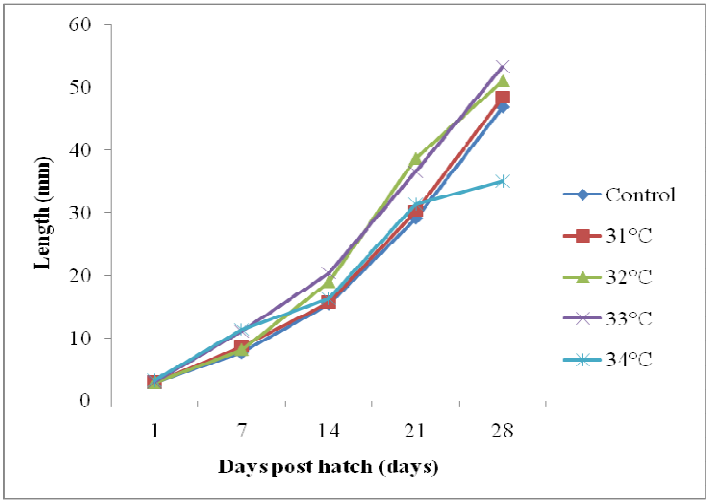


Table 2: Survival and growth rates of cobia larvae from day 1 to day 28 post hatch at different temperatures. Means in the same row followed by the same superscript letter are not significantly different (Duncan's, P-value)

Parameters	**Control (27.5-29.5)**	**31°C**	**32°C**	**33°C**	**34°C**
Survival rate as on D28PH (%)	8.65 ± 0.82^{a}	7.75 ± 0.98^{a}	7.91 ± 0.79^{a}	4.55 ± 0.43^{b}	2.12 ± 0.32^{c}
SGR (overall) (% d^{-1})	9.89 ± 0.53	10.35 ± 0.68	9.23 ± 1.06	10.24 ± 1.56	9.70 ± 0.54
SGR1 (% d^{-1})	13.24 ± 0.31^{a}	15.58 ± 0.54^{bc}	14.40 ± 0.65^{ab}	19.34 ± 0.26^{c}	17.04 ± 0.73^{d}
SGR2 (% d^{-1})	10.44 ± 0.32^{a}	9.76 ± 1.79^{a}	11.79 ± 0.70^{a}	9.95 ± 1.15^{a}	5.59 ± 0.77^{b}
SGR3 (% d^{-1})	9.57 ± 1.06^{abc}	10.81 ± 0.89^{bc}	12.29 ± 0.64^{c}	7.48 ± 0.57^{a}	9.24 ± 1.26^{ab}
SGR4 (% d^{-1})	7.95 ± 0.74^{a}	7.25 ± 0.45^{ab}	4.50 ± 0.44^{c}	5.93 ± 0.43^{bc}	1.89 ± 0.61^{d}

Effect of temperature on yolk-sac larvae in terms of yolk utilization and growth

A clear cut trend of increase in larval length with increase in temperature was noted (Fig.2). The maximum length recorded was 4.41 ± 0.11 at 33°C at the end of the experiment. The yolk-sac volume decreased proportionate to the rise in temperature. At the end of 52 hours, the lowest yolk-sac volume was recorded at a temperature range of 31 to 33°C (Fig. 3 and Fig. 4). The results of the present study suggest that temperature plays a vital role in the yolk-sac utilization as well as growth in length of the larvae of *R. canadum*.

Fig 2: Larval length (mm) of cobia, Rachycentron canadum at different temperatures

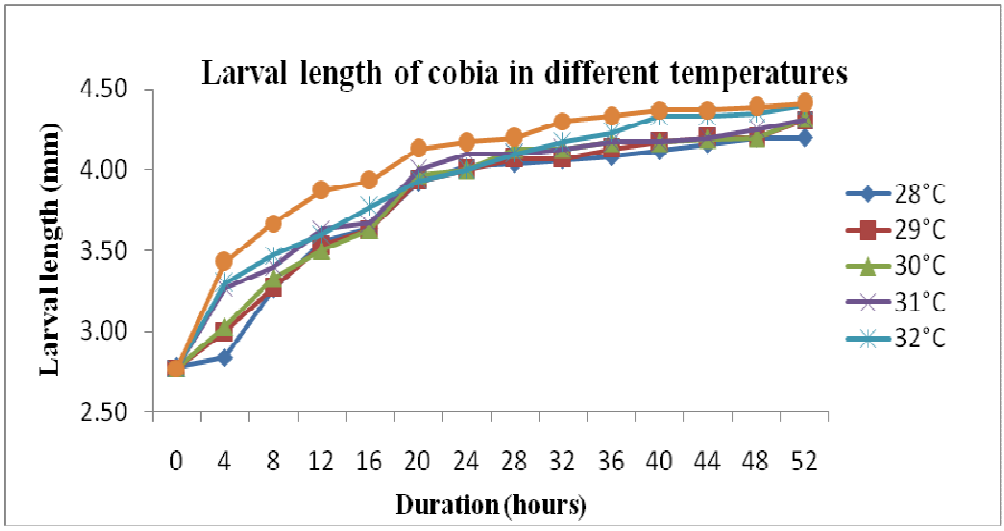


Fig 3: Yolk-sac volume (mm^3) of cobia, Rachycentron canadum at different temperatures

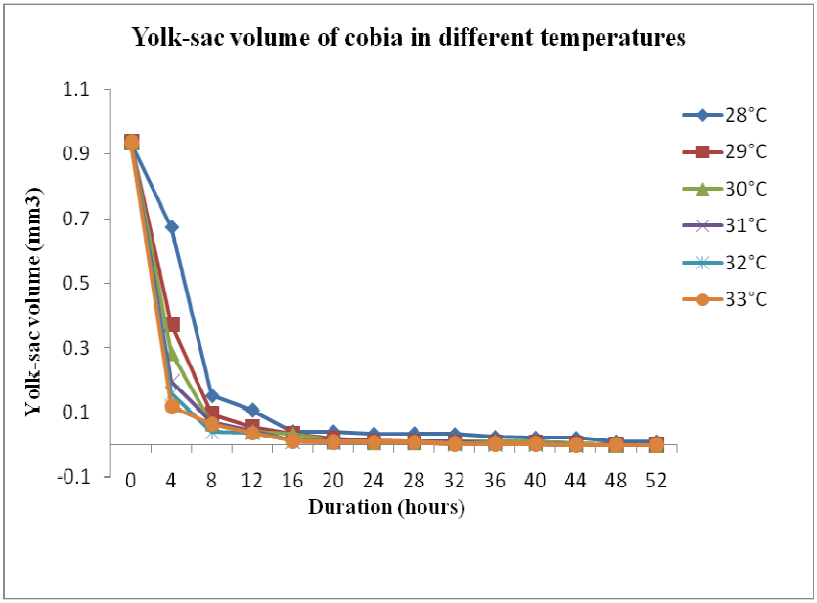


Fig 4: The size of larval yolk-sac of Rachycentron canadum under ambient temperature (27.0 to 28.5°C) at different time intervals

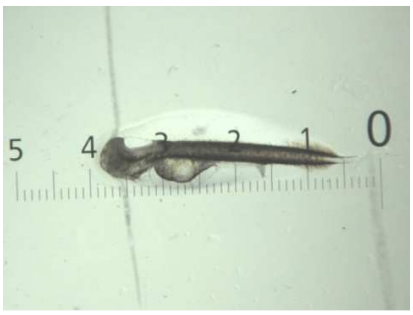
Zero hours

4 hours

8 hours

12 hours

20 hours



24 hours

32 hours

40 hours

48 hours

52 hours

Silver Pompano (*Trachinotus blochii*)

Effect of temperature on incubation, hatching, development and growth of larvae

The present study investigated the influence of water temperature on the incubation of eggs, hatching rate, larval survival and growth of silver pompano, *Trachinotus blochii*. Four temperature regimes *viz.*, 31, 32, 33 and 34°C maintained with submersible aquarium heaters were tested and the control group was maintained at ambient temperature. The incubation period was minimum (14:03±0:16 hours) at 34°C and the same increased as temperature decreased (Table 2). However, the increase in temperature reduced the hatching rate. The time taken for mouth and anal opening, and metamorphosis significantly reduced ($P<0.01$) with increase in temperature. The maximum length recorded (23.48±0.65 mm) was at 34°C (Fig. 5 and Fig. 6). However, the maximum survival rate (33.88±0.63 %) was at ambient temperature and it proportionately declined with increase in temperature.

Table 2: Influence of temperature on the embryonic and larval parameters of T.blochii. Means in the same row followed by the same superscript letter are not significantly different (Duncan's, P-value)

Parameters	**Control (27.5-29.5)**	**31°C**	**32°C**	**33°C**	**34°C**
Incubation period (h)	18:58±0:56^{a}	17:00±0:31^{b}	15:40±0:21^{bc}	15:03±0:18^{c}	14:03±0:16^{c}
Hatching rate (%)	73.40±2.32^{a}	63.76±1.26^{b}	48.98±2.11^{c}	32.56±2.53^{d}	27.61±8.67^{d}
Time taken for mouth opening (h)	49:26±1:34^{a}	41:45±1:21^{b}	35:09±0:38^{c}	32:23±0:34^{c}	28:38±0:39^{d}
Time taken for complete development of alimentary tract (h)	54:24±1:17^{a}	48:35±0:47^{b}	43:50±1:02^{c}	39:56±0:59^{d}	36:34±0:44^{e}

Metamorphosis period (days)	24.83±0.31[a]	22.83±0.17[b]	22.00±0.00[c]	20.00±0.26[d]	18.83±0.31[e]
Survival rate as on D28PH (%)	33.88±0.63[a]	31.99±0.59[a]	28.41±0.61[b]	25.14±0.83[c]	22.15±0.79[d]

Even though an optimum temperature for larval rearing could not be ascertained based on the study, the results indicate that a temperature range of 29-31°C may be advantageous in the larviculture of *T. blochii* for better survival as well as growth rate.

Fig 5: Mean total length (n=3 replicates) of T. blochii larvae from 1 to 28 dph at different temperatures

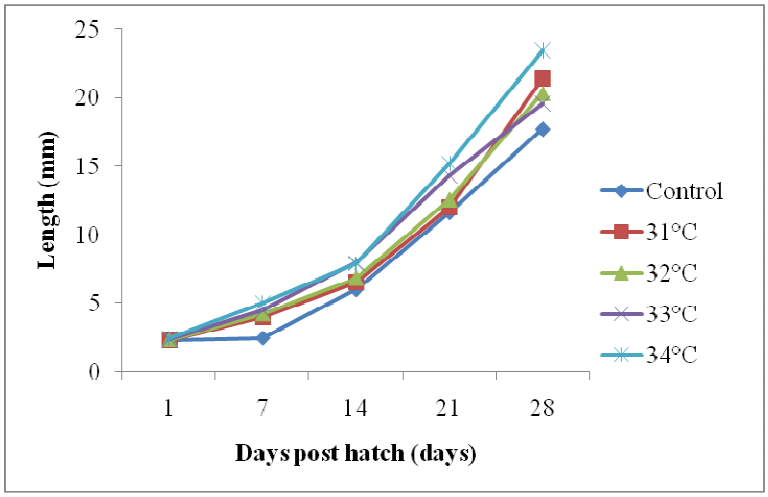
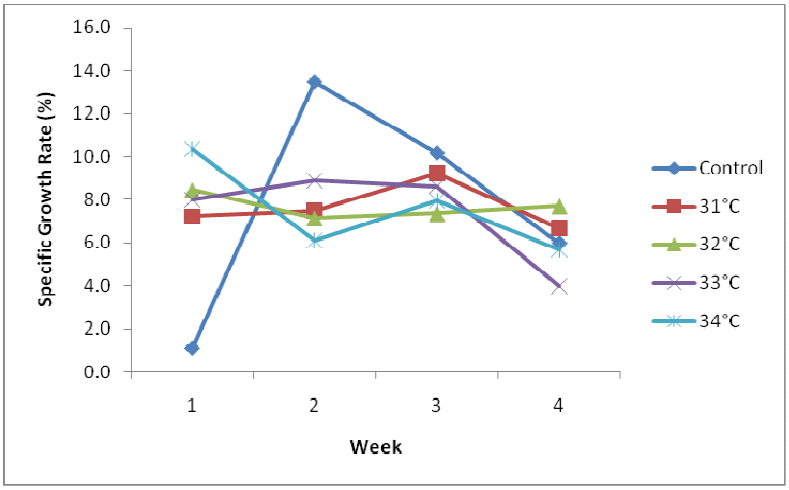


Fig 6: Weekly specific growth rates (n=3 replicates) of T. blochii larvae at different temperatures



Impact of high temperature and light intensity on growth and metamorphosis

The average increase of 2°C in water temperature resulted in reduced growth of about 10 to 33 per cent from 7 dph to 12 dph. Thereafter, the reduction percentage was stabilized. A delay of 3 days was noted in the metamorphosis in the high temperature set. The larval pigmentation became translucent white (8 to 14 dph), brown (15 to 20 dph) and silver (21 dph onwards) in the higher temperature set. The reduced growth rate coupled with change in pigmentation of larvae can be taken as the resilience response of the larvae to combat the temperature stress.

Fig 7: Total length (mm) of silver pompano larvae (1 to 25 dph) at different temperature regimes (set 1 & set 2) and the percentage reduction of growth. The straight line is given to indicate the trend of reduction.

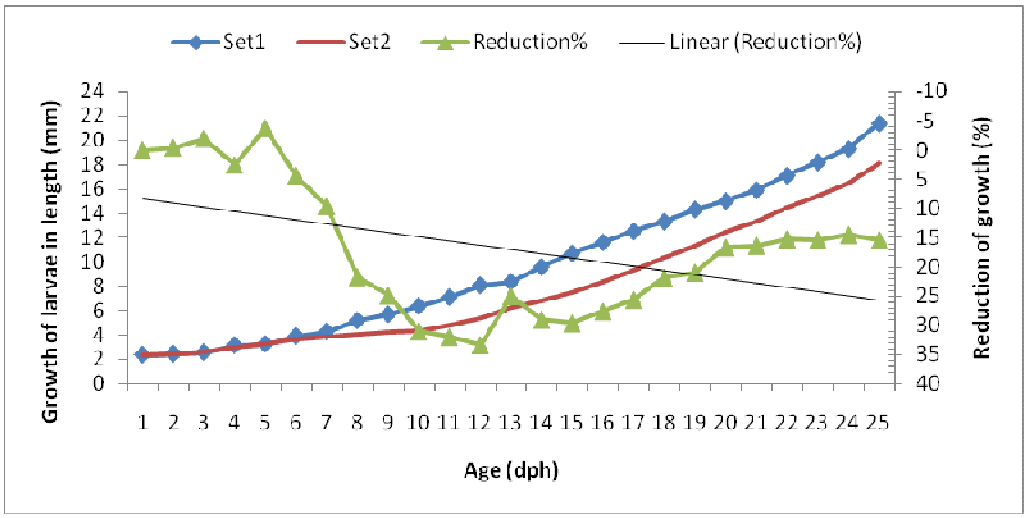


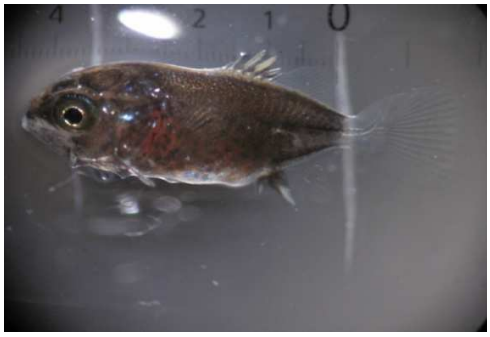
Fig 8: Variation in pigmentation of silver pompano larvae observed at different temperature regimes

<u>Set 1</u> (29.0 ± 0.2 °C)

Larvae at 8 dph (black)

<u>Set 2</u> (31.0 ± 0.2 °C)

Larvae at 8 dph (translucent white)



Larvae at 15 dph (black)

Larvae at 15 dph (brown)

Metamorphosed larvae at 22 dph (silvery)

Metamorphosed larvae at 22 dph (silvery)

Results of significant value from the experiments under NICRA project

- Many of the advantageous conditions viz., increase in hatching percentage, maximum larval survival and growth in the hatchery were at a temperature range of 27.5 to 32°C and hence the same is recommended for better production of cobia seed.
- Temperature plays a vital role in the yolk-sac utilization as well as growth of larvae of *Rachycentron canadum*.
- A temperature range of 29-31°C can be advantageous in the larviculture of *Trachinotus blochii* for better survival as well as growth rate
- At higher temperature and light intensity, reduced growth, change in pigmentation and extended metamorphosis period of silver pompano larvae was noted. This can be taken as the resilience response of the larvae to combat the temperature stress.
- The range of preferred temperature of eggs and larvae of both cobia and silver pompano are comparatively high and hence can contribute substantially to production through aquaculture in future years, even when the anticipated rise in sea water temperature is becoming a reality due to climate change.

B) Technology Demonstration component

Sea cage farming demonstration of cobia through participatory mode with Cobia Aquaculture Society, Rameshwaram, Tamil Nadu

About 6400 nos. of cobia fingerlings of 12 cm length and an average weight of 20 grams were stocked. The growth of cobia in four months culture period was observed to be an average length of 42.6 cm and a weight of 547.0 g. The demonstration is in progress.

Demonstration of cage farming of cobia through participatory mode with M/s. Vitality Aquaculture Pvt. Ltd., Thoothukudi, Tamil Nadu

About 2000 nos. of cobia fingerlings of 12 cm length and an average weight of 20 grams were stocked. The growth of cobia in six months culture period was observed to be an average length of 72.3 cm and a weight of 3.0 kg. The demonstration is in progress.

Demonstration of cobia farming in sea cages through participatory mode with a fishermen group of the adjoining village (Marakkayarpattinam) of CMFRI

About 400 nos. of cobia fingerlings of 22.0 cm length and an average weight of 118 g were stocked. The growth of cobia in two months culture period was observed to be an average length of 39.5 cm and a weight of 389.0 g. Another batch of about 2000 nos. of cobia fingerlings of 9.7 cm length and an average weight of 13.6 were stocked. The growth of cobia in one month culture period was observed to be an average length of 16.1 cm and a weight of 20.7 g. The demonstration is in progress.

Demonstration of pond farming of silver pompano through participatory mode with private entrepreneurs in Chidambaram, Tamil Nadu

About 1000 nos. of pompano fingerlings of 6.5 cm length and an average weight of 8.7 g were stocked. The growth of pompano in six months pond culture period was observed to be an average length of 20.5 cm and a weight of 135.0 g. Another batch of about 4000 nos. of cobia fingerlings of 5.0 cm length and an average weight of 7.2g were stocked. The growth of pompano in three month pond culture period was observed to be an average length of 14.2 cm and a weight of 50.3 g. The demonstration is in progress.

Demonstration of pond farming of silver pompano through participatory mode with private entrepreneurs in Andhra Pradesh

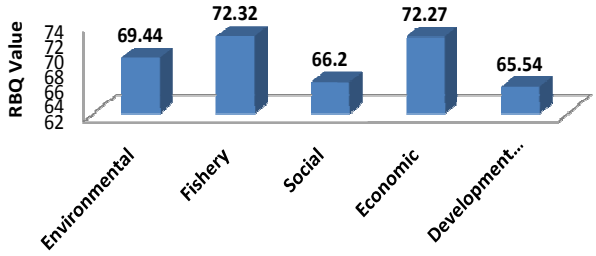
They results of pond farming of pompano are presented in the following table.

Sl.No	Details of the beneficiaries under demonstration of the technology		Mean weight (g)
1.	Mr. Raghu Sekar, Nagayalanka, Andhra Pradesh	:	45.0 g
2.	Mr. Kevin Saldhana, Perupalam, West Godavari district, Andhra Pradesh	:	120.0 g
3.	Mr. M.V.S. SubbaRaju, Bhimavaram, Andhra Pradesh	:	150.0 g
4.	Mr. Appal Raju, Bhimavaram, Andhra Pradesh	:	63.5 g
5.	Mr. Koteswara Raju, Peddapatnam, Krishna District, Andhra Pradesh	:	60.0 g

Developing integrated district level adaptation and mitigation for climate change – Collection, entry and analysis of data and construction of vulnerability indices in selected coastal district of Tamil Nadu

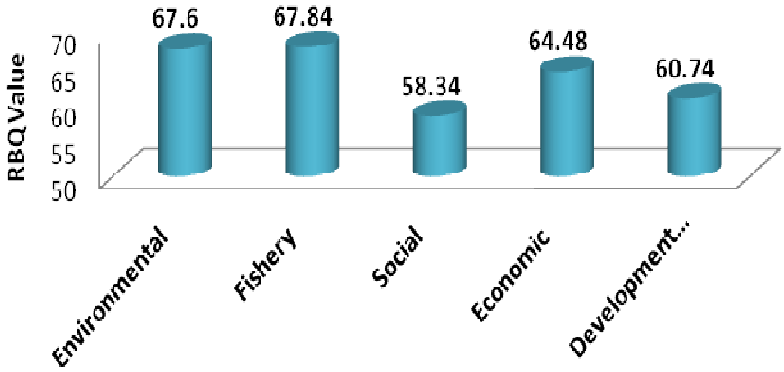
The vulnerability index was analysed and it was found that out of 13 coastal districts in Tamil Nadu, Ramanathapuram district had the highest vulnerability followed by Kanyakumari and Nagapattinam. The vulnerability index was also calculated for each coastal village in Ramanathapuram and Nagapattinam district. The highly vulnerable villages in Ramanathapuram district were Mandapam (0.5901), Rameswaram (0.4011),Valinokkam (0.2765), Natarajapuram (Dhanuskodi) (0.2699), Pamban (0.2684) and Nambuthalai (0.2683). The highly vulnerable villages in Nagapattinam district were Seruthur (0.3413), Tharangambadi (0.3242), Arkattuthurai (0.3078), Poompuhar (0.2824) and Nagore Pattinachery (0.2797). The study based on fishers' perception on different attributes in the selected fisher households in all the selected villages indicated that climate change has mostly impacted fishery followed by economic and environmental factors in Ramanathapuram district and environmental and economic factors in Nagapattinam district.

Fig. 1 Climate parameter assessment for combined six villages in Ramanathapuram district



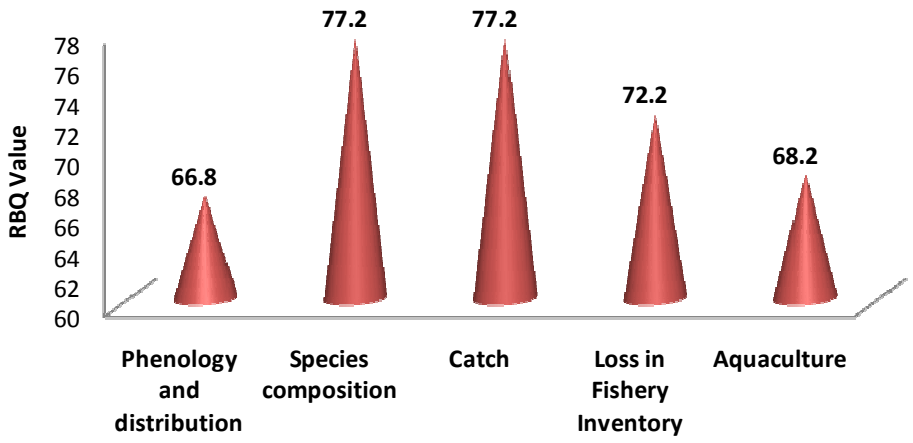
The attributes loss in fishery inventory and aquaculture followed the species composition and catch attributes. The analysis on the resilient indicator to this attribute indicated that fish catch has decreased drastically over the years and effort has increased fairly, the fishing ground has changed or fishes are not available from the areas where they were abundant once, the by-catch and landing of juveniles has increased highly over the years. According to fishers' coastal fishes have migrated to open sea and there is a shift in spawning season of major fishes along the coast due to climate change. There is also significant shift in fishing season. Due to extreme weather events there is considerable damage to craft and gear in recent years. In Ramanathapuram district, seaweed farming is adopted by more than 1000 fishermen families. In last ten years, occasionally in some season the entire crop was destroyed due to high temperature and cyclone. Hence, some fishers' perceived that climate change may significantly affect the aquaculture.

Fig. 2 Climate parameter assessment for combined five villages in Nagapattinam district



The process of fisheries and their associated communities adapting to climate change is facilitated and constrained by various social factors and involves value-based decisions and trade-offs. Now there is also a need for adaptive governance as well as integration of fisheries with available alternate avocations. The alternative avocations available across the different fishing villages need to be strengthened in order to negate the different risks and uncertainties of climate change and in ensuring a climate change informed fishers in the future. Thus a bottom up approach involving the primary stakeholders along with the community will adequately position them to climate change adaptation and mitigation by augmenting their traditional knowledge.

Fig. 3 Attribute analysis of climate change impacts on fishery in Ramanathapuram district



First harvest of cobia under technology demonstration component of NICRA was flagged off by Hon'ble DG, ICAR at Mandapam Regional Centre of CMFRI

A participatory technology demonstration of cage farming of cobia under NICRA by two SHGs with Mandapam Regional Centre of CMFRI was initiated during 29th September 2012 at Mandapam Sea. About 1,800 cobia seeds which were hatchery produced at Mandapam Regional Centre were stocked in four circular GI metal cages of 7 m dia and 3.5 mts depth. The initial length and weight of fingerlings ranged from 10 to 15 cm and 20 to 30 grams respectively. The stocking density was 4.1 /m^3. They were fed with trash fish *ad libitum* twice a day. During the farming period of 7 months they reached a size range of 2.0 to 3.5 kg weight, with an average size of 2.5 kg. The FCR was 5.9.

The harvest of cobia farmed by self help groups was flagged off by the Hon'ble Director General on 12th May 2013. A total of 4 tonnes of cobia was produced and a farm gate price of Rs. 250/kg was realized. The per kg cost of production was Rs. 134/-, with the net income of Rs. 4, 65,976/-

Aggregating the fish harvest

Harvested cobia in the hands of Hon'ble DG

Weighing of cobia

View of the harvested cobia

SHG members and scientists with harvested fishes

View of the harvested cobia

Results from biodiversity, biotechnology, capture fisheries and social sciences studies

- *Semperella megaloxea* sp.nov. (Family:Pheronematidae): A Hexactinellid Sponge species collected from the eastern side of North Andaman waters off Diglipur has been found to be a species new to science.

- Studies on the sponge diversity along the south-west coast of India is very less and the information available is fragmentary. A total of 24 species of sponges were identified during the underwater studies conducted in the coastal waters extending from Enayam to Kollam, which belonged to 20 genera, 13 families and 6 orders.

- Surveys conducted on the crab diversity in Mandapam waters revealed a total of 57 species belonging to 29 families from the coral reef, sea grass and mangrove ecosystems.

- A detailed study aimed at identifying the changes in biodiversity, live coral cover as well as health status of the Palk Bay reef corals revealed a substantial decrease in live coral cover in Velapertumuni and Kathuvallimuni reefs. Diseases such as brown band disease, Porites ulcerative white spot syndrome and pink line syndrome/Porites pinking were recorded in the corals of Palk Bay.

- Month-wise analysis of economics of marine fishing methods in Ramanathapuram district for the year 2013 revealed that the capital productivity of mechanized single day trawling for shrimp resources varied from 0.59 to 0.86. The economic performance was better during the month of January with the operating ratio of 0.59. The capital productivity of mechanized single day trawling for fish resources varied from 0.45 to 0.78. The economic performance was better during the month of February, April, November and December with the operating ratio of 0.45, 0.48, 0.49 and 0.48 respectively.

- The landing centre, wholesale and retail price for about 75 fish species in Ramanathapuram district of Tamil Nadu is being maintained from November 2012 to till date. The analysis of price for the year 2013 showed that the average landing centre price per kg ranged from ` 800 for silver pomfret (500 grams size) to Rs. 12 for oil sardine (20-25 nos per kg). The average retail price per kg ranged from Rs. 945 for silver pomfret (500 grams size) to Rs. 23 for oil sardine (20-25 nos per kg).The highest price spread was for silver pomfret(500 grams size) at Rs. 145 per kg and the lowest were for oil sardine (20-25 nos per kg) at Rs. 11 per kg.

- Based on the Patnaik and Narayan model coastal district vulnerability index was derived for different coastal districts of Tamil Nadu. The vulnerability index was analysed and it was found that out of 13 coastal districts in Tamil Nadu,

Ramanathapuram district had the highest vulnerability followed by Kanyakumari and Nagapattinam.

- Farming of seaweed *Kappaphycus alvarezii* is expanding fast as one of the alternate livelihood options at Ramanathapuram coast of Tamil Nadu. Heavy loss of *Kappaphycus alvarezii* was reported during the month of August and September, 2013. More than 10,000 rafts which were ready to harvest were completely decayed due to high temperature and the economic loss was about Rs. 37.5 lakhs. Maximum loss was reported at Sambai and Mangadu village in Ramanthapuram district of Tamil Nadu. An experiment was conducted in an environmental chamber for testing the temperature effects on *Kappaphycus* at Mandapam Regional of CMFRI during the month of October, 2013.Around 200 gms of *Kappaphycus* was placed in each of the five 250 litre glass tanks at temperature 31°, 32°, 33°, 34° and 35°C respectively and the control experiment was maintained at ambient temperature (28 -30°C). The water temperature was maintained with the thermostat. It was found from the study that the *Kappaphycus* which was placed in the tanks having water temperature 33°C and above started to lose pigments within 48 hours and resulted in paling and eventually whitening. The *Kappaphycus* which was placed in the tanks having water temperature 31°C and 32°C started to lose pigments on fourth day and resulted in paling and eventually whitening on fifth day. Based on the study it was recommended that the seaweed farmers should periodically measure the sea surface temperature with the help of thermometer. If they observe the temperature 33°C and above for two continuous days combined with less water current, they can go for immediate harvest.

- For preparation and characterization of marine algal oligosaccharides having medicinal and aquaculture values, the starting product is algin which was obtained from brown seaweed. The degradation of this algin was done with oxalic acid to get two fractions of oligomers. Standardization of the method and quantification of the products are in progress.

- As a first step for development and evaluation of functional feed additives**,** acidic aqueous soluble portion of brown seaweed was recovered from alcohol fractionation to the tune of 1.8% yield followed by the method of algin extraction from brown seaweed by alcohol fractionation was standardized. It was then converted into cream coloured calcium salt with bleaching in a single step process.
- The phenomenal landing of the diel migrating swimming crab *Charybdis* (Goniohellenus) *smithii* Mackleay 1838, from Gulf of Mannar, in trawls operated at a depth of 150 metres was fully dominated by male which indicated the sexual segregation of this species in pelagic and benthic mode of life.
- It has been observed that the gill nets (*nandu valai* & *singhi valai*) cause destruction to many non-target groups like the sponges and other invertebrates like starfishes in the

Gulf of Mannar. Also, operation of mini trawls (*thallu valai*) in sea grass beds cause destruction to many invertebrates like sponges, sea urchins, star fish and gastropods.

- The technique for propagation of soft coral *Cladiella* sp. has been standardized. New colonies were successfully established on coral rubbles, tiles and concrete blocks. The newly established colonies were also suspended in the sea for monitoring their growth performance and a higher increment in basal circumference (80 to 135mm) was observed in the suspended colonies when compared to the colonies maintained in laboratory (10 to 65 mm) in 75 days culture period.
- Studies have revealed that seaweeds are an excellent source for fixing high levels of carbon-di-oxide. Among the two seaweeds studied, *Padina gymnospora* was found to fix higher levels of CO_2 (2 to 5 mg/l) when compared to *Kappaphycus alvarezii* (1 to 2 mg/l). Gross and Net Primary Productivity was also higher in *P. gymnospora* when compared to *K. alvarezii*. Seaweed farming in large areas of coastal waters would therefore help to fix CO_2 to a great extend.
- The investigations conducted under the National Initiative for Climate Resilient Agriculture (NICRA)' revealed that temperature is the major factor which is influencing the spawning, larval survival, growth and metamorphosis of the marine fishes investigated *viz*., cobia and pompano. In addition, it was also noted that temperature has a critical role in the primary and secondary productivity.
- In Ramanathapuram district, primary data were collected from 30 families each in the village *Victoria Nagar, Susaiyaparpattinam and Olaikuda* respectively and Multidimensional Poverty Index (MPI) was estimated. It was found that 31.1 per cent of marine fisher folk in Ramanathapuram district of Tamil Nadu were multi dimensionally poor. Indicator-wise analysis revealed that majority were deprived of drinking water and sanitation facilities

Publications

The number of publications (year-wise) has been given in the following Table.

Type of Publication	2009-10	2010-11	2011-12	2012-13	2013-14	Total
Research Papers	03	04	11	05	03	**26**
Technical/ Popular Articles	10	07	26	14	08	**65**
Teaching Resource	01	--	--	01	12	**14**
Brochures	--	--	--	--	04	**04**
Books/Manuals	--	01	01	--	--	**02**
Total	**14**	**12**	**38**	**20**	**27**	**111**

Patents developed/ applied

A patent application has been filed for "GROWOUT PELLET FEED FOR SILVER POMPANO, *Trachinotus Blochii* (LACÉPÈDE) AND A PROCESS THEREFORE TO INCORPORATE FATTY ACIDS" under application no.2965/CHE/2013 dated 03/07/2013 in the name of Indian Council of Agricultural Research and submitted to the Intellectual Property Rights (IPR) office, Chennai.

Major Infrastructure developed /renovated during the period

The following are the infrastructure facilities developed during the period and a detailed report follows.

- Research and Administrative Block
- International Trainee`s Hostel
- Wet and Dry Laboratories
- Hatcheries for finfish and shellfishes
- Recirculation Aquaculture System
- National Marine Finfish Brood bank
- Centralized Instrumentation Facility
- Sea Cage farm
- Mariculture Complex
- Library
- Marine Reef Aquarium
- Marine Museum
- Conference hall
- Guest house
- R.O plant
- Residential quarters

At the Mandapam Regional Centre of CMFRI, India's first marine brood fish bank facility, a state of art Recirculating Aquaculture System (RAS) laboratory and a Mariculture complex were commissioned by the Hon'ble Secretary, DARE & Director General of ICAR, Dr. S. Ayyappan on 12th May 2013. A new Research & Administrative Block and an International Trainees' Hostel were also inaugurated by the Hon'ble Director General. The function was graced by Dr. B. Meenakumari, Deputy Director General (Fy.), ICAR, Dr. Madan Mohan, Assistant Director General (Fy.), ICAR, Shri. K. Nanthakumar, IAS, District Collector, Ramanathapuram and Commandant H.H. More, Commanding Officer, Indian Coast Guard, Mandapam Station.

A national marine finfish brood bank where the brooders of high value finfishes can be developed for breeding and seed production was designed and built. The concept of broodstock bank was evolved, designed and the same was constructed at the Mandapam Regional Centre. The broodstock tanks with continuous bio-filtration system can be used to maintain broodstocks of high value marine finfishes like cobia, silver pompano, groupers, snappers, breams, *etc.*, in healthy condition. Maintenance of marine finfish broodstock in land based system is generally expensive, time consuming and labour intensive which prohibits the private sector / entrepreneurs to venture in mariculture. Understanding this bottleneck, the CMFRI has established a National Marine Fish Brood Bank at Mandapam aimed to hold broodstocks of commercially important marine finfishes and to supply quality eggs / newly hatched larvae to the private hatcheries for fingerling production. This facility is the first of its kind in India and was commissioned by the Hon'ble Director General.

Commissioning of National Marine finfish brood bank

DG viewing the brood bank facility

A recirculation aquaculture system with components such as drum filter, fluidized-bed bioreactor, protein skimmer, UV sterilizer and egg collection facility, is inevitable for healthy maintenance of the marine finfish broodstocks and year-round breeding. The system will serve to develop the broodstocks into spawners. The photo-thermal conditioning for accelerating maturation can also be incorporated into the system. The safety of the spawners and year-round controlled spawning are ensured in this system. The RAS facility, which was installed at Mandapam by importing sophisticated equipment from M/s. Aquatic Ecosystems, USA, is the first of its kind in the fisheries scenario of India. This facility was commissioned by the Hon'ble Director General.

Unveiling of plaque by District Collector at RAS

Hon'ble DG viewing the RAS facility

Massive infrastructure for broodstock development is needed for developing the broodstocks of larger species such as yellowfin tuna. The large scale fingerling rearing also requires extensive facilities. To meet these requirements, a mariculture complex consisting of high volume concrete tanks (4 nos each of 1250 tonne capacity) was designed and established on the Palk Bay side of the Mandapam Regional Centre of CMFRI. This facility would support standardizing the technologies for broodstock development, grow-out culture and on-farm trials. This complex was dedicated to the nation by the Hon'ble Director General.

Unveiling of plaque by ADG at mariculture complex

Viewing the mariculture complex by Hon'ble DG

In addition, a Research & Administrative block has been built with facilities to accommodate the Scientists, Technical personnel, Administrative and Accounts sections. Besides, the facility incorporates an interpretation centre, dry and wet laboratories.

Inauguration of Research and administrative block

View of Research and administrative block

An International Trainees' hostel consisting of 13 nos. of well furnished one-room apartments to accommodate overseas trainees deputed to the Centre to acquire technical knowledge on the various technologies developed at the centre, was also inaugurated during this occasion.

Inaugurating the international traniees hostel by SIC Mandapam

Unveiling of plaque by Hon'ble DG at international trainees hostel

View of trainees hostel

Hon'ble Director General inaugurated a small-scale marine ornamental fish production unit run by all women self help group established within the premises of the Mandapam Regional Centre of CMFRI.

Inaugurating the all women small-scale hatchery unit by DDG

Hon'ble DG observing the hatchery run by all women

Hon’ble Director General delivered the inaugural address and honoured the fish farmer and entrepreneurs.

Inaugural address by Hon'ble DG

Handing over the fingerlings to the farmer by Hon'ble DG

Honouring entrepreneur by Hon'ble DG

Honouring farmer by Hon'ble DG

Honouring farmer by Hon'ble DG

Honouring farmer by Hon'ble DG

Handing over the MOU with entrepreneur by Hon'ble DG

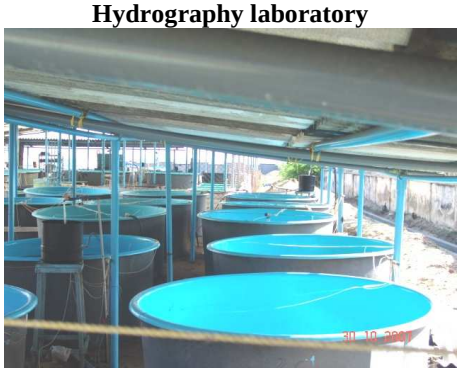
Handing over the MOU with entrepreneur by Hon'ble DG

DG with the staff of MRC of CMFRI

Press meet

Other Infrastructure Facilities of the Centre

Hydrography laboratory

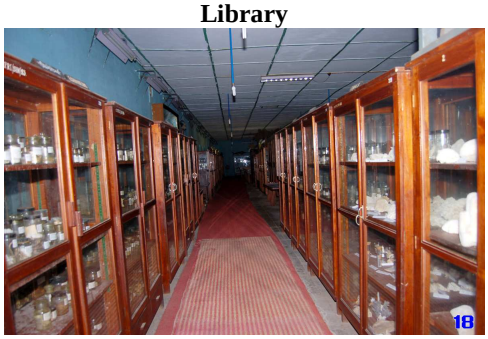


Instrumentation room

Ornamental Hatchery

Shrimp hatchery

Library



Marine Reef Aquarium

Marine museum

Guest house

Conference Hall

Sea cage farm

Fish Farm

Farming activity at fish farm

R O Plant

R O Plant (inside view)